Report to Congress:

**Expressions of
Interest in Commercial
Clean Coal Technology Projects
in Foreign Countries**

**United States Department of Energy
Assistant Secretary for Fossil Energy
Washington, DC 20585**

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Guidance provided by the Congress in the Conference Report (Nº 103-740) that accompanied Pub. L. Nº 103-332, the Department of the Interior and Related Agencies Appropriations Act, 1995, and the guidance contained in the corresponding Senate and House Reports (Nº 103-294 and Nº 103-551, respectively), directed the Department of Energy (DOE) to make the international dissemination of Clean Coal Technologies (CCTs) an integral part of its policy to reduce greenhouse gas emissions in developing countries. Congress also requested DOE to solicit statements of interest in commercial projects employing CCTs in countries projected to have significant growth in greenhouse gas emissions, and then to identify in a report to the Congress the extent to which various types of Federal incentives would accelerate the commercial availability of these technologies in an international context.

Accordingly, an "Announcement to Request Expressions of Interest (EOIs) in Commercial CCT Projects in Foreign Countries" was published in the *Federal Register* on 18 November 1994 (59 FR 59768) (Appendix A). Potential respondents were advised that DOE has no monies to fund or otherwise provide any incentive in support of the proposed projects. This solicitation was conducted to provide Congress with the information needed to consider the technical, economic, and environmental aspects of various incentives sought to support international CCTs, and their merit for future support.

1.2 DOE CLEAN COAL TECHNOLOGY (CCT) PROGRAM

The burning of coal releases carbon dioxide (CO₂), sulfur dioxide (SO₂), oxides of nitrogen (NO_x), particulate matter, and ash. The DOE CCT Program develops and demonstrates the means of economically utilizing coal while minimizing such emissions. CCTs are defined as coal-based systems that offer significant benefits when used for power generation, pollution control, or the conversion of coal into other alternate energy products. Environmental requirements have joined with cost reduction to become the primary forces driving coal technology development in new directions. When establishing the CCT Program, Congress envisioned a responsive and successful technology development and demonstration program, which it viewed as essential to realizing sustainable economic and environmental development of coal reserves, both domestically and on a global basis.

The CCT Program initiative is the largest technology development and demonstration effort now underway in DOE. The fact that the present and near term future of coal as an energy source depends upon continued advances in technology has been acknowledged, and is being acted upon through the CCT Program.

The goal of the CCT program is to make available to the U.S. (and ultimately to the global energy marketplace) a number of advanced, more efficient, and environmentally responsive coal technologies. These technologies will reduce or eliminate the economic and environmental impediments that limit the full use of coal. To this end, the CCT Program has managed five competitive solicitations for cost-shared demonstration proposals, that have resulted in 43 active projects as of this writing. Of particular importance to DOE is the level of financial participation in these projects by the private sector; although Congress required that such participation be a minimum of 50 percent, the participants are voluntarily providing an overall average of 66 percent of the funds in these projects.

1.3 EXPRESSION OF INTEREST (EOI) METHODOLOGY

The Announcement explained that Expressions of Interest (EOIs) and informational proposals submitted were to propose an international (non-domestic) project that would employ at least one CCT, and that is responsive to the Congressional guidance with regard to, at a minimum, the following:

1. Sponsored by a U.S.-based company or consortium,
2. Located in a developing country, or in a country making the transition from a centrally planned to a market economy, projected to have significant growth in greenhouse gas emissions,
3. Capability of reducing greenhouse gas emissions, particularly CO₂, as compared to technologies in common use in the proposed locale,
4. Versatility with regard to effective usage of various globally available coal types and characteristics, and
5. Likelihood of utilization on a broad commercial scale subsequent to successful demonstration.

An important aspect of the Announcement was the request by DOE for the respondents to provide comments or discussion on these questions:

- What are the greatest opportunities for commercializing U.S. CCTs abroad (short- and long-term)?

The respondents substantiated DOE's assessment that the greatest opportunities for commercializing U.S. CCTs abroad were for advanced power systems in China, the Pacific Rim, South Asia (India and Pakistan), Eastern Europe, and the Newly Independent States of the former Soviet Union. There are also opportunities for coal processing and environmental control devices in countries with expanding coal use.

- What role can DOE best play to facilitate commercialization of these technologies?

The respondents indicated that DOE can facilitate commercialization of CCTs by making existing programs more effective, developing an ongoing program of DOE technical assistance, implementing low-cost information exchange programs, conducting market-responsive research and development, assisting with innovative export finance mechanisms, and providing higher-cost financing options.

1.4 OVERVIEW OF THE RESPONSES

Thirty-three organizations responded to DOE's request for EOIs to build CCT projects in developing countries, Eastern Europe, or the Newly Independent States (NIS) of the former Soviet Union, where significant growth in greenhouse gas emissions is expected. Together, the respondents submitted 77 EOIs to DOE. Of the companies responding to the solicitation, CQ Inc., of Homer City, Pennsylvania, was the most prolific, with 14 separate proposals. New Jersey-based Foster Wheeler Energy International, Inc., was second with 12 EOIs, while the Babcock & Wilcox Co., of Alliance, Ohio, was third with 11 proposals. Seven other organizations submitted either two or three EOIs.

To the extent that the information was provided in the EOIs, Table 1-1 categorizes the types of CCTs that were proposed. The respondents proposed projects employing U.S.-developed CCTs in 21 countries, primarily in the Pacific Rim and Eastern European regions.

Table 1-1
Types of Clean Coal Technologies Proposed

Type of Clean Coal Technology	Number of EOIs Submitted
Emissions controls: Combined SO ₂ and NO _x	2
NO _x	3
SO ₂	5
Industrial applications	2
Advanced combustion	4
Miscellaneous	4
Coal preparation	6
New fuel forms	6
Atmospheric fluidized bed combustion (AFB)	7
Pressurized fluidized bed combustion (PFB)	8
Integrated gasification combined cycle (IGCC)	14
Computer software and modelling	16

With regard to the environmental aspects of the proposed international projects, including in particular CO₂, the EOIs addressed a range of potential emissions reductions and other environmental benefits; however, CO₂ was included in only 41 of the proposals. In addition to reducing air emissions, 13 of the EOIs included waste water improvements, and 15 EOIs reduced water consumption.

Table 1-2 presents a detailed overview of the responses on a country-by-country basis, noting, for each of the 22 represented countries, the number of EOIs received, and, *to the extent that the information was provided*, cumulative generating capacity of the proposals, cumulative dollar value, and the pollutants represented (CO₂, SO₂, NO_x, PM₁₀—particulate matter smaller than 10 microns in diameter, PM—particulate matter in general, and TOX—air toxics). On a per-country basis, the total proposed project sizes range from 20 megawatts in Indonesia (two EOIs received) to as much as 6,537 megawatts in China (for 20 proposals).

The total (similarly accumulated for all Expressions of Interest received) project costs per country range from \$250,000 in each of Bulgaria, Estonia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Romania, Slovak Republic, and Slovenia—all of which projects are for computer software—to as much as \$2.5 billion for the 20 projects proposed for China.

The types of governmental incentives requested by the respondents ranged from direct financial assistance, including cost shared support of the nature currently employed in the CCT Program, through various kinds of export assistance and market analysis services. EOIs also noted the merits of trade missions and reverse trade missions of the nature reflected by the recent highly successful activities of DOE and the Secretary of Energy, and governmental participation in addressing regulatory and other trade impediments encountered in the course of negotiating projects in foreign lands. The incentives requested are summarized in Table 1-3 below, and addressed in detail in Chapter 7 of this report.

1.5 ADDITIONAL MATERIALS RECEIVED

Albeit not responsive project proposals *per se*, five additional responses were received from Poznan University of Technology in Poland, Destec Energy, Inc. (Houston, Texas), the Electric Power Research Institute, the United Nations, and Bharat Heavy Electricals Ltd. (Tamil Nadu, India). These additional materials offer support for, and suggestions on, DOE assistance with commercializing Clean Coal Technologies and other approaches to coal usage in developing countries. They are reproduced in their entirety in Appendix D of this report.

Table 1-2
Salient Characteristics of the Expressions of Interest
Received, by Proposed Host Country

Country	No. EOs Recd.	Total Capacity (MWe)	Total Cost (\$U.S. thousand)	Emissions Reductions					
				CO ₂	SO ₂	NO _x	PM ₁₀	PM	TOX
Australia	1	not available	\$1,400				✓		
Brazil	1	not available	\$5,500	✓	✓	✓	✓	✓	
Bulgaria	1	4,000	\$250	✓	✓				
China	20	6,537	\$2,509,840	✓	✓	✓	✓	✓	✓
Czech Republic	5	4,210	\$455,250	✓	✓	✓	✓	✓	✓
Eastern Europe	4	700	\$578,000	✓	✓	✓		✓	✓
Estonia	1	3,000	\$250	✓	✓				
Hungary	2	4,000	\$3,225	✓	✓	✓			
India	10	1,110	\$2,081,000	✓	✓	✓	✓	✓	✓
Indonesia	2	20	\$65,400	✓	✓	✓	✓	✓	
Kazakhstan	1	4,000	\$250	✓	✓				
Kyrgyzstan	1	3,000	\$250	✓	✓				
Latvia	1	1,600	\$250	✓	✓				
Lithuania	1	4,000	\$250	✓	✓				
Mexico	1	100	\$160,000		✓	✓		✓	✓
Pacific Rim	3	740	\$650,000	✓	✓	✓	✓	✓	✓
Pakistan	1	350	\$120,000	✓	✓				
Poland	5	4,120	\$163,650	✓	✓	✓		✓	✓
Romania	1	4,000	\$250	✓	✓				
Russia	6	100	\$117,000		✓	✓			
Slovak Republic	1	4,000	\$250	✓	✓				
Slovenia	1	2,000	\$250	✓	✓				
Ukraine	4	4,550	\$162,250	✓	✓	✓		✓	
Unspecified	3	100	\$80,750	✓	✓	✓			
Totals	77	58,237	\$7,150,000						

NOTES:

Some EOIs did not address proposed project capacity.

CO₂ is carbon dioxide

SO₂ is sulfur dioxide

NO_x is oxides of nitrogen

PM₁₀ is particulate matter smaller than 10 microns in diameter

PM is particulate matter in general

TOX is air toxics

Table 1-3
Types of Federal Incentives Proposed
(note that some respondents proposed multiple incentives)

Type of Federal Incentive	Number of EOIs Submitted
Funding of Initial Project Development	33
Funding of Projects	34
Financial Assistance to U.S. Businesses	24
General Support Assistance to U.S. Businesses	18
Technical Assistance to Host Country	32

1.6 MARKET ASPECTS OF CCTs

The CCTs are directed toward satisfying the energy and environmental needs of four market sectors:

- Advanced electric power generation,
- Environmental control devices,
- Coal processing for clean fuels, and
- Industrial applications.

These demonstrations are being conducted at commercial scale, in actual user environments, and under conditions typical of commercial operations, thereby allowing the potential of the technologies to be evaluated in their intended commercial applications. The most promising CCTs for CO₂ reduction are the advanced electric power generation systems. These technologies are characterized by high thermal efficiency, and very low pollutant emissions including reduced CO₂ emissions. These highly efficient technologies produce less CO₂ per unit of power produced than do conventional coal-fired electric power generation technologies. For example, pressurized fluidized bed combustion (PFB) and integrated gasification combined-cycle technologies (IGCC) boost generating efficiencies into the 40-45 percent range, as compared to conventional technology efficiencies of approximately 33 percent. This can reduce CO₂ emissions by 17-27 percent. CCTs yet to be demonstrated, such as gasifier-fuel cell combinations and advanced turbines, have the potential to lower CO₂ emissions by up to 55 percent.

The environmental control devices address the need for efficient, effective, and economic means for existing and new conventional coal-fired units to comply with environmental regulations, and at the same time, mitigate broader environmental concerns such as waste disposal. Optimal performance for these technologies would be highly efficient pollutant capture, low capital and operating costs, high operating efficiency, availability and reliability, and recyclable or salable by-products. Technologies that would find application in this market sector include NO_x control technology, SO₂ control technology, and combined SO₂, NO_x and particulate control technology.

Coal processing for clean fuels technologies are directed toward the production of economic fuel options, which can be used to comply with environmental regulations or can be used to replace petroleum and natural gas in fuel or chemical production. Physical and chemical processes can be applied to coal resources to transform them into a cleaned low-sulfur, low-ash fuel for direct combustion in existing boilers. This is often the least cost method of achieving environmental compliance. Further, these cleaned coals have a higher energy density and reduced moisture, which reduces transportation costs on a Btu basis. Processing coal into new fuel forms such as gases and liquid is included in this market sector. The liquid fuels produced are low in sulfur and suitable for the transportation sector, stationary power generation, or as chemical feedstocks.

The industrial applications include those technologies developed for the industrial sector to resolve environmental problems similar to those of the electric power generators, such as reduction of acid rain precursor emissions, air toxics, greenhouse gases, and solid wastes. Technology may be specific to an industrial application, such as steel and cement manufacturing, or to broad industrial applications. These would include advanced combustors, fluidized-bed combustors, and a variety of environmental control technologies.

1.7 FEDERAL INCENTIVES

Federal incentives proposed by the respondents can be grouped into three broad categories:

- Funding of Initial Project Development,
- Funding of Projects, and
- Other Assistance.

Within each category, the respondents are seeking specific types of assistance as shown in Table 1-4. The 77 EOIs represent \$7.15 billion of total project costs for which U.S. firms are seeking \$1.4 billion in Federal funding incentives.

Funding of Initial Project Development. U.S. firms seeking business opportunities in foreign markets must engage in a variety of initial project development activities that are capital intensive, require cash outlays upfront, and bear substantial risk. U.S. firms requested \$156 million for initial project development activities for projects totaling approximately \$929 million.

Funding of Projects. This category represents 64 percent of all costs proposed in the 77 EOIs and 86 percent of total government incentive funding sought by U.S. firms. Twenty-eight EOIs requested project funding for a diverse array of projects ranging from greenfield power plants, retrofits and/or repowering projects, fuels, and analytical tools. The projects propose advanced technologies such as fluidized bed, integrated gasification combined cycle, add-on environmental controls, coal beneficiation, a coal log pipeline, and coal analytical tools. Twelve EOIs in this category requested an "investment cost share" from the Federal government in their projects. The remaining 16 EOIs did not specify a mechanism for managing requested funding.

Seven EOIs requested funding of equipment and services for projects the respondents are currently pursuing. These projects included greenfield, repowering/retrofit and fuels projects. Equipment and

services needs would be procured from U.S. vendors and businesses and include boiler components, an oxygen plant, "well-field piping," fieldwork, design fabrication and installation, infrastructure development, and architectural and engineering services.

Other Assistance. Other assistance that U.S. firms are seeking from the Federal government includes financial assistance, general export assistance and technical assistance to host countries.

Three of the twenty-four EOIs requested the \$32 million in financial assistance indicated in Table 1-4 below: the three respondents are seeking financial assistance for differential financing, performance guarantees, and guarantees against civil penalties. Other areas of financial assistance identified by the remaining 21 EOIs are low interest loans, loan guarantees, power price guarantees, and cost sharing to offset the risks of Clean Coal Technologies.

No dollar amount is shown as incentive funding sought for "General Export Assistance to U.S. Business" in Table 1-4 because this category does not include direct assistance to U.S. firms. Specific types of assistance requested by U.S. firms in this regard include intellectual property protection, "door opening" through embassies, greater demonstration of support for Clean Coal Technologies, and negotiation assistance.

Desired technical assistance to host countries includes: (1) assistance to governments in the area of regulatory reform, financial reform, and contract development; (2) student training on Clean Coal Technologies; and (3) training on the use of software analytical tools related to technical aspects of coal usage. The total project costs shown for this category in Table 1-4 are less than the total incentive funding sought because several EOIs did not specify the total project cost but identified the government incentive funding.

1.8 OTHER INDUSTRY EXPRESSIONS OF INTEREST

DOE has actively solicited other industry input in the course of international promotion of U.S. Clean Coal Technologies. The most important, perhaps, of these efforts was a series of three, two-day Stakeholder Meetings for the Fossil Energy International Program held in November 1994 in Pittsburgh, Pennsylvania; New Orleans, Louisiana; and San Francisco, California. The purpose of these meetings was to obtain industry comments on the proposed strategic plan for the office of Fossil Energy's International Program, a major emphasis of which is the promotion of CCTs in international markets.

Numerous specific industry suggestions were received during the meetings and are described in detail in the published proceedings¹. The general theme of these comments was that industry needed and wanted help to "level the playing field" in international markets. The international marketplace is perceived by U.S. industry as less than level because foreign competitors are provided several

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¹ *Summary Proceedings of International Stakeholders Meetings.* Office of Fossil Energy, U.S. Department of Energy, Washington, D.C., April 1995.

Table 1-4
Summary of Costs of Federal Incentives Sought by U.S. Businesses
(\$U.S. thousand)

TYPE OF ASSISTANCE	NUMBER OF EOIs*	TOTAL PROJECT COST	TOTAL FUNDING SOUGHT
Funding of Initial Project Development			
1 Prefeasibility and Feasibility Studies	19	\$250,400**	\$3,850
2 Project Development	15	na**	\$3,000
3 Engineering to Adapt Technologies to Local Conditions	4	\$215,000	\$31,700
4 Technology Demonstration	9	\$461,092	\$116,471
5 Export Assistance & Market Analysis	3	\$2,500**	\$ 1,250
	<i>Subtotals</i>	\$928,992	\$156,271
Funding of Projects			
6 Project Funding	27	\$3,666,257	\$961,737
7 Funding for Specified Project Components	7	\$905,000	\$264,000
	<i>Subtotals</i>	\$4,571,257	\$1,225,737
Other Assistance			
8 Financial Assistance to U.S. Businesses	24	\$1,566,000	\$32,000
9 General Export Assistance to U.S. Business	18	\$80,000	***
10 Technical Assistance to Host Country	32	\$4,280	\$3,860
	<i>Subtotals</i>	\$1,650,280	\$35,860
	TOTALS	\$7,150,529	\$1,417,868

* Sum of EOIs exceeds total projects because proposals that request multiple incentives appear in every category where Federal incentive funding was sought.

** Total project cost listed elsewhere to avoid double counting.

*** Government cost is not in direct assistance to U.S. firms.

types of export assistance not available to American companies. These include concessionary trade financing, timely market information, and government-to-government "door-opening" assistance.

As presented in detail in Chapter 7, several basic suggestions to make Federal export promotion of fossil energy technologies more effective were repeated throughout the meetings:

- Have a clear single point of contact.
- Improve the coordination of export promotion at several levels.
- Focus on important priorities but don't ignore the smaller ones.
- Don't be bureaucratic.
- Tailor assistance to real and varied company needs.
- Be flexible for different markets.

Additionally, several specific types of assistance were requested by industry attendees at the three Stakeholder Meetings:

- Financing is seen as the key to helping U.S. companies to compete.
- Help developing countries create viable project conditions.
- Information exchange and market intelligence.
- Opening foreign doors and providing introductions.
- Adapting U.S. technologies to the needs of foreign markets.

1.8.1 Comparison with Expressions of Interest

The EOIs and the suggestions of the Stakeholders at the November 1994 meetings are highly consistent. Both identified essentially the same barriers, and requested similar incentives to reduce those barriers. In both instances, financing was seen as the key to project development, but the EOIs were much more explicit in their request for Federal financing. The emphasis of comments made at the Stakeholder Meetings was on efforts to reverse institutional barriers, while the EOIs clearly requested financing.

1.9 INCENTIVE OPTIONS

The fundamental issue addressed by this analysis is how DOE (in coordination with other agencies, as appropriate) can best facilitate commercialization of high-efficiency CCTs in developing and transitional countries. DOE activities would have two fundamental and complementary objectives: (1) to promote the advantages of high-efficiency CCTs in foreign countries, and (2) to facilitate efforts by U.S. companies to compete on a level playing field. These objectives can be achieved only if DOE's efforts produce strategies that are "win-win" for both the United States and the other countries.

As discussed in Chapter 7, some existing programs already pursue these objectives, but industry would like DOE to do more. On the other hand, the Congress has indicated that Federal efforts should be smaller in scale than the demonstration projects originally proposed in the FY 1995 budget submittal. A number of incentive options would achieve both of these objectives, i.e., respond to the expressed industry needs for more assistance, yet meet Congressional requests for less costly incentives. These options are summarized below in six groups roughly in order of from least to most expensive. The sixth group consists of incentives that were requested by respondents, but that would exceed the Congressional guidance requesting less costly incentives. Detailed descriptions and discussion of the advantages and disadvantages of each option are provided in Chapter 7.

- 1. Make existing Federal programs more effective.** This includes activities that could be implemented with little or no added budget commitments. Many of them require coordination of the efforts of multiple Federal agencies.
  - a. Coordinate existing programs.
  - b. Better utilize existing U.S. Government personnel in key foreign markets to open doors and facilitate information exchange.
  - c. One-stop shopping for existing project finance programs.
  - d. Further assistance to foreign governments on institutional reform.
- 2. Develop an ongoing program of DOE technical assistance.** Such assistance could be provided to foreign governments, other U.S. agencies, and U.S. companies. It would leverage on DOE's key strength in technology.
  - a. Assistance to foreign governments on technical issues.
  - b. Assistance to Federal export finance agencies.
  - c. Work with foreign governments to generate more CCT feasibility studies for U.S. firms.
  - d. Station Department of Energy personnel in key foreign markets.
- 3. Implement low-cost information exchange programs.** Ensure that U.S. industry has the information they need about foreign markets in a timely manner and that potential foreign customers have information about U.S. offerings.
  - a. Clean Coal Technology and Power Information Center and dissemination programs.
  - b. Ongoing program of DOE trade missions and reverse trade missions.
  - c. CCT training for foreign personnel.
  - d. Initiatives for specific technologies.

4. **Market-responsive research and development (R&D).** The purpose would be to work with U.S. industry and their foreign partners to adapt U.S. technologies to the special needs of foreign markets.
  - a. Testing of foreign coals in U.S. facilities.
  - b. Cooperatively-funded R&D to adapt U.S. technologies to foreign conditions.
5. **Innovative export financing mechanisms.** In some cases, the needs may be satisfied by existing programs. However, in other instances, they might require additional commitments of Federal funds.
  - a. New feasibility study financing mechanism not requiring foreign government request.
  - b. Financing of project design studies.
6. **Higher-Cost Financing Options.** The following options were requested in many of the EOIs. All, however, require a substantial incremental commitment of Federal funds. In many cases, federal export credit is available for projects through Export-Import Bank (Ex-Im Bank) or Overseas Private Investment Corporation (OPIC) through their normal programs. None, however, is earmarked specifically for CCT projects, nor does the government bear the costs or risks of advanced technology in these programs.
  - a. Financing of incremental cost of advanced technologies.
  - b. Government funding of a portion of project costs.
  - c. Performance guarantees for advanced technologies.
  - d. Partially fund foreign demonstration projects.

1.10 EVALUATION OF OPTIONS

The requests for assistance received from industry in the EOIs and during the November 1994 Stakeholder Meetings are consistent with the results of DOE's own investigations into the barriers confronting international CCT and power project development. Constraints to the financing of CCT project development stand out as the most significant barriers, both to industry and in DOE's own evaluations. These barriers exist primarily in the developing and transitional countries that are major potential growth markets for CCTs and in which the growth in carbon dioxide emissions would be greatest. Financing is a constraint in these countries, both to energy project development in general and to the use of advanced technologies in specific.

Beyond financing, U.S. Government programs can help facilitate the exchange of information and people necessary to stimulate this growing segment of international trade. Many of the EOIs request such assistance. Programs and mechanisms already exist to do much of this. These can be focused on—and tailored to—the needs of this market with a priority commensurate with the opportunities they represent.

DOE can also help to overcome barriers related to the technical risk of advanced CCTs. A number of the options described above are designed to provide potential CCT users with needed information, help adapt U.S. CCTs to foreign markets, or reduce the technology risk of investing in advanced CCT projects. However, addressing these concerns will require the coordinated response of multiple Federal agencies, not just DOE. Such coordination is already underway through the Trade Policy Coordinating Committee (TPCC) subgroup on Clean Coal Technology.

Our objective is to identify optimal incentives for demonstrating Clean Coal Technologies in foreign markets. An optimal incentive is one that is both effective and low in cost. Accordingly, a priority has been assigned to each incentive that reflects both effectiveness and cost. If we regroup these options by priority, we can create "packages" of incentive options as follows:

- I. **High:** Incentive is both *low in cost and effective* in removing a difficult barrier to foreign markets.
- II. **Important:** Barriers may be reduced (but not necessarily removed), or these may address barriers that the private sector can overcome with some effort.
- III. **Helpful:** These incentives may benefit U.S. industry, but they may engender a high cost or risk to the U.S. Government.

OPTION PACKAGE

I. High Incentives

- 1a. Coordinate existing programs
- 2a. Assistance to foreign governments on technical issues
- 2b. Assistance to Federal export finance agencies
- 3a. CCT/Power Information Center and dissemination program
- 3b. Ongoing program of DOE trade and reverse trade missions

II. Important Incentives

- 1b. Better utilize existing U.S. Government personnel in key markets
- 1c. One-stop shopping for project finance
- 1d. Further assistance to foreign governments on institutional reform
- 2c. Work with foreign governments to generate more feasibility studies
- 2d. Station DOE personnel in key foreign countries
- 3c. CCT training for foreign personnel
- 4a. Testing of foreign coals in U.S. facilities
- 4b. Cooperatively-funded R&D to adapt U.S. technologies
- 5a. Feasibility study mechanisms not requiring foreign government request
- 5b. Financing of project design studies
- 6b. Government funding of project costs

III. Helpful Incentives

- 3d. Initiatives for specific technologies
- 6a. Funding of incremental costs of advanced technologies
- 6c. Performance guarantees for advanced technologies
- 6d. Foreign demonstration projects

2. INTRODUCTION AND BACKGROUND

2.1 INTRODUCTION

This report was prepared in response to the guidance provided by the Congress in the course of the Fiscal Year 1995 appropriations process for the Department of Energy's (DOE) Office of Fossil Energy (FE). As described in detail below, DOE was directed to make the international dissemination of Clean Coal Technologies (CCTs) an integral part of its policy to reduce greenhouse gas emissions in developing countries. Congress directed DOE to solicit "Statements of Interest" in commercial projects employing CCTs in countries projected to have significant growth in greenhouse gas emissions. Additionally, DOE was asked to submit to the Congress a report that analyzes the information contained in the Statements of Interest, and that identifies the extent to which various types of Federal incentives would accelerate the commercial availability of these technologies in an international context.

In response to DOE's solicitation of 18 November 1994, 77 Statements of Interest were received from 33 companies, as well as five additional materials. The contents of these submittals, including the requested Federal incentives, the CCTs proposed, the possible host countries, and the environmental aspects of the Statements of Interest, are described and analyzed in the chapters that follow.

2.2 BACKGROUND

In accordance with the guidance provided by the Congress, the "Announcement to Request Expressions of Interest (EOI) in Commercial Clean Coal Technology Projects in Foreign Countries" was published in the *Federal Register* on 18 November 1994 (59 FR 59768). As documented in this Notice, a complete copy of which is provided in Appendix A, DOE was directed to make the international dissemination of CCTs an integral part of its policy to reduce greenhouse gas emissions in developing countries. Congress directed DOE to solicit Statements of Interest in commercial projects employing CCTs in countries projected to have significant growth in greenhouse gas emissions, and then to identify in a report to the Congress the extent to which various types of Federal incentives would accelerate the commercial availability of these technologies in an international context.

The Announcement was issued pursuant to the Conference Report, No. 103-740, to accompany Pub. L. No. 103-332, the Department of the Interior and Related Agencies Appropriations Act, 1995, and the guidance contained in the corresponding Senate and House Reports, Nos. 103-294 and 103-551, respectively. Potential respondents were advised that DOE has no monies to fund or otherwise provide any incentive in support of the proposed projects. This solicitation was conducted to provide Congress with the information needed to consider the technical, economic, and environmental aspects of various incentives sought to support international CCTs, and their merit for future support.

2.3 DOE CLEAN COAL TECHNOLOGY PROGRAM

Technology has a vital role in ensuring that coal can continue to serve energy interests, enhancing opportunities for economic growth and employment while meeting commitments to a clean and healthy global environment. These technologies are being advanced through the Clean Coal Technology Demonstration Program (CCT Program). The CCT Program is a unique partnership between the United States Department of Energy (DOE) and industry that has, as its primary goal, the successful demonstration of a new generation of advanced coal-based technologies, with the most promising technologies being moved into the domestic and international marketplace.

When establishing the CCT Program, Congress envisioned a responsive and successful technology demonstration program, which it viewed as essential to realizing sustainable economic and environmentally acceptable use of the coal reserves, both domestically and on a global basis. Begun in 1985 and expanded in 1987 to meet the recommendations of the United States and Canadian Special Envoys on Acid Rain, the Program has resulted in a joint industry/government capital investment of over \$7 billion in 43 competitively selected projects. The project participants (i.e., the non-federal government participants) are providing over 66 percent of the total investment and DOE is providing about 34 percent. The 43 projects are directed toward satisfying the energy and environmental needs of four application categories:

- Advanced electric power generation,
- Environmental control devices,
- Coal processing for clean fuels, and
- Industrial applications.

The demonstrations, for the most part, are at a scale large enough to generate the data needed to enable potential domestic and international users to make judgments about the commercial potential of particular technologies. These technologies will improve the global environment through the reduction of emissions of sulfur oxides, nitrogen oxides, greenhouse gases, hazardous air pollutants, solid and liquid wastes, and other emissions resulting from coal use or conversion to other fuel forms. These emissions reductions are achieved with efficiencies equal to or greater than currently available technologies.

2.3.1 Previously Proposed CCT Program Initiatives

As described in Appendix A, DOE had proposed in its 1995 DOE Congressional Budget Request a new initiative to implement an international program, in part authorized by Section 1332 of the Energy Policy Act of 1992. This program would have focused on CCTs that substantially reduce environmental pollutants, including greenhouse gases, in developing countries or countries with economies in transition. The objective of the program was to increase trade exports and U.S. jobs by increasing the market share for U.S. energy and environmental technology services in developing countries, and to improve environmental performance of existing and new power generating facilities in these countries.

Furthermore, the National Coal Council (NCC) responded to a request by the Secretary of Energy for a study of future directions for the CCT Program. In its February 1994 report, *Clean Coal Technology for Sustainable Development*, NCC recommended, among other things, that:

- The Secretary of Energy promote the role of CCTs in the environmental technology programs of the Administration; that CCTs can improve the global environment as well as prevent pollution,
- The Secretary of Energy establish a new Federal Clean Coal Technology Incentive Program of approximately \$1.5 billion over 15 years to stimulate commercial deployment, and
- The Secretary of Energy ensure that future governmental policy continues to be monitored from the standpoint of the competitive position of and the ability to deploy CCTs.

In response to these proposals and recommendations, Senate Report No. 103-294 explained that:

No funds have been made available for the international initiative recommended by the administration, for a domestic commercial incentives program suggested by the National Coal Council, or for a new round VI procurement for additional projects. The Committee believes the highest priority for this program is to complete the existing projects as promptly as possible, but with reasonable assurance that sufficient data are generated to support subsequent commercialization activity.

Additionally, Congressional guidance was provided by the Senate Report specific to the solicitation for Statements of Interest in international CCT projects:

The Committee does, however, support efforts by the Department of Energy in promoting exports of clean coal technologies, particularly to countries experiencing rapid economic development. These technologies promise a number of significant economic and environmental benefits. In China, for example, the introduction of U.S. coal-fired power technology from the Clean Coal Technology Program would allow that country to use its energy resources 40 percent more efficiently. This U.S. technology would require 30 percent less of China's water resources. Potential carbon dioxide emissions from power generation would be cut by 40 percent and potential emissions of sulfur, nitrogen oxides, and particulates would be reduced by 90 percent or more. While the Committee does not support the particular mechanism proposed

by the Department of Energy to initiate a showcase demonstration project of clean coal technology in China in fiscal year 1995, the Committee does recognize the tremendous environmental potential of clean coal technologies, particularly in helping to reduce the possibility of future global climate change that may be the result of enhanced production of greenhouse gases in developing countries.

Accordingly, the Department of Energy is directed to make the dissemination of clean coal technologies overseas an integral part of its policy to reduce greenhouse gas emissions in developing countries. The Secretary [of Energy] is also directed to solicit, in the *Federal Register*, statements of interest in commercial projects employing clean coal technologies, and shall submit to the congressional committees of jurisdiction, no later than April 15, 1995, a report that analyzes the information contained in such statements of interest and that identifies the extent to which various types of Federal incentives will accelerate the commercial availability of these technologies. This report shall specifically discuss the interests in, prospects of, and optimal incentives for demonstrating clean coal technologies in countries projected to have significant growth in greenhouse gas emissions, using projects smaller in scale than those proposed in the fiscal year 1995 budget request.

2.4 EXPRESSION OF INTEREST METHODOLOGY

The Announcement explained that Expressions of Interest (EOIs) and informational proposals submitted were to propose an international (non-domestic) project that would employ at least one CCT, and that is responsive to the Congressional guidance with regard to, at a minimum, the following:

1. Sponsored by a U.S.-based company or consortium,
2. Located in a developing country, or in a country making the transition from a centrally planned to a market economy, projected to have significant growth in greenhouse gas emissions,
3. Capability of reducing greenhouse gas emissions, particularly CO₂, as compared to technologies in common use in the proposed locale,
4. Versatility with regard to effective usage of various globally available coal types and characteristics, and
5. Likelihood of utilization on a broad commercial scale subsequent to successful demonstration.

Proposed projects were required to be for either electric utility, industrial, or commercial applications, and could be suitable for either retrofit to existing facilities; repowering, modernizing, or life-extending existing facilities; or for new ("grass roots" or "greenfield") facilities. Interested parties were permitted to propose multiple projects, either within a single country or in multiple countries, either with the same CCT or with different CCTs, and either with the same requested type of Federal incentive or with different incentives. However, DOE required that each proposed project must be submitted in its own separate, complete ("stand alone"), Expression of Interest.

An important aspect of the Announcement was the request by DOE for the respondents to provide comments or discussion on these questions:

- What are the greatest opportunities for commercializing U.S. CCTs abroad (short- and long-term)?
  - What global regions or countries are the most promising?
  - Which types of CCTs are the most promising?
    - "Off-the-shelf" commercial technologies or cleaner and more efficient technologies now being demonstrated in the DOE CCT Program, or other advanced technologies not currently in the CCT Program?
    - Technologies to upgrade or modernize currently operating plants and systems abroad (through retrofit life extension, coal cleaning, and other approaches) or new, grassroots plants?
- What role can DOE best play to facilitate commercialization of these technologies?
  - Help identify market opportunities?
  - Help open doors for U.S. investors?
  - Be a strong advocate of U.S. projects?
  - Support feasibility studies and other project development activities?
  - Support regulatory changes if there are regulatory issues that are impeding foreign sales?
  - Support development of technical data that would enhance foreign sales, such as testing the performance of foreign coals with U.S. technologies?
  - Support any other mechanisms or incentives?

The respondents substantiated DOE's assessment that the greatest opportunities for commercializing U.S. CCTs abroad were for advanced power systems in China, the Pacific Rim, South Asia (India and Pakistan), Eastern Europe, and the Newly Independent States of the former Soviet Union. There are also opportunities for coal processing and environmental control devices in countries with expanding coal use. The respondents also indicated that DOE can facilitate commercialization of CCTs by making existing programs more effective, developing an ongoing program of DOE technical assistance, implementing low-cost information exchange programs, conducting market-responsive research and development, assisting with innovative export finance mechanisms, and providing higher-cost financing options.

The announcement provided a form that was to be used by the respondents to prepare the cover sheets of their Expressions of Interest. Submitters also were requested to complete a Public Abstract form for their submittals that provided an overview of the proposed projects; respondents were asked *not* to include any proprietary data or confidential business information in the Public Abstracts. The Announcement also called for the respondents to include in their Expressions of Interest the provided Project Summary form, that included such entries as the source of coal, project size, and environmental performance.

DOE held a Presubmittal Conference on 14 December 1994 in the agency's auditorium at the Forrestal Building in Washington, D.C. The purpose of this meeting was to provide the opportunity for prospective respondents to gain a better understanding and clarification of the objectives and requirements of the request for Expressions of Interest.

Responses were requested by 13 January 1995. Once DOE received the 77 Expressions of Interest and five additional materials, they were logged in, and information from each proposal was entered into a database. This database captures the data provided by the respondents relative to the technology, size, and cost of projects, as well as the environmental area each project would impact, and the requested incentives.

2.4.1 Regions Projected to Increase Carbon Dioxide Emissions

The following countries and regions of the world have been identified by the International Energy Agency (IEA)¹ of the Organization for Economic Cooperation and Development (OECD) as target areas that produce significant levels of greenhouse gases (CO₂):

- North America
- OECD Europe
- Former Soviet Union
- Central and Eastern Europe
- China
- East Asia
- South Asia
- Africa
- Latin America
- Middle East

The IEA estimates that CO₂ emissions from these areas will increase from a total of 21,579 million tons in 1991, to 31,931 million tons by the year 2012.

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¹

World Energy Outlook, 1994, International Energy Agency Annual Report, Organization for Economic Cooperation and Development, Paris.

3. OVERVIEW OF PROPOSALS RECEIVED

3.1 OVERVIEW OF THE RESPONDENTS

Thirty-three organizations responded to DOE's request for Expressions of Interest to build Clean Coal Technology projects in developing countries, Eastern Europe, or the Newly Independent States of the former Soviet Union, where significant growth in greenhouse gas emissions is expected. Together, as listed in Table 3-1, the respondents submitted 77 Expressions of Interest to DOE. Of the companies responding to the solicitation, CQ Inc., of Homer City, Pennsylvania, was the most prolific, with 14 separate proposals. New Jersey-based Foster Wheeler Energy International, Inc., was second with 12 Expressions of Interest, while the Babcock & Wilcox Co. of Alliance, Ohio, was third with 11 proposals. Seven other organizations submitted either two or three Expressions of Interest. A complete listing of all Expressions of Interest submitted, including the proposed technologies, is included in Appendix C, "Project Summary Sheets."

To the extent that the information was provided in the Expressions of Interest, Table 3-2 categorizes the types of Clean Coal Technologies that were proposed. The respondents proposed projects employing U.S.-developed Clean Coal Technologies in 22 countries, primarily in the Pacific Rim and Eastern Europe.

3.2 INCENTIVES AND ENVIRONMENTAL ASPECTS

The types of governmental incentives requested by the respondents ranged from direct financial assistance, including cost shared support of the nature currently employed in the Clean Coal Technology Program, through various kinds of export assistance and market analysis services. Expressions of Interest also noted the merits of trade missions and reverse trade missions of the nature of the recent highly successful activities of DOE and the Secretary of Energy, and governmental participation in addressing regulatory and other trade impediments encountered in the course of negotiating projects in foreign lands. The incentives requested are summarized in Table 3-3 below, and addressed in detail in Chapter 7 of this report.

With regard to the environmental aspects of the proposed international projects, including in particular CO₂, the Expressions of Interest addressed a range of potential emissions reductions and other environmental benefits; however, CO₂ was included in only 41 of the proposals. Table 3-4 summarizes this information in a fashion similar to Table 3-3.

Table 3-1
Expressions of Interest Submitted, by Respondent
(in alphabetic order within groups)

Respondent	Number of EOIs Submitted
ABB (ASEA Brown Boveri) Acurex Environmental Corp. Ahlstrom Pyropower, Inc. ALIAS Group, Inc. Bechtel Power Corp. Capsule Pipeline Research Center Coal Tech Corp. Control Techtronics International EER and U.S. EPA (AEERL) Energy International Corp. General Atomics Georgia Institute of Technology Gilbert/Commonwealth, Inc. Hiller Group, Inc., The KFx, Inc. Kress Corporation Leas Industrial Associates LSR Technologies, Inc. NOXSO Corp. Rosebud SynCoal Partnership Sorbent Technologies Corp. SRI and U.S. EPA (AEERL) Thermal Organic Recycling Equip.	<i>1 EOI each</i>
Custom Coals Corporation HYDROCARB Corp. TRW Space & Technology Division Viking Systems International	<i>2 EOIs each</i>
DB Riley International SGI International Texaco Inc.	<i>3 EOIs each</i>
Babcock & Wilcox	11
Foster Wheeler Energy International, Inc.	12
CQ Inc.	14

Table 3-2
Types of Clean Coal Technologies Proposed

Type of Clean Coal Technology	Number of EOIs Submitted
Emissions controls: Combined SO ₂ and NO _x	2
NO _x	3
SO ₂	5
Industrial applications	2
Advanced combustion	4
Miscellaneous	4
Coal preparation	6
New fuel forms	6
Atmospheric fluidized bed combustion (AFB)	7
Pressurized fluidized bed combustion (PFB)	8
Integrated gasification combined cycle (IGCC)	14
Computer software and modelling	16

Table 3-3
Types of Federal Incentives Proposed
 (note that some respondents proposed multiple incentives)

Type of Federal Incentive	Number of EOIs Submitted
Funding of Initial Project Development	33
Funding of Projects	34
Financial Assistance to U.S. Businesses	24
General Support Assistance to U.S. Businesses	18
Technical Assistance to Host Country	32

Table 3-4
Environmental Benefits Proposed
In Order of Increasing Frequency of Response
(note that some respondents proposed multiple benefits)

Type of Environmental Benefit	Number of EOIs Submitted
Air toxics emissions reductions	13
Waste water improvements	13
Water consumption reductions	15
Particulate (PM and PM ₁₀) emissions reductions	24
Oxides of nitrogen (NO _x) emissions reductions	37
Carbon dioxide (CO ₂) emissions reductions	41
Sulfur dioxide (SO ₂) emissions reductions	45

3.3 COUNTRY LISTINGS OF EXPRESSIONS OF INTEREST

Table 3-5 presents a detailed overview of the responses on a country-by-country basis, noting, for each of the 21 represented countries, the number of EOIs received, and, *to the extent that the information was provided*, cumulative generating capacity of the proposals, cumulative dollar value, and the pollutants represented (CO₂, SO₂, NO_x, PM₁₀—particulate matter smaller than 10 microns in diameter, PM—particulate matter in general, and TOX—air toxics). The total proposed project sizes per country range from 20 megawatts in Indonesia (two EOIs received) to as much as 6,537 megawatts in China (for 20 proposals).

The total (similarly accumulated for all Expressions of Interest received) project costs per country range from \$250,000 in each of Bulgaria, Estonia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Romania, Slovak Republic, and Slovenia—all of which are for computer software—to as much as \$2.5 billion for the 20 projects proposed for China.

Table 3-5
Salient Characteristics of the Expressions of Interest
Received, by Proposed Host Country

Country	No. EOs Recd.	Total Capacity (MWe)	Total Cost (\$ U.S.)	Emissions Reductions					
				CO ₂	SO ₂	NO _x	PM ₁₀	PM	TOX
Australia	1	not available	\$1,400,000				✓		
Brazil	1	not available	\$5,500,000	✓	✓	✓	✓	✓	
Bulgaria	1	4,000	\$250,000	✓	✓				
China	20	6,537	\$2,509,841,916	✓	✓	✓	✓	✓	✓
Czech Republic	5	4,210	\$455,250,000	✓	✓	✓	✓	✓	✓
Eastern Europe	4	700	\$578,000,000	✓	✓	✓		✓	✓
Estonia	1	3,000	\$250,000	✓	✓				
Hungary	2	4,000	\$3,225,000	✓	✓	✓			
India	10	1,110	\$2,081,000,000	✓	✓	✓	✓	✓	✓
Indonesia	2	20	\$65,400,000	✓	✓	✓	✓	✓	
Kazakhstan	1	4,000	\$250,000	✓	✓				
Kyrgyzstan	1	3,000	\$250,000	✓	✓				
Latvia	1	1,600	\$250,000	✓	✓				
Lithuania	1	4,000	\$250,000	✓	✓				
Mexico	1	100	\$160,000,000		✓	✓		✓	✓
Pacific Rim	3	740	\$650,000,000	✓	✓	✓	✓	✓	✓
Pakistan	1	350	\$120,000,000	✓	✓				
Poland	5	4,120	\$163,650,000	✓	✓	✓		✓	✓
Romania	1	4,000	\$250,000	✓	✓				
Russia	6	100	\$117,000,000		✓	✓			
Slovak Republic	1	4,000	\$250,000	✓	✓				
Slovenia	1	2,000	\$250,000	✓	✓				
Ukraine	4	4,550	\$162,250,000	✓	✓	✓		✓	
Unspecified	3	100	\$80,750,000	✓	✓	✓			

NOTES:

Some EOIs did not address proposed project capacity.

CO₂ is carbon dioxide

SO₂ is sulfur dioxide

NO_x is oxides of nitrogen

PM₁₀ is particulate matter smaller than 10 microns in diameter

PM is particulate matter in general

TOX is air toxics

3.4 ADDITIONAL MATERIALS RECEIVED

Albeit not responsive project proposals *per se*, five additional responses were received from Poznan University of Technology in Poland, Destec Energy, Inc. (Houston, Texas), the Electric Power Research Institute, the United Nations, and Bharat Heavy Electricals Ltd. (Tamil Nadu, India). These additional materials offer support for, and suggestions on, DOE assistance with commercializing Clean Coal Technologies and other approaches to coal usage in developing countries. They are summarized in Chapter 8, and reproduced in their entirety in Appendix D of this report.

4. COUNTRY SUMMARIES

4.1 INTRODUCTION

This chapter summarizes the EOIs received for each proposed host country or region. Each country or region summary discusses the information provided in the EOIs in the following format:

- **Technologies Proposed.** Types of technologies proposed in the country, the sources of coal, and the companies interested in the country.
- **Environmental Benefits.** Environmental benefits of each type of proposed technology by emissions category (CO₂, SO₂, NO_x, PM₁₀, PM, and Toxics) and total number of projects proposed that impact each emissions category.
- **Incentives.** Types of incentives requested by each EOI proposal.
- **Market Applicability.** Commercialization potential of proposed technologies in the host country or region.
- **EOI Profiles.** Brief summary of each EOI submitted for the host country or region.

Where appropriate, the countries have been grouped by region for discussion [Asia and Pacific Rim (Section 4.2), Newly Independent States (Section 4.3), Eastern Europe (Section 4.4), Latin America (Section 4.5), and Country Unspecified (Section 4.6)]. Some EOIs were incomplete and did not indicate a specific technology, emissions target, or other requested information. Therefore, the totals in the summary tables throughout this chapter might not match the number of respondents in specified groups. No attempt was made to supplement the data supplied in the EOIs.

Table 4-1 lists all EOIs submitted, in alphabetical order, by respondent or company, and provides the EOI number, technology category, incentive, and country or region. Where appropriate, multiple entries are provided. Appendix E provides detailed summaries of the EOIs, which are discussed in this chapter, also by region or country.

Table 4-1
EOI Index

Respondent	EOI No.	Technology Category	Incentive	Country or Region
ABB (ASEA Brown Boveri) Inc.	65	PFB	Export; Financial; Trade	Asia and Pacific Rim
Acurex Environmental Corporation and ABB Environmental Systems	62	Emissions Controls: SO ₂	Export; Financial	Poland
Ahlstrom Pyropower, Inc.	64	PFB	Financial	Czech Republic
ALIAS Group, Incorporated	49	Computer Software and Modelling	Financial	Hungary
Babcock & Wilcox	9	Emissions Controls: Combined SO ₂ /NO _x	Financial	Russia
Babcock & Wilcox	10	PFB	Financial	Russia
Babcock & Wilcox	11	AFB	Unspecified	Russia
Babcock & Wilcox	12	Emissions Controls: SO ₂	Financial	Russia
Babcock & Wilcox	67	AFB	Financial	Ukraine
Babcock & Wilcox	68	AFB	Financial	Czech Republic
Babcock & Wilcox	69	PFB	Financial	Pacific Rim
Babcock & Wilcox	70	Advanced Combustion	Financial	Pacific Rim
Babcock & Wilcox	71	Emissions Controls: NO _x	Financial	Eastern Europe
Babcock & Wilcox	72	Emissions Controls: NO _x	Financial	Eastern Europe
Babcock & Wilcox	73	Emissions Controls: SO ₂	Financial	China
Bechtel Power Corporation	42	IGCC	Financial	China
Capsule Pipeline Research Center	66	Coal Preparation	Financial	China
Coal Tech Corporation	54	Advanced Combustion	Financial	India

Table 4-1
EOI Index (cont.)

Respondent	EOI No.	Technology Category	Incentive	Country or Region
Control Techtronics International	51	Computer Software and Modelling	Financial	China
CQ Inc.	28	Computer Software and Modelling	Export; Financial; Market	Ukraine
CQ Inc.	29	Computer Software and Modelling	Export; Financial; Market	Slovenia
CQ Inc.	30	Computer Software and Modelling	Export; Financial; Market	Slovak Republic
CQ Inc.	31	Computer Software and Modelling	Export; Financial; Market	Romania
CQ Inc.	32	Computer Software and Modelling	Export; Financial; Market	Poland
CQ Inc.	33	Computer Software and Modelling	Export; Financial; Market	Lithuania
CQ Inc.	34	Computer Software and Modelling	Export; Financial; Market	Latvia
CQ Inc.	35	Computer Software and Modelling	Export; Financial; Market	Kyrgyzstan
CQ Inc.	36	Computer Software and Modelling	Export; Financial; Market	Kazakhstan
CQ Inc.	37	Computer Software and Modelling	Export; Financial; Market	Hungary
CQ Inc.	38	Computer Software and Modelling	Export; Financial; Market	Estonia
CQ Inc.	39	Computer Software and Modelling	Export; Financial; Market	Czech Republic
CQ Inc.	40	Computer Software and Modelling	Export; Financial; Market	China
CQ Inc.	41	Computer Software and Modelling	Export; Financial; Market	Bulgaria
Custom Coals Corporation	57	Coal Preparation	Regulatory	Poland
Custom Coals Corporation	58	Coal Preparation	Financial	China
DB Riley International, Inc.	46	AFB	Financial	China

Table 4-1
EOI Index (cont.)

Respondent	EOI No.	Technology Category	Incentive	Country or Region
DB Riley International, Inc.	47	PFB	Financial	China
DB Riley International, Inc.	48	AFB	Financial	China
EER and U.S. EPA (AEERL)	14	Emissions Controls NO _x	Financial	Russia
Energy International Corporation	55	IGCC	Financial; Trade	Pakistan
Foster Wheeler Energy International, Inc.	16	PFB	Financial	India
Foster Wheeler Energy International, Inc.	17	AFB	Financial	Ukraine
Foster Wheeler Energy International, Inc.	18	IGCC	Financial	India
Foster Wheeler Energy International, Inc.	19	IGCC	Financial	China
Foster Wheeler Energy International, Inc.	20	IGCC	Financial	India
Foster Wheeler Energy International, Inc.	21	IGCC	Financial	China
Foster Wheeler Energy International, Inc.	22	IGCC	Financial	India
Foster Wheeler Energy International, Inc.	23	IGCC	Financial	India
Foster Wheeler Energy International, Inc.	24	PFB	Financial	China
Foster Wheeler Energy International, Inc.	25	PFB	Financial	Mexico
Foster Wheeler Energy International, Inc.	26	IGCC	Financial	China
Foster Wheeler Energy International, Inc.	27	IGCC	Financial	China
General Atomics	15	AFB	Financial	India
Georgia Institute of Technology	5	Miscellaneous	Financial	Unspecified

Table 4-1
EOI Index (cont.)

Respondent	EOI No.	Technology Category	Incentive	Country or Region
Gilbert/Commonwealth, Inc.	56	Miscellaneous	Export; Financial; Market; Regulatory; Trade	Eastern & Central Europe
Hiller Group, Inc., The	8	Industrial Applications	Financial	Brazil
HYDROCARB Corporation	75	New Fuel Forms	Export; Financial; Trade	Poland
HYDROCARB Corporation	76	New Fuel Forms	Export; Financial; Market	China
KFx, Incorporated	77	Coal Preparation	Financial; Regulatory; Trade	Czech Republic
Kress Corporation	60	Industrial Applications	Financial	Australia
Leas Industrial Associates	1	IGCC	Regulatory	Unspecified
LSR Technologies, Inc.	50	Miscellaneous	Financial	China
NOXSO Corporation	63	Emissions Controls: Combined SO ₂ /NO _x	Financial	China
Rosebud SynCoal Partnership	52	Coal Preparation	Financial	Indonesia
SGI International	4	New Fuel Forms	Financial	Indonesia
SGI International	59	New Fuel Forms	Financial	China
SGI International	61	New Fuel Forms	Financial	Poland
Sorbent Technologies Corporation	3	Emissions Controls: SO ₂	Financial	Czech Republic
SRI and U.S. EPA (AEERL)	13	Emissions Controls: SO ₂	Financial	Russia
Texaco Inc.	43	IGCC	Export; Financial; Market; Regulatory; Trade	India
Texaco Inc.	44	IGCC	Export; Financial; Market; Regulatory; Trade	Eastern Europe
Texaco Inc.	45	IGCC	Export; Financial; Market; Regulatory; Trade	China

Table 4-1
EOI Index (cont.)

Respondent	EOI No.	Technology Category	Incentive	Country or Region
Thermal Organic Recycling Equipment, Inc.	74	New Fuel Forms	Unspecified	Unspecified
TRW Space & Technology Division	2	Advanced Combustion	Financial	China
TRW Space & Technology Division	53	Advanced Combustion	Financial	Ukraine
Viking Systems International	6	Coal Preparation	Financial	India
Viking Systems International	7	Miscellaneous	Financial	India

4.2 ASIA AND THE PACIFIC RIM

For purposes of this description, Asia and the Pacific Rim nations are grouped together. A total of 37 EOIs would site proposed projects in Asia and the Pacific Rim. China and India are the countries in this group that are the most well represented by the EOIs, with China indicated as the host country for 20 EOIs and India hosting 10.

4.2.1 China

4.2.1.1 Technologies Proposed

China drew the most attention from respondents with EOIs for 20 proposed projects, as shown in Table 4-2.

Of the 20 EOIs submitted with China as the host country, 11 involved advanced electric power generation systems and 6 of these involved IGCC. Of the remaining nine EOIs, four addressed coal processing for clean fuels, two involved environmental control devices, and three were other types of technologies.

The coal for most of the proposed projects in China would come from within China.

Fourteen companies expressed interest in Chinese projects. Two companies submitted multiple proposals for this country: five from Foster Wheeler Energy International, Inc., and three from DB Riley International, Inc.

Table 4-2
China: EOIs

Technology Category	EOI No.	Respondent
Coal Processing for Clean Fuels		
Coal Preparation	58	Custom Coals Corporation
	66	Capsule Pipeline Research Center
New Fuel Forms	59	SGI International
	76	HYDROCARB Corporation
Advanced Electric Power Generation		
Advanced Combustion	2	TRW Space and Technology Division
PFB	24	Foster Wheeler Energy International, Inc.
	47	DB Riley International, Inc.
AFB	46	DB Riley International, Inc.
	48	DB Riley International, Inc.
IGCC	19	Foster Wheeler Energy International, Inc.
	21	Foster Wheeler Energy International, Inc.
	26	Foster Wheeler Energy International, Inc.
	27	Foster Wheeler Energy International, Inc.
	42	Bechtel Power Corporation
	45	Texaco Inc.

Table 4-2
China: EOIs (cont.)

Technology Category	EOI No.	Respondent
Emissions Controls: Combined SO ₂ /NO _x	63	NOXSO Corporation
Other		
Computer Software and Modelling	40	CQ Inc.
	51	Control Techtronics International
Miscellaneous	50	LSR Technologies, Inc.

4.2.1.2 Environmental Benefits

The projects proposed for China address all major environmental areas, as shown in Table 4-3 (emissions categories and the number of EOIs received).

Although sulfur dioxide represents the emission most addressed by the EOIs, many will also address carbon dioxide and the oxides of nitrogen. Several EOIs also propose to address particulate and toxic emissions.

4.2.1.3 Incentives

All 20 EOIs for projects in China expressed interest in financial incentives. Four EOIs mentioned export assistance; three, market analysis; and two each, regulatory assistance and trade missions. Table 4-4 summarizes the Federal incentives requested in each EOI and the justification provided by the respondent.

Table 4-3
China: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	12	17	12	5	7	2
Coal Preparation	✓	✓		✓	✓	
New Fuel Forms	✓	✓	✓	✓		
Advanced Combustion		✓	✓			✓
PFB	✓	✓	✓	✓		
AFB	✓	✓	✓			
IGCC	✓	✓	✓	✓		
Emissions Controls: SO ₂		✓				
Emissions Controls: Combined SO ₂ /NO _x		✓	✓			
Computer Software and Modelling	✓	✓			✓	
Miscellaneous						

Table 4-4
China: Incentives

Respondent	EOI No.	Federal Incentives
Babcock & Wilcox	73	- Financial support including direct subsidy of demonstration unit, project financing, engineering and development costs, warranty costs, characterization of coal costs, up-front engineering studies, and performance guarantees. - Justification for Incentives: The greatest limitations to implementation of the demonstration is financing. As such, direct financial assistance to pay for hard currency expenses of the project(s) will be needed. Trial of new technology usually involves an element of risk which international customers are unwilling to assume without some form of extended warranty. Federal government performance guaranteed support is necessary since domestic companies are not familiar with guarantee practices in Europe.
Bechtel Power Corporation	42	- Financial support. - International technology transfer. - Justification for Incentive: None provided.
CQ Inc.	40	- Financial support: 100 percent of project costs. - Market analysis to identify host utilities. - Export assistance to facilitate equipment to host country. - Justification for Incentive: None provided.

Table 4-4
China: Incentives (cont.)

Respondent	EOI No.	Federal Incentives
Custom Coals Corporation	58	• U.S. government assistance with host country to reduce or eliminate the risks to host country decision makers (i.e., a guarantee against civil penalties). • Financial support: 50 percent of project costs. • Justification for Incentive: Support and reassurance arranged by the DOE through the appropriate host country authorities that power sector executives will not be unduly exposed to risks (civil and criminal liability for major management decisions) which deter them from selecting a CCT solution.
DB Riley International, Inc.	46-48	• Financial support: 10-35 percent of project costs. • Quicker commercialization through improvements in financing or services or infusion of dollars into the project(s). • Financial assistance through funding of testing, project development, feasibility studies, proposal preparation. • Government support through actions other than financial • Justification for Incentive: One of the major drawbacks in the host country selected is the financing of the projects. Any improvements in financing or services or infusion of dollars into the project will allow a quicker commercialization of U.S. technologies into this country. Quicker commercialization means more widespread use of U.S. clean coal technologies in the world market, which provides more work for the U.S. companies involved and ultimately leads to the infusion of more money from foreign companies into the United States.
Foster Wheeler Energy International, Inc	19, 21, 24, 26, 27	• Financial support for feasibility study, project development work, generated power price guarantee, and investment cost share. - Justification for Incentive: None provided.
HYDROCARB Corporation	76	• Financial support: 25 percent of project costs. • Informal partnerships between U.S. government and industry to allow firms to utilize government offices such as embassies in foreign countries. • Patent protection. • Facilitate export of U.S. manufactured components. • U.S. government to assist in the resolution of legal and trade restrictions. • Ease language and cultural differences. • Justification for Incentive: While there will always be risks in foreign business ventures, many emerging nations remain politically unstable and therefore pose greater risks to U.S. business involvement. Federal government incentives are necessary in order to encourage U.S. business to more actively pursue business opportunities in these areas, not only financial incentives. Partnerships would put the world on notice that the power and influence of the U.S. government is behind these energy projects.
LSR Technologies, Inc.	50	• Financial : 77 percent of project costs. • Justification for Incentive: None provided.

Table 4-4
China: Incentives (cont.)

Respondent	EOI No.	Federal Incentives
NOXSO Corporation	63	- Financial: 75 percent of project costs. - Government protection of intellectual property when installed in other countries. - Justification for Incentive: None provided.
SGI International	59	- Financial support: 50 percent of feasibility study. - Justification for Incentive: Federal share requested to meet host country site (half of the expense). If results of the study are positive, ready commercial and institutional support for a complete project are anticipated.
TRW Space & Technology Division	2	- Financial support for U.S.-made hardware and U.S.-based services. - Justification for Incentive: To procure specialized U.S.-based services and hardware not currently manufactured in China.
Texaco Inc	45	- Facilitate access to foreign markets. - Financial support in pre-feasibility stage. - Improved coordination among U.S. government agencies and departments. - Closer cooperation with private industry in assembling a financing package. - Providing assistance to host countries in resolving issues (e.g., contractual, currency convertability, financing). - No direct funding of project requested or required. - Justification for Incentives: For host countries making a CCT selection, support in the financing and commercial structure of the project is often as important as the technology itself. Without coordinated, aggressive support by the U.S. government, U.S. companies can be expected to lose in the competition for the lucrative and strategically critical project opportunities. The financial community is hesitant to provide typical financing packages in developing countries without substantial political and coordinating support from both the host government as well as the government of the project developers or technology providers.

4.2.1.4 Market Applicability

China is one of the largest potential markets for clean coal technologies in the world. Coal represents 93 percent of their proved reserves in millions of tons of oil equivalent, and 25 percent of world coal reserves are in China. Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation. China requires enormous additions of power over the next several decades to support the planned development and growth. In addition, China has considerable experience in operating fluidized-bed combustion systems and coal gasifiers and is therefore comfortable with this type of technology.

4.2.2 India

4.2.2.1 Technologies Proposed

India is the proposed location for 10 EOIs. These projects represent six types of CCTs, as shown in Table 4-5.

Table 4-5
India: EOIs

Technology Category	Eoi No.	Respondent
Coal Processing for Clean Fuels		
Coal Preparation	6	Viking Systems International
Advanced Electric Power Generation		
Advanced Combustion	54	Coal Tech Corporation
PFB	16	Foster Wheeler Energy International, Inc.
AFB	15	General Atomics
IGCC	18	Foster Wheeler Energy International, Inc.
	20	Foster Wheeler Energy International, Inc.
	22	Foster Wheeler Energy International, Inc.
	23	Foster Wheeler Energy International, Inc.
	43	Texaco Inc.
Other		
Miscellaneous	7	Viking System International

For India, 5 of the 10 EOIs (50 percent) proposed IGCC projects.

Coal for the projects in India would come from a variety of sources both inside and outside of that country. China and Mexico are also mentioned as possible sources of coal.

Five companies submitted the EOIs for India projects. Foster Wheeler Energy International, Inc., submitted five EOIs, and Viking Systems International submitted two. Coal Tech Corporation, General Atomics, and Texaco Inc. also submitted one EOI each for an India project.

4.2.2.2 Environmental Benefits

The EOIs for India address all major environmental areas. Eight projects address SO₂ emissions; three projects address each of NO_x, particulate, and toxic emissions; and two projects address CO₂, as shown in the following table.

Table 4-6
India: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	6	7	7	4	4	2
Advanced Combustion		✓	✓	✓	✓	✓
AFB*						
Coal Preparation*						
IGCC	✓	✓	✓	✓	✓	
PFB	✓	✓	✓	✓		✓

* EOIs did not specify emissions reductions in these categories.

4.2.2.3 Incentives

These EOIs submitted for other Asian and Pacific Rim countries request all five types of incentives, as shown below. All expressed interest in financial assistance. Export assistance, market analysis, regulatory assistance, and trade missions each appeared in one EOI.

Table 4-7
India: Incentives

Respondent	EOI No.	Federal Incentives
Coal Tech Corporation	54	• Financial support: 33 percent of project costs. • Ex-Im Bank financing for manufacture of U.S.-supplied equipment. • Justification for Incentive: Financial assistance required for the first demonstration plant because of the major technical risks, the long-term impact of the very high ash content of the coal, the durability of the combustor and boiler, and the likelihood of an extended shakedown period before customer acceptance.
Texaco Inc.	43	• Facilitate access to foreign markets. • Financial support in pre-feasibility stage. • Improved coordination among U.S. government agencies and departments. • Closer cooperation with private industry in assembling financing package. • Providing assistance to host countries in resolving issues (e.g., contractual, currency convertability, financing). • No direct funding of project requested/required. • Justification for Incentives: For host countries making a CCT selection, support in the financing and commercial structure of the project is often as important as the technology itself. Without coordinated, aggressive support by the U.S. government, U.S. companies can be expected to lose in the competition for the lucrative and strategically critical project opportunities. The financial community is hesitant to provide typical financing packages in developing countries without substantial political and coordinating support from both the host government as well as the government of the project developers or technology providers.
Viking System International	6, 7	• Availability of guaranteed low interest loans. • Justification for Incentive: None provided.

4.2.2.4 Market Applicability

India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal-based power of some 140,000 MWe by 2030. The high-efficiency, low-emission characteristics of this technology can be expected to enable it to capture a significant portion of this market. Demonstrated success with these projects would open considerable opportunities for further application of this technology in India to repower existing plants or to build new grassroots installations.

4.2.3 Other Asian and Pacific Rim Countries

4.2.3.1 Technologies Proposed

Two EOIs were submitted for Indonesia: a coal preparation project from Rosebud SynCoal Partnership, and a new fuel forms project from SGI International. Each EOI proposes using local sources of coal and financial incentives. These projects address CO₂ and SO₂ emissions.

Two other EOIs were submitted for projects in Australia and Pakistan. The Australian EOI, from Kress Corporation, is an industrial applications to help control fine particulate emissions; financial government incentives. The Pakistani EOI, from Energy International, utilizes IGCC technology and seeks both financial and trade mission incentives. Both EOIs specified the use of local coal sources.

Babcock & Wilcox submitted two EOIs for the Pacific Rim but did not specify a country; both projects would use Pacific Rim bituminous and lignite coals. One of the projects will use pressurized fluidized-bed combustion, the other, a high-efficiency coal-fired boiler design. In addition, ABB Inc. proposed the application of pressurized fluidized-bed technology in Asia and the Pacific Rim.

4.2.3.2 Environmental Benefits

These EOIs primarily address CO₂ and SO₂ emissions, as shown in the next table.

Table 4-8
Other Asian and Pacific Rim Countries: EOIs

Technology Category	EOI No.	Respondent
Coal Processing for Clean Fuels		
Coal Preparation	52	Rosebud SynCoal Partnership
Advanced Combustion	70	Babcock & Wilcox
PFB	65	ABB Inc.
	69	Babcock & Wilcox
IGCC	55	Energy International Corporation
Industrial Applications		
Industrial Applications	60	Kress Corporation

Table 4-9
Other Asian and Pacific Rim Countries: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	4	5	4	1	2	3
Coal Preparation	✓	✓	✓		✓	✓
IGCC	✓	✓				
PFBC		✓	✓			
Advanced Combustion	✓	✓	✓	✓	✓	✓
Industrial Applications						✓

4.2.3.3 Incentives

These EOIs submitted for other Asian and Pacific Rim countries request all five types of incentives. All expressed interest in financial assistance, however, export assistance, market analysis, regulatory assistance, and trade missions each appeared in one EOI.

Table 4-10
Other Asian and Pacific Rim Countries: Incentives

Country	Respondent	EOI No.	Federal Incentives
Asia and Pacific Rim	ABB (ASEA Brown Boveri) Inc.	65	• Government-to-Government communication to expedite negotiations. • Financial assistance such as low cost financing and/or loan guarantees. • Justification for Incentive: Financial assistance is especially important to offset any perceived financial risks related to the project where the customer organizations are very conservative on their view of newer technologies and thus hesitant to deploy technologies that have not already been proven for a long time elsewhere.
Pacific Rim	Babcock & Wilcox	69, 70	• Financial support including direct subsidy of demonstration unit, project financing, engineering and development costs, warranty costs, and characterization.

Table 4-10
Other Asian and Pacific Rim Countries: Incentives (cont.)

Country	Respondent	EOI No.	Federal Incentives
Pakistan	Energy International Corporation	55	• Financial risk reduction policies (e.g., price guarantees, low interest capital loan guarantees). • Financing resource confirmation and pre-commercial field work. • U.S. government support of host country infrastructure development. • Justification for Incentive: Risks need to be adequately addressed and resolved. Economics for the project need to offer a sufficiently high rate of return to reward the added commercial risk level. Actions to reduce the technical and financial risks would be appropriate to instill confidence in the evaluation and review of the project.
Australia	Kress Corporation	60	• Financial support: 50 percent of project costs. • Justification for Incentive: None provided.
Indonesia	Rosebud SynCoal Partner	52	• Financial support: differential cost financing. • Justification for Incentive: None provided.
Indonesia	SGI International	4	• Financial support: 50 percent of feasibility study. • Justification for Incentive: Federal share requested to meet host country site half of the expense. If results of the study are positive, ready commercial and institutional support for a complete project are anticipated.

4.2.3.4 Market Applicability

Indonesia

Large coal reserves and rapid growth will raise the demand for coal-fired electricity. SynCoal® has the potential to supply clean solid fuel for a significant percentage of the growth in energy consumption. SGI's clean coal refineries, which could total more than 100, are only a small portion of all the new electrical generating plants in Indonesia that would use the fuel between now and 2030.

Pakistan

Software programs that can identify cost savings in power plant operations are reported to have wide application, particularly with many older, less efficient plants currently in operation.

4.3 NEWLY INDEPENDENT STATES

4.3.1 Russia

4.3.1.1 Technologies Proposed

Six EOIs were submitted for projects in Russia. Two proposed fluidized-bed combustion projects—one atmospheric and one pressurized. Four others proposed emission control projects—two for control of SO_2 , one for control of NO_x , and one for combined controls of SO_2 and NO_x . EOIs specifying a coal source indicated Russian coal.

Three respondents submitted EOIs for Russian projects. Babcock & Wilcox submitted four of the six proposals.

4.3.1.2 Environmental Benefits

The EOIs proposed reductions from oxides of carbon, nitrogen, and sulfur.

Table 4-11
Russia: EOIs

Technology Category	EOI No.	Respondent
Advanced Electric Power Generation		
PFB	10	Babcock & Wilcox
	11	Babcock & Wilcox
Environmental Control Devices		
Emissions Controls: NO_x	14	EER and U.S. EPA
Emissions Controls: SO_2	12	Babcock & Wilcox
	13	SRI and U.S. EPA
Emissions Controls: Combined SO_2/NO_x	9	Babcock & Wilcox

Table 4-12
Russia: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects		1	1			
Advanced Combustion*						
Atmospheric Fluidized-Bed		✓	✓			
Flue Gas Cleanup; Combined SO ₂ /NO _x *						
Flue Gas Cleanup; Sulfur Control*						
Coal Preparation*						

* EOIs did not specify environmental benefits in these six categories.

4.3.1.3 Incentives

Respondents mentioned only financial assistance as a governmental incentive. One EOI (No.11) did not specify any incentive.

Table 4-13
Russia: Incentives

Respondent	EOI No.	Federal Incentives
Babcock & Wilcox	9, 10, 12	- Financial support: 50 percent of project costs. - Justification for Incentive: None provided.
Babcock & Wilcox	11	None specified.
EER and U.S. EPA (AEERL)	14	- Financial support: 50 percent of project costs. - Justification for Incentive: None provided.
SRI and U.S. EPA (AEERL)	13	- Financial support: 50 percent of project costs. - Justification for Incentive: None provided.

4.3.1.4 Market Applicability

There are vast opportunities emerging for clean coal technologies as Russia continues to transition to a market economy.

4.3.2 Ukraine

4.3.2.1 Technologies Proposed

Two of the four Ukrainian EOIs proposed atmospheric circulating fluidized-bed combustion as the primary technology, one EOI proposed an advanced combustion technology, and one specified computer software and modelling technology. All four projects proposed using Ukrainian coal.

Each of the four projects was proposed by a different respondent: Babcock & Wilcox, CQ Inc., Foster Wheeler Energy International, Inc., and TRW Space & Technology Division.

Table 4-14
Ukraine: EOIs

Technology Category	EOI No.	Respondent
Advanced Electric Power Generation		
Advanced Combustion	53	TRW Space & Technology Division
AFB	17	Foster Wheeler Energy International, Inc.
	67	Babcock & Wilcox
Other		
Computer Software and Modelling	28	CQ Inc.

4.3.2.2 Environmental Benefits

All four EOIs proposed sulfur dioxide reductions. Two proposed reductions in oxides of nitrogen. One proposed reduction in carbon dioxide emissions. Finally, one EOI proposed reduction in particulate emissions.

Table 4-15
Ukraine: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	4	4	3		2	
Advanced Combustion	✓	✓	✓			
Atmospheric Fluidized-Bed Combustion	✓	✓	✓		✓	
Computer Software and Modelling	✓	✓				

4.3.2.3 Incentives

While all four EOIs specified the use of financial incentives, one Ukrainian EOI also requested export assistance and market analysis.

Table 4-16
Ukraine: Incentives

Respondent	EOI No.	Federal Incentives
Babcock & Wilcox	67	- Financial support including direct subsidy of demonstration unit, project financing, engineering and development costs, warranty costs, characterization of coal costs, up-front engineering studies, and performance guarantees. - Justification for Incentive: The greatest limitation to implementation of the demonstration is financing. As such, direct financial assistance to pay for the hard currency expenses of the project(s) will be needed. Many Western European equipment supplying competitors offer Eastern European customers attractive financial packages with the supply of their equipment. U.S. companies must meet or exceed this advantage to establish a presence in the Eastern European market. Trial of new technology usually involves an element of risk that international customers are unwilling to assume without some form of extended warranty. Federal government performance guarantee support is necessary since domestic companies are not familiar with guarantee practices in Europe.
CQ Inc.	28	- Financial support: 100 percent of project costs. - Market analysis to identify host utilities. - Export assistance with equipment to host country. - Justification for Incentive: None provided.

Table 4-16
Ukraine: Incentives (cont.)

Respondent	EOI No.	Federal Incentives
Foster Wheeler Energy International, Inc.	17	• Financial support for feasibility study, project development work, generated power price guarantee, and investment cost share. • Justification for Incentive: None provided.
TRW Space & Technology Division	53	• Financial assistance for procurement of components and services imported from the U.S. for partial retrofit. • Justification for Incentive: Lack of financing available from host country for equipment not manufactured within the host country.

4.3.2.4 Market Applicability

Large, low-grade coal reserves and a large number of utility candidates (approximately 89) for repowering make this country an attractive market. Uncertainties over natural gas supplied from Russia also improves the market for clean coal technologies.

4.3.3 Other Newly Independent States

4.3.3.1 Technologies Proposed

CQ Inc. expressed an interest in introducing its computer software, the Coal Quality Expert, in the following five Newly Independent States: Estonia, Latvia, Lithuania, Kazakhstan, and Kyrgyzstan. The software helps plants make optimal use of local coal sources and aids in the reduction of carbon dioxide and sulfur dioxide emissions.

Table 4-17
Other Newly Independent States: EOIs

Technology Category	EOI No.	Respondent
Other		
Computer Software and Modelling	33, 34, 35, 36, 38	CQ Inc.

4.3.3.2 Environmental Benefits

All five CQ Inc. proposals present opportunities for reductions in SO₂ and CO₂.

Table 4-18
Other Newly Independent States: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	5	5				
Computer Modelling	✓	✓				

4.3.3.3 Incentives

CQ Inc. specified export assistance, financial assistance, and market assessment as desired government incentives for these projects in five Newly Independent States.

Table 4-19
Other Newly Independent States: Incentives

Country	Respondent	EOI No.	Federal Incentives
Estonia Kazakhstan Kyrgyzstan Latvia Lithuania	CQ Inc.	33, 34, 35, 36, 38	- Financial support: 100% of project costs. - Market analysis to identify host utilities. - Export assistance to facilitate equipment to host country. - Justification for Incentive: None provided.

4.3.3.4 Market Applicability

Software programs that can identify cost savings in power plant operations are reported to have wide application, particularly with many older, less efficient plants currently in operation.

4.4 EASTERN AND CENTRAL EUROPEAN COUNTRIES

Five projects were proposed for Poland and five for the Czech Republic. In addition, eight projects were proposed for other Eastern European countries, such as Bulgaria, Hungary, and Romania.

4.4.1 Poland

4.4.1.1 Technologies Proposed

The five EOIs submitted for Polish projects proposed technologies in the following categories: coal preparation, new fuel forms, emissions controls (SO₂), and computer software and modelling. Each of the projects was proposed by a different respondent.

4.4.1.2 Environmental Benefits

Four respondents submitted EOIs that proposed reductions in CO₂ emissions for Poland. All five EOIs also proposed SO₂ reductions. Three proposed toxic emission reductions, and one each proposed NO_x and particulate emission reductions.

4.4.1.3 Incentives

All respondents expressed an interest in receiving financial assistance, three in receiving export assistance, and one each for market analysis, regulatory support, and trade missions.

Table 4-20
Poland: EOIs

Technology Category	EOI No.	Respondent
Coal Processing for Clean Fuels		
Coal Preparation	57	Customs Coals Corporation
	61	SGI International
New Fuel Forms	75	HYDROCARB ^{sm} Corporation
Environment Control Devices		
Emissions Controls: SO ₂	62	Acurex Environmental Corporation and ABB
Other		
Computer Software and Modelling	32	CQ Inc.

Table 4-21
Poland: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	4	5	1	3	1	
Emissions Controls: SO ₂	✓	✓		✓		
Coal Preparation	✓	✓		✓	✓	
Computer Software and Modelling	✓	✓				
New Fuel Forms	✓	✓	✓	✓		

4.4.1.4 Market Applicability

Poland's coal-based energy system offers market opportunities for many different clean coal technologies. Many opportunities exist for coal preparation and new fuel forms, as well as environmental control devices to meet emission standards.

Table 4-22
Poland: Incentives

Respondent	EOI No.	Federal Incentives
Acurex Environmental Corporation and ABB Environmental Systems	62	• U.S. government-negotiated duty-free treatment for U.S. projects and technologies. • Financial support via "debt-for-environment" swap. • World Bank financing. • DOE-sponsored technology transfer meetings. • Justification for Incentive: U.S. environmental technology battles fierce competition from the European Community, which is supported by the duty-free treatment of EC products. Another factor affecting the availability of U.S. technology is the host country's limited ability to finance environmental protection projects. The government could help the private sector by assuring that the proportionate share of funds is directed to U.S. firms and/or to commercialize U.S. technologies.
CQ Inc.	32	• Financial support: 100 percent of project costs. • Market Analysis to identify host utilities. • Export assistance to facilitate equipment to host country. • Justification for Incentive: None provided.

Table 4-22
Poland: Incentives (cont.)

Respondent	EOI No.	Federal Incentives
Custom Coals Corporation	57	- Financial support: 50 percent of project costs. - U.S. government assistance with host country to reduce or eliminate the risks to host country decision makers (i.e., a guarantee against civil penalties). Justification for Incentive: Support and reassurance arranged by DOE through the appropriate host country authorities that power sector executives will not be unduly exposed to risks (civil and criminal liability for major management decisions), which deter them from selecting a CCT solution.
HYDROCARB Corporation	75	- Financial support: 25 percent of project costs. - Informal partnerships between U.S. government and industry to allow firms to utilize government offices, such as embassies. - Patent protection. - Facilitate export of U.S.-manufactured components. - U.S. government to assist in the resolution of legal and trade restrictions. - Ease language and cultural differences. - Justification for Incentive: While there will always be risks in foreign business ventures, many emerging nations remain politically unstable and therefore pose greater risks to U.S. business involvement. Federal government incentives are necessary in order to encourage U.S. business to more actively pursue business opportunities in these areas, not only financial incentives. Partnerships would put the world on notice that the power and influence of the U.S. government is behind these energy projects.
SGI International	61	- Financial support: 50 percent of feasibility study. - Justification for Incentive: Federal share requested to meet host country site half of the expense. If results of the study are positive, ready commercial and institutional support for a complete project are anticipated.

4.4.2 Czech Republic

4.4.2.1 Technologies Proposed

Five EOIs proposed projects for the Czech Republic. Each proposed using a different technology; these technologies include new fuel forms, pressurized fluidized-bed combustion, atmospheric fluidized-bed combustion, emissions controls (SO₂), and computer software and modelling. Of the Czech projects that specified a coal source, all indicated the Czech Republic. The five EOIs were submitted by five different respondents.

4.4.2.2 Environmental Benefits

Three respondents expect that their projects will reduce SO₂ emissions and two will reduce CO₂ emissions. Nitrogen oxide, particulates, and toxic emissions are each addressed in one EOI.

4.4.2.3 Incentives

Four of the five EOIs specified financial incentives; two specified export assistance, market analysis, and trade missions. One EOI specified regulatory assistance.

Table 4-23
Czech Republic: EOIs

Technology Category	EOI No.	Respondent
Coal Processing for Clean Fuels		
New Fuel Forms	77	KFx, Incorporated
Advanced Electric Power Generation		
PFB	64	Ahlstrom Pyropower, Inc.
AFB	68	Babcock & Wilcox
Environmental Control Devices		
Emissions Controls: SO ₂	3	Sorbent Technologies Corporation
Other		
Computer Software and Modelling	39	CQ, Inc.

Table 4-24
Czech Republic: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	3	4	2	1	2	2
Atmospheric Fluidized-Bed Combustion		✓	✓		✓	
Emissions Controls: SO ₂		✓		✓		✓
Computer Software and Modelling	✓	✓				
Coal Preparation	✓					
Pressurized Fluidized-Bed Combustion	✓	✓	✓		✓	✓

Table 4-25
Czech Republic: Incentives

Respondent	EOI No.	Federal Incentives
Ahlstrom Pyropower, Inc.	64	- Financial support: 30-40 percent of project costs. - Justification for Incentive: To make this demonstration project feasible in the competitive Eastern European market, the project cost must be subsidized such that the savings to the utility offset the perceived additional project risk associated with new technology.
Babcock & Wilcox	68	- Financial support including direct subsidy of demonstration unit, project financing, engineering and development costs, warranty costs, characterization of coal costs, up-front engineering studies, and performance guarantees. - Justification for Incentive: The greatest limitation to implementation of the demonstration is financing. As such, direct financial assistance to pay for the hard currency expenses of the project(s) will be needed. Many Western European equipment supplying competitors offer Eastern European customers attractive financial packages with the supply of their equipment. U.S. companies must meet or exceed this advantage to establish a presence in the Eastern European market. Trial of new technology usually involves an element of risk that international customers are unwilling to assume without some form of extended warranty. Federal government performance guaranteed support is necessary since domestic companies are not familiar with guarantee practices in Europe.
CQ Inc.	39	- Financial support: 100 percent of project costs. - Market Analysis to identify host utilities. - Export assistance to facilitate equipment to host country. - Justification for Incentive: None provided.
Kfx, Incorporated	77	- Financial support. - Education of policy makers in target cities on technology's effectiveness and cost advantages. - Education of policy makers on regulatory frameworks. - Justification for Incentive: The development of the household market for this technology will depend on Federal and local government measures that support the use of cleaner fuels.
Sorbent Technologies Corporation	3	- Financial support: 50 percent of project costs. - U.S. assistance to influence outside investment community (World Bank, European). - Increased export potential. - Justification for Incentive: U.S. government financial support might influence decisions of other potential financing sources; the technology represents significant export potential.

4.4.2.4 Market Applicability

The Czech Republic faces many energy challenges. Environmental regulations are becoming tougher. Many district heating plants need expansion or repowering, and current plans are to renovate a large portion of existing coal-fired capacity. In the future, the need for large-scale clean coal-fired power stations will grow as the economy grows.

4.4.3 Other Eastern and Central European Countries

4.4.3.1 Technologies Proposed

In addition to the EOIs submitted for Plzeň and the Czech Republic, eight EOIs proposed projects for other Eastern and Central European countries, including two EOIs for Hungary and one each for Bulgaria and Romania. Four other EOIs listed the region as the location and did not specify a country. Technologies proposed include integrated gasification combined cycle, emissions controls (NO_x), and computer software and modelling. A total of five respondents submitted EOIs. Babcock & Wilcox submitted two EOIs and CQ Inc. submitted three.

4.4.3.2 Environmental Benefits

Both Hungarian projects will use Eastern European or Hungarian coal and address sulfur dioxide emissions. The ALIAS Group project will also address oxides of nitrogen. The CQ Inc. proposals for Bulgaria, Romania, the Slovak Republic, and Slovenia help plants make optimal use of local coals to help reduce carbon dioxide and sulfur dioxide emissions.

Table 4-26
Other Eastern & Central European Countries: EOIs

Technology Category	EOI No.	Respondent
Advanced Electric Power Generation		
IGCC	44	Texaco, Inc.
Environmental Control Devices		
Emissions Controls: NO_x	71, 72	Babcock & Wilcox
Other		
Computer Software and Modelling	31,37,41	CQ Inc.
	49	ALIAS Group, Incorporated

Table 4-26
Other Eastern & Central European Countries: EOIs (cont.)

Technology Category	EOI No.	Respondent
Miscellaneous	56	Gilbert/Commonwealth, Inc.

Table 4-27
Other Eastern & Central European Countries:
Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	6	6	3	1	1	
Computer Modelling	✓	✓	✓			
Emissions Controls: NO _x	✓		✓	✓		
IGCC		✓	✓			

4.4.3.3 Incentives

These projects will utilize export assistance, financial, and market assessment incentives. CQ specified export assistance, financial assistance, and market assessment as desired government incentives.

Table 4-28
Other Eastern & Central European Countries: Incentives

Country	Respondent	EOI No.	Federal Incentives
Bulgaria, Hungary, Romania, Slovak Republic, Slovenia	CQ Inc.	29, 30, 31, 37, 41	- Financial support: 100 percent of project costs. - Market Analysis to identify host utilities. - Export assistance to facilitate equipment to host country. - Justification for Incentive: None provided.
Hungary	ALIAS Group, Incorporated	49	- Financial support: 50 percent of project costs. - Government involvement through technology transfer/demonstration of technology. - Justification for Incentive: The primary impediments faced with respect to implementation of this technology are financial and acceptability by plant operators. The involvement of the U.S. government can positively influence the initial demonstration of new technologies by enhancing the ability of government and industrial participants to focus on opportunities. Projected revenues and plant operating costs are not sufficient in the targeted area to justify plant retrofits or other major capital investments.
Eastern Europe	Gilbert/Commonwealth, Inc.	56	- Loan guarantees, low interest loans, cost sharing sufficient to offset risks and enable U.S. companies to compete. - Identify Market Opportunities. - U.S. Government support of technologies through assistance with foreign contracts. - Financial support of feasibility studies. - U.S. Government support of regulatory changes to clarify issues of permitting, tariffs, taxes. - Support development of technical data through testing foreign coals in U.S. demonstration plants. - Justification for Incentive: First entries into the market are difficult for many manufacturers because experience with and recognition of U.S. product features is lacking. Available funding is the greatest deterrent to the work. It is possible that funding from the U.S. Government which can support a demonstration of a high-efficiency technology will offset the risk and high capital associated with the project.

Table 4-28
Other Eastern & Central European Countries: Incentives (cont.)

Country	Respondent	EOI No.	Federal Incentives
Eastern Europe	Babcock & Wilcox	71, 72	- Financial support including direct subsidy of demonstration unit, project financing, engineering and development costs, warranty costs, characterization of coal costs, up-front engineering studies, and performance guarantees. - Justification for Incentive: The greatest limitation to implementation of the demonstration is financing. As such, direct financial assistance to pay for the hard currency expenses of the project(s) will be needed. Many Western European equipment supplying competitors offer Eastern European customers attractive financial packages with the supply of their equipment. U.S. companies must meet or exceed this advantage to establish a presence in the Eastern European market. Trial of new technology usually involves an element of risk that international customers are unwilling to assume without some form of extended warranty. Federal government performance guaranteed support is necessary since domestic companies are not familiar with guarantee practices in Europe.
Eastern Europe	Texaco, Inc.	44	- Facilitate access to foreign markets. - Financial support in pre-feasibility stage. - Improved coordination among U.S. government agencies and departments. - Closer cooperation with private industry in assembling financing package. - Providing assistance to host countries in resolving issues (e.g. contractual, currency convertability, financing). - No direct funding of project requested/required. - Justification for Incentive: For host countries making a CCT selection, support of the project is often as important as the technology itself. Without coordinated, aggressive support by the U.S. Government, in the petition for the lucrative and strategically critical project opportunities. The financial community is hesitant to provide typical financing packages in developing countries without substantial political and coordinating support from both the host government as well as the government of the project developers or technology providers.

4.4.3.4 Market Applicability

Hungary

There are up to 12 coal-fired power plants in Hungary that could benefit from retrofitting advanced sensors and control technologies that improve operation efficiencies.

Bulgaria, Romania, Slovak Republic, Slovenia

Software programs that can identify cost savings in power plant operations are reported to have wide application, particularly with many older, less efficient plants currently in operation.

4.5 LATIN AMERICA**4.5.1 Brazil and Mexico**

4.5.1.1 Technologies Proposed

Two EOIs, one for Mexico and one for Brazil, were submitted for Latin America. Foster Wheeler Energy International submitted an EOI proposing a pressurized fluidized-bed combustor for Mexico. This project will use Mexican coal. The Hiller Group submitted an EOI for an industrial application using U.S. coal in Brazil.

Table 4-29
Latin America: EOIs

Technology Category	EOI No.	Respondent
Advanced Electric Power Generation		
PFB	25	Foster Wheeler Energy International, Inc.
Industrial Applications		
Industrial Applications	8	The Hiller Group, Inc.

4.5.1.2 Environmental Benefits

The Foster Wheeler International pressurized fluidized bed combustor project in Mexico will reduce sulfur dioxide, nitrogen oxides, particulate, and toxic emissions. The Hiller Group industrial process project in Brazil will reduce emissions of carbon dioxide, sulfur dioxide, nitrogen oxides, particulates, and fine particulates.

Table 4-30
Latin America: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	1	2	2	2	2	1
Pressurized Fluidized-Bed Combustion		✓	✓	✓	✓	
Industrial Applications	✓	✓	✓	✓	✓	✓

4.5.1.3 Incentives

Both EOIs for Latin America sought financial incentives.

Table 4-31
Latin America: Incentives

Country	EOI No.	Respondent	Federal Incentives
Brazil	8	The Hiller Group, Inc.	• Financial support: 50 percent of project costs. • Justification for Incentive: None provided.
Mexico	25	Foster Wheeler Energy International, Inc.	• Financial support for feasibility study, project development work, generated power price guarantee, and investment cost share. • Justification for Incentive: None provided.

4.5.1.4 Market Applicability

Brazil

The market for coal-based fuel in industrial applications is reported to be large in Brazil.

Mexico

Software programs that can identify cost savings in power plant operations are reported to have wide application, particularly with many older, less efficient plants currently in operation.

4.6 COUNTRY UNSPECIFIED

Three EOIs did not specify or otherwise indicate a country or region of interest.

4.6.0.1 Technologies Proposed

Three different technologies were proposed by three respondents: Thermal Organic Recycling Equipment, Inc., proposes a new fuel forms technology using its THOR process. Leas Industrial Associates proposes an IGCC project using its catalytic coal gasification process. The Georgia Institute of Technology proposes to train people in the international power industry on clean coal technologies.

Table 4-32
Country Unspecified: EOIs

Technology Category	EOI NO.	Respondent
Coal Processing for Clean Fuels		
New Fuel Forms	74	Thermal Organic Recycling Equipment, Inc.
Advanced Electric Power Generation		
IGCC	1	Leas Industrial Associates
Other		
Miscellaneous	5	Georgia Institute of Technology

4.6.0.2 Environmental Benefits

The project from Leas Industrial Associates will address emissions of CO₂, SO₂, and NO_x. The training proposed by Georgia Institute of Technology will cover a broad array of environmental benefits. The Thermal Organic Recycling process provides a method for recovering valuable products from waste streams.

4.6.0.3 Incentives

Leas Industrial Associates requested permitting assistance incentives. Georgia Institute of Technology requested financial incentives.

Table 4-33
Country Unspecified: Environmental Benefits

Technology	Emissions Categories to be Reduced					
	CO ₂	SO ₂	NO _x	Toxics	PM	PM ₁₀
Number of Projects	1	1	1			
New Fuel Forms*						
IGCC	✓	✓	✓			

* no specific environmental effects were described in the EOI.

Table 4-34
Country Unspecified: Incentives

Respondent	EOI No.	Federal Incentives
Georgia Institute of Technology	5	• Matching funds up to 50% of project total. • Justification for Incentive: None provided.
Leas Industrial Associates	1	• Energy, State, Commerce; EPA, Legal Permits. • Demonstrate a full-scale IGCC unit within U.S. • Justification for Incentive: None provided.
Thermal Organic Recycling Equipment, Inc.	74	• Justification for Incentive: None provided.

4.6.0.4 Market Applicability

This set of EOIs did not specify a particular market.

5. ENVIRONMENTAL ASPECTS OF CCTs

5.1 OVERVIEW

World energy consumption is projected to increase by about 1.6 percent per year between 1990 and 2010 as all regions of the world, but particularly the newly industrializing countries, continue to pursue policies that encourage economic growth and raise living standards.¹ This increased energy consumption, so necessary to spur economic growth, has the concomitant potential for a serious negative impact on global environmental quality. However, the energy intensity of economic activity is projected to decrease steadily over the period as a benefit of the application of advanced technology and other economic factors. Combined with advanced emissions control technologies, global environmental degradation can be mitigated, although perhaps not fully offset for all pollutants.²

Coal is the world's most ubiquitously chosen fuel for baseload electric power generation by virtue of its abundance in many parts of the world, and its economical extract ability, handling, and storage. Amongst all energy sources, it ranks second between the years 1990 and 2010, although its contribution to total energy consumption declines slightly from 27 to 25 percent. However, mostly due to economic considerations, the total amount of coal consumed is expected to grow by 32 percent during that period, from 6,606 million short tons in 1990. Electricity generation will continue to account for most of the coal consumption worldwide.³

As noted earlier, the burning of coal releases CO₂, SO₂, NO_x, particulate matter, and ash. The business of DOE's CCT Program is to develop and demonstrate the means of economically utilizing coal with attendant minimal emissions of these undesirable pollutants. When we speak of CCTs, we mean coal-based systems that offer significant benefits when used for power generation, pollution control, the conversion of coal into other alternate energy products, and industrial applications. The challenge confronting us for the future is less whether coal will be used, but more to ensure that its use is accomplished in the most efficient manner (thermodynamically and economically) consistent with the least adverse impact on the environment. Environmental

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¹ *International Energy Outlook, 1994*. Report DOE/EIA-0484(94), Energy Information Admin., U.S. Dept. Of Energy, Washington, D.C., July 1994, pages 5 and 8.

² *ibid.*, page 5.

³ *ibid.*, page 31.

requirements have joined with cost reduction to become the primary forces driving coal technology development in new directions. A responsive and successful technology development and demonstration program is essential to realizing sustainable economic and environmental development of our coal reserves, both domestically and on a global basis. The fact that the present and near term future of coal as an energy source depends upon continued advances in coal utilization technology has been accepted, and is being acted upon via the auspices of the Clean Coal Technology Program.

The goal of the Program is to make available to the United States, and indeed to the global, energy marketplace a number of advanced, more efficient, and environmentally responsive coal utilization technologies. These technologies will reduce or eliminate the economic and environmental impediments that limit the full use of coal. This activity and the resulting processes that will be commercialized are in recognition of the strategic importance of coal to the U.S. economy and the international marketplace. They are efforts that will resolve the conflict between the increasing use of coal and the growing concern about the environmental impact of such use.

CCTs promise to reduce emissions of CO₂, SO₂, NO_x, toxic air pollutants, and solid and liquid wastes through significant improvements in coal preparation, combustion, and post-combustion emissions control technologies. New high-efficiency technologies also are being demonstrated that result not only in efficient and cost-effective use of coal resources but also in reduction of CO₂ emissions. In higher efficiency systems, less fuel need be consumed per unit of power produced, hence less CO₂ is produced by the combustion process. Accordingly, CCTs offer industrializing countries attractive technology options for reducing emissions while retaining the benefits of coal-fired electric power generation.

Table 5-1 summarizes the market applicability and environmental performance characteristics of the CCTs. These demonstrations are being conducted at commercial scale, in actual user environments, and under conditions typical of commercial operations, thereby allowing the potential of the technologies to be evaluated in their intended commercial applications.

5.2 GLOBAL CARBON DIOXIDE EMISSIONS

DOE's Energy Information Administration⁴ estimates total CO₂ emissions worldwide from the combustion of fossil fuels to be 6 billion tons in 1990, rising to 8 billion tons in 2020, much of which is directly attributable to coal combustion. Just over 50 percent of these emissions are produced in transitional and industrializing economies. As described earlier, the higher efficiencies of advanced combustion CCTs offer significant reductions in CO₂ emissions. Table 5-2 shows the current and projected world carbon emissions by country for 1990-2010.

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⁴ *International Energy Outlook 1994*. Report DOE/EIA-0484(94), Energy Information Admin., U.S. Dept. of Energy, Washington, D.C., July 1994.

Table 5-1
Clean Coal Technology Markets and Attributes

Type of Clean Coal Technology	Applicable Market(s)	% Energy Conversion Efficiency	Emissions Reductions (%)		
			CO ₂	SO ₂	NO _x
Advanced Electric Power Generation					
Atmospheric Fluidized-Bed Combustion	Util ^a , Ind ^b , Inst ^c	35-36.5	5.7-9.6	90-95	60
Pressurized Fluidized-Bed Combustion	Util, Ind, Inst	36-40	8.3-17.5	90-95	70
Integrated Gasifier Combined Cycle	Util	36-40	8.3-17.5	92-99	92
Integrated Gasifier Fuel Cell	Util, Ind, Inst	40-60	17.5-45.5	92-99	92
Slagging Combustor	Util, Ind, Inst	36	8.3	90	50
Limestone Injection Multistage Burner	Util, Ind, Inst	36	8.3	50-60	45-60
Coal-Fired Gas Turbine	Util, Ind, Inst	35-45	5.7-26.7	85-95	70-80
Coal-Fired Diesel	Util, Ind, Inst	35-40	5.7-26.7	80	50
Environmental Control Devices					
Advanced Flue Gas Desulfurization	Util, Ind	-	-	90-95	0
Sorbent Injection	Util, Ind, Inst	-	-	55-75	0
Spray Dryer	Util, Ind, Inst	-	-	70-90	0
Combined SO/NO _x Control	Util, Ind	-	-	70-95	70-90
Reburning	Util, Ind, Inst	36	8.3	0-20	60
Low-NO _x Combustor	Util, Ind, Inst	36	8.3	0	45-60
Post-Combustion NO _x Control	Util, Ind	-	-	0	40-90
Coal Processing for Clean Fuels					
Advanced Physical Cleaning	Util, Ind, Inst	90 ^d	-	30°	0
Chemical/Biological Cleaning	Util, Ind, Inst	85-90 ^d	-	90-95°	0
Low-Rank Coal Upgrading	Util, Ind, Inst	80 ^d	-	30-95°	0
Coal/Oil Mixtures	Util, Ind, Inst	36 ^f	8.3	80-90°	0
Coal/Water Mixtures	Util, Ind, Inst	34.5-35.5 ^f	4.4-7.0	50-75°	0
Mild Gasification	All Sectors	65-80 ^d	-	90°	70°
Surface Coal Gasification	Util, Ind, Inst	79-80 ^d	-	92-99°	N/A
Indirect Liquefaction	All Sectors	60 ^d	-	94°	70°
Direct Liquefaction	All Sectors	57-61 ^d	-	99°	97°

Table 5-1
Clean Coal Technology Markets and Attributes (cont.)

Type of Clean Coal Technology	Applicable Market(s)	% Energy Conversion Efficiency	Emissions Reductions (%)		
			CO ₂	SO ₂	NO _x
Industrial Applications					
Blast Furnace Granulated Coal Injection	Ind	-	-	40	40
Coke Oven Gas Cleaning	Ind	-	-	80	-
Integrated Coal/Ore Reduction	Ind	47.2 ⁸	35	90	97
Advanced Cyclone Combustor	Ind	-	-	80	75-85
Cement Kiln Flue Gas Recovery Scrubber	Ind	-	-	90-98	-
Pulse Combustion Steam Gasification	Util, Ind	72 ⁶	-	99	

^a Electric Utility^b Industrial^c Institutional^d Process efficiency^e Emission reduction assumes fuel replaces coal or a fuel in uncontrolled boiler^f Power plant efficiency using identified fuel^g Compared to a net efficiency of 29.1% for a comparably sized conventional facility

The major greenhouse gases are CO₂, nitrous oxide, methane, halocarbons, and water vapor. All of these except halocarbons occur naturally. The contribution of greenhouse gas concentrations from all human activities (such as fossil fuel combustion and industrial processes) is small in comparison to releases from natural factors, such as the combustion of vegetation in wildfires, volcanic eruptions, and the biological processes of animals and microbes. Anthropogenic CO₂ is emitted primarily in the burning of fossil fuels such as coal, petroleum, and natural gas.

When a fossil fuel is burned, almost all of its carbon content combines with oxygen in the atmosphere to form CO₂. For every ton of fossil fuel burned, about ¾ of a ton of carbon is released as CO₂. Although coal releases the highest volume of CO₂ per unit of fuel consumed, the larger amounts of oil used as energy sources around the world make the latter fuel a larger overall contributor of these emissions. Natural gas ranks behind both coal and oil in absolute terms and also in terms of releases per unit of energy.

Currently, countries of the Organization for Economic Cooperation and Development (OECD) are responsible for about half of all energy-related CO₂ emissions. OECD emissions during 1992 were measured at nearly 3 billion tonnes of carbon. Carbon emissions for these countries are projected to increase slowly through 2010 (at approximately 1.2 percent per year between 1990 and 2010). After 1995, when the non-OECD countries are expected to begin increasing their share of emissions, the OECD world share is expected to drop from 49 percent in 1992 to 45 percent in 2010.

One reason for the increase in the non-OECD share of CO₂ emissions is that consumption in the non-OECD countries is expected to actually exceed that of the OECD countries before 2010. A drop in the non-OECD energy consumption share and a corresponding drop in emissions in the early to mid-1990s is explained by the political and social upheaval in the former Soviet Union (FSU) and Eastern Europe. In these two regions combined, carbon emissions dropped by 17.5 percent between 1990 and 1992—from 1,338 million metric tons to 1,105 million metric tons. CO₂ emissions from both areas are expected to drop further through 1995. In the FSU, they should regain their 1990 levels by 2010, but in Eastern Europe they are projected to stay well below their 1990 levels through 2010.

5.3 SO₂ AND NO_x EMISSIONS REDUCTIONS WITH CCTs

Clean Coal Technologies can reduce SO₂ and NO_x emissions at any one of three stages in the traditional fuel cycle, or in a fourth manner that departs from the traditional method of coal combustion:

1.   **Precombustion:**   Sulfur and other impurities in coal are removed before it reaches the boiler.
2.   **Combustion:**   Pollutants inside the combustor or boiler are removed while the coal burns.
3.   **Post-combustion:**   Flue gases released from coal boilers are cleaned in the ductwork leading to the smokestack or in advanced versions of today's scrubbers.
4.   **Conversion:**   The combustion process is bypassed altogether; coal is changed into a gas or liquid that can be cleaned and used as a fuel.

All four of these Clean Coal Technology categories address SO₂ and NO_x; the benefits of each category is discussed in turn below.

5.3.1 Precombustion: Coal Processing for Clean Fuels

About 40 percent of the coal used in the U.S. today receives some cleaning to remove sulfur before it is combusted. Virtually all coal cleaning is done with physical techniques that remove small dirt particles, rock and pyritic sulfur. Physical cleaning can remove 30-50 percent of the pyritic sulfur and about 60 percent of the ash-forming minerals, but it cannot remove organic sulfur that is chemically bound with the coal, nor can it remove nitrogen. However, chemical and biological coal cleaning processes can remove as much as 90 percent of the total sulfur (pyritic and organic), and chemical techniques can also remove 99 percent of the ash.

Several coal conversion techniques also have SO₂ and NO_x reduction benefits. Coal gasification and mild gasification processes convert coal into fuel gas with solid and liquid byproducts. Variations

on the processes can result in a 90 to 99 percent reduction in SO₂ and 70 percent reduction in NO_x emissions. Coal liquefaction involves the addition of hydrogen to coal by various processes so that the fuel's ratio of hydrogen to carbon is increased to a level comparable to petroleum-based fuels. Once produced, the coal-derived liquid can be cleaned of its sulfur and ash before being combusted.

Table 5-2
Total World Carbon Dioxide Emissions, 1990-2010
(Million Metric Tons)

Region/Country	History		Projections								
			2000			2005			2010		
			Base Case	Sensitivity Range		Base Case	Sensitivity Range		Base Case	Sensitivity Range	
	1990	1992		Low	High		Low	High		Low	High
OECD											
United States	1,338	1,341	1,483	1,454	1,514	1,553	1,513	1,597	1,632	1,566	1,702
Canada	130	134	158	143	175	164	146	187	168	145	192
Japan	310	320	395	353	460	425	343	517	443	343	545
OECD Europe	995	1,042	1,184	1,115	1,273	1,253	1,154	1,379	1,314	1,192	1,455
United Kingdom	164	174	207	188	230	218	189	251	230	195	269
France	112	119	133	113	156	140	110	175	147	107	191
Germany	265	254	292	257	335	311	261	369	325	266	393
Italy	118	120	136	122	153	143	124	166	148	125	174
Netherlands	59	62	68	63	74	71	64	79	72	64	80
Other Europe	274	312	346	323	374	370	333	413	392	343	444
Other OECD	92	96	106	101	112	112	103	122	115	105	129
Total OECD:	2,865	2,932	3,326	3,216	3,488	2,507	3,330	3,734	3,672	3,449	3,929
Eurasia											
China	649	678	907	803	1,017	1,040	870	1,223	1,170	935	1,435
Former Soviet Union	1,014	868	868	802	931	950	840	1,065	1,037	870	1,209
Eastern Europe	325	236	272	245	295	285	249	320	297	249	346
Total Eurasia:	1,987	1,783	2,047	1,889	2,207	2,275	2,010	2,551	2,504	2,124	2,918
Rest of World (ROW)											
Middle East	204	221	273	257	294	303	269	362	329	290	425
Africa	193	216	245	226	266	263	231	310	280	241	355
Asia	474	530	668	619	727	763	667	904	855	725	1,087
Latin America	275	286	353	335	377	395	360	464	434	389	555
Total ROW:	1,147	1,252	1,539	1,437	1,665	1,723	1,527	2,040	1,899	1,645	2,422
World Total:	5,999	5,968	6,911	6,636	7,264	7,505	7,041	8,140	8,075	7,452	9,001

OECD = Organization for Economic Cooperation and Development

NOTE: The U.S. numbers include carbon dioxide emissions attributable to renewable energy sources.

SOURCE: *International Energy Outlook 1994*. Report DOE/EIA-0484(94). Energy Information Admin., U.S. Dept. of Energy, Washington, D.C., July 1994.

SENSITIVITY RANGE: The Sensitivity Range, and comparisons with the "Base Case," result from a complex set of calculations and five different scenarios: Reference, High Economic Growth, Low Economic Growth, High Oil Price, and Low Oil Price. Details and references to additional source documents are provided in *International Energy Outlook 1994* and *Annual Energy Outlook 1994*, DOE/EIA-0383(94).

5.3.2 Combustion: Advanced Electric Power Generation

Advanced electric power generation systems are characterized by high thermal efficiency, very low pollutant emissions, reduced CO₂ emissions, fewer solid waste problems, and enhanced economics. The major Clean Coal Technologies with SO₂ and NO_x benefits are discussed below:

Fluidized Bed Combustion. Fluidized bed combustion (FBC) reduces emissions of SO₂ and NO_x by controlling combustion parameters and by injecting a sorbent (such as crushed limestone) into the combustion chamber along with the coal. More than 90 percent of the sulfur released from coal can be captured this way. Fluidized bed combustion can be either atmospheric (AFBC or just AFB) or pressurized (PFBC or just PFB). At combustion temperatures of 1,400–1,600°F, the fluidized mixing of the fuel and sorbent enhances both coal combustion and sulfur capture. The operating temperature range is almost half the temperature of a conventional boiler and is below the threshold where thermally induced NO_x is formed. Thus, fluidized bed combustors substantially reduce both SO₂ and NO_x emissions.

Integrated Gasification Combined Cycle. The coal gasification combined cycle process employs the following four basic steps: (1) a fuel gas is generated by coal reacting with high-temperature steam and an oxidant (oxygen or air) in a reducing atmosphere; (2) the gas is cooled, producing steam, and then purified to further remove particulates and sulfur and nitrogen compounds; (3) the clean fuel gas is combusted in a gas turbine generator to produce electricity; and (4) the residual heat in the hot exhaust gas from the turbine is recovered in a heat recovery steam generator, while the steam is used to produce additional electricity in a steam turbine generator.

Gasification combined cycle systems are amongst the cleanest and most efficient of the emerging Clean Coal Technologies. Sulfur, nitrogen compounds, and particulates are removed before the fuel is burned in the gas turbine, i.e., before combustion air is added. For this reason, there is a much lower volume of gas to be treated than in a post-combustion scrubber. In a coal gasifier, the sulfur in coal is released in the form of hydrogen sulfide rather than as SO₂, which is the case in coal combustion. In some integrated gasification combined cycle (IGCC) systems, as in the case of clean combustion, much of the sulfur-containing gas is captured by a sorbent injected into the gasifier. In addition, several commercial processes are capable of removing hydrogen sulfide, whereby more than 99 percent of the sulfur is removed from the gas, making it as clean as natural gas. Hot-gas cleanup systems pass the hot coal gas through a bed of metal oxide particles such as zinc ferrite, removing more than 99.9 percent of the sulfur in the gas stream.

High levels of nitrogen removal are possible. Some of the coal's nitrogen is converted to ammonia, which can be almost totally removed by commercially available chemical processes. NO_x formed from the combustion air can be held to well within allowable levels by staging the combustion process at the turbine or by adding moisture to hold down flame temperature.

Indirectly Fired Cycle. An indirectly fired closed-cycle gas turbine uses a non-reacting gas (such as helium) as a working fluid. The gaseous working fluid is compressed, heated with a high-temperature air heater, expanded in a turbine, and cooled in a waste heat exchanger. Because the closed cycle is fuel-independent, the use of direct coal-firing or coal-derived fuels of any quality is permitted as long as fouling of the primary air heater exchanger does not occur. SO₂

emissions can be avoided through removal of sulfur in the coal conversion or coal combustion process; NO_x emissions can be controlled through improved furnace design.

Coal-Fired Diesel. This technology involves firing a diesel-engine-driven electric generating system with a coal-oil or coal-water slurry. Environmental control systems for SO_2 , NO_x , and particulate removal treat the cooled exhaust before release to the atmosphere. The diesel system is expected to achieve 45–48 percent thermal efficiency.

Coal-Fired Gas Turbine. In a coal-fired gas turbine, coal is combusted in a two-stage system. The first stage is a rich-zone combustor (reducing atmosphere). The rich gas is then cleaned in a hot-gas cleanup system to remove sulfur impurities and particulates, and combustion is completed in a lean-zone combustor. In the second stage, the clean, hot gas is expanded in a gas turbine which drives an electric generator and the compressor for the combustion air. Direct coal-fired heat-engine systems are characterized by net system efficiencies of 40 percent.

Slagging Combustor. Most of these new coal-burning technologies are based on the cyclone combustor concept. In a cyclone combustor, coal is burned in a separate chamber outside the furnace cavity. The hot combustion gases then pass into the boiler where the actual heat exchange takes place. The advantage of a cyclone combustor is that the ash is kept out of the furnace cavity where it could collect on boiler tubes and lower heat transfer efficiency. Results to date show that by positioning air injection ports so that coal is combusted in stages, NO_x emissions can be reduced by 70–80 percent. Injecting limestone into the combustion chamber has the potential to reduce sulfur emissions by 90 percent.

5.3.3 Post-Combustion: Environmental Control Devices

Environmental control technologies include advanced NO_x control, advanced SO_2 control, and combined SO_2 and NO_x control.

NO_x Control Technology. Control of NO_x emissions can be accomplished by modifying the combustion process or by post-combustion selective noncatalytic or catalytic reduction (SNCR or SCR) processes, or combinations of the two principal approaches. Modified combustion processes include the use of specially designed advanced low- NO_x burners, alone or in conjunction with advanced overfire air (AOFA) ports, AOFA ports without low- NO_x burners, or natural gas and coal-fired reburning processes. All of these technologies utilize staged combustion whereby the primary combustion zone is kept deficient in oxygen and the combustion process is completed in stages. The more gradual mixing of fuel and air results in lower flame temperatures and reducing-atmosphere combustion conditions before the combustion process is complete, which reduces the oxidation of nitrogen to NO_x . Emissions reductions for NO_x of 50–70 percent are achievable with these systems.

SO_2 Control Technology. Advanced combustion or post-combustion flue gas cleaning techniques are approaches for removal of sulfur from flue gas. Examples of advanced combustion techniques were previously discussed under the Advanced Electric Power Generation heading. These

techniques involve injection of calcium sorbents (lime or limestone) into slagging combustors or into the combustion zones, i.e., fluidized bed combustion and some coal gasification processes.

Post-combustion cleanup involves removal of SO_2 from the downstream flue gas after it exits the boiler. There are three basic approaches: (1) advanced flue gas scrubbing using lime or limestone (wet scrubbers) to capture 95 percent or more of the SO_2 in the flue gas before it exits the stack; (2) in-duct injection of sorbents utilizing the existing flue gas ductwork; and, (3) inserting one or more separate vessels into the downstream ductwork where the sorbents are added. In-duct methods can achieve removal levels of 90 percent, depending upon the sorbent used.

Combined SO_2 and NO_x Control Technology. Many of the technologies discussed above can be successfully combined to reduce SO_2 and NO_x emissions. Examples from the CCT Program include:

- Low- NO_x burners with sorbent injection into the boiler or in-duct injection
- Advanced cyclone combustor with internal ash, sulfur and nitrogen control
- Gas reburning with in-duct sorbent injection
- Low- NO_x burners supplemented with in-boiler urea injection; SNCR for NO_x control; in-duct sorbent injection for SO_2

5.3.4 Conversion: Industrial Applications

Technologies developed for industry can resolve environmental problems similar to those of electric power generators, such as toxic emissions, global climate change, and solid waste disposal, in addition to SO_2 and NO_x control. The CCT Program presently is demonstrating specific applications for the steel and cement manufacturing industries. However, many of the technologies identified principally in the other marketplace areas will be applicable to the industrial market, including advanced combustors, fluidized-bed combustors, coal gasification processes, and a variety of the environmental control systems. Examples from the CCT Program include:

- Integration of the Deutsche Voest-Alpine Industrieanlagenbau COREX® iron-making process with a combined-cycle power generation system;
- Industrial applications of the advanced air-cooled cyclone slagging combustor with internal sulfur, nitrogen and ash control;
- Cement kiln flue gas SO_2 and waste recovery scrubber; and
- Advanced combustion using a pulse combustion/gasifier for steam gasification of coal.

5.4 OTHER ENVIRONMENTAL ASPECTS OF CCTs

Commercial deployment of Clean Coal Technologies results in other changes to environmental impacts beyond the decreases in the emissions of CO_2 , SO_2 , and NO_x discussed above. For example, technologies produce different levels of solid waste generation. However, most such solid wastes typically are not characterized as hazardous in the U.S., which is the benchmark for all of the

analyses contained in this report. This section will discuss issues of solid waste disposal, water resource use, particulate matter, and air toxics.

5.4.1 Disposal of Solid Wastes

One of the major environmental trade-offs associated with reducing atmospheric emissions through Clean Coal Technologies is the generation of solid wastes (ash, sludge, and other solid wastes), which require disposal in landfills or ponds, or which may be suitable for recycling. Some coal-fired boiler operations may dispose of their solid wastes in ponds and landfills located on the actual plant site (most in the U.S. do this). Many of the existing disposal sites in the U.S. are reaching capacity and cannot be expanded to accommodate additional wastes.

Experience with alternatives to disposal of coal combustion wastes have found that fly ash, bottom ash, boiler slag, and flue gas desulfurization (FGD) wastes generally do not exhibit hazardous characteristics under current U.S. regulations. Some maintenance and water purification wastes do occasionally exhibit Resource Conservation and Recovery Act-type (RCRA) hazardous characteristics. The chemical and physical properties of the solid wastes from a number of Clean Coal Technologies are not well known at present.

Operators of utility and industrial coal-fired boilers who adopt clean coal repowering technologies that would extend the lifetime of their plants would frequently need to find new disposal sites for their solid wastes. However, while most of these Clean Coal Technologies leads to increased solid waste generation, several technologies produce by-products that are commercially usable in locales where markets exist. For example, while developing countries have increasing electric demands while they are expanding their infrastructure, that expansion provides ready markets for by-products such as in the course of construction of roads and buildings. Some technologies produce elemental sulfur or some industrial sulfur compound (e.g., liquid SO_2). The hurdles these by-products must overcome in order for them to be put to beneficial use include purity requirements, transportation costs, and competition from current suppliers of similar materials. Most of the technologies are expected to produce wastes that are easier to handle and dispose of than FGD sludges.

Information on the amount of solid waste that would be generated by the different Clean Coal Technologies is limited because many of the technologies have not yet been operated on a commercial scale.

5.4.2 Impacts on Water Resources

Many of the Clean Coal Technologies would consume different amounts of water than the conventional technologies they might be replacing. In lieu of CCTs, water typically would be consumed for: (1) processing coal prior to combustion, at about half of new plants; (2) steam electric generation, including boiler makeup water and cooling water; and (3) wet FGD. On the other hand, some CCTs, such as IGCC, do not require coal cleaning because other processes are used to remove nitrogen, sulfur, and particulates. The only CCTs that do not require water for steam-electric generation are fuel cells and liquefaction technologies that produce fuel used in gas

Many CCTs do not include wet scrubbers, so scrubber water would not be required. High-efficiency systems also use less water.

The following information is available on water consumption by some specific Clean Coal Technologies:

- **Atmospheric fluidized bed:** An electric power plant using AFB combustion with bituminous coal is expected to consume about 180 acre-feet (220×10^6 liters) of water per 10^{12} Btu, including water for power generation. An electric power plant using AFB combustion with western subbituminous coal is expected to consume about 580 acre-feet (700×10^6 liters) of water per 10^{12} Btu, including water for power generation.
- **Gasification:** A Lurgi high-Btu coal gasification plant is expected to use about 10 acre-feet (12×10^6 liters) of water per 10^{12} Btu of gas produced.
- **Indirect liquification:** An electric power plant using the Lurgi Fischer-Tropsch indirect liquefaction process is expected to consume about 110 acre-feet (130×10^6 liters) of water per 10^{12} Btu, including power generation.

The major impact on water resources from commercialization of CCTs could be an improvement in the quality of surface waters that may result from reduced emissions of SO_2 (and, to a lesser extent, NO_x) leading to less acidic deposition.

5.4.3 Particulates and Air Toxics

Suspended particulates, resulting primarily from extensive and inefficient use of coal, cause serious air pollution problems. In developing countries and Eastern Europe, for example, this is particularly due to residential coal usage. As a case in point, consider that, in 1989, northern cities in China had concentrations of particulate matter that are six times the U.S. Ambient Air Quality Standard, and southern cities averaged almost 11 times the U.S. standard.

While particulates remain a problem in the United States, the use of modern technology, namely the baghouse, has virtually eliminated the problem of particulate emissions from the power generating sector. Although this technology is not specifically proposed in any of the EOIs, it is in fact an established component of any new power generation system that would be installed in the host countries. Therefore, the baghouses should be perceived as an automatic benefit that would reduce particulate emissions for any greenfield project proposed in an EOI, as well as for those proposals that would involve major new installations at existing facilities. Of the proposals submitted, a number specify projections for reductions in particulates, including, for example, one project in India with a PM_{10} emission rate of 7.6×10^{-6} lb/kwhr.

The other emissions group of concern is air toxics, or hazardous air pollutants (HAPs). There are many uncertainties as to the identities of these HAPs, their prevalence in various types and sources of coal, and their nature and fate as functions of combustion characteristics and the particular Clean

Coal Technology utilized. While initial analysis concludes that HAPs may be released by conventional coal-fired power plants, they also presumably may be released from CCTs.⁵

In the United States, recent regulatory requirements impose limitations on a number of categories of HAPs. Some 19 projects in the CCT Program currently are monitoring HAPs emissions, which now are considered important environmental performance criteria for CCTs. Along this line, many of the EOI projects propose to control air toxics, including mercury and lead. One such proposal in the Czech Republic notes that currently there are no such controls in that region.

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Clean Coal Technology Demonstration Program, Program Update 1994. Report DOE/FE-0299P, Office of Fossil Energy, U.S. Department of Energy, Washington, D.C., April 1995.

6. BENEFITS OF COMMERCIALIZING CCTs

6.1 INTRODUCTION

Fostering the commercialization of CCTs in foreign countries by the U.S. Government can be shown to create benefits that accrue globally, both to the foreign countries that elect to use CCTs and to the United States itself. As previously discussed, a major global benefit is the reduction in greenhouse gases, primarily CO₂ emitted when coal is combusted. Countries that use CCTs realize cost-effective power generation and other favorable uses of coal while reducing environmental impacts. The United States benefits through increased exports—and the jobs that those exports create—from the widespread use of CCTs, and are greater than those associated directly with the specific projects proposed in the EOIs.

This chapter provides quantitative estimates of the potential total benefits of active U.S. promotion of CCTs. This analysis focuses on electric power generation because this is the only sector for which reliable worldwide data are available at this high level of aggregation. Nevertheless, as discussed below, substantial opportunities exist for CCTs in other sectors, particularly in industry. In addition, the outputs of those CCTs that involve the production of new fuel forms or coal beneficiation may be used to supply fuel to virtually all energy use sectors.

The CCTs are directed toward satisfying the energy and environmental needs of four market sectors:

- Advanced electric power generation,
- Environmental control devices,
- Coal processing for clean fuels, and
- Industrial applications.

These demonstrations are being conducted at commercial scale, in actual user environments, and under conditions typical of commercial operations, thereby allowing the potential of the technologies to be evaluated in their intended commercial applications. The most promising CCTs for CO₂ reduction are the advanced electric power generation systems. These technologies are characterized by high thermal efficiency, very low pollutant emissions including reduced CO₂ emissions. These highly efficient technologies produce less CO₂ per unit of power produced than do conventional coal-fired electric power generation technologies. For example, pressurized fluidized bed combustion (PFB) and integrated gasification combined-cycle technologies (IGCC) boost generating efficiencies into the 40-45 percent range, as compared to conventional technology

efficiencies of approximately 33 percent. This can reduce CO₂ emissions by 17-27 percent. CCTs yet to be demonstrated, such as gasifier-fuel cell combinations and advanced turbines, have the potential to lower CO₂ emissions by up to 55 percent.

The environmental control devices address the need for efficient, effective and economic means for existing and new conventional coal-fired units to comply with environmental regulations, and at the same time, mitigate broader environmental concerns such as waste disposal. Optimal performance for these technologies would be highly efficient pollutant capture, low capital and operating costs, high operating efficiency, availability and reliability, recyclable or salable by-products. Technologies that would find application in this market sector include NO_x control technology, SO₂ control technology, and combined SO₂, NO_x and particulate control technology.

Coal processing for clean fuels technologies are directed toward the production of economic fuel options which can be used to comply with environmental regulations or can be used to replace petroleum and natural gas in fuel or chemical production. Physical and chemical processes can be applied to coal resources to transform them into a cleaned low sulfur, low ash fuel for direct combustion in existing boilers. This is often the least cost method of achieving environmental compliance. Further, these cleaned coals have a higher energy density and reduced moisture which reduces transportation costs on a Btu basis. Processing coal into new fuel forms such as gases and liquids is included in this market sector. The liquid fuels produced are low in sulfur and suitable for the transportation sector, stationary power generation, or as chemical feedstocks.

The industrial applications include those technologies developed for the industrial sector to resolve environmental problems similar to those of the electric power generators such as reduction of acid rain precursor emissions, air toxics, greenhouse gases and solid wastes. Technology may be specific to an industrial application such as steel and cement manufacturing or to broad industrial applications. These would include advanced combustors, fluidized-bed combustors and a variety of environmental control technologies.

6.2 ANALYTICAL APPROACH

This analysis takes as its starting point projections to 2010 of world coal-fired power generation and generation capacity by region and energy source as developed by the International Energy Agency.¹ Similarly, world coal consumption is projected to increase by 32 percent between 1992 and 2010, from 5.0 to 6.6 billion short tons.²

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¹ *World Energy Outlook*. International Energy Agency, Paris, 1994.

² *International Energy Outlook 1994*. Energy Information Administration, Report DOE/EPA-0484(93), Washington, D.C., July 1994, p. 69.

Five regions stand out as major foreign markets for the export of U.S. CCTs:

- China, with its large coal use and rapid growth;
- The Pacific Rim (other than China), including both developing and developed countries;
- South Asia, primarily India and, to a much lesser extent, Pakistan;
- Central Europe, from Poland south to Bulgaria; and
- The Newly Independent States of the former Soviet Union.

More than half of EIA's expected worldwide growth in coal utilization will occur in China, over one quarter in the OECD countries, and the remainder mostly in developing countries. China is the world's largest coal consumer, and EIA forecasts nearly a billion tons per year of additional coal consumption in China between 1990 and 2010, a virtual doubling of that country's coal consumption. A 46 percent increase in coal consumption is projected in other developing countries over that same period. This increased coal usage will be accompanied by an increase in demand for technologies with which to burn coal cost effectively, efficiently and cleanly.

In China and Central Europe, coal has long been the dominant energy source, providing 77 percent of primary energy consumption in 1993 in China and 50 percent in Eastern Europe. Economic progress will continue to depend on coal in all these countries. Coal consumption in Central Europe and the Newly Independent States, however, is expected to remain flat over the next 20 or so years, due to economic restructuring.

In the Pacific Rim and Southern Asia, rapid economic growth coupled with substantial indigenous coal supplies combine to create a largest potential CCT market. In Central Europe and the Newly Independent States, the challenge will be to correct the damage of decades of environmental neglect without adding to already-considerable economic disruption. Though the situation varies, all these countries share the basic need to use coal cleanly and efficiently.

6.2.1 Scenarios for Increased Coal Use

Several scenarios illustrate alternative ways by which these projected needs for future coal-fired generating capacity could be met. Within these scenarios, estimates are made of the investment required by region for new and retrofit coal-fired capacity, the portion of that investment that is imported, the U.S. market share of those imports, U.S. jobs created by exports, and 2010 and 2020 carbon emissions. Carbon emissions estimates are based on the efficiencies of the mix of coal-fired power generation technologies expected to be built. The scenarios differ in the mix of these technologies, the share of existing coal-fired generating units retrofit or repowered with CCTs or rehabilitated, and the U.S. market share.³

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³ Details of these projections are documented in *Estimated Benefits of Clean Coal Technology Export Promotion*. Unpublished manuscript submitted to DOE, Resource Dynamics Corporation, Vienna, Va., March 1995.

Four basic scenarios are projected:

1. **Typical Practice.** This scenario assumes that the technologies that have historically been utilized continue to be built for new capacity in each region and that current U.S. market shares are maintained.
2. **Conventional Commercial.** This scenario assumes that the U.S. Government takes no further actions to promote CCTs or to assist U.S. companies in exporting CCTs. It assumes a distribution of new unit and retrofit technologies typical of what is now commercial for each type of country, and a continuation of current U.S. market shares. Most new coal-fired capacity expected to come "on line" in this scenario has efficiencies equal to today's conventional technology.
3. **Advanced Technology.** This scenario assumes an active U.S. Government role in accelerating the commercial availability of the technology. At a minimum, this would include the incentives ranked as "High" priority in Section 7.6, "Evaluations of Options." Further actions, as discussed in Chapter 7, also would increase the likelihood of its availability. More advanced technologies are installed, requiring more imports. In addition, U.S. exporters are projected to capture a target share of the market in many countries up to 15 percent greater than its current level; see Table 6-1, which shows that U.S. power generation equipment providers compete with varying degrees of success in different regions. It also indicates a large potential to increase market share.
4. **Advanced Technology/Rehabilitation.** Rehabilitation and repowering offer the greatest potential for reducing CO₂ emissions because this increases the efficiency of the large base of existing power plants. This scenario assumes that, in addition to all the technology choices of the "Advanced Technology" promotion scenario, all existing power plants are rehabilitated, thus increasing their efficiency to the current state-of-the-art for pulverized coal.

6.2.2 Scenarios for Reduced CO₂ Emissions

As was discussed earlier in this report, advanced CCTs reduce CO₂ emissions due to their higher efficiencies. The anticipated carbon emissions reductions that would take place in the years 2010 and 2020 are illustrated in Table 6-2. Even in the *Conventional Commercial* case, carbon emissions are substantially lower than what they would have been if coal-fired generation were merely to increase at current efficiency levels. New conventional coal-fired capacity incorporates many of the improvements over earlier technologies, and is significantly more efficient (on the order of 2,000 to 3,000 Btu/kWh) than the existing base of generating units in many developing and transitional countries. Further reductions would be realized as generation from existing, less-efficient, installations is displaced by more advanced technologies.

The *Typical Practice* scenario shows rapidly-increasing carbon emissions, rising to 2,193 tonnes in 2020, or 126 percent of 1995 levels. These increases are most pronounced where coal use is growing fastest, for example in China, other Pacific Rim countries, and South Asia.

The *Conventional Commercial* scenario projects a reduction of 56 million tonnes of carbon emitted from coal-fired power generation in 2010, and 166 million tonnes in 2020. These represent 3.7 percent and 7.6 percent improvements, respectively, as compared to the *Typical Practice* scenario.

Table 6-1
U.S. Share of Import Power Generation Equipment Market

Region	Current U.S. Share (Percent)	Target U.S. Share (Percent)
Canada	66	66
Western Europe	13	26
OECD Pacific Rim	47	62
Newly Independent States	70	70
Central and Eastern Europe	25	40
China	31	46
East Asia	24	39
South Asia	13	26
Africa	14	28
Latin America	47	62
Middle East	29	41

SOURCE: Compiled from Industry Subsector Analyses, Business Market Reports, and Market Research Reports, International Trade Administration, U.S. & Foreign Commercial Service, U.S. Dept. Of Commerce, 1993-95.

Such improvements are derived primarily from the greater use in developing and transitional countries of technologies now in widespread use in developed countries. This scenario represents essentially a reaping of the benefits of technology development that has taken place over about the last 15 years.

Much greater emission reductions are realized in the *Advanced Technology Promotion* scenario due to the considerably higher efficiencies of the coal technologies utilized, particularly after 2010. Carbon emission reductions of 6.7 percent in 2010 and 15.3 percent in 2020 are realized overall as compared to the *Typical Practice* scenario. Again, these reductions are largest in the developing and transitional countries.

One relatively low-cost way to further reduce carbon emissions from coal is to rehabilitate or repower less-efficient units and improve operational practices at those units. This is represented in

the *Advanced Technology Promotion/Rehabilitation* scenario. By 2020, there would be 382 million fewer tonnes of carbon emitted annually, representing a 17.4 percent reduction from the *Typical Practice* scenario. Much of the added benefit comes in the Newly Independent States and China, both of which have large amounts of existing inefficient coal-fired capacity.

Table 6-2
Reductions in Carbon Emissions, 2010 and 2020
(Million Tonnes)

Year	Region	Total Emissions		Reduction in Emissions		
		1995 Emissions	Typical Practice	Conventional Commercial	Advanced Technology	Advanced Technology/Rehabilitation
2010	N. America (Canada)	24	29	0	0	1
	Western Europe	228	327	2	3	9
	OECD Pacific	75	139	1	4	6
	Newly Independent States	121	116	12	13	23
	Central and Eastern Europe	76	87	8	10	15
	China	182	387	11	33	45
	East Asia	57	170	7	15	20
	South Asia	69	133	7	12	18
	Africa	56	100	8	9	17
	Latin America	11	32	1	3	3
	Middle East	0	0	0	0	0
	TOTAL	898	1,519	56	102	158
	Percent Reduction		--	3.7	6.7	10.4
2020	N. America (Canada)	24	32	0	1	1
	Western Europe	228	385	3	19	22
	OECD Pacific	75	171	2	12	13
	Newly Independent States	121	169	22	33	42
	Central and Eastern Europe	76	107	11	18	22
	China	182	594	50	107	118
	East Asia	57	272	26	51	56
	South Asia	69	223	24	45	50
	Africa	56	179	22	37	45
	Latin America	11	59	6	13	12
	Middle East	0	1	0	0	0
	TOTAL	898	2,193	166	337	382
	Percent Reduction	--	--	7.6	15.3	17.4

While advanced CCTs will reduce carbon emissions through their higher efficiencies, reductions in particulates and sulfur dioxide emissions are the primary environmental benefits in which most countries are interested. Many of the countries that will be major markets for CCTs—China, the developing countries of the Pacific Rim, India, the Newly Independent States, and Central and Eastern Europe—already have severe air pollution problems. As discussed earlier, CCTs are a way (and, in coal-dependent countries, the *only* feasible way) to reduce these problems. It should be kept in mind that these benefits have been quantified in this report only for projects proposed in the EOIs, not for the countries as a whole; nonetheless, such benefits could be expected to be substantial.

6.3 COMMERCIALIZATION POTENTIAL OF THE PROPOSED CCTs

The following is a summary by individual country and/or region of the potential for commercialization of proposed CCTs as reported by the EOIs. Additional detailed information on each EOI is provided in Appendix E; these detailed descriptions may also serve to clarify some of the following excerpted statements. Attribution to the source EOI is provided at the end of each bullet.

Australia:

EOI Number	Company	Technology
60	Kress Corporation	Coke Oven Product Recovery Emissions Control

- Up to five recovery-type coke oven batteries and one non-recovery type coke oven battery. [60]

Brazil:

EOI Number	Company	Technology
8	The Hiller Group, Inc.	Low Ash Coal Reductants

- The commercial potential will come from increased production, new markets for high-priority products, lower electricity costs, lower costs compared to charcoal, and more consistent carbon charcoal compared to low ash coal reductants. A 100 percent replacement of charcoal petroleum coke and metallurgical coke is a \$2.4 billion annual market. [8]

Bulgaria:

EOI Number	Company	Technology
41	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [41]

China:

EOI Number	Company	Technology
2	TRW Space & Technology Division	Slagging Coal Combustion Spray Dryer Absorber FGD
19	Foster Wheeler International, Inc.	IGCC
21	Foster Wheeler International, Inc.	High Efficiency Integration Combined Cycle (HEICC) Technology Repowering
24	Foster Wheeler International, Inc.	Advanced Pressurized Circulating Fluidized Bed Power Generator Process
26	Foster Wheeler International, Inc.	High Efficiency Integration Combined Cycle (HEICC) Technology
27	Foster Wheeler International, Inc.	IGCC
40	CQ Inc.	Coal Quality Expert
42	Bechtel Power Corp.	IGCC
45	Texaco, Inc., Alternate Energy Group	IGCC
46	DB Riley International	Atmospheric Circulating Fluid Bed-Circofluid
47	DB Riley International	Pressurized Fluidized Bed Combustor (PFCB)
48	DB Riley International	Flyash Carbon Burnout Cell-Bubbling Bed
50	LSR Technologies, Inc.	Core Separator for Particulates Emissions
51	Control Techtronics International	Combustion Control Technology
58	Custom Coals Corp.	Advanced Coal Preparation Technology

59	SGI International	SGI International's Liquid from Coal (LFC) Process
63	NOXSO Corporation	The NOXSO Process: A No-Waste Emission Control Technology
66	Capsule Pipeline Research Center	Coal Log Pipeline
73	Babcock & Wilcox	Sorbent Injection for SO ₂ Removal
76	HYDROCARB Corporation	HYDROCARB ^{sm} Process

- The commercial potential in China could be considered to be unlimited. [76]
- There are widespread opportunities for commercialization in China. [73]
- At least two 500-mile pipelines are projects with commercial potential. [66]
- NOXSO expects to attain 2 percent of retrofits and new installed capacity in China. Between the years 1999 and 2030, this is equivalent to 19,200 MW or 64 facilities. [63]
- China is one of the largest potential markets for clean coal technologies in the world. Coal represents 93 percent of their proven reserves in millions tons of oil equivalent (TOE), and 25 percent of the world coal reserves are in China. [19, 21, 24, 26, 27]
- Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation. [19, 21, 24, 26, 27]
- It is certain that a significant portion of funding will come from multilateral development banks, which should put emphasis on efficiency, economics and environmental aspects of the project. Advanced PCFB technology will be very attractive from each of these points of view. [19, 21, 24, 26, 27]
- Demonstrated success with this project would open considerable opportunities for further application of this technology in China, to repower existing plants or to build new grassroots installations. [19, 21, 24, 26, 27]
- China requires enormous additions of power over the next several decades to support the planned development and growth. [19, 21, 24, 26, 27]
- There have been estimates that China's power requirements could average at least 25,000 MW every five years (based on coal) between now and 2030, or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15 percent of the market over the period being considered, namely, about 25,000 MW. [19, 21, 24, 26, 27]
- In addition, China has considerable experience in operating fluidized-bed combustion systems and coal gasifiers, and therefore is comfortable with this type of technology. [19, 21, 24, 26, 27]
- China is in massive need of affordable environmental control technologies. [19, 21, 24, 26, 27]
- One of the world's most attractive regions for pursuing SGI's business strategy is China. China has between 160 billion and 185 billion tons of proven coal reserves, of which over 71 billion are classified as subbituminous or lignite. China also is the world's largest

producer and user of coal, with 1992 production being nearly 1.1 billion tons. Approximately 74 percent of China's electricity is generated from coal-fired plants. Even at current rates of production and growth, these reserves are sufficiently ample to supply China with hundreds of years of energy. China also has a large population and an emerging industrial infrastructure. Industrialization and improvements in the standard of living depend, in large measure, on the ability of the nation to generate hard currency through export of a portion of its natural resources. Export of a clean coal product also contributes to cleaner, more environmentally favorable power production in the Pacific Rim. The country's leadership is committed to limiting the environmental impact of its energy policies. All of these factors were considered in evaluating SGI's business opportunities in China based on the use of the proprietary LFC Process for upgrading coal and producing petroleum substitutes. Should only a small portion of all the new electrical generating plants in China between now and 2030 employ Process Derived Fuel (PDF), a vast number of LFC Clean Coal Refineries could be designed and built. [59]

- This technology is badly needed in China. [50]
- There exist tremendous commercial potential in China. [58]
- Every coal-fired plant is a potential user. [48]
- 8 to 12 waste coal projects of 25-125 MW each. [46]
- 1-2 new plants annually through 2010 and beyond. [45]
- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [40]
- We anticipate that successful entry into the Chinese market through this project will result in significant market potential for CTI. Our experiences with the Krakow Clean Fuels Project lead us to project a potential Polish market of 2,000 installations at approximately \$200,000 (U.S.) each, for a total market of \$400 million. Given the difference in populations between Poland and China, where China's population is approximately 30 times larger, this translates into a potential market of somewhere around \$12 billion. [51]
- China is projected to add 17 GWe over the next 10 years. Potential market for slagging coal contribution is 340-1700 MWe during this period, or 2-10 percent market share. [2]

Czech Republic:

EOI Number	Company	Technology
3	Sorbent Technologies Corporation	Flue Duct Sorbent Injection Process for SO ₂ (particulates control)
39	CQ Inc.	Coal Quality Expert
64	Ahlstrom Pyropower, Inc.	Pressurized Circulating Fluidized Bed (PCFB)
68	Babcock & Wilcox	Circulating Fluidized Bed Combustion (CFBC)
77	KFx, Incorporated	K-Fuel Coal Beneficiation

- Many district heating plants need expansion or repowering. [68]
- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [39]
- All of the phases of the K-fuel Bilina project will be commercial ventures. In the first phase, over 80 percent of the 220,000-ton per year production will be placed in competitive contracts with industrial/commercial boilers. The remaining 20 percent production will be used to demonstrate the advantages to cities and towns of having all households switch to burning K-Fuel instead of raw coal. The additional phases of the K-Fuel Bilina project will provide K-Fuel to cities that introduce legislation supporting clean air, and to industrial/commercial boilers. Currently there is an estimated 3-million ton per year market for upgraded solid fuels in the Czech Republic. This market is expected to grow as environmental regulations increase. The market growth for upgraded coal will be offset by the increased use of natural gas and liquid fuels. However, a 2-million ton per year market for K-Fuel beyond the year 2000 is a conservative estimate. [77]
- Commercial opportunity is very high. There are more than a dozen boilers of similar size to that proposed (30-60 MWe), as well as larger boilers. [3]
- Existing electric power plants in Central and Eastern Europe are of a medium size (100-200 MWe). Due to the recession linked to development of an open market, most investment in power generation is aimed at renovating the existing plants to bring them into conformity with Western European environmental standards. This phase of renovation and modernization is expected to extend through the years 2000-2005. Following that period, the market for new thermal power plants and expansions is expected to follow that of Western Europe toward larger plants with high efficiencies. [64]
- CEZ is the largest power generator and distributor in the Czech Republic. CEZ controls approximately 75 percent of the Czech power market, with a total installed power generation capacity of 14,285 MWe. Of this capacity, 65 percent is fossil fueled, with the balance evenly distributed between hydroelectric, nuclear, and other sources. In addition, CEZ makes electric power purchases (about 4 percent of their total power distribution) from Independent Power Producers, and is a net exporter of power. [64]
- The current plan by CEZ is to refurbish 1,000 MWe of new nuclear power capacity, and to renovate an additional 500 MWe of existing capacity. As part of their power restructuring program, existing coal units will be replaced or decommissioned. Of the 500 MWe of refurbishment, 382 MWe are coal fired, where use of atmospheric or pressurized fluidized-bed boilers is planned. [64]
- In the future, the return of the need for new, large scale clean coal fired power stations throughout Europe is expected. The size of the market has not been completely identified, but it is clear that low-emissions, high-efficient power production will be the choice for the utility market. A successful demonstration of the PCFB process will position this technology to be ready to capitalize on this expanding market. [64]

Eastern Europe:

EOI Number	Company	Technology
44	Texaco, Inc., Alternate Energy Group	IGCC
71	Babcock & Wilcox	Low-NO _x Combustion Technology
72	Babcock & Wilcox	Pulverized Coal Reburning

- Potential market is \$100-\$200 billion between 1993 and 2010. [44]
- Approximately 25,000 MW market in Poland alone. [72]
- Between 40 and 200 boilers could use low-NO_x combustion technology. [71]

Estonia:

EOI Number	Company	Technology
38	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [38]

Hungary:

EOI Number	Company	Technology
37	CQ Inc.	Coal Quality Expert
49	ALIAS Group, Inc.	Process Monitoring, Modelling, Optimization and Control

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [38]
- With 12 plants in Hungary subject to retrofit technologies, in excess of 20,000 Gwh could be installed by 2030. [49]

India:

EOI Number	Company	Technology
6	Viking Systems International	Coal Preparation
7	Viking Systems International	Utilization of Ash from Power Plants
15	General Atomics	Atmospheric Circulating Fluidized Bed Combustion

16	Foster Wheeler International, Inc.	Advanced Pressurized Circulating Fluidized Bed Power Generation Process
18	Foster Wheeler International, Inc.	High Efficiency Integration Combined Cycle (HEICC) Technology Repowering
20	Foster Wheeler International, Inc.	IGCC
22	Foster Wheeler International, Inc.	IGCC
23	Foster Wheeler International, Inc.	High Efficiency Integrated Combined Cycle (HEICC)
43	Texaco, Inc., Alternate Energy Group	IGCC
54	Coal Tech Corp	Slagging Coal Combustor

- According to a recent study by RCG/Hagler, Bailly, Inc., and American Tractable (cite: Proceedings of the 2nd Annual Clean Coal Conf., Atlanta, GA, Sept., 1993), installed capacity in Asia in 1991 was 534 GW (534 x 10⁹ W). Planned additions between 1991-2000 are 285 GW. China plans 12 GW of annual additions in this decade, equal to 120 GW, or 22 percent of the Asian total. Assuming the same rate of additions to the year 2030, and assuming that India, which has the second largest population in Asia, will add at least 6 GW annually during that time span, one obtains a 180 GW total in the 30 years of the 21st century. With its low installed capital cost, use of local coals, and small power plant size, a conservative estimate for the installed slagging combustor would result in a market potential of at least 10 percent of the total. Therefore, the potential for the slagging combustor system for India would be at least 18 GW over a 30 year span. At a minimum of \$650/kW, this translates to about \$12 billion. [54]
- Annual power growth is 8,000 MW through 2000; about 65 percent will be coal fired plants. [43]
- India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal-based power of some 140,000 MW by 2030. The high-efficiency, low-emission characteristics of this technology can be expected to enable it to capture a significant portion of this market. [16, 18, 20, 22, 23]
- Coal represents a major proportion of India's fossil energy reserves. [16, 18, 20, 22, 23]
- It is certain that a significant portion of funding will come from multilateral development banks, which put emphasis on efficiency, economics and environmental aspects of the projects. IGCC technology will be very attractive from each of these points of view. [16, 18, 20, 22, 23]

- Demonstrated success with this project would open considerable opportunities for further application of this technology in India, to repower existing plants or to build new, grassroots installations. [16, 18, 20, 22, 23]
- India requires enormous additions of power over the next several decades to support the planned development and growth. In the next ten years, India is expected to increase its power generation capacity by about 100,000 MW with about 40 percent being coal based or, by proration, 140,000 MW by the year 2030 using coal as fuel. Much of this power will be in the 100-MW to 200-MW range, and therefore offers an appropriate market for this technology. Indeed, this technology could capture 15 percent of the market or 20,000 MW. [16, 18, 20, 22, 23]
- New capacity is projected at 72 GWe by 2005 and 150 MWe by 2030. ACFB could capture between 15-30 percent. [15]
- Considerable interest has been expressed even without a feasibility study. [7]
- Minimum 6-8 plants of similar size to demonstration project. [6]

Indonesia:

EOI Number	Company	Technology
4	SGI International	Liquid from Coal Process
52	Rosebud Syncoal Partnership	Advanced Coal Cleaning and Conversion

- Indonesia has very large coal reserves. LFC clean coal refineries could total more than 100 should only a small portion of all the new electrical generating plants in Indonesia use it between now and 2030. [4]
- Syncoal® has the potential to supply clean solid fuel for a significant percentage of the growth in energy consumption. [52]

Kazakhstan:

EOI Number	Company	Technology
35	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [35]

Kyrgyzstan

EOI Number	Company	Technology
36	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [36]

Latvia:

EOI Number	Company	Technology
34	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [34]

Lithuania:

EOI Number	Company	Technology
33	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [33]

Mexico:

EOI Number	Company	Technology
25	Foster Wheeler International, Inc.	Advanced Pressurized Circulating Fluidized Bed Power Generator Process

- Mexico requires considerable additions to its power generation capacity over the next several decades, and is one of the key potential markets for clean coal technologies in the world, with an expected need for increased coal based power of some 20,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market. Demonstrated success with this project would open considerable opportunities for further application of this technology in Mexico to repower existing plants, or to build new grass roots installations. [25]

Pacific Rim:

EOI Number	Company	Technology
69	Babcock & Wilcox	Pressurized Fluidized Bed Combustion
70	Babcock & Wilcox	High Efficiency Coal-Fired Power Plants

- Expand and accelerate trial of technology elements that will be needed for the next generation of super-high efficiency boiler systems. [69, 70]

Pakistan:

EOI Number	Company	Technology
55	Energy International Corp.	Underground Coal Gasification

- There are large opportunities for this technology. An estimated 100 billion tons of lignite exist in Pakistan. The UCG technologies that have been developed are in the midst of being commercialized both domestically and internationally. [55]

Poland:

EOI Number	Company	Technology
32	CQ Inc.	Coal Quality Expert
57	Custom Coals Corp.	Advanced Coal Preparation
61	SGI International	SGI International's Liquid from Coal (LLFC) Process
62	Acurex Environmental Corporation	Duct Injection
75	HYDROCARB Corporation	HYDROCARB ^{sm} Process

- The commercial potential in Poland could be considered to be unlimited. [75]
- Potential market is estimated at 10,000 MWe of power plants requiring less than 50 percent SO₂ reduction. [62]
- Of the approximately 16.7 billion tons of hard coal that are classified as available for mining, about 15.7 billion tons are located in the Upper Silesia coal fields in 65 operating mines. This resource includes subbituminous coals that may be suitable for upgrading through the use of mild gasification technology, such as the LFC Process. LFC Clean Coal Refineries also may be appropriate for upgrading some of the lignite reserves located in southwestern Poland (Turow, 1 billion tons of reserves), western Poland (Scinawa, Legnica, Cybinka, and Gubin, a total of 4.9 billion tons), or central Poland (Konin, Adamow, and Belchatów). The Belchatów mine alone produces some 40 million tons per year of lignite at the present time, all of which is dedicated to a nearby 4,320-MWe power station. All of these factors were considered in evaluating SGI's business opportunities in Poland based on the use of the proprietary LFC Process for upgrading coal and producing petroleum substitutes. Should only a small portion of all the new electrical generating plants in Poland between now and 2030 employ Process Derived Fuel (PDF), a vast number of LFC Clean Coal Refineries could be designated and built. [61]
- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [32]
- Currently, less than 30 percent of Polish steam coal is cleaned to long-term compliance levels. The Polish Power Grid Company has very limited resources to meet system upgrade requirements. CCC's technology offers the opportunity to meaningfully expand the number

of power stations that meet forthcoming emissions standards by minimizing Polish investment requirements. Up to 30 million tons per year of additional coal cleaning capacity is possible. Custom Coals realistically projects that 10 million tons could be built. [57]

Romania:

EOI Number	Company	Technology
31	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [31]

Russia:

EOI Number	Company	Technology
9	Babcock & Wilcox	SNRB Technology
10	Babcock & Wilcox	Pressurized Circulating Fluidized-Bed Combustion
11	Babcock & Wilcox	Atmospheric Circulating Fluidized-Bed Combustion
12	Babcock & Wilcox	LIDS De SOx-12
13	SRI	E-SOx Technology for Moderate Flue Gases
14	EER	Micronized Coal Reburning

- Over 300 boilers could be modernized. [9, 10, 11, 12, 13, 14]

Slovak Republic:

EOI Number	Company	Technology
30	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [30]

Slovenia:

EOI Number	Company	Technology
29	CQ Inc.	Coal Quality Expert

- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [29]

Ukraine:

EOI Number	Company	Technology
17	Foster Wheeler International, Inc.	Atmospheric Circulating Fluidized Bed
28	CQ Inc.	Coal Quality Expert
53	TRW Space & Technology Division	Slagging Coal Combustor
67	Babcock & Wilcox	Circulating Fluidized Bed Combustion (CFBC)

- Ukraine has large reserves low grade coals that need CFB technology. 89 units have been identified as candidates for repowering (approximately 14,000 MWe) over the next 10-15 years. [67]
- 200 to 300 MWe per year for over 20 years to retrofit existing power plants. [53]
- U.S. equipment with millions of dollars will be selected based on plant improvements identified by CQE. [28]
- At the present time there are 95 utility boilers in Ukraine in the range from 80 to 300 MWe. Approximately 50 percent of them operate on coal, with the balance firing mostly gas. The quality of their coal has significantly deteriorated over the past 10 years. The ash content has greatly increased from the original design of 15-20 percent, with a corresponding decrease in calorific value (from 9,400 Btu/lb to 7,900 Btu/lb) and volatile matter. Also, in the most recent years there were numerous interruptions in the supply of natural gas, most of which comes from Russia. Great potential for adaptation of this ACFB technology exists in Ukraine for the following reasons:
  - ACFB technology is one which effectively can utilize poor-grade Ukrainian coals.
  - ACFB technology substantially reduces emissions for SO₂ and NO_x.
  - The ages of Ukrainian fossil-fired power plants range from 20 to 40 years.
  - The Ukrainian government has placed top priority on rebuilding their energy sector, especially that of generation of electricity.
  - Any conversion of existing or construction of new power plants is likely to utilize local coals.

Thus, a successful demonstration of the ACFB project in Ukraine will open considerable opportunities for further application of this technology in Ukraine, to repower existing plants and construct of new ones. [17]

6.4 U.S. EXPORTS AND JOB CREATION

The active promotion of U.S. CCTs in foreign countries could have potentially large export benefits as compared to what would happen without such promotion. Projections of these benefits are summarized in Table 6-4.

Conventional Commercial. Even without any further U.S. promotion, a substantial international market exists for products and services related to coal-fired generation. The total investment expected outside the U.S. between 1995 and 2010 for coal-fired generating capacity is \$ 713 billion. Of this amount, \$658 billion will be for new generating equipment and the remaining \$55 billion will be for retrofits of existing units.

However, only a portion of that investment will go to imported products and services, with the exact fraction depending on the country. Overall, the U.S. will compete for its share of a \$9.5 billion annual import market. Approximately 90,000 direct and indirect jobs will be created in support of the \$2.6 billion of annual exports that would result if the U.S. market share continues at its current level.

Not surprisingly, more U.S. exports are expected to flow to regions where the market for coal-fired generation is large and growing, equipment and services are imported rather than locally provided, and U.S. market share is high. Over half the jobs projected to be created are due to exports to the Pacific Rim, particularly China, with its rapidly-growing need for coal-fired generating capacity. Even so, opportunities elsewhere are still substantial.

Advanced Technology. The worldwide investment in coal-fired power generation between 1995 and 2010 is expected to be \$738 billion; this is a slight increase over the "Conventional Commercial" case.

Total imports, however, are significantly larger at \$11.3 billion because more of the advanced plant components will have to be imported. Approximately 162,000 direct and indirect jobs will be created in the U.S. to provide \$4.6 billion of annual exports of equipment and services. This almost doubles the exports and job creation under the "Conventional Commercial" scenario.

Table 6-3
Comparison of Exports and Job Creation

	Annual Exports (\$ Million)				Export Jobs			
	Typical Practice	Conventional Commercial	Advanced Technology	Advanced Technology/Rehabilitation	Typical Practice	Conventional Commercial	Advanced Technology	Advanced Technology/Rehabilitation
North America (Canada)	50	51	50	63	1,637	1,814	1,813	2,253
Western Europe	191	191	391	434	6,577	6,863	14,024	15,595
OECD Pacific	339	339	454	477	12,768	12,175	16,314	17,116
Newly Independent States	13	224	282	298	617	8,504	10,677	11,289
Central and Eastern Europe	14	142	281	288	513	5,386	10,642	10,929
China	151	717	1,341	1,362	5,187	24,596	46,002	46,735
East Asia	307	434	867	875	10,521	14,876	29,752	30,038
South Asia	104	154	380	388	3,564	5,296	13,042	13,321
Africa	57	74	185	192	1,960	2,525	6,335	6,592
Latin America	205	229	378	382	7,379	8,224	13,579	13,713
Middle East	0	1	1	1	14	18	32	34
TOTAL	1,431	2,555	4,609	4,824	50,736	90,277	162,212	167,615

6.5 OPPORTUNITIES FOR CCT BENEFITS IN OTHER SECTORS

Large volumes of coal are used in many countries for purposes other than power generation, and many of these applications are also amenable to CCTs. Table 6-5 shows patterns of coal use in those regions and countries where coal use for other purposes is most prevalent: China, the Newly Independent States, Central Europe, and India. Most of the countries in these regions are highly dependent on coal as an energy source, and coal is therefore widely used for many purposes, not just power generation. Coal is used for a variety of purposes in other countries as well.

Major industrial uses for coal in most of these countries include iron and steel making, in the chemical industry (especially fertilizer production), and cement manufacture. Coal is also widely used for space heating in many countries in residential housing, large buildings, industry and district heating. In many of these countries, this coal use is highly inefficient and uncontrolled, often leading to severe environmental and health consequences. CCTs such as those proposed in response to this solicitation could bring substantial improvements in efficiency and environmental performance for these countries.

Table 6-4
Use of Coal by Sector in Selected Regions
and Countries, 1990
(Million Tonnes of Oil Equivalent; Quads in parentheses)

Region	Industrial	Residential	Other/Unclassified
China	225.9 (8.96)	82.7 (3.28)	37.3 (1.48)
Newly Independent States	89.6 (3.55)	n.a.	56.7 (2.25)
Central Europe	19.8 (0.79)	4.9 (0.19)	16.7 (0.66)
India	42.4 (1.68)	0.7 (0.03)	2.5 (0.10)

Source: *Energy Statistics and Balances of Non-OECD Countries, 1990-1991*. International Energy Agency, Paris, 1993.

Some of the currently-commercial CCT opportunities in these sectors include the following:

- **Coal Preparation** can be used to improve the quality of coal used in virtually any sector. The most significant benefit in many areas is often a reduction in particulate emissions due to removal of ash. Preparation can also reduce sulfur dioxide emissions, and improved coal quality can improve combustion efficiency.
- **New Fuels**, such as coal liquids or briquettes can substitute for other fuels and reduce the impacts of those fuels.
- **High Efficiency Boilers** to replace the old inefficient units that are widely used in many countries.
- **Replacements for feedstocks and fuels** in the iron and steel industry where both product quality and cost are key issues.
- **Integrated gasifier combined cycles** can be used to improve efficiency in the petroleum refining or other chemical industries.
- **High-efficiency gasifiers** can be used in the petroleum and chemical industry for the production of heat and chemicals. In some countries, such as China, they can be used to produce town gas for local distribution.
- **Atmospheric Fluidized Bed Combustion** can be cost-effectively used in many heating applications where it improves efficiency and decreases emissions.

U.S. industry has a strong technical edge in each of these technologies and would have many export opportunities, which can be quite significant. As indicated above, China uses more coal for more purposes than any other country. A rough estimate of the size of the market for several of these applications in China is provided in Table 6-6.

These anticipated investments would represent a substantial commitment to improve the coal utilization infrastructure of a country that is highly dependent on coal. The greatest opportunities for exporting countries such as the United States are those involving relatively more advanced industrial technologies that are unavailable domestically. Moreover, these technologies are

integrated into an industrial setting that poses opportunities for other related imports once a relationship is established (e.g., other types of process equipment in the chemical industry). Yet, these are by no means the only opportunity outside of power generation, and indeed China is not the only such market.

Table 6-5
Selected Opportunities for Clean Coal Technologies in
Industrial and Domestic Applications in China, 1995-2010
(Millions of U.S. Dollars)

Market	Investment	Potential Imports	Direct Export Jobs
Fluid Bed Combustion for Industrial Heating	24,200	7,300	6,800
Gasifiers in the Chemical Industry	13,000	3,900	3,600
Coal Preparation	7,500	750	700
Briquettes for Household Use	2,500	400	400
TOTALS:	47,200	12,350	11,500

6.6 IN SUMMARY, WHERE ARE THE OPPORTUNITIES?

The preceding discussion and the EOIs give similar indications of the regions of the world with the greatest opportunities for Clean Coal Technologies:

1. China.

China attracted the most EOIs—20 out of 77—and is also projected by DOE to be the largest single market country, with a \$717 million average annual export potential; this constitutes 28 percent of the world market. These exports can create an estimate of almost 25,000 direct and indirect jobs annually. China's potential under the "advanced technology" scenario amounts to an annual average of \$1,341 million.

2. Pacific Rim and Asia.

A total of 5 EOIs were submitted for Pacific Rim countries other than China, and one EOI was submitted for Asia, other than India. Under the "conventional commercial" scenario, DOE projects that the average annual export potential for the U.S. is \$434 million for East Asia, creating 15,000 jobs per year.

3. India.

Ten EOIs were submitted for India, which is the principal region in South Asia. South Asia represents an annual import market of \$1,195 million, creating an export potential for the U.S. of \$154 million under the "conventional commercial" scenario.

4. Newly Independent States (NIS), Central and Eastern Europe.

These regions attracted 35 EOIs (15 in the NIS and 20 in Central and Eastern Europe). Together, the NIS and Central and Eastern Europe account for 10 percent of the world power generation equipment and services market. The U.S. export potential could amount to \$366 million per year, creating an estimated 14,000 jobs under the "conventional commercial" scenario.

5. Other Regions.

A total of 6 proposals were submitted for Latin America and unspecified host countries (2 for Latin America and 4 EOIs had no specified host countries). Latin America ranks fifth with an estimated U.S. export potential of \$229 million. Western Europe has the second largest import market of all regions, and represents the sixth potential U.S. export market.

7. FEDERAL INCENTIVES

7.1 OVERVIEW

Senate Report No. 103-294 directs DOE to:

specifically discuss the interests in, prospects of, and optimal incentives for demonstrating clean coal technologies in countries projected to have significant growth in greenhouse gas emissions, using projects smaller in scale than those proposed in the fiscal year 1995 budget request.

The FY 1995 budget request referred to above had included an extensive program to finance a portion of the differential cost (when compared to conventional technology used in the host country) of using high-efficiency environmentally-sound U.S. technology in two "showcase" projects, one in China and another in Eastern Europe. The total proposed budget, including additional international activities, was \$100 million. This chapter provides the requested analysis of less-costly federal incentives.

As demonstrated earlier in this report, developing and transitional countries are projected to have the most significant growth in greenhouse gases. Consequently, many of the incentives discussed here are tailored specifically to conditions in those countries.

The analysis will start with an overview of the incentives identified in the EOIs, and compare these to the types of incentives that were requested by industry in another recent forum, the November 1994 Fossil Energy International Program Stakeholder Meetings. These incentives are then compared to the types of export assistance already provided by the U.S. Government in order to determine similarities and differences between what is requested and what is already being provided. Finally, options for meeting expressed unfulfilled needs are described and evaluated.

7.2 INCENTIVES REQUESTED BY RESPONDENTS

The announcement issued by DOE asked for EOIs from U.S. industry regarding the commercialization of CCTs in foreign countries. It asked respondents to identify the types of Federal incentives that would accelerate the commercial availability of these technologies in international markets. The announcement requested respondents to identify the type of Federal incentive sought, to project the cost to the Government, and to provide an explanation on how the

incentive would accelerate the commercial availability of the technology in the host country. The announcement explicitly stated that no DOE funds were available for this effort, and gave the background on DOE's earlier budget proposals. Respondents were requested to address the incentive with as much specificity, clarity and justification as reasonably possible. In particular, they were asked to identify the impediments that would be alleviated by the requested incentive.

As detailed in Chapter 3, 35 respondents submitted 77 EOIs in response to the DOE announcement, including vendors of advanced technologies, architectural and engineering (A&E) firms, and academia. These organizations are pursuing a wide range of opportunities including greenfield projects, retrofit and/or repowering projects, technology demonstrations, fuels development and exploitation, and training programs. Respondents are pursuing these activities using a variety of different mechanisms. Some respondents are pursuing opportunities on their own, while others are in partnership with host country government agencies or in joint ventures with foreign companies.

7.2.1 Types of Incentives Requested

Federal incentives proposed by the respondents can be grouped into three broad categories:

- Funding of Initial Project Development;
- Funding of Projects; and
- Other Assistance.

Within each category, the respondents are seeking specific types of assistance as shown in Table 7-1. The 77 EOIs represent \$7.15 billion of total project costs for which U.S. firms are seeking \$1.4 billion in Federal funding incentives.

Funding of Initial Project Development. U.S. firms seeking business opportunities in foreign markets must engage in a variety of initial project development activities that are capital intensive, require cash outlays upfront, and bear an amount of risk. U.S. firms requested \$156 million for initial project development activities for projects totaling approximately \$929 million.

Initial project activities include export assistance and market analysis for firms that are investigating opportunities for their technologies in foreign markets. An EOI was submitted by a firm requesting assistance for a retrofit project in China and two EOIs were submitted for fuels development projects in China and Poland, respectively.

Other firms are beyond the market analysis phase and are seeking to embark on specific projects where other types of initial project development activities are required. These activities include prefeasibility and feasibility studies, technology demonstrations, technology adaptation to local conditions, and project definition. Nineteen respondents requested government assistance for prefeasibility and feasibility studies; fifteen for project development; nine for technology demonstrations, and four for technology testing and engineering to adapt to local conditions. Technology demonstrations are the most capital intensive of the initial project development

activities for which respondents sought Federal incentives, accounting for 70 percent of total project costs and nearly 75 percent of total funding sought.

Funding of Projects. This category represents 64 percent of all costs proposed in the 77 EOIs and 86 percent of total government incentive funding sought by U.S. firms. Twenty-eight EOIs requested project funding for a diverse array of projects ranging from greenfield power plants, retrofits and/or repowering projects, fuels, and analytical tools. The projects propose advanced technologies such as fluidized bed, integrated gasification combined cycle, add-on environmental controls, coal beneficiation, a coal log pipeline, and coal analytical tools. Twelve EOIs in this category requested an "investment cost share" from the Federal government in their projects. The remaining 16 EOIs did not specify a mechanism for managing requested funding.

Seven EOIs were for funding of equipment and services for projects the respondents are currently pursuing. These projects included greenfield, repowering/retrofit and fuels projects. Equipment and services needs would be procured from U.S. vendors and businesses and include boiler components, an oxygen plant, well-field piping, fieldwork, design fabrication and installation, infrastructure development, and architectural and engineering services.

Other Assistance. Other assistance that U.S. firms are seeking from the Federal government includes financial assistance, general export assistance and technical assistance to host countries. Three of the twenty-four EOIs requested the \$32 million in financial assistance indicated in Table 7-1 below: the three respondents are seeking financial assistance for differential financing, performance guarantees, and guarantees against civil penalties. Other areas of financial assistance identified by the remaining 21 EOIs are low interest loans, loan guarantees, power price guarantees, and cost sharing to offset the risks of Clean Coal Technologies.

No dollar amount is shown as incentive funding sought for "General Export Assistance to U.S. Business" in Table 7-1 because this category does not include direct assistance to U.S. firms. Specific types of assistance requested by U.S. firms in this regard include intellectual property protection, "door opening" through embassies, greater demonstration of support for Clean Coal Technologies, and negotiation assistance.

Desired technical assistance to host countries includes: (1) assistance to governments in the area of regulatory reform, financial reform and contract development; (2) student training on Clean Coal Technologies; and (3) training on the use of software analytical tools related to technical aspects of coal usage. The total project costs shown for this category in Table 7-1 are less than the total incentive funding sought because several EOIs did not specify the total project cost but identified the government incentive funding.

7.2.2 Rationales Provided for Federal Incentives

Although only some of the respondents gave specific explanations of why government assistance was needed and appropriate, to some extent the rationale can be inferred from the requests. However, an important number of submittals did include very thoughtful explanations. These explanations identify a number of hurdles faced by the respondents as well as the type of

Table 7-1
Summary of Costs of Federal Incentives Sought by U.S. Businesses
(\$U.S. thousand)

TYPE OF ASSISTANCE	NUMBER OF EOIs*	TOTAL PROJECT COST	TOTAL FUNDING SOUGHT
Funding of Initial Project Development			
1 Prefeasibility and Feasibility Studies	19	\$250,400**	\$3,850
2 Project Development	15	na**	\$3,000
3 Engineering to Adapt Technologies to Local Conditions	4	\$215,000	\$31,700
4 Technology Demonstration	9	\$461,092	\$116,471
5 Export Assistance & Market Analysis	3	\$2,500**	\$ 1,250
	<i>Subtotals</i>	\$928,992	\$156,271
Funding of Projects			
6 Project Funding	27	\$3,666,257	\$961,737
7 Funding for Specified Project Components	7	\$905,000	\$264,000
	<i>Subtotals</i>	\$4,571,257	\$1,225,737
Other Assistance			
8 Financial Assistance to U.S. Businesses	24	\$1,566,000	\$32,000
9 General Export Assistance to U.S. Businesses	18	\$80,000	***
10 Technical Assistance to Host Country	32	\$4,280	\$3,860
	<i>Subtotals</i>	\$1,650,280	\$35,860
	TOTALS	\$7,150,529	\$1,417,868

* Sum of EOIs exceeds total projects because proposals that request multiple incentives appear in every category where Federal incentive funding was sought.

** Total project cost listed elsewhere to avoid double counting.

*** Government cost is not in direct assistance to U.S. firms.

government assistance needed to overcome them. They believe that these hurdles go beyond the normal difficulties facing a U.S. company entering a foreign market, and identified three specific areas:

- **Foreign governments provide their companies with extensive support.** A number of responses specifically mention European countries (e.g., Germany) and Japan, stating that their governments play a more active role in opening markets for their companies than does the United States. Several respondents state that, despite their belief that U.S. technologies have a competitive edge over those offered by European and Japanese competitors, the U.S. firms nevertheless are at a disadvantage in key foreign markets because they must compete not only with their foreign counterparts, but also against the foreign governments themselves.

Many of the potential customers in developing countries are government entities that are more comfortable dealing with firms that have the support or endorsement of the home governments of the offering companies. The respondents believe that this preference for government-business interaction and cooperation places U.S. firms at a disadvantage when they attempt to make deals in foreign markets without the like support of the U.S. Government. Another disadvantage is that products from the European Union enjoy tax breaks in the form of duty-free status in Eastern Europe, while U.S. products must incur duty costs. Many respondents state that current Federal financial support through the Overseas Private Investment Corp. (OPIC), the Export-Import Bank, and the U.S. Agency for International Development (USAID) is insufficient to overcome the economic and technical risks inherent in Clean Coal Technology Projects. Better coordination of Federal financial services is needed. One respondent believes that U.S. Government financial support might positively influence decisions of other potential financing sources; in this respondent's opinion, the lack of U.S. Government support could ultimately lead to a loss of competitive edge.

- **Clean Coal Technologies (CCTs) are new and present technology risks.** Several respondents indicated that while CCTs are considered commercially ready, they present significant technology risks because they lack long "track records" of field or real-world application. (In this respect, the risk factor is a similar concern with regard to domestic commercialization as well as to foreign.) As a result, one respondent stated that the financial community is hesitant to provide typical financing packages to projects involving these technologies in developing countries without substantial political and coordinating support from both the host government as well as the government of the project developer or technology providers. Respondents expressed concern that this handicap can have far reaching consequences because the inability to finance projects involving CCTs could result in a loss of business opportunities in key foreign markets.

One respondent stated that many Western European competitors offer Eastern European customers attractive financial packages. U.S. firms must meet or exceed terms offered by Western European competitors to establish a presence in Eastern Europe. Another respondent stated that any improvements in financing or services or infusion of dollars into

a project would allow quicker commercialization of U.S. technologies in developing countries. In general, many respondents believe that considerable government financial support is needed to overcome the technology risks of CCTs.

Another hurdle mentioned by respondents is the newness of CCTs. Decision makers are reluctant to select these technologies over proven systems. In some countries, there is good reason for wariness in making large capital investments. For example, one respondent related that managers in Poland can face criminal and civil prosecution for their decisions. This respondent requested U.S. Government assistance in protecting decision makers from such prosecution. One respondent explained that first entries into developing country markets are difficult for U.S. businesses because developing countries lack experience with and recognition of U.S. product features. Respondents stated that this hesitance would slow market penetration for CCTs in many key markets. One EOI indicated that technology guarantees are needed from our government to offset the risk. Many respondents stated that successful field demonstrations of their technologies would play a major role in raising the profile of U.S. CCTs and overcoming the current funding and acceptability handicaps. One respondent stated that partnerships between the U.S. Government and industry would put the world on notice that the U.S. Government stands behind the energy projects of its companies.

- **Host Countries Lack Adequate Funding.** Several EOIs reported that officials in host countries are very interested in pursuing proposed projects, but they lack the funding needed to proceed. Thus, the host countries are seeking funding from outside sources. The respondents indicate that the U.S. Government can help overcome this barrier by providing funding to host countries. Many developing countries will face this problem in the future as more of these projects are pursued.

7.3 OTHER INDUSTRY EXPRESSIONS OF INTEREST

In addition to the EOIs received in response to this specific request, DOE has actively solicited other industry input in the course of international promotion of U.S. Clean Coal Technologies. The most important, perhaps, of these efforts was a series of three two-day Stakeholder Meetings for the Fossil Energy International Program held in November 1994 in Pittsburgh, Pennsylvania; New Orleans, Louisiana; and San Francisco, California. The purpose of these meetings was to obtain industry comments on the proposed strategic plan for the office of Fossil Energy's International Program, a major emphasis of which is the promotion of CCTs in international markets. The program was widely publicized through a *Federal Register* notice and targeted mailings. The meetings were attended by over 500 industry and government representatives. Both plenary and breakout sessions for the various regions of the world were held. Throughout each, the comments and suggestions of the industry representatives were solicited.

Numerous specific industry suggestions were received during the meetings and are described in detail in the published proceedings.¹ The general theme of these comments was that industry needed and wanted help to "level the playing field" in international markets, but this help must be effective. The international marketplace is perceived by U.S. industry as less than level because foreign competitors are provided several types of export assistance not available to American companies. These include concessionary trade financing, timely market information and government-to-government "door-opening" assistance.

7.3.1 Basic Principles for Requested Assistance

Several basic suggestions to make Federal export promotion of fossil energy technologies more effective were repeated throughout the meetings:

- **Have a clear single point of contact.** Many companies, particularly the smaller ones, are not as knowledgeable or sophisticated as their multinational corporate counterparts with regard to export assistance available from the government. The concept of "one-stop shopping" was mentioned repeatedly, i.e., the identification of a single cognizant Federal office that would serve as the gateway to all of the relevant governmental organizations offering international marketing assistance or other forms of financial or knowledge-based support services.
- **Improve the coordination of export promotion activities at several levels.** Consistent with the above point, better coordination is needed among Federal agencies, between Federal agencies and Multilateral Development Banks responsible for much international power project financing, and even within agencies.
- **Focus on important priorities but don't ignore the smaller ones.** Large markets and the opportunities they present are important, but smaller markets are still very significant and may grow later.
- **Don't be bureaucratic.** Be "user friendly" and flexible in meeting industry needs.
- **Tailor assistance to real and varied company needs.** Products and services differ, as do the needs of small and large companies. Much of the assistance now available does not support exports tied to project development, which is the need of much of the fossil energy industry.
- **Be flexible for different markets.** These needs also vary. Focus on those technologies most appropriate for individual countries.

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¹ *Summary Proceedings of International Stakeholders Meetings.* Office of Fossil Energy, U.S. Department of Energy, Washington, D.C., March 1995.

7.3.2 Incentives Requested by Stakeholders

Several specific types of assistance were requested by industry attendees at the three Stakeholder Meetings:

- **Financing is seen as the key to helping U.S. companies to compete.** Lack of adequate financing was stated to be the most significant constraint to the development of CCT projects. CCTs are large, complex projects and firms that secure the most competitive financing often have a competitive edge. Federal financing assistance was seen as needed for several purposes:
  - Providing front-end financing for market and feasibility studies and project definition,
  - Reducing technology risk for advanced technologies, and
  - Facilitating counter trade mechanisms in countries with weak domestic currencies.

In addition, a need was seen to coordinate existing Federal export financing activities to meet the needs of CCTs and the power sector.

- **Help developing and transitional countries create viable project conditions.** This would involve working with foreign governments and multilaterals to achieve several objectives depending on the circumstances:
  - Promoting legal and regulatory reform,
  - Reducing political risks,
  - Creating a predictable business environment,
  - Developing local capital markets,
  - Making privatization succeed, and
  - Promoting electrification.
- **Information exchange and market intelligence.** A two-way information flow is desired, both to inform U.S. companies about foreign opportunities, and also to educate potential foreign customers about U.S. offerings. Several speakers stated that U.S. information offices knowledgeable about the power industry or CCTs in key markets—currently a rare phenomenon—could inform local customers of U.S. capabilities. It was also emphasized that the private sector should help define the information to be exchanged in order to keep it responsive to real market needs.
- **Opening foreign doors and providing introductions.** Several types of door-opening assistance were requested. Visits by high-ranking officials were seen as demonstrating support for U.S. industry and giving U.S. companies credibility. Assistance by U.S. embassies or other on-site U.S. Government agencies would help U.S. industry meet key energy and environmental decision makers. Participants also stated that *trade missions* and *reverse trade missions* have proven effective in facilitating contacts.

The development of international power and CCT projects often requires joint ventures between U.S. and local companies. One additional way for the Federal government to help

would be to provide the mechanisms to introduce U.S. companies and potential local partners to each other.

- **Adapting U.S. technologies to the needs of foreign markets.** Markets vary widely, and the most advanced technologies are not necessarily the best options for every market. Participants stated that U.S. efforts should focus on the technologies that are the most appropriate for specific countries, not just the most advanced technologies. (The term "Appropriate Technologies" is becoming a buzzword of the mid-90s akin to "Sustainable Development.") In many cases, overcoming the high capital costs associated with advanced technologies is particularly difficult in these countries. Several participants also stated that it was important for new technologies to be operational in foreign countries in order to show that they can be operated by those countries.

7.3.3 Comparison with Expressions of Interest

The EOIs and the suggestions of the Stakeholders at the November 1994 meetings are highly consistent with each other. Both identified essentially the same barriers, and requested similar incentives to reduce those barriers. In both instances, financing was seen as the key to project development, but the EOIs were much more explicit in their request for Federal financing. The emphasis of comments from the Stakeholder Meetings was on efforts to reverse institutional barriers, while the emphasis of the EOIs was primarily on financing.

7.4 U.S. GOVERNMENT ASSISTANCE TO CLEAN COAL TECHNOLOGY EXPORTERS AND DEVELOPERS

Much of the support assistance requested by industry is already provided by Federal agencies. This support may be broadly classified as either export finance or export promotion. Export finance activities are those that provide funding or other financial services to exporters, typically as a supplement to private financing of exports. Export promotion involves a wide range of activities other than providing financial services that promote U.S. exports and assist exporters. Table 7-2 shows the types of export assistance available from Federal agencies.

As Table 7-2 illustrates, individual agencies offer a variety of programs relevant to CCT exports, sometimes in both export finance and export promotion categories. Those that are more important as incentives for CCT exports are discussed below.

One activity that is not shown is government-to-government cooperative assistance on institutional reform, economic development, and technical issues. Such assistance is not export promotion *per se*, but it does serve to broaden and strengthen the market for CCTs and other advanced technologies by helping countries to create the conditions where they can be successfully utilized. Several of the respondents noted the need for such assistance in developing and transitional countries.

Table 7-2
Federal Export Assistance

Type of Assistance:	Finance			Promotion				
Agency/ Organization	Loans	Loan Guarantee	Insurance	Trade Missions	Exporter Information	Trade Policy	Technology Demonstration	Feasibility Studies
Agency for International Development (USAID)	X				X		X	X
Department of Commerce				X	X	X		
Department of Energy				X	X		X	
Department of State					X	X		
Environmental Protection Agency							X	
Export-Import Bank of the U.S. (Ex-Im)	X	X	X					
International Trade Commission						X		
Overseas Private Investment Corp. (OPIC)	X	X	X	X	X			
Small Business Administration	X	X		X	X			
Trade Development Agency					X			X
U.S. Trade Representative						X		

Source: Materials from listed Agencies.

7.4.1 Financial Assistance

Four U.S. agencies are actively involved in providing financial assistance to CCT project developers. The Overseas Private Investment Corporation (OPIC) and the Export-Import Bank of the United States (Ex-Im Bank) provide a variety of services including direct loans, loan guarantees, and various types of insurance. The Agency for International Development supports infrastructure development. The Small Business Administration (SBA) has programs that help small business exporters of goods and services to these projects but, for the most part, these companies are suppliers to primary contractors. SBA has no direct role in project financing, thus it is not a major resource contributor.

CCTs often involve international project finance transactions that are larger, more complex, and different from the typical exporting program that might require just the use of U.S. agency guarantees. The role of the agency is that of an involved party to the transaction, not just a guarantor. Historically, U.S. agencies have relied on host country guarantees as the ultimate repayment source for a transaction, but now they must spend considerably more time and effort evaluating all of the parties and the agreements between them used in these limited-recourse transactions. Also, they must evaluate different structures for risk reduction, since they are not

primarily relying on the sovereign guarantees. A detailed discussion of the financing of international CCT projects is found in two earlier DOE reports to Congress.²

U.S. Government financial assistance is not additive. That is, individual programs may be used under conditions that would preclude other programs from being available. The process of weaving government and multilateral development bank support with private sources of capital is not an easy one because some agencies and/or multilateral development bank programs are meant to benefit sovereign nations, and some are to be used in the private sector. In addition, qualification criteria vary, and some are mutually exclusive.

The **Overseas Private Investment Corporation (OPIC)** provides project finance assistance to qualified³ overseas ventures with significant U.S. participation. OPIC loans and loan guarantees are available to projects that have met OPIC's technical, economic, and environmental criteria and its standards for marketing and financial soundness. OPIC requires that the projects they finance meet World Bank environmental standards. OPIC's loan guarantees range from \$2 million to \$50 million; direct loans typically range in size from \$500,000 to \$6 million. OPIC limits its participation in a new project to 50 percent of total costs, and 75 percent of total costs for the expansion of an existing business. OPIC investment insurance protects U.S. investors, contractors, exporters and financial institutions against three types of risks: currency inconvertibility, expropriation, and political violence. OPIC's insurance commitment was \$6 billion in 1994, and finance commitments were \$1.7 billion. OPIC's 1994 projects supported a total investment of \$11.3 billion in 48 countries.

Another way in which OPIC can participate in funding a project is through equity participation, whereby OPIC is authorized to make capital stock investments and/or purchase a project's debentures convertible to stock. By allowing OPIC to share in the project's equity, the project managers can increase their capital base and improve their chances of obtaining outside financing.

The **Export-Import Bank of the United States (Ex-Im)** offers four support programs to U.S. exporters. Ex-Im is an independent agency of the U.S. Government whose objective is to aid in financing and facilitating U.S. exports. Ex-Im assumes risks that the private sector is unwilling or unable to accept.

Ex-Im may offer guarantees for short-term working capital loans for U.S. exporters. Ex-Im also offers a comprehensive export credit insurance program to support U.S. exporters and commercial banks. Finally, Ex-Im offers a medium- and long-term loan and guarantee program for up to 85 percent of the U.S. export value. Ex-Im is open in many but not all markets; it is prohibited by law from assisting U.S. exports to certain Marxist-Leninist countries unless the President determines

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² *Clean Coal Technology Export Finance Programs*. DOE/FE-0286, September 30, 1993; and, *Foreign Markets for U.S. Clean Coal Technologies*, Report to Congress, DOE/FE-0317, May 2, 1994. U.S. Department of Energy, Washington, D.C.

³ OPIC programs are not available in China, Myanmar, Vietnam, Cambodia, Nepal, Afghanistan, Pakistan, and Mexico.

that such support would be in the U.S. national interest. Also, Ex-Im may be closed in certain countries because of poor economic conditions that would not offer a reasonable assurance of repayment.

As part of Ex-Im's long-term loan and guarantee program, the bank considers "limited recourse project risk financing" (project finance) type applications. In project finance applications, Ex-Im may provide loans or guarantees for new projects of substantial size in which the Bank would rely for repayment on the cash flows of the project itself without full recourse to a third party guarantor in the form of a government or commercial bank. Ex-Im's project finance approach is primarily to assume or share risks in order to mobilize scarce sources of capital which otherwise would not be available.

Project finance is a highly specialized area, and Ex-Im applies strict and comprehensive criteria. To qualify for Ex-Im support, the product or service must have at least 50 percent U.S. content. There is a statutory requirement that the loans, guarantees, and insurance provided by Ex-Im offer a reasonable assurance of repayment. Over the years, Ex-Im has enabled U.S. companies to market new products and technologies that commercial lenders could not finance on their own. Open for business in more than 150 countries, Ex-Im provides most of its financing support to developing countries. Ex-Im Bank does not play a lead role in structuring projects: that is a task for investment bankers, sponsors or investors. As such, applications must be well-developed and structured, with feasibility studies prepared prior to an approach to Ex-Im.

The Private Export Funding Corporation (PEFCO) is a private corporation, owned by 44 commercial banks, six industrial corporations, and two financial services companies. In cooperation with Ex-Im, PEFCO's principal purpose is to mobilize additional private capital to finance the sale of U.S. goods and services to foreign buyers. Under its loan program, PEFCO makes loans directly to public and private borrowers located outside the United States who require dollar financing for the purchase of U.S. goods and services. Under its Note Purchase Facility, PEFCO purchases, without recourse to the seller, medium-term promissory notes. All of PEFCO's loans and notes purchased under the Note Purchase Facility carry the unconditional guarantee of Ex-Im as to the timely repayment of principal and payment of interest. The Ex-Im guarantee represents the full faith and credit of the United States. PEFCO's programs are not specifically designed to assist the export of CCTs.

The **Small Business Administration** provides a limited amount of financial support to potential U.S. exporters. As its name implies, SBA directs its energies toward serving the needs of smaller exporters. SBA financial assistance may only be used for facilities and equipment or as working capital. SBA offers assistance through three programs: the Regular Business Loan Program, the Export Revolving Line of Credit Program and the International Trade Loan Program. Through the Regular Business Loan Program, SBA offers guarantees for a maximum of 90 percent of a bank loan of up to \$155,000, or the lesser of 85 percent of a larger loan or \$750,000. SBA loan guarantees for acquisition of fixed assets under this program have a maturity of 25 years, while guarantees for working capital have a maximum maturity of seven years.

Under the Export Revolving Line of Credit Program, SBA guarantees a line of credit to the exporter for a period of 36 months. Loans made under this program mature within 12 months. Export Revolving Line of Credit-guaranteed funds are intended to be used for three purposes: to pay for labor and materials to be directly used in export manufacturing, to develop new foreign markets, and to finance foreign accounts receivable. Applicants for Export Revolving Line of Credit funding must have been in business for at least one year.

The International Trade Loan Program provides loan guaranties to small businesses seeking to enter into or expand foreign export operations. This guarantee program is limited to financing domestic facilities and equipment. SBA will guarantee a maximum of 85 percent of the loan amount (for loans of \$155,000 or more), with a maximum total exposure of \$1 million for facilities and equipment and an additional \$250,000 for working capital. Loans guaranteed under the International Trade Loan Program must mature in 25 years or less. To be eligible, applicants must demonstrate that SBA-guaranteed funds will allow the applicant to expand existing export markets or create new ones, or that the applicant's business is being harmed by competition from overseas. SBA-guaranteed funds may not be used for debt repayment.

The **Agency for International Development (USAID)** plays a role in project finance through the Energy Project Development Fund (EPDF). The goal of EPDF is "to accelerate the sustainable social and economic development of AID-assisted countries by increasing the supply of reliable, affordable energy, particularly electric power, for productive purposes."⁴ The program addresses this goal by promoting policy reform and institutional development and by coordinating environmental reform and energy development.

USAID offers three types of programs: technical assistance for project development, project financing, and a commodity imports program. EPDF helps to spur policy reform and institutional development in developing countries by providing technical assistance to host governments and electric utilities. The goal of EPDF is to establish the necessary legal, institutional, financial, technical and environmental infrastructure to attract private capital for project finance transactions. Toward this end, EPDF sponsors private power conferences and workshops, arranges for study tours to the U.S., provides private power training and internships, supplies expert assistance in private power training (on such topics as avoided cost pricing and contracting issues) and undertakes special studies on issues related to private power.

EPDF seeks to coordinate environmental reform and energy development by pursuing the goal of increasing private sector participation while maintaining a satisfactory level of environmental safeguards. This is accomplished by assisting host country governments and utilities to perform cost/benefit analyses on the addition of environmental equipment and controls to new and existing power plants; helping to establish regulatory frameworks for environmental protection; and providing advice as to the best methods of incorporating environmental impacts into future energy capacity decisions.

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Private Sector Energy Development Program. U.S. Agency for International Development, Washington, D.C., page 2.

7.4.2 Export Promotion

The Trade and Development Agency (TDA). TDA's main activity is funding feasibility studies. Upon request by a foreign government, TDA can fund a feasibility study, definitional missions, conferences and technical symposia, orientation visits, trade related training, technical assistance cooperation with multilateral development banks, and design engineering and financial packaging. In 1994, over \$41 million funded 125 feasibility studies. TDA funded \$10.8 million in power generation and distribution projects and \$11.1 million in manufacturing projects that year, which represented a total of 40 percent of its \$54 million budget. TDA plays an important role in the promotion of U.S. CCT exports. Major development projects overseas represent potential export potential because such projects generally use expensive imported capital goods and incorporate a high level of technology. TDA's role of funding feasibility studies is in particular relevant to capital intensive industries like power generation and manufacturing.

However, several factors limit TDA's capability to help U.S. companies generate exports. TDA plays a limited role in the major development project process, such as its involvement in the initial feasibility phase rather than in architectural and engineering design. In addition, TDA depends on services provided by other U.S. Government organizations to help it generate exports. These services include overseas representation and support by the Department of Commerce, financing by the U.S. Export-Import Bank, and specialized activities offered by other U.S. Government agencies.

A study conducted by the General Accounting Office in 1993 concludes that France, Germany, Italy, Japan and the United Kingdom use an integrated approach to identifying and funding projects, such as combining traditional export financing with foreign aid to obtain commercial benefits from major projects. Data reported to OECD reveal that major development projects play a larger role in the economic development strategies of these five countries than in the United States. As shown in Table 7-3, for example, Japan spends nearly \$6 billion of its assistance on major development projects, compared to only \$658 for the U.S.⁵ Germany, Italy, France, and the United Kingdom also spend more than the U.S. on major infrastructure projects.

The differences remain even when making a comparison based on actual expenditures rather than just relative shares. The relatively low level of U.S. spending on major development projects reflects a deliberate policy decision made in the early 1970s. In 1973, the U.S. Government de-emphasized major development projects as part of its development aid program in favor of humanitarian aid.

Other countries centralize their major development projects programs among fewer agencies than does the United States, or they use various means to coordinate the inputs of the different agencies involved in planning major development projects. TDA, on the other hand, is independent from the

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⁵ *The U.S. Trade and Development Agency: Limitations Exist in its Ability to Help Generate U.S. Exports.* General Accounting Office, Washington, D.C., October 1993.

Export-Import Bank, USAID, OPIC and SBA. Every project will be considered separately by each of these agencies.

USAID established the Center for Trade & International Investment Services (CTIS) to foster commercial linkages between the private sectors in USAID-assisted developing countries and the U.S. business community to stimulate private enterprise, technology transfer, and sustainable economic growth. CTIS acts as a central point of contact for U.S. and developing country entrepreneurs for information and counseling regarding USAID programs, policies and projects; procurement and contacting opportunities; and business intelligence and opportunities generated by USAID's development activities.

USAID also sponsors projects aimed at finding market-based solutions to developing country environment and energy problems by providing services and financial assistance that facilitate the transfer of appropriate technologies. USAID's approach includes information dissemination, market development, partner identification, transaction assistance, and financial support or assistance.

The Center for International Electric Power Development, established by the Office of Energy of USAID, assists the private sector to help solve the energy and power shortage problems of developing countries. To accomplish this, the Center sponsors the Private Sector Energy Development Feasibility Study Fund that provides financial support to the private sector for the development of private sector energy and power projects, such as private power generation or cogeneration plants. The fund will cost share up to 50 percent of the allowable costs of prefeasibility or feasibility activities of eligible private energy and power projects. Under special circumstances the fund may contribute more than 50 percent of the cost. Eligible projects include, but are not limited to, privately financed, owned and operated energy and power production, generation, conversion, transmission and/or distribution facilities.

Table 7-3
Six Countries' Bilateral Spending on Major Development Projects,
1991 (\$ million)

Country	Transportation	Communications	Energy	Industry/Mining/ Construction	Total
Japan	\$2,714	\$610	\$1,960	\$435	\$5,719
Germany	750	40	505	143	1438
Italy	176	80	565	290	1111
France	303	219	222	138	882
United Kingdom	193	7	487	155	842
United States	232	31	308	87	658

SOURCE: U.S. Trade and Development Agency: *Limitations Exist in its Ability to Help Generate U.S. Exports*. General Accounting Office, October 1993.

The **United States Department of Energy (DOE)** provides the framework for a comprehensive and balanced national energy program through the coordination and administration of the energy functions of the Federal government. Two DOE programs promote the exports of coal related energy technology, equipment, and services: the Fossil Energy International Program and the Export Initiative Program.

The DOE Fossil Energy International Program, within the Office of Fossil Energy, serves as a focus for international information on U.S. Clean Coal Technologies and other fossil energy-related technologies, and as the U.S. Government liaison for coal companies and technology firms in order to promote the export of U.S. clean coal products and services. The Fossil Energy International Program, carried out in concert with other Federal programs, states and private industry, has expanded the United States world leadership role in the developing and opening markets for fossil energy technologies, energy resources and services. Program activities consist of six strategic elements: Organization and Management, Marketing Strategy and Development, Communication, Financial, Legal and Regulatory, and Technology and Services

The DOE Export Initiative Program, located in the Office of International Affairs, seeks to promote and facilitate the export of energy related goods and services by U.S. companies. These goals are accomplished by identifying business opportunities overseas; assisting U.S. companies in pursuing overseas business opportunities; eliminating discriminatory overseas trade barriers; evaluating and advocating changes in U.S. laws and regulations to facilitate trade; identify possible financing alternatives for U.S. companies and working with appropriate U.S. Government agencies in these areas to ensure a coordinated and unified effort.

The **International Trade Administration (ITA)** offers assistance and information to help exporters. Three organizations within ITA are responsible for export promotion: the U.S. & Foreign Commercial Service (US&FCS), Trade Development (TDA), and International Economic Policy (IEP). US&FCS gathers information about trends and barriers to trade and provides a range of services to potential exporters traveling abroad, such as assisting with appointments with key buyers and government officials. US&FCS develops marketing packages for individual companies, individually tailored to a firm's specific products or services. TDA industry specialists work with manufacturing and services industry representatives and associations to identify trade opportunities and obstacles by product or service, industry sector, and market. IEP is the key Department of Commerce source for information on trade potential for U.S. products in specific countries. Individual IEP country desk officers, plus several regional business centers, highlight new opportunities for trade and investment.

The **U.S. International Trade Commission (ITC)** is an independent, bipartisan, quasi-judicial agency with broad powers to investigate all factors relating to the effect of U.S. foreign trade on domestic production, employment, and consumption. The Commission contributes substantially to the development of sound, equitable international trade policy, though it is not charged with a policy making role.

The U.S. Trade Representative (USTR) is the President's chief advisor on international trade policy. In addition to having primary responsibility within the U.S. Government for developing international trade policy and coordinating its implementation, USTR is the Nation's chief negotiator for international trade agreements.

The Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air and water systems. EPA strives to formulate and implement actions that lead to a compatible balance between human activities and the ability of natural systems to support and nurture life. In 1991, trade and environment issues became a priority of EPA. EPA's mission also includes research and development for a number of environmental technologies that can be commercially valuable in international markets, including some CCTs. Conflict of interest concerns, however, prevent EPA from working directly to assist the export activities of private firms.

7.4.3 Coordination of Assistance

The Trade Promotion Coordinating Committee (TPCC) is an interagency task force created as a vehicle to facilitate more effective and cooperative U.S. Government export promotion efforts. The TPCC has the fundamental responsibility of coordinating all U.S. Government export promotion and finance activities, and developing a government-wide strategic plan for Federal trade promotion. TPCC is the official mechanism for coordinating export assistance among Federal agencies. TPCC operates through a series of working groups in specific areas; a Clean Coal Technology Subgroup to the TPCC Environmental Working group has been specifically charged with coordination related to CCTs.

The following Federal Agencies are members of TPCC: Agency for International Development, Council of Economic Advisors, Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Department of Interior, Department of Labor, Department of State, Department of Transportation, Environmental Protection Agency, Export-Import Bank of the United States, Office of Management and Budget, Overseas Private Investment Corporation, Small Business Administration, Trade and Development Agency, Treasury Department, U.S. Trade and Development Agency, U.S. Information Agency, and U.S. Trade Representative.

7.4.4 Comparison of Incentives Available and Requested

The Federal government offers a wide range of support to U.S. project developers and exporters. Many of the requests for assistance by industry are met by the existing programs that are not specifically targeted to CCTs and perhaps not on as favorable terms as expected (see Table 7-4). The requested Federal assistance that is not met by existing programs involves hard dollar grants to help overcome the additional technology cost and commercial risk of new technologies. Five requests from the EOIs or the Stakeholder Meetings are not addressed by existing programs: project development, engineering to adapt technologies to local conditions, technology demonstrations, cost share and power price guarantees. TDA has a program to fund Design Engineering in a limited

number of competitive situations. Industry does not believe that this Design Engineering program meets its demands.

Most requests for assistance asked for Federal funding as a cost share. The specific form of these funds was not specified; however, existing loan and loan guarantee programs from Ex-Im Bank, OPIC and SBA can meet this need partially. Ex-Im Bank's goal is to provide financing where private capital cannot take the risk.

Table 7-4
Comparison of Available Federal Incentives and EOIs

Assistance Requested in the EOIs	Assistance Available
Funding of Initial Project Development	
Feasibility Study	TDA (funding of feasibility studies, definitional missions, technical symposia, training)
Project Development	-
Engineering to Adapt Technologies to Local Conditions	-
Technology Demonstrations	-
Export Assistance & Market Analysis	ITA (market analysis, liaison in host country, identify trade opportunities), DOE (identify business opportunities, Trade missions, technical assistance)
Funding of Projects	
Project Funding	SBA, EXIM, OPIC, USAID (loans, loan guarantees, equity financing, grants for environmental programs, financing of working capital)
Funding for Specified Project Components	SBA (Commodity Import Program)
Other Assistance	
Financial Assistance for CCTs	-
General Export Assistance to U.S. business	DOS, ITA, SBA (management assistance, international cooperative agreements)
Technical Assistance to Host Country	DOE, USAID (technical and management assistance USTR, ITC (regulatory assistance and trade policy)

7.5 INCENTIVE OPTIONS

The fundamental issue addressed by this analysis is how DOE (in coordination with other agencies, as appropriate) can best facilitate commercialization of high-efficiency CCTs in developing and transitional countries. DOE activities should have two fundamental and complementary objectives: (1) to promote the advantages of high-efficiency CCTs in foreign countries, and (2) to facilitate efforts by U.S. companies to compete on a level playing field. These objectives can be achieved only if DOE's efforts produce strategies that are "win-win" for both the U.S. and the other countries.

As discussed above, some existing programs already pursue these objectives, but industry would like DOE to do more. On the other hand, the Congress has stated that Federal efforts should be smaller in scale than the demonstration projects originally proposed in the FY 1995 budget submittal. A number of incentive options would achieve both of these objectives, i.e., respond to the expressed industry needs for more assistance, yet meet Congressional requests for less costly incentives. These options are derived by comparing the requests in the EOIs (and, to a lesser extent, the recommendations received at the Stakeholder Meetings) to the existing government programs with which they are most closely aligned. This procedure identifies the changes that would be necessary for those programs to implement the EOI requests. Often, these changes are program improvements; in a few cases, they are entirely new initiatives. These options are listed below in six groups roughly in order of least to most expensive. The sixth group consists of incentives that were requested by the respondents in the EOIs, but would exceed the Congressional guidance requesting less costly incentives. Descriptions and an enumeration of the advantages and disadvantages of each option are also provided.

1. Make existing Federal programs more effective. This includes activities that could be implemented with little or no added budget commitments. Many of them require coordination of the efforts of multiple Federal agencies.

- a. *Coordinate existing programs.* This coordination would take place through the TPCC CCT Subgroup. Efforts in this area are just now beginning to be implemented.

ADVANTAGES:

- More effectively meet private sector needs
- Greater cross fertilization among participating agencies
- Less duplication of effort
- Effort is already underway.

DISADVANTAGES:

- None.

- b. *Better utilize existing U.S. Government personnel in key foreign markets to open doors and facilitate information exchange.* These personnel include USAID Mission staff, State Department commercial officers, and Foreign and Commercial Service officers, who are responsible for this type of activity. This effort would help them to focus attention on the large power sector market opportunity.

ADVANTAGES:

- This use of time has a potentially high payoff in terms of U.S. jobs and exports due to the high number of extremely large projects.
- Personnel are already in country and are familiar with host government officials.

DISADVANTAGES:

- Detracts from other duties that these personnel have.

- c. *One-stop shopping for existing project finance programs.* This effort would deal with the broad and unique set of issues faced by project developers using non-recourse project finance techniques. It does not necessarily have to be limited to CCT projects, because this type of effort could also benefit the developers of a wide range of projects.

ADVANTAGES:

- Simplifies the application process for financial assistance
- Creates a single point of contact for CCT developers.

DISADVANTAGES:

- Requires interagency coordination beyond what is currently taking place, and hence incremental staff and administrative support.

- d. *Further assistance to foreign governments on institutional reform.* Such assistance would help to reduce many of the barriers to the development of CCT and other power projects in developing and transitional countries. Such programs are already underway under the auspices of USAID. This program would uniquely target those institutional changes required for effective private finance of power projects. Since the issues crosscut the activities of several agencies, this option would best be implemented through the TPCC subgroup on Clean Coal Technology.

ADVANTAGES:

- Removes many of the institutional barriers to project development.
- The U.S. will gain better understanding of regulatory decision making in key foreign markets.

DISADVANTAGES:

- Successful implementation depends on decisions and actions of foreign governments.

2. **Develop an ongoing program of DOE technical assistance.** Such assistance could be provided to foreign governments, other U.S. agencies and U.S. companies. It would leverage on DOE's key strength in technology.

- a. *Assistance to foreign governments on technical issues.* The objective of this assistance would be to make foreign governments more knowledgeable about CCTs.

ADVANTAGES:

- Potential customers are more likely to adopt technologies they understand.
- Increases the likelihood that those technologies will be from the U.S.
- Takes advantage of a key DOE strength.

DISADVANTAGES:

- Diverts DOE efforts from domestic to international activities.

- b. *Assistance to Federal export finance agencies.* The processing of applications for project finance assistance requires both a high degree of expertise and effort beyond what is required of conventional export financing. Technical personnel resources within export finance agencies are limited.

ADVANTAGES:

- Takes advantage of a key DOE strength.

DISADVANTAGES:

- As above, could divert DOE efforts.

- c. *Work with foreign governments to generate more CCT feasibility studies for U.S. firms.* As part of an ongoing assistance program for foreign governments, DOE would attempt to identify potential CCT projects that would benefit those governments. DOE would then encourage the foreign government to apply to TDA for feasibility study assistance.

ADVANTAGES:

- Potentially creates win-win situations for both countries.
- Brings U.S. firms into the beginning of the planning for a power plant.

DISADVANTAGES:

- Needs to be part of a broader assistance program.

- d. *Station Department of Energy personnel in key foreign markets.* These personnel would be located at U.S. embassies and would cover specific regions. They would be the focus for information exchange, door opening and assistance in the for energy companies.

ADVANTAGES:

- U.S. industry and foreign parties would have a clear single point of contact.
- U.S. embassy would have an individual with high degree of knowledge and interest in relevant energy issues.

DISADVANTAGES:

- Potential for duplication of effort with other agencies, which would need to be carefully avoided.

3. **Implement low-cost information exchange programs.** Ensure that U.S. industry has the information they need about foreign markets in a timely manner and that potential foreign customers have information about U.S. offerings.

- a. *Clean Coal Technology and Power information center and dissemination programs.* Much useful information about CCTs and their markets is already publicly available from a wide variety of sources. U.S. firms and others, however, must be able to find and retrieve these sources, which may be difficult. DOE could systematically collect this information and develop mechanisms to effectively disseminate it to interested parties. Such an effort should be conducted with existing TPCC information programs.

ADVANTAGES:

- Creates a single source of information to which industry and foreign governments can turn.

DISADVANTAGES:

- None.

- b. *Ongoing program of DOE trade mission and reverse trade missions.* DOE and other Federal agencies already conduct numerous trade and reverse trade missions. This would be a coordinated series of missions specifically focused on CCTs.

ADVANTAGES:

- An ongoing program would develop visibility and momentum.
- Trade missions have historically had a high payoff in terms of new contacts signed.

DISADVANTAGES:

- None.

- c. *CCT training for foreign personnel.* The evaluation and operation of CCTs often require specialized knowledge currently unavailable in many developing and transitional countries. Such training could be coordinated with and possibly cofunded by industry.

ADVANTAGES:

- Key foreign personnel would become more knowledgeable about CCTs.
- This would facilitate contacts between U.S. companies and potential foreign customers and decision makers.
- Potential foreign customers and decision makers would become knowledgeable about U.S. technologies.

DISADVANTAGES:

- This program would take time and money to develop and implement

- d. *Initiatives for specific technologies.* Such efforts would be coordinated with U.S. industry to promote specific technologies that would benefit both U.S. industry and foreign countries. They would be incorporated as part of overall DOE export assistance activities. The initiative might include a coordinated and targeted agenda of informational material development and dissemination, publicity releases, trade missions and reverse trade missions, and information exchange. Examples of technologies for which initiatives might be conducted include:

- Coal preparation.
- Low-cost retrofits for particulate and SO₂ control.
- Repowering applications.
- Newly-commercial power generation technologies.

Others may be suggested by industry. Those that are selected should meet specified criteria of market need and industry interest.

ADVANTAGES:

- Focuses export promotion efforts on high-payoff markets.

DISADVANTAGES:

- Less effort and attention would be devoted to technologies not so promoted.

4. **Market-responsive research and development (R&D).** The purpose would be to work with U.S. industry and their foreign partners to adapt U.S. technologies to the special needs of foreign markets.

- a. *Testing of foreign coals in U.S. facilities.* The performance of coal utilization equipment has traditionally been highly dependent on the properties of the specific coals used. A significant advantage of many of the CCTs developed in the U.S. over the last decade, however, is fuel flexibility. In this option, DOE would facilitate the testing of foreign coals in facilities in the U.S. This would involve working with foreign customers to identify where such testing would be beneficial and putting them in touch with U.S. facilities for testing. The cost of the testing would be borne by the companies.

ADVANTAGES:

- Provides clear demonstration that foreign coals can work well with U.S. technologies.

DISADVANTAGES:

- None.

- b. *Cooperatively-funded R&D to adopt U.S. technologies to foreign conditions.* Potential foreign customers may have specific problems adopting CCTs to their particular applications. Such a program of cooperative R&D could be cofunded with foreign governments and participating companies.

ADVANTAGES:

- Ensures that problems are solved to mutual benefit.
- Matches potential foreign customers to U.S. companies that could solve their problems.

DISADVANTAGES:

- U.S. may bear some of the technical risk of the R&D.

5. **Innovative export financing mechanisms.** In some cases, the needs may be satisfied by existing programs. However, in other instances, they might require additional commitments of Federal funds.

- a. *New feasibility study financing mechanism not requiring foreign government request.* Currently, all international feasibility study financing is consolidated into the Trade and Development Agency (TDA). In order to fund a feasibility study, however, TDA must respond to a request from a foreign government for that study. It then puts out bids to U.S. firms to perform these studies. This procedure makes U.S. firms with project concepts hesitant to go to TDA for feasibility funding because it would delay the process and has the risk of revealing their intentions to competitors.

ADVANTAGES:

- Allows U.S. firms to obtain feasibility study financing without waiting for the foreign government request and without competitors.
- Reduces delay.
- More attuned to the reality of private markets.

DISADVANTAGES:

- Less likelihood that the project is actually needed.

- Reduces competition among U.S. firms.
- Gives the foreign host government fewer options.

- b. *Financing of project design studies.* These studies consist of the design work and other studies beyond the feasibility study necessary to obtain financing and begin construction. TDA already does a limited number of design engineering studies in competitive situations. This number would be expanded and focused on CCTs.

ADVANTAGES:

- Overcomes one initial financing barrier faced by project developers.
- Potentially helps to seed a variety of projects.

DISADVANTAGES:

- Added commitment of Federal funds

6. **Higher-Cost Financing Options.** The following options were requested in many of the EOIs. All, however, require a substantial incremental commitment of Federal funds. In many cases, federal export credit is available for projects through Ex-Im or OPIC through their normal programs. None, however, is earmarked specifically for CCT projects, nor does the government bear the costs or risks of advanced technology in these programs.

- a. *Financing of incremental cost of advanced technologies.* The incremental cost is the investment required beyond that of a more conventional technology.

ADVANTAGES:

- Eliminates one key barrier to the adoption of advanced technologies.
- Matches government contribution to the above-market cost.

DISADVANTAGES:

- The U.S. Government would bear the incremental cost.

- b. *Government funding of a portion of project costs.* U.S. Government funding beyond that provided by export credit agencies would be provided to CCT projects regardless of whether or not they are first-of-a-kind applications (i.e., "technology demonstrations"). Funding might be tied to the specific requirements of the participating agency or program. This incentive was the one that was most frequently requested by respondents to the solicitation. The proposed Governmental cost share of the project varied, but 50 percent was typical.

ADVANTAGES:

- Greatly simplifies the complex job for developers of project financing.
- Focuses promotion of CCTs.

DISADVANTAGES:

- Requires a substantial commitment of public funds.
- May crowd out private funding that otherwise might be available.
- Some government financing for this purpose is already available through the Ex-Im Bank and OPIC.
- Replaces market judgment of commercial viability with that of the Government.
- U.S. taxpayer's funds bear commercial risks.

- c. *Performance guarantees for advanced technologies.* DOE would give foreign customers of U.S. firms guarantees of their performance.

ADVANTAGES:

- Reduces perceived technology risk to the customer.

DISADVANTAGES:

- Potential cost to the government if payments must be made.
- Significant administrative burden.

- d. *Foreign demonstration projects.* A total of nine of the 77 respondents requested funds for foreign demonstration projects. A so-designated "demonstration project" would provide a first-commercial use of a technology in a specific market. The purpose is to demonstrate the commercial viability of the technology to potential customers and financial institutions under the conditions of the target market. This might be modeled on the domestic CCT program, which appears to be what some of the EOIs had in mind.

Because these technologies are not, in general, commercial technologies, they require demonstrations (these will require considerable financing). The foreign markets are huge, but no one will buy these CCTs unless they are commercial (not just commercially available) or are demonstrated in their country (to gain first-hand experience). The EOIs requested financing because the U.S. firms need demonstrations (foreign demos). These foreign demos are the only way U.S. firms see to convince foreign customers to buy.

ADVANTAGES:

- Provides clear demonstration of success of U.S. technology in foreign markets.

DISADVANTAGES:

- High cost to the U.S. Government.

7.6 EVALUATION OF OPTIONS

The requests for assistance received from industry in the EOIs and during the November 1994 Stakeholder Meetings are consistent with the results of DOE's own investigations into the barriers confronting international CCT and power project development. These barriers are extensively described in several previous DOE reports to Congress⁶ and are reflected in the options enumerated above.

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⁶ *Clean Coal Technology Export Programs*, DOE/S-0095P, February 1992;
Clean Coal Technology Export Finance Programs, DOE/FE 0286, September 30, 1993;
Foreign Markets for U.S. Clean Coal Technologies, DOE/FE-0317, May 2, 1994; and *Report to the United States Congress: Clean Coal Technology Exports Market and Financing Mechanisms*, FE-0307P, May 1994.
All U.S. Department of Energy, Washington, D.C.

Of these barriers, constraints to the financing of CCT project development stand out as the most significant, both to industry and in DOE's own evaluations. These barriers exist primarily in the developing and transitional countries that are major potential growth markets for CCTs and in which the growth in carbon dioxide emissions would be greatest. Financing is a constraint in these countries, both to energy project development generally and to the use of advanced technologies in specific.

In a previous report to Congress,⁷ DOE projected a \$28 billion per year potential financing "gap" for CCT development in developing and transitional countries. That gap represents a need for foreign exchange beyond what is available from domestic government, multilateral, and bilateral sources that traditionally have funded power projects in those countries. Such a gap can be filled only by private capital.

To a large extent, this gap arises because the countries have not yet created the conditions necessary to attract private capital. Some of the difficulties they face in attracting capital include:

- Insufficient domestic capital resources,
- Lack of legal and institutional frameworks,
- Regulated power prices too low for an adequate return on investment,
- Convertibility of currency difficulties, and
- Management problems in local utilities.

The gap can be filled only if the affected countries act to resolve such issues.

Beyond financing, U.S. Government programs can help facilitate the exchange of information and people necessary to stimulate this growing segment of international trade. Many of the EOIs request such assistance. Programs and mechanisms already exist to do much of this. These can be focused on—and tailored to—the needs of this market with a priority commensurate with the opportunities they represent.

DOE can also help to overcome barriers related to the technical risk of advanced CCTs. A number of the options described above are designed to provide potential CCT users with needed information, help adapt U.S. CCTs to foreign markets, or reduce the technology risk of investing in advanced CCT projects.

Our objective is to identify optimal incentives for demonstrating Clean Coal Technologies in foreign markets. An optimal incentive is one that is both effective and low in cost. Accordingly, a priority has been assigned to each incentive that reflects both effectiveness and cost, and these are enumerated in Table 7-5. Three priority rankings are given:

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⁷

U.S. Department of Energy, *Foreign Markets for U.S. Clean Coal Technologies*, Report to Congress, May 4, 1994, DOE/FE-0317, pp 5-15 to 5-20.

- I. High:** Incentive is both *low in cost and effective* in removing a difficult barrier to foreign markets.
- II. Important:** Barriers may be reduced (but not necessarily removed), or these may address barriers that the private sector can overcome with some effort.
- III. Helpful:** These incentives may benefit U.S. industry, but they may engender a high cost or risk to the U.S. Government.

Table 7-5
Evaluation of Options to Promote CCTs in International Markets

Group/Option	Priority	Current Status (If Any)
1. Make existing programs more effective		
1a. Coordinate existing programs	High	Planned through TPCC
1b. Better utilize personnel in key markets	Important	Under interagency discussion
1c. One-stop shopping for existing project finance programs	Important	Under interagency discussion
1d. Further assistance to foreign governments on institutional reform	Important	Implemented by USAID
2. Develop an ongoing program of DOE technical assistance		
2a. Assistance to foreign governments on technical issues	High	
2b. Assistance to Federal export finance agencies	High	
2c. Work with foreign governments to generate more feasibility studies	Important	Contingent on 2a.
2d. Station DOE personnel in key foreign markets	Important	
3. Implement low-cost information exchange program		
3a. CCT/Power info. center and dissemination programs	High	
3b. Ongoing of DOE trade and reverse trade missions	High	
3c. CCT training for foreign personnel	Important	
3d. Initiatives for specific technologies	Helpful	
4. Market-responsive R&D		
4a. Testing of foreign coals in U.S. facilities	Important	
4b. Cooperatively-funded R&D to adapt U.S. technologies	Important	
5. Innovative export finance mechanisms		
5a. Feasibility study mechanism not requiring foreign govt. request	Important	
5b. Financing of project design studies	Important	
6. Higher-cost financing options		
6a. Funding of incremental costs of advanced technologies	Helpful	
6b. Government funding of project costs	Important	Provided by Ex-Im and OPIC
6c. Performance guarantees for advanced technologies	Helpful	
6d. Foreign demonstration projects	Helpful	Not planned

The most frequently requested type of Government incentive is cost-shared project funding support. Typically, direct cost assistance is desired because such technologies engender greater expense and risk than do conventional, and hence familiar, technologies. Accordingly, it is likely that an international Government program of cost-shared funding support would further accelerate the commercialization of these advanced CCTs. However, although DOE understands industry's desire for this incentive, such a program would be extremely costly, and would directly benefit only individual projects, and hence is not viewed as a high priority option. Moreover, such an incentive program would bear problematic costs to the Government in excess of the amounts likely to be palatable in light of current Administration and Congressional budget concerns.

If these options are regrouped by priority (extracting them from Table 7-5), "packages" of incentive options, can be created as follows:

OPTION PACKAGE

I. High Incentives

- 1a. Coordinate existing programs
- 2a. Assistance to foreign governments on technical issues
- 2b. Assistance to Federal export finance agencies
- 3a. CCT/Power Information Center and dissemination program
- 3b. Ongoing program of DOE trade and reverse trade missions

II. Important Incentives

- 1b. Better utilize existing U.S. Government personnel in key markets
- 1c. One-stop shopping for project finance
- 1d. Further assistance to foreign governments on institutional reform
- 2c. Work with foreign governments to generate more feasibility studies
- 2d. Station DOE personnel in key foreign countries
- 3c. CCT training for foreign personnel
- 4a. Testing of foreign coals in U.S. facilities
- 4b. Cooperatively-funded R&D to adapt U.S. technologies
- 5a. Feasibility study mechanisms not requiring foreign government request
- 5b. Financing of project design studies
- 6b. Government funding of project costs

III. Helpful Incentives

- 3d. Initiatives for specific technologies
- 6a. Funding of incremental costs of advanced technologies
- 6c. Performance guarantees for advanced technologies
- 6d. Foreign demonstration projects

Overall, industry has indicated that it requires further assistance in the export of Clean Coal Technologies, and recommends that the assistance that the U.S. Government already provides be more effective. The options for providing improved service vary both in priority and relative cost.

8. ADDITIONAL MATERIALS RECEIVED

8.1 INTRODUCTION

Five of the responses to the Announcement requesting EOIs in commercial Clean Coal Technology projects in foreign countries have been categorized as "Additional Materials Received." These submittals are reproduced in their entirety in Appendix D, and described briefly here in alphabetic order.

8.1.1 Bharat Heavy Electricals Limited

This response from Tiruchirapalli, Tamil Nadu, India, was submitted indirectly, and hence reached DOE belatedly. Although the Announcement required sponsorship by a U.S.-based company or consortium, the Bharat submittal identifies only "possible collaborating agencies" in the U.S. Two proposals are offered: "Control of air toxic metals in Indian high ash coal fired boilers," and "Demonstration of coal water slurry and hydrothermally dewatered lignite slurry firing systems in boilers." In both cases, the projects would be located in India. Project costs and desired incentives are not identified.

8.1.2 Destec Energy, Inc.

This one-page letter submittal from Houston, Texas, observes that "... developing countries are not willing to pay any premium for CCTs when they are allowed to build unscrubbed pulverized coal units. Destec Energy sees this as the greatest barrier for commercialization of coal gasification combined cycle (CGCC) and other Clean Coal Technologies ... Destec Energy wishes to continue development and use of Clean Coal Technologies like CGCC and we stand behind our commitment to support DOE and your office toward that objective."

8.1.3 Electric Power Research Institute

This letter submittal from the Electric Power Research Institute (EPRI), Palo Alto, California, notes that "EPRI has supported and actively participated in the CCT Program, and we view its possible extension to deploy CCTs internationally as an opportunity not only to benefit U.S.

industry but also to help address global environmental issues. Thus, we are interested in partnering with DOE and/or others on future programs to disseminate CCTs into developing countries. We see this opportunity as a logical next step in CCT development ..."

8.1.4 Poznan University of Technology

This letter from Poznan, Poland, observes that 98.5 percent "of electric energy [in Poland] is generated from hard coal and brown coal" without pollution controls, such that "It causes the emission of great amount of dust, SO₂, and NO_x." The correspondent, Professor Zaporowski, briefly notes that they are engaged in IGCC research, and that they expect to "suggest [to the Department of Commerce and Trade of Poland] the cooperation with the program Clean Coal Technology realised in USA. For Poland, the most important will be possibility to buy gas generators for total, pressure gasification of coal and gas desulphurizing equipment."

8.1.5 United Nations

The submittal from United Nations Economic Commission for Europe (ECE) describes their "Implementation Programme on Accelerating Clean Coal Technology" (IMPACCT), "designed with a purpose of promoting the application of economic (smaller-size capacities at more reasonable cost) coal technologies in the countries of central and eastern Europe and Commonwealth of Independent States (CIS) members." Mr. Pastizzi-Ferencic, the Deputy Executive Secretary of ECE, adds that "Our work will be closely coordinated with the activities related to environmental protection in which ECE has a long-standing experience. The correspondence includes additional information on IMPACCT, and concludes with the statement that, "We are aware of the DOE's Clean Coal Technology Demonstration Programme and we would like to explore the possibilities of establishing mutually supportive arrangements."

APPENDICES

A: FEDERAL REGISTER NOTICE

B: TECHNOLOGY ASSESSMENTS

C: PROJECT SUMMARY SHEETS

D: ADDITIONAL MATERIALS RECEIVED

E: SUMMARIES OF EOIs

APPENDIX A

FEDERAL REGISTER NOTICE

DEPARTMENT OF ENERGY

Clean Coal Technology Program

AGENCY: Department of Energy.

ACTION: Request for Expressions of Interest.

SUMMARY: The U.S. Department of Energy (DOE), Office of Fossil Energy (FE), is issuing this Announcement to request Expressions of Interest in Commercial Clean Coal Technology Projects in Foreign Countries in accordance with the guidance provided by the Congress. DOE is directed to make the international dissemination of Clean Coal Technologies (CCTs) an integral part of its policy to reduce greenhouse gas emissions in developing countries. Accordingly, DOE is required to solicit Statements of Interest in commercial projects employing CCTs in countries projected to have significant growth in greenhouse gas emissions. Additionally, DOE shall submit to the Congress, by April 15, 1995, a report that analyzes the information contained in the Statements of Interest, and that identifies the extent to which various types of Federal incentives would accelerate the commercial availability of these technologies in an international context. Specific information regarding the preparation and submittal of Statements of Interest follows.

DATES: The deadline for receipt of submittals at the address identified below is 3:30 p.m., E.S.T., on Friday, the 13th of January, 1995.

Presubmittal Conference: A Presubmittal Conference for this invitation for Statements of Interest will be held on Wednesday, December 14, 1994, at 10:00 a.m. local Washington, D.C., time in the DOE Auditorium of the Forrestal Building, as noted below. The purpose of this meeting will be to provide the opportunity for prospective respondents to gain a better understanding and clarification of the objectives and requirements of this Announcement. The Conference will be conducted informally to facilitate constructive dialog, and advance submittal of questions or comments is not required. Seating will be available on a first come, first served, basis.

The Presubmittal Conference will be held at the following location:

Departmental Auditorium
U.S. Department of Energy
Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Attendees must enter via the Main Lobby of the Forrestal Building, register for the Conference, and obtain an access pass for the purpose of the meeting. Accordingly, please take this registration process into account in planning your arrival time.

ADDRESS: Mailed submittals should be addressed to: Dr. Howard Feibus, Director, Office of Clean Coal Technology, Fossil Energy, FE-221 (270 CC), U.S. Department of Energy, Washington, D.C., 20585.

FOR FURTHER INFORMATION CONTACT: For further information on this Announcement, contact Dr. Howard Feibus, Director, Office of Clean Coal Technology, Fossil Energy, FE-221 (270 CC), U.S. Department of Energy, Washington, D.C., 20585, Tel. (301) 903-4348, Facsimile (301) 903-0243.

SUPPLEMENTARY INFORMATION:

Background: This Announcement is issued pursuant to the Conference Report, No. 103-740, to accompany Pub. L. No. 103-332, the Department of the Interior and Related Agencies Appropriations Act, 1995, and the guidance contained in the corresponding Senate and House Reports, Nos. 103-294 and 103-551, respectively. The following is a summary description of DOE's CCT Program, international and other recommendations that have been proposed by various parties regarding the future of the Program, and the Congressional guidance for this Announcement.

Potential respondents are advised that DOE has no monies or wherewithal to fund, or to otherwise provide any incentive in support of, any of the projects that may be proposed, does not anticipate endorsing or supporting any proposals pursuant to this

Announcement, and cannot reimburse submitters for any expenses they may incur in responding to this Announcement. This solicitation is being conducted, as requested by the Congressional guidance, so that Congress may have the information it requires in order to consider the technical, economic, and environmental aspects of various incentives to support international CCTs, and their merits for potential future support.

DOE's CCT Program: The burning of coal releases carbon dioxide (CO_2), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), particulate matter, and ash. The business of DOE's CCT Program is to develop and demonstrate the means of economically utilizing coal with attendant minimal emissions of these undesirable pollutants. When we speak of CCTs, we mean coal-based systems that offer significant benefits when used for power generation, pollution control, or the conversion of coal into other alternate energy products. The challenge confronting us for the future is less whether coal will be used, but more to ensure that its use is accomplished in the most efficient manner (thermodynamically and economically) consistent with the least adverse impact on the environment. Environmental requirements have joined with cost reduction to become the primary forces driving coal technology development in new directions. A responsive and successful technology development and demonstration program is essential to realizing sustainable economic and environmental development of our coal reserves, both domestically and on a global basis.

The CCT Program initiative is the largest technology development and demonstration effort now underway in DOE. To date, the level of funding has responded directly to the strategic importance of coal in the U.S. economy and the international marketplace, and has recognized the need to develop solutions for the problems (economic and environmental) associated with meeting increased demand for this source of energy. The fact that the present and near term future of coal as an energy source depends upon continued advances in coal utilization technology has been accepted, and is being acted upon.

The CCT Program is a technology development and demonstration effort, jointly funded by the Government and industry, whereby the most promising of the advanced coal-based technologies are being moved into the marketplace through demonstration. The demonstration effort is at a scale large enough to generate the data needed by the public sector to judge the commercial potential of the processes being developed. The goal of the Program is to make available to the U.S., and indeed to the global, energy marketplace a number of advanced, more efficient, and environmentally responsive coal utilization technologies. These technologies will reduce or eliminate the economic and environmental impediments that limit the full use of coal. This activity and the resulting processes that will be commercialized are in recognition of the strategic importance of coal to the U.S. economy and the international marketplace. They are efforts

that will resolve the conflict between the increasing use of coal and the growing concern about the environmental impact of such use.

The Program, as directed by Congress, has consisted of five competitive solicitations for cost-shared demonstration proposals, such that there now are 45 projects in the Program with a combined estimated cost of about 7 billion dollars. Of particular importance to DOE is the level of financial participation in these projects by the private sector. Although the Congress, in its guidance, requires that such participation be a minimum of 50 percent, the participants are voluntarily providing an overall average of 66 percent of the funds in the Cooperative Agreements that have been negotiated to date.

The Future of DOE's CCT Program: With the announcement of the results of the fifth competitive CCT solicitation in May 1993, the goals of the CCT Program as originally envisioned by the U.S. and Canadian "Special Envoys on Acid Rain" have been largely met, as innovative pollution control technologies are beginning to move into the marketplace. By the completion of this fifth "round," the Program will have laid the basis for a new generation of advanced industrial and electric power technologies. In the course of evaluating future prospects for DOE's CCT Program, in its May 1994 report to the Congress entitled, "CCT Program: Completing the Mission," DOE found that "an expansion of the current demonstration program in the form of

an additional round of competition is not recommended." However, the report conjectured a likelihood that, by virtue of possible termination of one or two CCT projects prior to completion, "\$150 million would be available both to fund new initiatives and provide program direction in the out years." Thus, DOE recommended "that Congress initially establish an International Technology Transfer Program."

In its Fiscal Year (FY) 1995 Congressional Budget Request for the CCT Program, DOE proposed to proceed in this direction:

A new initiative is to implement an international program, in part authorized by Section 1332 of the Energy Policy Act of 1992, for CCTs that substantially reduce environmental pollutants, including greenhouse gases, in developing countries or countries with economies in transition. The objective of the program is to increase trade exports and U.S. jobs by increasing the market share for U.S. energy and environmental technology services in developing countries and to improve environmental performance of existing and new power generating facilities in these countries. The Program would finance a portion of the differential cost (when compared to conventional technology currently used in the host country) of using high efficiency and environmentally sound U.S. technology in two "showcase" projects—one in China, another in Eastern Europe—for the generation of power from new facilities or the improvement of performance of existing facilities. These projects would be examples of the U.S. Initiative on Joint Implementation which is consistent with the provisions of the President's Climate Change Action Plan.

Prospective overseas markets promise to increase U.S. employment opportunities related to CCT sales and services. Eastern Europe and China were selected since each respectively far exceeds other regional markets for rehabilitation and new applications for power facilities. It is envisioned [that] the project in China will involve integrated gasification combined

cycle technology and [that] Eastern Europe will demonstrate repowering/rehabilitation technologies.

In response to a request by the Secretary of Energy for a study of future directions for the CCT Program, the National Coal Council, in its February 1994 report, *Clean Coal Technology for Sustainable Development*, recommended that:

1. The Secretary of Energy not engage in any further solicitations under the existing CCT Program. Where unused funds exist, the continuation of operating demonstrations should be pursued as a means of facilitating commercial deployment through expanded operating experience.
2. The Secretary of Energy promote the role of CCT in the environmental technology programs of the Administration; that CCT can improve the global environment as well as prevent pollution.
3. The Secretary of Energy establish a new Federal Clean Coal Technology Incentive Program of approximately \$1.5 billion over 15 years to stimulate commercial deployment,
4. The Secretary of Energy ensures that future governmental policy continues to be monitored from the standpoint of the competitive position of and the ability to deploy CCT.

Congressional Guidance: In response to these proposals and recommendations, the Senate Report (No. 103-294) explained that:

No funds have been made available for the international initiative recommended by the administration, for a domestic commercial incentives program suggested by the National Coal Council, or for a new round VI procurement for additional projects. The Committee believes the highest priority for this program is to complete the existing projects as promptly as possible, but with reasonable assurance that sufficient data are generated to support subsequent commercialization activity.

Additionally, Congressional guidance was provided by the Senate Report specific to this solicitation for Statements of Interest in international CCT projects, as follows:

The Committee does, however, support efforts by DOE in promoting exports of CCTs, particularly to countries experiencing rapid economic development. These technologies promise a number of significant economic and environmental benefits. In China, for example, the introduction of U.S. coal-fired power technology from the CCT program would allow that country to use its energy resources 40 percent more efficiently. This U.S. technology would require 30 percent less of China's water resources. Potential carbon dioxide emissions from power generation would be cut by 40 percent and potential emissions of sulfur, nitrogen oxides, and particulates would be reduced by 90 percent or more. While the Committee does not support the particular mechanism proposed by DOE to initiate a showcase demonstration project of CCT in China in FY 1995, the Committee does recognize the tremendous environmental potential of CCTs, particularly in helping to reduce the possibility of future global climate change that may be the result of enhanced production of greenhouse gases in developing countries.

Accordingly, DOE is directed to make the dissemination of CCTs overseas an integral part of its policy to reduce greenhouse gas emissions in developing countries. The Secretary [of Energy] is also directed to solicit, in the *Federal Register*, statements of interest in commercial projects employing CCTs, and shall submit to the congressional committees of jurisdiction, no later than April 15, 1995, a report that analyzes the information contained in such statements of interest and that identifies the extent to which various types of Federal incentives will accelerate the commercial availability of these technologies. This report shall specifically discuss the interests in, prospects of, and optimal incentives for demonstrating CCTs in countries projected to have significant growth in greenhouse gas emissions, using projects smaller in scale than those proposed in the FY 1995 budget request.

Commensurate with the above guidance, Conference Report No. 103-740 accompanying the appropriations legislation noted that:

The managers agree with the Senate language asking [DOE to] solicit expressions of interest in commercial projects employing CCTs, limited to international (non-domestic) projects of the type described in the Senate report. These expressions of interest should be sought from U.S.-based companies or consortia expecting to provide significant domestic content to such projects.

Similarly, the Congressional guidance provided by the House Report No. 103-551 noted, in part, that:

The Committee does not support the construction of "showcase" facilities in international markets as proposed by the Administration. Many large projects to prove the use of gasifiers in power plants are currently underway in the United States, through the CCT program, and at several other worldwide locations. Gasifiers of the kind envisioned in the proposed China project are already operating in China as well as in other areas. Providing a subsidy to one more gasification project will not make it commercial even if it makes it "welcome." Retrofit technologies for emissions control are already commercial and can be applied to Eastern European markets provided capital is available and electricity is sold on a commercial basis. A subsidy might be accepted in this case also, but does not address the main market problems of lack of capital and sale of electricity at less than commercially viable rates.

Previous Respondents: Prospective submitters are advised that previous respondents to any one or more of the previous CCT Program solicitations (Program Opportunity Notices) are welcome to submit a Statement of Interest in response to this Announcement. Respondents may propose projects similar to those previously submitted, providing they otherwise satisfy the

requirements set forth in this Announcement, including the international and global climate change aspects.

Statements of Interest and Informational Proposals: Statements of Interest and informational proposals submitted in response to this Announcement shall propose an international (non-domestic) project that would employ at least one CCT, and that is responsive to the Congressional guidance with regard to, at a minimum, the following:

- (1) Sponsored by a U.S.-based company or consortium;
- (2) Location in a developing country, or in a country making the transition from a centrally planned to a market economy, projected to have significant growth in greenhouse gas emissions;
- (3) Capability of reducing greenhouse gas emissions, particularly CO₂, as compared to technologies in common use in the proposed locale;
- (4) Versatility with regard to effective usage of various globally available coal types and characteristics; and
- (5) Likelihood of utilization on a broad commercial scale subsequent to successful demonstration.

It is important to note that proposals that do not satisfy the requirements for locales in developing countries, or in countries making the transition from centrally planned to market economies, projected to have significant growth in greenhouse gas emissions, or having the potential for significant reductions in emissions from existing facilities, will be considered to be unresponsive to this solicitation and hence will be neither analyzed nor included in the Report to Congress.

Proposed projects may be for either electric utility, industrial, or commercial applications, and may be suitable for either retrofit to existing facilities; repowering, modernizing, or life-extending existing facilities; or for new ("grass roots" or "greenfield") facilities.

Interested parties may propose multiple projects, either within a single country or in multiple countries, either with the same CCT or with different CCTs, and either with the same requested type of Federal incentive or with different incentives. *However, each proposed project must be submitted in its own separate, complete ("stand alone"), Statement of Interest.* Each Statement of Interest must be limited to a single proposed project.

Respondents are reminded again that no monies currently are available to fund proposals for projects submitted in response to this Announcement. Statements of Interest should be brief, but should include the following information *to the extent known*, and in sufficient detail to permit analysis and meaningful reporting to the Congress of the data they require to allow them to ascertain the merits of support for such projects in the future, specifically the interests in, prospects of, and optimal incentives for demonstrating CCTs in the identified foreign countries:

1. The identity of the responding U.S.-based company or consortium, including the name, title, telephone number, and facsimile number, of an individual point-of-contact.

2. Show that the respondent would provide "significant domestic content" for the proposed project.
3. Identify the proposed project location as specifically as possible, and describe why the candidate developing country, or country making the transition from a centrally planned to a market economy, is projected to have significant growth in greenhouse gas emissions, or has the potential for significant reductions in emissions from existing facilities.
4. Provide the rationale for the particular CCT(s) chosen, in the context of above Entry 3.
5. Identify the likely source(s) of the coal(s), i.e., whether indigenous to the project host country or to be imported, and, if the latter, from what country.
6. Document the status of the selected CCT(s) with regard to commercial readiness for use in the proposed project.
7. Describe the environmental attributes of the proposed project, particularly regarding carbon dioxide emissions, but also in terms of emissions of SO₂, NO_x, particulates (with emphasis on PM₁₀), hazardous and toxic pollutants, water requirements, especially consumptive water loss, and solid waste quantities and characteristics.
8. Identify the type of Federal incentive sought, including the costs to the Government, and documentation of the means whereby the incentive would accelerate the commercial availability of the technology(ies) in the host country for the proposed project. Since this subject is central to the subsequent Report to Congress, it is essential that respondents address the incentive with as much specificity, clarity, and justification as reasonably possible. In particular, identify the impediments that would be alleviated by the requested incentive.
9. Further to above Entry 8, explain the merits of governmental support, including, but not limited to, potential for increased U.S. exports of goods and services, possible U.S. coal use, and mitigation of potential global climate change.
10. Address environmental aspects of the siting of the specific proposed project, including potential impacts to the host country and neighboring countries, and impact assessment requirements that could possibly be applicable, such as might be imposed by the laws of the host country or member organizations that include this country, e.g., the European Union or the North American Free Trade Agreement.

Respondents are advised that DOE is *not* requesting extensive data on technical performance, project design, partnership arrangements, or detailed project economics as part of any proposed submission under this Announcement.

In order for DOE to have a clear understanding of the international markets for CCTs and how the Federal Government can best assist U.S. industry in commercializing U.S. technologies abroad, it would be useful for the offerors to include any comments or discussion on the following questions:

- o What are the greatest opportunities for commercializing U.S. CCTs abroad (short and long term)?
  - What global regions or countries are the most promising?
  - Which types of CCTs are the most promising?
    - "Off-the-shelf" commercial technologies or cleaner and more efficient technologies now being demonstrated in the DOE CCT Program, or other advanced technologies not currently in the CCT Program?
    - Technologies to upgrade or modernize currently operating plants and systems abroad (through retrofit life extension, coal cleaning, and other approaches) or new, grass-roots plants?
- o What role can DOE best play to facilitate commercialization of these technologies?
  - Help identify market opportunities?
  - Help open doors for U.S. investors?
  - Be a strong advocate of U.S. projects?
  - Support feasibility studies and other project development activities?
  - Support regulatory changes if there are regulatory issues that are impeding foreign sales?
  - Support development of technical data that would enhance foreign sales, such as testing the performance of foreign coals with U.S. technologies.
  - Support any other mechanisms or incentives?

Special Instructions: Statements of Interest shall be prepared to comply with the special instructions provided below, and shall be structured in the order that follows. Respondents may reproduce and complete these forms electronically (by computer software) in lieu of completing the actual forms published in this Program Announcement. There is no preference given to the use of the published forms versus electronically recreated forms.

- (1) Statement Cover Sheet (Appendix A; see *Special Instruction No. 1*, below).
- (2) Public Abstract (Appendix B; see *Special Instruction No. 2*, below).
- (3) Project Summary (Appendix C; see *Special Instruction No. 3*, below).
- (4) Statement of Interest Narrative Text.

1. Statement of Interest Cover Sheet

Appendix A of this Announcement provides a form that shall be used for the preparation of the Cover Sheet of the Statement of Interest. Submitters are required to complete the form in accordance with the instructions that follow, and then to

photocopy that form for use as Page 1 of each copy of the submittal. Each submittal shall be provided in one (1) original and six (6) copies. In the space provided on the Cover Sheet, indicate the copy number of the particular volume, using "number 1" for the original and "numbers 2 through 7" for the six copies. Instructions for the form are provided below:

- (1) Technology(ies). Identify the CCT(s) that would be employed in your project.
- (2) Federal Incentive. Identify the type of Federal incentive sought. Describe (name) the incentive as specifically as reasonably possible.
- (3) Title. Provide the full title of the Statement of Interest. The title should be informative, i.e., reflect the substance of the project.
- (4) Project Location: To the extent possible, identify (i) the geographic location of the proposed project within the host country and (ii) the name of the host country.
- (5) Respondent. Identify the name(s) of the submitting U.S.-based company or consortium, listing the primary party first.
- (6)(7)(8)(9) Mailing Address. Provide the full mailing address of the primary party, i.e., for the entity that DOE should contact, if necessary.
- (10) Primary Contact. The name of the person who will serve as the primary point of contact for the Statement of Interest.
- (11)(12) Phone/Fax Numbers: The telephone and facsimile numbers for the person identified above, area code first.
- (13) Proprietary information instructions. Self-explanatory.

2. Public Abstract

Submitters shall provide a Public Abstract for their submittal that provides an overview of the proposed project. Appendix B of this Announcement provides a form that shall be used for the preparation and submittal of the Public Abstract. Detailed instructions for Appendix B follow:

- (1) Technology(ies). Same as for the Statement Cover Sheet, Entry 1.
- (2) Federal Incentive. Same as for the Statement Cover Sheet, Entry 2.
- (3) Title. Same as for the Statement Cover Sheet, Entry 3.
- (4) Respondent. Same as for the Statement Cover Sheet, Entry 5.
- (5) Abstract. One continuation sheet may be used if necessary, for a total length not to exceed two (2) pages. The Public Abstract should describe the proposed project, the specific CCT(s) proposed, the application(s) best suited to the CCT(s), i.e., whether for retrofit, repowering, modernizing, or life-extending existing facilities, or for new facilities, the objective, methodology, sponsoring organization(s), time frame (project duration), environmental characteristics, particularly with regard to global climate change gases, suitable coal(s), total estimated project cost, and the Federal incentive requested.

Respondents are advised that this Public Abstract will be released and distributed to the public by DOE. Therefore, it shall not contain any proprietary data or confidential business information.

Respondents should include photocopies of the Public Abstract in each of the seven copies of their Statement of Interest. Nothing should appear on the reverse side of any of the copies of the Public Abstract.

3. *Project Summary*

Submitters also shall complete and include in their Statements of Interest the Project Summary form provided as Appendix C of this Announcement. As was specified for Appendices A and B, photocopies of Appendix C should be included in each of the seven submittal copies. Please note that it is to the benefit of all concerned to provide information that is as specific and complete as possible. Detailed instructions for Appendix C follow:

- (1) Technology(ies). Same as for the Statement Cover Sheet, Entry 1.
- (2) Federal Incentive. Same as for the Statement Cover Sheet, Entry 2.
- (3) Project Title. Same as for the Statement Cover Sheet, Entry 3.
- (4) Respondent. Same as for the Statement Cover Sheet, Entry 5.
- (5)(6)(7)(8) Mailing Address. Same as for the Statement Cover Sheet, Entries 6, 7, 8, and 9.
- (9) Primary Contact. Same as for the Statement Cover Sheet, Entry 10.
- (10)(11) Telephone and Facsimile Numbers. Same as for the Statement Cover Sheet, Entries 11 and 12.

- (12) Project Location. Same as for the Statement Cover Sheet, Entry 4, but specifically the geographic location of the proposed project within the host country.
- (13) Host Country. Same as for the Statement Cover Sheet, Entry 4, but specifically the name of the host country itself.

The following Entries should be completed in as much detail as possible to the extent that information is available:

- (14) Applicability. This entry refers to the proposed CCT(s) with regard to whether it is best suited to the electric utility, industrial, or commercial sector, and whether it lends itself most readily to retrofit, repowering, modernizing, or life-extending existing facilities, or for the construction of new facilities.
- (15) Source(s) of Coal. Describe the type(s) of coal that would be used. Identify the likely source(s) of these coals, in terms of the country(ies) in which the coals would be mined.
- (16) Project Size. This entry requests a measure of size appropriate to the type of project, e.g., megawatts capacity, kilograms of steam produced per hour, and coal use rate (throughput) in metric tons per hour.
- (17) Environmental Performance. Describe the environmental attributes of the proposed project, particularly regarding CO₂ emissions and the degree to which these emissions would be reduced as compared to existing conventional technologies in common use in the proposed locale. Also summarize estimates of emissions of SO₂, NO_x, particulates, especially PM₁₀, hazardous and toxic pollutants, water requirements, especially consumptive water loss, and solid waste quantities and characteristics.
- (18) Project Duration. The total length of time projected for project completion, measured from onset of design and permitting to completion of construction and startup ("shakedown").
- (19) Estimated Total Cost of the Project. This entry includes the total cost of support from all sources, including the requested Federal incentive, stated in U.S. dollars.

- (20) Government's Incentive Cost. Estimate the cost to the Federal government of the cost of the requested incentive. If the proposed incentive is of a form other than direct financial cost-sharing, estimate the value of the potential governmental exposure, e.g., of a loan guarantee or of a generated-power price guarantee, over the projected life of the project or of the provisions of the incentive, whichever is shorter.
- (21) Commercialization Potential in Host Country. If the project were to succeed, i.e., attain its design objectives, estimate the potential for commercialization of that CCT in the host country in terms of number of additional facilities and projected total installed capacity by the year 2030.
- (22) Global Commercialization Potential. As for Entry 21 above, but now in a world context, estimate the potential for commercialization of that CCT globally in terms of number of additional facilities and projected total installed capacity by the year 2030.
- (23) Notes or Comments: This is an **optional** space for additional information not included elsewhere on the forms, but which the respondent wishes to communicate. There is no benefit or disbenefit *per se* associated with completing or not completing this entry.

Number of Copies Required: Each submittal should consist of seven (7) copies, one original and six (6) photocopies. The original copy of the Statement of Interest shall contain all documents that bear original signatures.

Cover Sheets, Public Abstracts, and Project Summaries should each be on separate sheets of paper that contain no writing or information of any kind on the reverse sides. In each instance, for all three items, no other information shall appear with, or be added to, that required in Appendices A, B, and C.

Proprietary Information: Submitters should strive to avoid including proprietary and confidential business information in their Statements of Interest. However, information provided by a respondent and identified as a trade secret or confidential business information will be treated in confidence, to the extent permitted by law, provided that this information is clearly marked by the submitter with the term, "Confidential Proprietary Information," and provided that appropriate page numbers are inserted into the legend that is set forth below which must be placed on the Statement of Interest cover sheet:

Notice re Restriction on Disclosure and Use of Data

This submission includes data that constitute trade secrets or confidential business information and shall not be duplicated, used, or disclosed, in whole or in part, for any purpose other than to analyze information contained in this submission, except to the extent permitted or required by law. This restriction does not limit the Government's right to use information contained in these data if it is obtained from another source without restriction. The data that are subject to this restriction are contained in sheets _____ [insert page numbers or other identification of sheets].

Also, each sheet of data the respondent wishes to restrict must be marked with the following legend:

Use or disclosure of data contained on this sheet is subject to the restriction on the cover sheet of this submission.

Submission Preparation Costs: The Department of Energy is not able to reimburse respondents for any costs associated with the preparation of Statements of Interest or informational proposals.

Issued in Washington, D.C., on Thursday 10 November 1994

/s/

Patricia Fry Godley
Assistant Secretary
for Fossil Energy

COPY Nº

U.S. DEPARTMENT OF ENERGY

DOE USE ONLY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

STATEMENT/PROPOSAL COVER SHEET

(1) Technology(ies): _____

(2) Federal Incentive: _____

(3) Title: _____
_____
_____

(4) Project Location: _____

(5) Respondent: _____
_____

(6) Mailing Address: _____
_____
_____

(7) City: _____ (8) State: _____ (9) Zip: _____

(10) Primary Contact: _____

(11) Phone No.: (_____) (12) Fax No.: (_____)

(13) Does this submittal contain proprietary or business-confidential
information?

Circle: YES or NO

If you answer YES, insert the "Notice re Restriction on Disclosure and
Use of Data" (provided in the Program Announcement) in the box below:

NOTICE RE RESTRICTION ON DISCLOSURE AND USE OF DATA

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PUBLIC ABSTRACT

(1) Technology(ies): _____

(2) Federal Incentive: _____

(3) Title: _____

_____

_____

(4) Respondent: _____

_____

(5) Abstract:

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

(1) Technology(ies): _____

(2) Federal Incentive: _____

(3) Project Title: _____
_____
_____

(4) Respondent: _____
_____

(5) Mailing Address: _____
_____
_____

(6) City: _____ (7) State: _____ (8) Zip: _____

(9) Primary Contact: _____

(10) Phone No.: (   ) _____ (11) Fax No.: (   ) _____

(12) Project Location: _____

(13) Host Country: _____

(14) Applicability: _____
_____
_____

(15) Source(s) of Coal: _____
_____
_____
_____

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: _____

(17) Environmental Performance: _____

(18) Project Duration: _____

(19) Estimated Total Cost of the Project: _____

(20) Government's Incentive Cost: _____

(21) Commercialization Potential in Host Country: _____

(22) Global Commercialization Potential: _____

(23) Notes or Comments (Optional): _____

APPENDIX B

TECHNOLOGY ASSESSMENTS

B. TECHNOLOGY ASSESSMENTS

B.1 ADVANCED POWER SYSTEMS

The advanced power systems technologies are characterized by high thermal efficiency, low pollutant emissions, reduced CO₂ emissions, fewer solid waste problems and enhanced economics. These technologies can be used to repower existing electricity generating plants or in new facilities. The advanced power systems may be deployed in modules, thus allowing phased construction to match demand growth more predictably and to meet the requirements of smaller municipal utilities and non-utility generators.

The advanced power systems have been grouped into three major technologies: fluidized-bed combustion, integrated gasification combined-cycle and advanced combustion.

B.1.1 Fluidized-Bed Combustion

Description

A fluidized-bed combustion boiler is a combustion chamber for converting the chemical energy of coal or waste products into thermal energy for process heat, steam, or electricity. The technology's name is derived from the vigorous agitation, or fluidization, that takes place inside the boiler. In a fluidized bed, solid, liquid, and/or gaseous fuel, together with a sorbent (limestone or dolomite) are kept suspended in a combustion chamber through the action of fluidizing air distributed below the bed. The fluid-like motion of the solids in the combustion chamber promotes turbulent mixing that improves combustion efficiency. Combustion occurs at a temperature which enhances sulfur capture by the sorbent and which is below the thermal NO_x formulation threshold. No special coal handling is needed other than the addition of limestone or other sorbent to the coal feed. All types of coals or coal wastes can be used, including high-ash coals, because fluidized bed combustion is relatively nonsensitive to feedstock.

Fluidized bed combustion can be either atmospheric (AFB) or pressurized (PFB). AFB operates at normal atmospheric pressure while PFB operates at pressures 6 to 16 times higher than normal atmospheric pressure. The PFB boiler offers potentially higher efficiency, reduced operating costs, and less waste product than does an AFB boiler. Currently, various fluidized bed combustion designs can be classified as bubbling beds with solids recirculation, fluid beds with internal circulation, hybrid designs combining several fluidization concepts, or full-fledged circulating (entrained) fuel flow.

In power plant applications, the steam produced by AFB and PFB boilers is expanded through a steam turbine to produce electricity. However, in a PFB power plant, the hot combustor exhaust gas has sufficient pressure to be expanded through a gas turbine to generate additional, or combined-cycle, electric power. An advanced PFB power plant is currently being developed and demonstrated. The advanced PFB system uses a circulating PFB combustor and carbonizer to fuel a gas-turbine topping cycle and a steam-turbine bottoming cycle. The integration of the carbonizer and turbine topping cycle improves the efficiency when compared to earlier PFB systems.

Environmental Characteristics

In AFB and PFB, SO_2 and NO_x emissions are reduced by controlling combustion parameters and by injecting a sorbent, such as crushed limestone, into the combustion chamber along with coal. Coal mixed with limestone is suspended on jets of air (or fluidized) in the combustion chamber. At combustion temperatures of 1,400-1,800°F, the fluidized mixing of fuel and sorbent enhances both coal combustion and sulfur capture. Sulfur released when the coal is burned is captured by the limestone before it escapes from the boiler. The sulfur chemically combines with the limestone to form a new solid waste product, a mixture of calcium sulfite and calcium sulfate. More than 90 percent of the sulfur released from the coal is captured this way. The operating temperature range (1,400-1,600°F) is much less than the temperature of a conventional boiler and is below the threshold where thermally induced NO_x is formed. NO_x levels of 0.18 lb/million Btu have been consistently demonstrated. The only downstream emissions control equipment needed is for particulate matter through the use of cyclones, electrostatic precipitators or fabric filters. The solid waste, a combination of ash, calcium sulfite and calcium sulfate may be easily disposed of in landfills or possibly sold for industrial or agricultural applications.

Technology Status

Atmospheric Fluidized-Bed Combustion

AFB technology has had a long history dating to the 1920s. By the 1950s commercial fluidized-bed processes were used on catalytic crackers in refineries, on roasters, and on calciners. In the 1970s, renewed interest in fluidized-bed combustion was stimulated by regulations to reduce emissions from coal-fired plants. AFB is considered commercial for industrial and smaller utility-scale (under 200 MWe) units.

A number of utility-scale units have been built and put into service during the past ten years both domestically and overseas. Two major demonstration projects of second generation AFB have been undertaken through the industry/government cost-shared Clean Coal Technology (CCT) Program: Nucla atmospheric circulating AFB project and the York County Energy Partners Cogeneration Project.

In 1984, the Colorado-Ute Electric Association (now the Tri-State Generation and Transmission Association, Inc.) repowered its Nucla Station facility with an Ahlstrom Pyropower Incorporated (API) circulating, AFB boiler and a new 74-megawatt electric (MWe) steam turbine. This was the first successful utility repowering project in the United States. It increased the capacity of the original Nucla station from 36 MWe to 110 MWe and extended its life by 30 years. When

constructed, the Nucla circulating AFB boiler was the largest of its kind in the world, providing the last critical link between small test facilities and commercial size plants. Before the project was completed in April 1992, the Nucla circulating AFB plant had operated for over two years under DOE and EPRI sponsorship in the CCT Program. The ability of circulating AFB technology to easily burn a variety of coals cleanly and efficiently was demonstrated. The plant is currently in commercial operation.

Although continued operation and improved reliability will increase marketplace confidence in circulating AFB technology, demonstration of a utility-scale (greater than 200 MWe) circulating AFB unit in the United States is still necessary to gain widespread acceptance by domestic utilities. The proposed¹ CCT Program's York County Energy Partners Cogeneration Project would cogenerate 227 MWe of electric power and 400,000 pph of steam in North Codorus Township, Pennsylvania. The project features Foster Wheeler Energy Corporation's (FW) circulating AFB combustor and aims to verify expectations of the technology's economic, environmental, and technical performance in a greenfield application. Currently, the project is in the design stage and undergoing environmental review.

Pressurized Fluidized-Bed Combustion

The PFB technology has advanced from very small-scale laboratory units in the late 1960s to the design and construction of large utility-scale plants. Considerable international effort has been invested by industry and the governments of the United States, United Kingdom, Sweden, Spain, and Germany.

Progress in PFBC research and development programs has led to four major PFB demonstration projects under DOE's CCT Program: the Tidd PFB Demonstration Project, the PFB Utility Demonstration Project, the PCFB Demonstration Project, and the Four Rivers Energy Modernization Project. Successful demonstration of integrated PFBC systems at or near commercial scale is needed to ensure penetration of the technology into the industrial and utility marketplaces.

The Tidd PFBC Demonstration Project was the first large-scale demonstration of PFB technology in the United States, and one of only five worldwide. The project repowered the Ohio Power Company's Tidd Plant in Brilliant, Ohio, with a 70-MWe Babcock & Wilcox (B&W) Company PFB system (under license from ABB Carbon). The repowered plant accumulated 11,500 hours of coal-fueled operation, routinely achieving SO₂ and NO_x emission levels well below New Source Performance Standards (NSPS) requirements. Approximately 100 parametric tests were conducted on different coals and sorbents. In addition, advanced ceramic hot-gas filtration elements underwent approximately 5,500 hours of exposure to one-seventh of the slipstream. Testing was completed on March 30, 1995.

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1 CCT Program projects are subject to the requirements of the National Environmental Policy Act. Accordingly, a project is considered to be "proposed" until the Environmental Assessment (EA)—if the potential environmental impacts are expected not to be significant—or the Environmental Impact Statement (EIS) is completed and either a finding of No Significant Impact (in the case of an EA) or a Record of Decision (for an EIS) is issued.

The PFB Utility Demonstration Project would demonstrate a four-fold scaleup of B&W Company's PFB system. Appalachian Power and DOE are currently assessing the merits of pursuing the proposed 340-MWe greenfield project.

The circulating PFB Demonstration Project would feature Pyropower Corporation's PYROFLOW circulating PFB combined-cycle system. The proposed project originally was to repower a boiler at the Midwest Power Company's Des Moines Energy Center (DMEC) with a single 80-MWe circulating PFB combustor; however, an alternative site now is under consideration. The performances of an integral, ceramic, hot-gas filter and a slightly modified, commercial gas turbine will be assessed.

The proposed Four Rivers Energy Modernization Project would demonstrate FWs fully-integrated circulating PFB system. The system includes a combustor, carbonizer, ceramic hot-gas filtration system, topping combustor, and a slightly modified commercial gas turbine. The 95-MWe (equivalent) plant will replace two industrial boilers at the Calvert City chemical manufacturing plant in Marshall County, Kentucky. Preliminary design of the project and environmental review are currently underway.

Commercialization of PFB systems will require that several other DOE programs continue to interact to provide the support required for these demonstrations. DOE's contracted research and development activities are focused on two programs: FW advanced PFB research program at their Livingston, New Jersey facility, and the Power Systems Development Facility (PSDF) at Wilsonville, Alabama.

The FW effort includes testing of key system components including a circulating PFB carbonizer, circulating PFB combustor, and particulate cleanup systems. This project also includes demonstration of an advanced PFB topping combustor at the University of Tennessee Space Institute. The final phase of the program includes partial integration of system components, including the circulating PFB carbonizer and combustor, to demonstrate the hot solids transfer required in a fully integrated operation.

The PSDF will be a flexible test facility at which advanced power system components can be developed and their integration and control assessed. The facility will include an advanced circulating PFB combustor and a high-pressure, medium-temperature carbonizer. A hot gas filtration system will remove particulates from the carbonizer and circulating PFB combustor exhausts. Product gases will be combusted in a low-NO_x combustion system using a multi-annular swirl-burner.

Internationally, three additional demonstration projects are underway. These are: (1) Energys Vartan, Stockholm Sweden, two 80-MWe units put into service in 1991; (2) Endesa, Escatron, Spain, one 76-MWe unit put into service in 1990; and (3) Electric Power Development Company, Wakamatsu Japan, one 70-MWe unit put into service in 1993.

Commercial Applications

Both AFB and PFB systems are environmentally attractive options for meeting increasing demand for electric power without relying on high cost fuels. Countries in need of hard currency can use fluidized bed systems to reduce their reliance on oil and natural gas for power generation.

Atmospheric Fluidized-Bed Combustion

AFB has good potential for application in both the industrial and utility sectors, whether for use in repowering existing plants or in new facilities. AFB is attractive for both baseload and dispatchable power applications because it can be efficiently turned down to 25 percent of full load. Coal of any sulfur content can be used, and any type or size of a coal-fired boiler can be repowered. In repowering applications, an existing plant area is used and coal-handling, waste-handling and steam turbine equipment are all retained.

In its commercial configuration, AFB offers several potential benefits when compared to conventional pulverized coal-fired systems: lower capital costs; reduced SO₂ and NO_x emissions at lower operating costs; higher combustion efficiency; and a dry, granular solid waste that is easily disposed of or sold as a by-product.

The Nucla circulating AFB demonstration significantly advanced the environmental, operational, and economic potential of AFB technology, precipitating a large number of orders for AFB equipment. Today, multiple AFB manufacturers are offering 150-MWe AFB units with commercial warranties. Although AFB plants are generally selected for more difficult fuel and environmental applications, their average availabilities and capacity factors are now comparable to those of pulverized coal-fired plants with flue gas desulfurization (PC/FGD). AFB calcium to sulfur molar ratios, which range from 2.0 to 5.0 for 90 percent SO₂ removal.

Pressurized Fluidized-Bed Combustion

Combined-cycle PFB permits use of a wide range of coals, including high-sulfur coals. Bubbling PFB technology, along with other advanced technologies, will compete with circulating PFB systems to repower or replace conventional power plants. PFB technology appears to be best suited for applications of 50 MWe or larger. Capable of being constructed modularly, PFB generating plants permit utilities to add increments of capacity economically to match load growth. In repowering applications, an existing plant area is used and coal-handling, waste-handling, and steam turbine equipment are all retained. Another advantage of repowering with PFB is its compactness (due to pressurized operation), which reduces space requirements per unit of energy generated.

In addition to the demonstration projects being conducted under the CCT Program, there are eight PFB units with output ranging between 80-400 MWe for a total of 2,500-2,700 MWe.

B.1.2 Integrated Gasification Combined-Cycle

Description

Integrated Gasification Combined-Cycles (IGCCs) are among the cleanest and most efficient of the emerging clean coal technologies. IGCC systems represent the union of two established technologies: coal gasification and combined-cycle power generation. The coal gasification combined-cycle process basically has four steps: (1) a fuel gas is generated as coal reacts with high-temperature steam and an oxidant (oxygen or air) in a reducing atmosphere; (2) the gas is cooled, producing steam, and then purified to further remove particulates and sulfur and nitrogen compounds; (3) the clean fuel gas is combusted in a gas turbine generator to produce electricity; and (4) the residual heat in the hot exhaust gas from the turbine is recovered in a heat recovery steam generator, and the steam is used to produce additional electricity in a steam turbine generator.

The fuel gas generation is generally accomplished in one of three types of reactors: fixed-bed, fluidized-bed, or entrained flow reactors. Gas cleanup involves the removal of contaminants in the fuel gas before they can cause damage to the gas turbine or be released into the atmosphere. The major contaminants of concern are sulfur compounds, ammonia (a precursor to NO_x), alkali metals, and particulates. The gas turbines provide the shaft horsepower to drive the electric generators. The gas turbine exhaust flows into the heat recovery steam generator and produces steam to run a conventional steam turbine to produce electricity. In general, approximately one-third of the total power output is generated in this bottoming cycle.

The IGCC has a number of attributes which enhance its viability as an advanced power system. The IGCC can meet all future environmental permitting constraints for generation of electric power. In an IGCC system, 99 percent of the coal's sulfur compounds are removed before combustion. NO_x is reduced by over 90 percent and CO_2 is reduced by up to 35 percent. The efficiency that will be achieved by the IGCC over the next two decades ranges from 42 to 52 percent as compared to 34 percent efficiency for existing coal-fired plants with installed flue-gas desulfurization capabilities. Deployment of IGCC is enhanced by the ability to repower existing plants, to construct plants in blocks ranging in size from 100-450 MWe, and to phase construction of plant modules so demands of utility growth patterns can be met in the most economical way. Finally, the combined-cycle portion of an IGCC plant can be fueled by natural gas, oil, or coal. This means that a plant can switch to coal from natural gas as gas becomes unavailable or unacceptably expensive. In addition, most gasifiers can be easily adapted to different coals.

Environmental Characteristics

IGCC systems are among the cleanest of the emerging advanced power systems. Sulfur compounds, nitrogen compounds, and particulates are removed before the fuel is burned in the gas turbine, that is, before combustion air is added. For this reason, there is a much lower volume of gas to be treated than in a post-combustion scrubber.

IGCC gas cleanup systems fall into one of two broad categories: hot (dry) gas cleanup and cold (wet) gas cleanup. These cleanup systems consist of particulate removal devices followed by

either wet or dry sulfur removal processes. Cold gas cleanup (100°F to 300°F) represents state-of-the-art technology. Hot gas cleanup (800°F to 1,200°F), which is just reaching the demonstration stage, will allow IGCC systems to achieve greater efficiency.

The gas stream must be cleaned to a high level not only to achieve low emissions but also to protect downstream components, such as the gas turbine, from erosion and corrosion. In some IGCC systems, much of the sulfur is captured by a sorbent injected into the gasifier. Several commercial cold gas cleanup processes are capable of removing hydrogen sulfide, whereby more than 99 percent of the sulfur is removed from the gas, making it almost as clean as natural gas. Sulfur species captured in this way can be recovered as elemental sulfur or converted to sulfuric acid. In a hot gas cleanup system, the fuel gas is passed through a bed of metal oxide particles such as zinc ferrite. Zinc ferrite can absorb sulfur contaminants at temperatures in excess of 1,000°F, and the sorbent can be regenerated and reused with little loss of effectiveness. During the regeneration stage, salable sulfur is produced. The technique is capable of removing more than 99 percent of the sulfur in the gas stream, much better than the NSPS requirement of 90 percent removal for new plants.

Nitrogen compounds (principally ammonia) are contained in varying amounts in the fuel gas, depending on the gasifier operating temperature. The highest ammonia levels are produced in the lowest temperature reactor, the fixed-bed gasifier; lesser amounts are produced in fluidized-bed gasifiers; and the lowest amount in entrained-flow gasifiers, which have the highest operating temperature. NO_x emissions can be reduced to less than 10 percent of NSPS limits by commercially available cold gas cleanup systems. NO_x formed from the combustion air is held to well within allowable levels by staging the turbine combustion process or by adding moisture to suppress flame temperature.

Some lower temperature gasification processes produce tars and oils which could potentially lead to operational problems and increased pollution. Using a cold-water cleanup system to remove tars and oils requires treatment of the wastewater to remove organic compounds before discharge. However, in many systems employing hot gas cleanup processes, the tars and oils produced are maintained in the vapor phase and decomposed during combustion.

When the fuel gas is burned in a gas turbine to produce electricity, the level of entrained particulate matter in the fuel gas must be controlled to a low level to protect the gas turbine. Therefore, the exit gases from the combustor are well below acceptable particulate emission limits. The solids captured during gas cleanup are disposed of as solid wastes along with the primary ash from the gasifier. The gasifier ash will melt at very high temperatures. Some gasifiers take advantage of this in their ash removal process.

Technology Status

The primary focus of research and development is associated with reducing the technical and economic risk associated with a new technology and to improving the operability, availability, and reliability of fully integrated IGCC systems. This is being achieved through demonstration and early commercial applications of the technology.

There are five active IGCC projects underway under the CCT Program. These five projects will generate approximately 1,000 MWe of electricity. The first of these projects, Wabash River Coal Gasification Repowering Project, will come on-line in mid-1995. The following is a brief summary description of the six projects:

Wabash River Coal Gasification Repowering Project: A joint venture of PSI Energy, Inc., and Destec Energy, Inc., is demonstrating an IGCC system using Destec's two-stage entrained-flow oxygen-blown gasification system. The system will repower one of six units at PSI's Wabash River plant with a 262-MWe system. The IGCC has the following subsystems: a coal grinding and slurry plant, an entrained-flow coal gasifier, a syngas heat recovery subsystem, a cold gas cleanup subsystem that produces a marketable sulfur by-product, a combustion turbine, a heat recovery steam generator, and a repowered steam turbine. As of year-end 1994, construction was 70 percent complete with operations scheduled to begin in September 1995.

Tampa Electric IGCC Project: Tampa Electric in Lakeland, Florida, is building a 250-MWe (net) IGCC facility as part of a major expansion over the next decade. The IGCC system will use Texaco's pressurized, oxygen-blown, entrained-flow gasifier incorporating both conventional, low-temperature acid gas removal and hot gas moving-bed desulfurization. A gas turbine will generate about 192 MWe (gross) and the steam cycle consisting of a heat recovery steam generator and steam turbine will generate an additional 120 MWe (gross). Construction was initiated in November 1994 and is schedule for completion is mid-1996.

Piñon Pine IGCC Project: Sierra Pacific Power Company is installing a 99-MWe (net) IGCC system at its Tracy Station near Reno, Nevada. The system uses the KRW air-blown, pressurized, fluidized-bed gasifier, hot gas cleanup using an embedded sulfur capture process, ceramic filters, and external desulfurization. A combustion turbine coupled to a generator will produce 61 MWe (gross). Exhaust gas is used to produce steam in a heat recovery steam generator. Superheated steam drives a condensing steam turbine to produce about 46 MWe (gross). Construction started in early 1995 and is scheduled for completion in late 1996.

Combustion Engineering IGCC Repowering Project: ABB Combustion Engineering, Inc., is planning to demonstrate an IGCC system using an advanced dry-feed, air-blown, two-stage, entrained flow gasifier with a moving-bed zinc titanate hot-gas cleanup system. The total plant capacity is planned to be 65 MWe net with 40 MWe (net) generated by a gas turbine and 25 MWe (net) generated from a steam bottoming cycle. Schedules for the project are being re-examined due to project restructuring.

Clean Energy Demonstration Project: A limited partnership consisting of Clean Energy Genco, Inc., an affiliate of Duke Energy Corp.; Makowski Clean Energy Investors, Inc.; British Gas America, and an affiliate of General Electric Company plans to demonstrate an IGCC system using British Gas/Lurgi slagging fixed-bed gasifier; cold-gas cleanup, a gas turbine, and a 1.25 MWe molten carbonate fuel cell. The schedule for this proposed project is under negotiation.

In addition to these CCT Program demonstrations, several large-scale dedicated research facilities are adding to the technology base. These are the PSDF, the Gasifier Product Improvement Facility (GPIF), the Hot Gas Desulfurization Process Development Unit (HGD/PDU), and the Hot Gas Cleanup Pilot Plant.

At the PSDF, an advanced transport gasifier will supply hot gas for the evaluation of high temperature emission control devices for both gasification and combustion applications. Development and integration studies for advanced power systems will also be performed. Startup of the PSDF transport reactor is scheduled for October 1995 in Wilsonville, Alabama.

Located at the Monongahela Power Company's Fort Martin Station, the GPIF will demonstrate an advanced, composite, air-blown gasifier that will minimize pollutants in the fuel gas and, when incorporated into an IGCC, have superior efficiency and capital cost. Pre-operational testing of the GPIF is scheduled for September 1996.

The purpose of the HGD/PDU is to test the performance of a fluidized-bed hot gas desulfurization system fueled by a syngas generator. The preliminary design of the unit has been completed and startup is scheduled for April 1997 in Morgantown, West Virginia.

Work at General Electric's Hot Gas Cleanup Pilot Plant in Schenectady, New York, has been focused on resolving issues regarding large-scale operation of their moving-bed hot gas desulfurizer. In their related gas turbine combustion test facility, development of advanced turbine concepts for the combustion of low-Btu gas continues.

Commercial Applications

IGCC systems offer an economic and environmentally acceptable option for meeting increased demand for power, in both repowering and greenfield applications. In repowering with IGCC, a gasifier, gas stream cleanup unit, gas turbine, and waste heat recovery boiler are added. In most cases, these replace an existing coal boiler. The remaining equipment is left in place, including the coal-handling equipment, the steam turbine, and electrical generator. The result is an extension of plant life to essentially that of a new plant, an increase in efficiency from a nominal 35 percent to over 40 percent, and an increase in overall plant output of 50 to 150 percent with significantly reduced overall emissions. The incremental costs of the additional capacity are low compared to the cost of a new conventional pulverized coal plant.

IGCC systems offer developing countries an environmentally attractive option for meeting their increasing demand for electric power without relying on high cost fuels. Countries rich in coal can reduce their reliance on oil and natural gas by substituting coal-fired IGCC systems for power generation.

B.1.3 Advanced Combustion/Heat Engines

Description

The primary function of a fuel-burning system is to provide controlled, efficient conversion of a fuel's chemical energy into heat energy. Numerous advanced combustion/heat engine technologies can be included under the advanced power system category. However, for this technology assessment the following five will be discussed: indirect-fired cycle, slagging combustor, coal-fired diesel, and coal-fired gas turbine.

Indirect-Fired Cycle: An indirectly fired closed-cycle gas turbine uses a nonreaction gas (such as helium) as a working fluid. The gaseous working fluid is compressed, heated by means of a high temperature air heater, expanded in a turbine, and cooled in a waste heat exchanger. Because the closed cycle is fuel-independent, the use of direct coal-firing or coal-derived fuels of any quality is permitted as long as fouling of the primary heat exchanger does not occur. An overall conversion efficiency of 50-55 percent can be obtained by combining a closed-cycle gas turbine system with a steam cycle for application in mid- and baseload plants. The mating of the steam cycle is accomplished by the replacement of the waste-heat exchanger with a waste-heat boiler.

Slagging Combustor: Most of these new coal-burning technologies are based on the cyclone combustor concept. In a cyclone combustor, coal is burned in a separate chamber outside the furnace cavity. The hot combustion gases then pass into the boiler where the actual heat exchange takes place. The advantage of the slagging combustor is that the ash is kept out of the furnace cavity where it could collect on the boiler tubes and lower the heat transfer efficiency. To keep ash from being deposited in the furnace, the combustion temperature is maintained at a level where the mineral impurities melt and form slag. A vortex of air (the cyclone) forces the slag to the outer walls of the combustor where it can be removed.

Coal-Fired Diesels: This technology involves firing diesel-engine-driven power systems with a coal-oil or coal-water slurry. The heat exhaust from the diesel engine is routed through a heat recovery steam generator to produce steam for steam-turbine electric generation (combined-cycle). The mechanical work produced by the diesel can be used for electric generation or as a source of power for other mechanical systems. The diesel system is expected to achieve 45-48 percent thermal efficiency. The 10-100 MWe capacity range of the technology would be most applicable to small utility (municipal) and industrial cogeneration applications.

Coal-Fired Gas Turbine: In a coal-fired gas turbine, coal is combusted in a two-stage system. The first stage is a rich zone combustor (reducing atmosphere). The rich gas is then cleaned in a hot gas cleanup system to remove sulfur impurities and particulates. Combustion is completed in a clean-zone combustor. In the second stage, the clean, hot gas is expanded in a gas turbine which drives an electric generator and the compressor for the combustion air. The turbine exhaust passes through a heat recovery steam generator which produces steam for a bottoming-cycle steam-turbine electric generator. Direct coal-fired turbines are characterized by net efficiencies of 40 percent or higher.

Environmental Characteristics

In the indirect-fired cycle, SO₂ emissions can be significantly reduced or avoided through the removal of sulfur in the coal conversion or coal combustion process. NO_x emissions can be controlled through low-NO_x combustion technologies, and removal of particulates can be achieved through current processes. Slagging combustor tests have shown that by positioning air injection ports so that coal is combusted in stages, NO_x emissions can be reduced by 70-80 percent. Injecting limestone into the combustion chamber has the potential to reduce sulfur emissions by 90 percent. The exhaust emissions cleanup system on a coal-fired diesel system incorporates cyclones to remove the larger particulates, a selective catalytic recovery system for NO_x control, a duct sorbent injection system for SO₂ control, and a baghouse for final collection of ash particulates and spent sorbent. SO₂ emissions are also controlled through the reduction of sulfur in the coal-oil or coal-water mixture which is used to fuel the diesel. In the coal-fired gas turbine, sulfur removal is accomplished either at high temperature following coal combustion, at intermediate temperatures between the expander and heat recovery steam generator, or at relatively low temperature after the heat is recovered from the combustion products by the steam cycle. SO₂ emissions can be reduced 80-95 percent using the zinc ferrite sulfur removal system. Two stage combustion can reduce NO_x formation by 70-80 percent. Particulates can be reduced by the use of cyclones and filters.

Technology Status

Indirect-Fired Cycle: Pennsylvania Electric Company will demonstrate a 62.5-MWe externally fired combined-cycle system at its Warren Station. In this proposed system, coal is combusted in a staged combustor for NO_x control. Particulate-laden gas exits the combustor and enters the slag screen where larger particulates are collected. Air from the turbine compressor is heated in a ceramic air heater. The hot air from the ceramic air heater is passed through a gas turbine to generate about 18 MWe. The warm combustion gas leaves the air heater and passes through a heat recovery steam generator where more heat is extracted to drive a steam turbine to produce about 47 MWe.

The gas is finally passed through a gas cleanup system consisting of a flue gas desulfurization unit and a fabric filter. SO₂ emissions are expected to be reduced by over 90 percent and NO_x emissions are expected to be below 0.13 lbs/million Btu.

Slagging Combustor: The slagging combustor has advanced to the stage that the technology has been and is being demonstrated in industrial and utility applications. Under the CCT Program, Coal Tech demonstrated an air-cooled cyclone combustor which was retrofitted to a 23-million-Btu-per-hour, oil-designed package boiler at the Tampella-Kieler boiler factory. The novel features of Coal Tech's patented ceramic-lined, slagging cyclone combustor included air-cooled walls and environmental control of SO₂, NO_x and solid waste emissions. The demonstration showed that SO₂ reduction of over 55 percent was achievable with a calcium-to-sulfur ratio of 2. Sulfur capture of over 90 percent was achieved using hydrated lime injected into the boiler with a calcium-to-sulfur ratio of 3. In another CCT Program Project, the Alaska Industrial Development and Export Authority will demonstrate a 50-MWe slagging combustor in Healy, Alaska. The system consists of a TRW slagging combustion system with staged fuel and air, a

boiler that controls fuel- and thermal-related conditions, and limestone injection. Further, SO_2 will be removed using Joy's activated recycle spray dryer absorber system. Performance goals are to achieve NO_x emissions of less than 0.2 lbs/million Btu, and SO_2 reduction greater than 90 percent. About 70-80 percent of the coal ash is removed as molten slag. Construction of the Healy project began in early 1995 and operation is scheduled to begin in January 1998.

A research effort is being conducted to perform extended duration testing of a 20 MBtu/hr air-cooled, slagging coal combustor. The tests focus on durability and automatic control of the combustor. Another goal is to achieve 0.4 lb/MBtu of SO_2 emissions, 0.2 lb/MBtu of NO_x emissions, and 0.02 lb. particulates/MMBtu in the combustor boiler system. The average NO_x level for all test conditions to date was 0.5 lb/MBtu. At optimum staged combustion conditions, the lowest NO_x level measured was 0.26 lb/MBtu. With sorbent injection into the combustor at an effective calcium-to-sulfur ratio of 3, the average SO_2 reduction of 70 percent was achieved with a 1.7 percent sulfur coal. The maximum reduction achieved was about 85 percent, with a 1.5 percent sulfur coal.

Coal-Fired Diesels: Development of medium speed coal-fired diesels has been pursued for more than a decade. The R&D program began as an exploratory effort and grew into a proof-of-concept program. This R&D program reached a significant milestone with the operation of a full scale 6-cylinder diesel engine for over 225 hours on coal-water mixture fuel. As part of the CCT program, an engine with the same bore and stroke is planned to be demonstrated by Arthur D. Little, Inc., at Easton Utilities Commission's plant in Easton, Maryland. The proposed project involves modifying two Cooper-Bessemer medium speed (400 RPM) diesels (6.3 MWe each) to operate on coal-water fuels. The system uses a coal-water fuel with a nominal 50 percent solids loading with a 2 percent ash clean coal. The coal-water fuel is injected into each of the engine's 20 cylinders.

The exhaust gases pass through an integrated emissions control system capable of reducing pollutants while protecting the engine's turbocharger and maintaining high engine and overall efficiency of about 45 percent. The exhaust gases pass through a heat recovery steam generator coupled to a steam turbine to produce an additional 1.4 MWe. The exhaust emissions cleanup system incorporates cyclones to remove the larger particulates, a selective catalytic recovery system for NO_x control, a duct sorbent injection system for SO_2 control, and a baghouse for final collection of ash particulates and spent sorbent.

Coal-Fired Gas Turbines: The coal-fired gas turbine system is in a development stage in which optimum system configurations are being defined. Research is directed toward developing improved combustors, turbines, and ancillary equipment. Most of the work on coal-fired gas turbine development is focused on its application to power generation and cogeneration for electric utilities and large industries. General Electric Company, Westinghouse Electric Corporation, and United Technologies Corporation, among others, have carried out significant research and development on coal-fired gas turbine systems.

Commercial Applications

The advanced combustors/heat engines discussed in this section are particularly well suited for small (under 50 MWe) electric generation markets. Projected markets include small non-utility generators, cogenerators, and repowering applications for small coal-fired boilers.

B.2 ENVIRONMENTAL CONTROL DEVICES

Advanced environmental control device technologies are directed toward meeting the needs for high emissions reduction efficiency, reduced capital costs, and the use of innovative designs to mitigate or eliminate solid waste management problems. These technologies can be applied as a retrofit to existing facilities or integrated into new electric generating plants or industrial facilities. The technologies include NO_x control technology, SO₂ control technology, and combined SO₂ and NO_x control technology.

B.2.1 NO_x Control Technology

Description

Control of NO_x emissions can be accomplished by modification of the combustion process, post-combustion selective noncatalytic reduction (SNCR) or selective catalytic reduction (SCR) processes, or by combinations of the two approaches.

Modified combustion processes include the use of specially designed advanced low-NO_x burners, alone or in conjunction with advanced over-fire air (AOFA) ports, AOFA ports without low-NO_x burners, or natural gas and coal-fired reburning processes. All of these technologies utilize staged combustion whereby the primary combustion zone is maintained deficient in oxygen and the combustion process is completed in stages. The more gradual mixing of fuel and air results in lower flame temperatures and reducing-atmosphere combustion conditions before the combustion process is completed, which reduces the oxidation of nitrogen to NO_x.

The use of air ports alone, which are installed in the furnace wall above the top row of burners, creates a fuel-rich primary combustion zone with minimal hardware changes. However, NO_x emissions reductions, which average 15-30 percent, are lower than when air ports are used in combination with low-NO_x burners.

Natural gas or coal-reburning technologies for NO_x control are being developed and demonstrated. About 10-30 percent of the total fuel input to the boiler is injected above the normal combustion zone, creating the fuel-rich primary combustion zone. NO_x rising from the lower region of the furnace is reburned in the zone where the secondary fuel enters and converted to nitrogen. Reburning technology can be applied in conjunction with low-NO_x burners.

Postcombustion SCR processes are characterized by high NO_x emissions reductions of 80-90 percent or more. SCR involves injecting ammonia into the boiler flue gas and passing the gases

through a catalyst bed where the NO_x and ammonia react to form nitrogen and water vapor. Noncatalytic processes utilize ammonia and/or urea injection into the boiler after combustion is complete to chemically reduce NO_x to nitrogen. NO_x emission reductions are less than with catalytic processes.

Environmental Characteristics

The control of NO_x emissions for the broad range of NO_x control technologies discussed in this section range from as little as 15 percent to as high as 90 percent reduction. Low- NO_x burners used in conjunction with over-fire air can achieve reductions of NO_x of 50-70 percent. The gas and coal reburning technologies can achieve NO_x emissions reductions in the 60-70 percent range, while catalytic reduction processes can achieve over 90 percent reduction. The noncatalytic process combined with low- NO_x burners can achieve reductions in the 60-70 percent range.

Technology Status

Among the NO_x control technologies, the low- NO_x burner technologies are the most mature and are being used commercially to control NO_x emissions. The technology has been demonstrated on several boiler firing configurations. Southern Company Services Inc. (SCS) is demonstrating the FW low- NO_x burner (LNB) with AOFA in a wall-fired boiler at Georgia Power Company's Plant Hammond. At full load, NO_x emission reductions in the LNB/AOFA configuration were approximately 67 percent. SCS also demonstrated the ABB Combustion Engineering's Low- NO_x Concentric Firing System (LNCFS) with AOFA on a 180-MWe tangentially-fired boiler at Gulf Power Company's Plant Lansing Smith. NO_x reductions of up to 48 percent were achieved. B&W demonstrated a low- NO_x cell burner retrofit on the 605 MWe Dayton Power and Light Company's J.M. Stuart Plant. Long-term tests at or near full load showed NO_x emissions averaged 0.49 lb/million Btu: a reduction of 58 percent from baseline emissions. As part of a combined NO_x/SO_2 control technology demonstration, Public Service Company of Colorado is demonstrating B&W low- NO_x DRB-XCL® down-fired burners with over-fire air at its Arapahoe Station. Testing of the combustion modifications showed that, while firing western bituminous coal, NO_x was reduced from an original baseline of 1.15 lbs/million Btu to about 0.4 lbs/million Btu—a 65 percent reduction with no operating problems.

Reburning, using coal and natural gas as the reburn fuel, is also being demonstrated. B&W demonstrated coal reburning for cyclone boiler NO_x control at Wisconsin Power and Light Company's 100-MWe Nelson Dewey Station. Tests were conducted with Illinois Basin bituminous coal (Lamar) and Western subbituminous coal (Powder River Basin). Results showed a NO_x reduction of 36 percent (at 60-MWe) to 52 percent (at 110-MWe) for Lamar coals and 53 percent (at 60-MWe) to 62 percent (at 110-MWe) for Powder River Basin coals. Gas reburning has been successfully demonstrated by Energy and Environmental Research (EER) Corporation. In a 172 MWe demonstration at Public Service Company of Colorado's Cherokee Station, a combined gas reburning and low- NO_x burner (GR-LNB) system was able to achieve 60-65 percent NO_x reductions with a gas input of 5-10 percent. NO_x reductions by LNB alone were typically 30-40 percent. EER showed at the 80-MWe Illinois Power Company's tangentially-fired Hennepin Plant that NO_x reductions of 65 percent were routinely achieved. At City Water, Light and

Power's 40-MWe cyclone-fired Lakeside Station, the project goal of 60 percent reduction was achieved during long-term testing.

EER is also developing a hybrid NO_x control technology that combines modified reburning and promoted SNCR. The concept, called advanced reburning, used reburning with either coal or natural gas to generate the optimum amount of carbon monoxide to promote the SNCR reaction. EER found that the performance of the SNCR agent, often urea, depends on the local oxidation of carbon monoxide. Usually, lower levels of reburning are required compared to the traditional reburning process. When combined with urea injection, the advanced reburning process removed greater than 80 percent of the NO_x in bench-scale tests on actual flue gas from a 10-mm Btu/hr coal combustor.

Postcombustion Processes

The postcombustion processes include SNCR and SCR processes. A urea-based SNCR process supplied by Noell Inc. is being demonstrated by Public Service Company of Colorado at its 100-MWe Arapahoe Station as part of an integrated dry SO₂/NO_x emissions control system. In this system, urea is injected into the furnace. Results showed that 49 percent NO_x reduction was achieved with a 10-ppm ammonia slip.

The NALCO Fuel Tech NO_xOUT SNCR system will be tested as part of New York State Electric and Gas Corporation's Milliken Clean Coal Technology Demonstration scheduled to begin operation in July 1995. The urea injection process was patented by the Electric Power Research Institute and commercialized by NALCO Fuel Tech. The levels of NO_x removal are very specific to the power plant as performance is very sensitive to reagent distribution in the exhaust gas stream, the temperature and residence times available for the NO_x reaction to occur, and the uncontrolled NO_x level.

SCR is a post combustion technology which is able to achieve 80-90 percent NO_x reductions. In the SCR process, ammonia is injected into the flue gas and is passed through a catalytic reactor where the ammonia reacts with NO_x to produce nitrogen and water. The SCR process, already in use overseas on boilers that are burning natural gas, oil, and low sulfur coals, has never been fully demonstrated on boilers burning high sulfur coal. The SCR process is currently being tested at a pilot plant (2.5 MWe reactors), utilizing a flue gas from the burning of a high sulfur coal, at Gulf Power Company's Plant Crist. Tests results show that NO_x reductions of 80 percent or greater are achieved with each of the six catalysts being tested. SCR is also part of the SO_x-NO_x-Rox Box™ (SNRB) Flue Gas Cleanup project being conducted by B&W at Ohio Edison Company's R.E. Burger Plant. The Norton Company's NC-300 series zeolite SCR catalyst is located inside filter bags to protect the catalyst from potential particulate erosion or fouling. Tests showed that NO_x reductions above 90 percent were consistently achieved with an NH₃: NO_x ratio of 0.9 and an ammonia slip below 5 ppm.

In some applications, it is possible to reach the desired NO_x emission levels by achieving some NO_x reduction by SNCR followed by a catalyst system. The major advantages of combining the two technologies are that a smaller SCR system can be used to attain the overall NO_x removals, thereby reducing costs. Second, an in-duct SCR system may be used, as opposed to a separate

SCR reactor with associated ducting, because of the reduction in the amount of catalyst needed. Also, the ammonia slip from the SNCR system can be used in the SCR system, eliminating the need for a separate ammonia injection system. The Hybrid SNCR/SCR technology has been tested at full-scale on a coal-fired utility boiler and achieved greater than 90 percent NO_x reduction.

Commercial Applications

NO_x control technology is in commercial use domestically and internationally. For example, B&W has sold six contracts for its low NO_x Cell Burner (LNCB®) technology. These contracts involve 144 burners and have an estimated value of \$25 million. To date, B&W has installed the LNCB® technology on more than 2,500 MWe of capacity in the United States. In addition, LNCB® retrofits have been ordered for an additional 3,250 MWe. B&W has also sold 85 contracts (61 domestic and 24 international) for the DRB-XCL® Low NO_x burner. These sales involve 1,515 burners and over 20,000 MWe of capacity and are estimated to have a value of over \$200 million. FW's commercial sales of its low-NO_x burners have an estimated value of \$20 million. The low NO_x Concentric Firing System (LNCFS) is being retained by Gulf Power at its Plant Lansing Smith. The system is also being used at a number of other installations. B&W's coal reburning technology was retained by Wisconsin Power and Light for commercial use at its Nelson Dewey Station. Further, Illinois Power is retaining the gas reburning system for use in 1995 for NO_x control at its Hennepin Plant. City Water, Light and Power also is retaining the gas-reburning technology at its Lakeside Station.

B.2.2 SO₂ Removal Processes Description

Description

Flue gas desulfurization involves removal of SO₂ from the downstream flue gas after it exits the boiler. There are three basic approaches: (1) advanced flue gas scrubbing using lime or limestone (wet scrubbers) to capture 95 percent or more of the SO₂ in the flue gas before it exits the stack, (2) in-duct injection of sorbents utilizing the existing flue gas ductwork, and (3) inserting one or more separate vessels into the downstream ductwork where the sorbents are added.

In wet processes, the sulfur oxides are removed from the flue gas by scrubbing with an excess aqueous solution or slurry. In general, wet scrubbers are characterized by high SO₂ removals efficiencies along with high sorbent utilizations. To avoid vaporization of the water and associated problems, the gas must be cooled before it enters the scrubber. Several different types of scrubbers have been designed for achieving intimate contact between the gas and the scrubbing (absorbing) liquid. Although liquid-gas scrubbing is simple in principal, several problems arise in practice. These problems include deposition of scale especially with a slurry scrubber, blockage or plugging of the demister, and corrosion and erosion of the equipment.

In-duct sorbent injection involves spraying sulfur absorbents, such as hydrated lime with water, into the center of the existing ductwork. By controlling the humidity of the flue gas and the spray pattern for the sorbent, 50-70 percent of the SO₂ can be removed. Selective additives, such as adipic acid, may improve removal levels to around 90 percent. Advantages of this technology include the waste being composed of dry particles that can be easily removed downstream and new

construction being eliminated because the plant's existing ductwork is used. This makes in-duct sorbent injection an attractive option for retrofitting smaller, older plants where space availability might be limited.

When separate vessels are used, one or more process chambers are inserted in the flue gas ductwork, and various sorbents are injected to remove the pollutants. Generally the separate vessels provide a longer residence time for the absorbent to react with the gas, and pollutant capture is greater. Although more costly than in-duct injection, this approach has the potential of capturing more than 90 percent of the pollutants. Due to the cost and added size requirements, the use of separate vessels tends to be more suitable to new plant applications or to plants that can accommodate the additional size requirements.

Environmental Characteristics

Currently available post-combustion cleanup technologies for SO₂ control essentially consist of using either wet limestone scrubbers or lime spray dryers. Wet limestone-based scrubber processes are most commonly used because limestone is much less expensive than alternative reagents, such as lime, and the cost differential becomes magnified as the sulfur content of the coal increases. The increasing use of forced oxidation in conjunction with limestone scrubbing generates a gypsum product that is readily dewatered and negates many of the problems associated with the handling and disposal of a thixotropic sulfite sludge. The potential also exists for reducing capital cost through elimination of dewatering equipment. Utilities must, however, cope with the fly ash disposal problem, which is compounded by the flue gas desulfurization (FGD) waste disposal problem. Limestone scrubbers are effective (in excess of 90 percent SO₂ control), but are relatively expensive to purchase and operate. Reliability and availability have also been problem areas in addition to the waste handling and disposal.

The spray dryer can offer advantages over the commercially available limestone scrubbers, especially for retrofit installations where space requirements and availability of land for waste disposal can limit the application of wet scrubbers, or where remaining boiler life is low. Spray dryers generally have lower capital costs than scrubbers. The spray dryer cleanup systems capture sulfur dioxide by contacting the hot flue gas with a finely atomized lime slurry in a spray dryer vessel. The water in the slurry is evaporated by the heat in the flue gas and the SO₂ reacts with the lime to form a dry calcium sulfite/sulfate product. The solid product plus ash is collected in the electrostatic precipitator (ESP) or baghouse. The resulting dry solids product is more manageable than the sludges produced in many wet scrubbing processes. These solids can be disposed of in suitable landfills. If high concentrations of unreacted alkalis remain, however, special consideration may be needed in its disposal. It should be noted also that application of the lime spray dryer processes to high sulfur coals is in a relatively early stage of development, although it can now be considered commercially proven for use with low-sulfur western coal. More compact and somewhat less complex than the wet limestone scrubbers, the spray dryer's economic advantages over limestone scrubbers decrease with increasing coal sulfur content as a result of higher reagent costs.

Regenerable scrubbing processes do not produce a throwaway solid waste, but instead produce salable products such as elemental sulfur or sulfuric acid. In the dry sorbent approach, a solid

absorbent is used to absorb SO_2 and NO_x . Upon regeneration at higher temperature using a reducing gas, sulfur and nitrogen compounds are stripped off. These compounds are subsequently destroyed or converted to salable products using commercially available technologies. Consequently, regenerable systems avoid the growing problem of disposal of the solid wastes experienced by traditional flue gas cleanup technologies.

Technology Status

Wet Scrubbing

The vast majority of wet scrubber systems installed in the United States are non-regenerable processes, which use either lime or limestone as the sorbent. For advanced SO_2 control technologies, the primary emphasis is on reagent regeneration and salable product processes to eliminate or minimize solid waste disposal problems. These processes are in pilot-scale development and it is uncertain when they will be commercially available. For existing and new wet scrubbers, process improvements such as using organic acids to improve SO_2 removal efficiencies and sorbent utilizations have been demonstrated. Also, advanced limestone/gypsum FGD processes, which produce marketable gypsum through forced oxidation of the spent slurry, have been recently demonstrated on utility boilers in the United States.

Under the DOE CCT Program, two advanced wet flue gas desulfurization processes are being demonstrated by Pure Air on the Lake, L.P., and Southern Company Services (SCS). Pure Air on the Lake has been operating an Advanced Flue Gas Desulfurization (AFGD) process since June 1992, at Northern Indiana Public Service Company's 528-MWe Bailly Generating Station. The AFGD process has demonstrated simultaneous removal of 90-95 percent or more SO_2 while producing commercial grade gypsum by-product in lieu of solid waste. Tests have been conducted on bituminous coals containing 2.0-4.5 percent sulfur. As of March 1995, the facility has accumulated almost 22,000 hours of operation with availability in excess of 99.9 percent and 100 percent reliability. Approximately 181,500 tons of SO_2 have been removed and more than 500,000 tons of gypsum produced.

SCS has completed the demonstration of the Chiyoda CT-121 flue gas desulfurization system at its 100 MWe unit located at Georgia Power Company's Plant Yates. The CT-121 process combines limestone FGD reaction, forced oxidation and gypsum crystallization in one process vessel, the jet-bubbling reactor (JBR). The JBR is built using fiberglass-reinforced plastic, which eliminates the use of rubber-lined carbon steel or costly alloys. By the end of 1994, over 1,200 hours of successful operations had been logged. At inlet SO_2 levels of about 2,000 ppm, the CT-121 system's SO_2 removal ranged between 93 and 98 percent at all loads, on coals with sulfur contents ranging between 1.35 percent to 2.5 percent. Availability has been 98 percent and reliability has exceeded 99 percent.

Semi-Dry Processes

In semi-dry processes, the sulfur oxides are removed by an alkaline sorbent slurry that is dried by the flue gas and subsequently collected in a particulate control device. In general, semi-dry scrubber processes require higher sorbent injection rates and have lower SO₂ removal efficiencies than wet scrubber processes.

The spray dryer cleanup systems capture SO₂ by contacting the hot flue gas with a finely atomized lime spray in a spray dryer vessel. The water in the slurry is evaporated by the heat in the flue gas and the SO₂ reacts with the lime to form a dry calcium sulfite/sulfate product. The solid product plus ash is collected in the electrostatic precipitator or baghouse. The resulting solids product is more manageable than the sludges produced in many wet scrubbing processes and can be disposed of in suitable landfills. If high concentrations of unreacted alkalis remain, special considerations may be needed in its disposal.

Currently, the commercial semi-dry process that has been installed on utility boilers in the United States is the spray dryer absorber. Advances in this technology have also been demonstrated.

Under the DOE CCT Program, Bechtel Corporation demonstrated a 73.5-MWe in-duct confined zone dispersion flue gas desulfurization (CZD/FGD) process at Pennsylvania Electric Company's Seward Station. In the CZD/FGD process, a finely atomized slurry of reactive lime is sprayed into the flue gas stream between the boiler air heater and the electrostatic precipitator (ESP). As the spray moves downstream and expands, the gas cools and the SO₂ is rapidly absorbed in the liquid droplets. The droplets mix with the hot flue gas, and the water evaporates rapidly. Fast drying precludes wet particle buildup in the duct and aids the flue gas in carrying the dry reactor products and unreacted lime to the ESP. The demonstration showed the following:

- CZD/FDZ can achieve 50 percent SO₂ removal efficiency when a 1.2-2.5 percent sulfur coal was used;
- During normal operations, no deposits of flyash on reactive products took place in the flue gas duct;
- Availability of the system was very good; and
- Economic results indicate that the CZD/FGD process can achieve costs of \$300/ton of SO₂ removed when operating a 500-MWe unit burning 4 percent sulfur coal.

In another CCT Program, AirPol, Inc., demonstrated FLS miljo a/s Gas Suspension Adsorption (GSA) on a 10-MWe slipstream at the Tennessee Valley Authority's Center for Emissions Research. The GSA system consists of a vertical reactor where flue gas comes into contact with lime slurry, reaction products and flyash. A cyclone separator located between the reactor and the particulate control device removes a substantial portion of the particulate from the absorber. Over 99 percent of the particulate collected in the cyclone separator is recycled back into the reactor. Fresh lime is injected as a lime slurry in the bottom of the reactor and the reactor temperature is controlled by adjusting the slurry concentration. The reactor is able to run at low approaches to

the adiabatic saturation temperature which increases the reactivity of the sorbent and the high recycle allows for increased lime utilizations.

The GSA system has been demonstrated on a 10-MW slipstream. During the GSA demonstration, a western Kentucky coal with approximately 3 percent sulfur was used. SO₂ removal efficiency during the tests ranged from about 60 percent (approach-to-saturation temperature of 28°F and Ca:S of 1.00) to nearly 91 percent (approach-to-saturation temperature of 8 and 18°F and Ca:S of 1.30). The demonstration of a GSA/cyclone/pulse jet baghouse showed the SO₂ removal efficiency averaged more than 96 percent, or about 3 to 5 percentage points higher than that achieved with the GSA/electrostatic precipitator. Levelized cost for a 300 MWe GSA and wet limestone, forced-oxidation system were 10.4 mills per kilowatt-hour and 13.04 mills per kilowatt-hour, respectively.

Dry Scrubbing

In dry scrubbing processes, the sulfur oxides are removed by a dry alkaline sorbent that is subsequently collected in a particulate control device. In general, dry scrubbing processes were developed as low capital cost retrofit technologies for older boilers. The dry scrubbing processes have lower SO₂ removal efficiencies and lower sorbent utilizations than semi-dry scrubbing processes.

The dry scrubbing processes are characterized by location of the sorbent injection. If the sorbent is injected into the boiler, the removal takes place in the temperature window of 1,600-2,300°F, and humidification of the flue gas for SO₂ removal is not required. However, additional removal can be obtained by cooling the flue gas between the air preheater and the particulate control device.

Most dry processes inject the sorbent into the flue gas between the air preheater and the particulate control device. SO₂ removal efficiencies and sorbent utilizations are directly related to the extent of flue gas humidification and the residence time of the sorbent in the flue gas. In general, there are trade-offs between increased SO₂ removal efficiencies and sorbent utilizations, and the size and cost of the process equipment. Dry scrubbing processes that have been developed and demonstrated cover a range of SO₂ removal efficiencies and sorbent utilizations.

The Furnace Sorbent Injection (FSI) process has been developed as a low capital cost retrofit technology. In FSI, the sorbent is injected into the furnace above the burners to capture SO₂. The sorbent then travels through the system where it is collected in the particulate control device. FSI performance is characterized by low SO₂ removal efficiencies (~50 percent) and low sorbent utilizations (~25 percent).

B&W's limestone injection multistage burner (LIMB), a version of FSI, was demonstrated at the 105-MWe Ohio Edison's Edgewater Station as part of the CCT Program. The demonstration showed that the highest sulfur removal efficiencies without humidification were attained using lignolime—61 percent SO₂ was achieved while burning 3.8 percent sulfur coals.

Lower SO₂ emissions and higher sorbent utilizations can be obtained when FSI is coupled with Gas Reburning (for NO_x control). In Gas Reburning (GR), a portion of the coal is replaced by natural gas (typically 15-20 percent). The displacement of coal with gas proportionally reduces the amount of SO₂ generated.

In the CCT Program, Gas Reburning and Sorbent Injection (GR/SI) was demonstrated by Energy and Environmental Research Corporation at Illinois Power Company's 80 MWe Hennepin tangential-fired unit and at City Water, Light and Power's 40-MWe Lakeside cyclone-fired unit. The GR/SI demonstration at Hennepin showed an average SO₂ removal of approximately 53 percent at a Ca:S of 1.26 using Linwood hydrated lime and an average NO_x removal of 67 percent. The GR/SI operations at Lakeside showed SO₂ reductions using sorbent injection only was 44 percent at a Ca:S of 20. Combined GR/SI operation resulted in an average SO₂ removal efficiency of 58 percent.

LIFAC-North American demonstrated its flue gas desulfurization technology at Richmond Power and Light's 60-MWe Whitewater Valley units. In the LIFAC process, pulverized limestone is injected into the upper portion of the boiler where it is calcined and captures SO₂. The flue gas then travels through a humidification chamber, located between the air preheater and the particulate control device, where additional SO₂ is removed. A portion of the sorbent material collected is recycled back into the humidification chamber to increase overall efficiency.

The coals used during the demonstration had a sulfur content ranging from 2.0 to 2.9 percent. Operational testing was completed in June 1994 and consisted of 2,800 hours of operation. Long-term testing showed that SO₂ reduction of 70 percent or more could be maintained under normal boiler operations at a Ca:S of 2.0. The economic evaluations indicate that the capital costs of a LIFAC installation is lower than both spray dryers and wet scrubbers and range from \$66/kw at 300 MWe to \$76/kw at 150 MWe.

Other dry scrubber technologies include:

- The Duct Sorbent Injection (DSI) process has been developed as a low capital cost retrofit technology. In the DSI process, the dry sorbent is injected downstream of the air preheater, followed by flue gas humidification. The spent sorbent along with the flyash is collected in the particulate control device. DSI has been shown to achieve over 50 percent SO₂ removals with sorbent utilizations over 25 percent. Substantial improvements in removals (up to 70 percent) can be obtained when a sodium additive is used in the humidification water. The DSI process has been demonstrated on a 14 MW slipstream and on a 105 MW boiler.
- The ADVACATE/MDI process is a DSI technology that uses a highly reactive sorbent. The sorbent is prepared by hydrating calcium oxide, which is mixed with flyash to form a calcium silicate, or advanced silicate (ADVACATE). The sorbent, which has the ability to hold substantial amounts of water while remaining a free-flowing powder, is injected into the flue gas between the air preheater and the particulate control device. The sorbent and flyash are removed in the ESP and over 85 percent of the solids are recycled through

the system. The ADVACATE/MDI process has been tested at a 10-MW pilot facility and was briefly tested on a full scale 105-MW boiler system.

- The Hybrid Pollution Abatement System (HYPAS) consists of a humidification duct and a pulsed-jet baghouse installed between the ESP and stack. The ash-free flue gas from the ESP is humidified and sorbent is injected before entering the baghouse. The SO_2 removal occurs in both the duct (short residence time) and the baghouse (long sorbent residence time) where the sorbent is collected. A portion of the sorbent is recycled resulting in increased SO_2 removal efficiencies and sorbent utilizations. A 4-MW pilot plant evaluation was conducted at EPRI's High Sulfur Test Center.
- The SOXAL™ process is a regenerable sodium-based scrubbing system coupled with urea/methanol injection in the boiler with the goal of 90 percent SO_2 and NO_x removal. A sodium sulfite scrubbing solution absorbs SO_2 and is regenerated by an electrochemical process using bipolar membranes. Urea reduces 50-70 percent of the NO_x to N_2 , and methanol oxidizes the remaining NO_x to NO_2 , which is then removed in the sodium sulfite scrubber. A 3-MW pilot program was completed by Allied Signal, Inc., at the Niagara Mohawk Power Corporation's Dunkirk Station. Removals of 98 percent SO_2 and up to 70 percent NO_x were observed. However, high oxidation of the sodium sulfite solution to sodium sulfate occurred during the simultaneous SO_2/NO_x scrubbing mode. As of December 1994, the Graver Company's AQUALYTICS Division has acquired the SOXAL™ technology and is marketing it commercially, mainly as an SO_2 removal process.
- In the E-Beam process, irradiation of flue gas with high-energy electrons initiates chemical reactions that oxidize SO_2 to SO_3 and NO_x to NO_2 , which can be further reacted with a suitable base to form solid salts. An E-beam process being developed by Ebara demonstrated removals of over 90 percent and 80 percent for SO_2 and NO_x , respectively, in a 5-MW pilot plant. Using ammonia (NH_3) as a base, an ammonium-sulfate/ammonium-nitrate by-product with potential value as an agricultural fertilizer was produced. A similar process developed by Research-Cottrell using lime rather than NH_3 as the base achieved removals of 90 percent for SO_2 and 60 percent for NO_x in pilot-scale tests. Ebara is currently investigating the concept of zone irradiation to achieve high efficiencies at lower total dose rates. It is hoped that this will reduce the process energy use by about one-third, to no more than 2 percent of the plant's gross output. Most of the current process work is occurring outside of the United States.

Commercial Applications

Most of the commercial flue gas desulfurization (FGD) installations are the wet non-regenerable processes, which use either lime or limestone as a sorbent. However, some of the more advanced FGD technologies are finding their way into the domestic and international marketplace. For example, Pure Air of Manatee, L.P., entered into a contract to provide 1,600 MWe of SO_2 scrubbing capacity at Florida Power and Light's Manatee power plant, using the advanced technology demonstrated at Northern Indiana Public Service Company's Bailly Generating Station under the CCT Program. Georgia Power will continue to operate the CT-121 FGD system installed at its Plant Yates. In 1994, a tar sands oil extraction facility in Murray, Canada,

purchased a CT-121 unit. As a result of the AirPol demonstration of the GSA technology, the City of Hamilton, OH, received a \$5 million grant from the Ohio Coal Development Office to install the GSA technology to control emissions from a 50-MWe coal-fired boiler at the city municipal power plant. In addition, FLS miljö a/s has been awarded a major project in Sweden for a high-performance GSA system to remove sulfur from a 4-million-ton/year iron ore sinter plant.

Currently, there are 10 full-scale LIFAC units in operation or under construction in Canada, China, Finland, Russia, and United States. The LIFAC system demonstrated under the CCT Program is being retained by Richmond Power and Light.

B.2.3 Combined SO₂ and NO_x Removal Processes

Description

The integrated removal of both SO₂ and NO_x in a single system can offer significant advantages over the use of several separate processes, including such factors as reduced system complexity, better operability, and lower costs. Combined systems can also take advantage of beneficial synergisms between the pollutants in the removal process. In some cases, integration of the technology with other processes in the plant can yield additional benefits, such as significant energy savings. Combined SO₂ and NO_x removal processes which have been or are currently being developed at the development-scale or larger are summarized in this section.

Environmental Characteristics

The environmental characteristics of the combined removal technology are generally the same as both those associated with NO_x control technologies and the individual SO₂ control technologies discussed in Sections B.2.1 and B.2.2 above.

Technology Status

The combined SO₂/NO_x emissions control technologies have progressed to the point where their technical, environmental, and economic performance is being demonstrated, and in many cases, being offered commercially by the technology owners. A number of these technologies are discussed below.

The SNOX™ process developed by Haldor Topsoe a/s has been demonstrated under the CCT Program on a 35-MWe flue gas stream at Ohio Edison's Niles Station. In the process, the stack gas leaving the boiler is cleaned of fly ash in a high-efficiency fabric filter baghouse. The ash-free gas is reheated, and NO_x is reacted with small quantities of ammonia in the first of two catalytic reactors where the NO_x is converted to harmless nitrogen and water vapor. The SO₂ is oxidized to SO₃ in a second catalytic converter. The gas then passes through a novel glass-tube condenser which allows SO₃ to hydrolyze to concentrated sulfuric acid. Between March 1992 and December 1994, the system operated for over 7,800 hours and produced more than 5,400 tons of commercial-grade sulfuric acid. The facility routinely operated at full capacity, achieving removal efficiencies of 96 percent for SO₂, 94 percent for NO_x and 99.9 percent for particulates.

The SO_x-NO_x-Rox Box™ (SNRB™) process of B&W combines injection of an SO₂ sorbent with a hot catalytic baghouse for NO_x and PM removal. A calcium- or sodium-based sorbent is injected downstream of the boiler economizer and reacts with SO₂ in both the duct and filter cake on the bags. Ammonia injected into the flue gas reacts with NO_x over a catalyst suspended within the filter bags, producing nitrogen gas (N₂) and water. A key process feature is the use of woven ceramic fiber filter bags to withstand temperatures of 425-470°C. Low exit SO₂ and SO₃ levels may permit lower air preheater exit temperatures and greater system thermal efficiency. A 5-MWe process demonstration was completed at Ohio Edison's R.E. Burger Plant under the CCT Program. During the one-year demonstration program, SO₂ removal efficiencies greater than 80 percent were achieved using commercial hydrated lime at Ca:S stoichiometries of 1.8-2.0. Testing with sodium bicarbonate showed that SO₂ removals over 90 percent were attainable at a normalized stoichiometry (Na₂:S) of 2.0 over a wide range of baghouse temperatures from 220-470°C. Nitrogen oxides reductions of greater than 90 percent were achieved at NH₃:NO_x molar ratios of 0.85-0.90.

The NOXSO process is a dry, regenerable FGC system designed to simultaneously remove over 90 percent of the SO₂ and 70-90 percent of the NO_x from flue gas. The gas is cleaned as it passes through a fluidized bed of sodium-impregnated alumina sorbent at about 120°C. Removal of PM can be accomplished either before or after the process. Regeneration of the sorbent is performed separately for NO_x and SO₂. Adsorbed NO_x is released as the sorbent is heated to about 620°C with hot air in a second fluidized bed. The off-gas can be recycled to the combustor with the combustion air. As a result of chemical equilibria in the combustor, NO_x formation is suppressed, resulting in a new, slightly higher, steady-state NO_x concentration in the flue gas. Thus, the only NO_x by-product is N₂. After heating, the sorbent is treated with a reducing gas, such as methane, and steam to produce a concentrated stream of SO₂ and hydrogen sulfide (H₂S). These species are converted in a Claus reactor to elemental sulfur, which is sold as a by-product. Proof-of-concept testing has been completed in a 5-MWe pilot plant at Ohio Edison's Toronto Plant. A 150-MW demonstration of the process at ALCOA's Warrick Plant is anticipated under the CCT Program. During pilot-plant tests, removal efficiencies averaged 95 percent for SO₂ and 80 percent for NO_x.

The Milliken Station Project was selected to be demonstrated under the CCT Program. A Saarberg-Hölter-Umwelttechnik (S-H-U) wet scrubber system enhanced with formic acid will be tested in a Stebbins tile-lined split-module absorber for SO₂ removal. The NALCO/FuelTech NO_xOUT SNCR system, which involves urea injection into the boiler gas, will be used in conjunction with other combustion modifications for NO_x control. A heat-pipe air-heater system by ABB Air Preheater Inc. will be used with advanced temperature control to reduce air leakage and the flue gas temperature from the air heater. A 300-MWe integrated demonstration of these technologies will begin in the summer of 1995 at the Milliken Station in Lansing, New York. The overall project goals are 98 percent SO₂ removal efficiency while burning high-sulfur coal, up to 70 percent NO_x reduction, production of marketable by-products, including commercial grade gypsum and calcium chloride, zero wastewater discharge, and maintenance of station efficiency through use of the heat-pipe air-heater system and a low-power-consuming scrubber system.

A gas reburning-sorbent injection process was demonstrated on a 71-MWe tangentially-fired boiler at Illinois Power Company's Hennepin Plant and a 33-MWe cyclone-fired boiler at City Water,

Light and Power's Lakeside Station under the CCT Program. At Hennepin, NO_x reductions up to 77 percent were achieved, with an average removal of 65 percent. Furnace sorbent injection of lime with downstream humidification resulted in a maximum SO₂ removal of 62 percent at a Ca:S ratio of 1.75. Average SO₂ removals were typically 52 percent. Similar results were obtained at the Lakeside Station. The gas reburning-sorbent injection system can be retrofitted to any coal-fired boiler, including stokers, cyclones, and pulverized coal-fired equipment. These complementary technologies have the potential to extend the life of a boiler or power plant and also provide a way to use higher sulfur coals.

Several processes use duct injection of sorbents to achieve combined SO₂ and NO_x control or to supplement other removal measures. Depending upon the configuration, these processes are often well suited for retrofit situations. One of these processes is being developed by a team led by the Public Service Co. of Colorado. This process was selected for testing under the CCT Program. A 100-MWe demonstration at Arapahoe Power Station's Unit 4 top-fired boiler combines low-NO_x burners, overfire air, and SNCR for NO_x control and dry injection of either calcium- or sodium-based sorbents with humidification for SO₂ control. A baghouse is used for particulate control and provides a site for additional SO₂ removal. Total NO_x reduction with low-NO_x burners and overfire air ranges from 63 to 69 percent with no increase in unburned carbon or CO emissions. Adding urea injection increases the total NO_x removal to greater than 80 percent with an ammonia (NH₃) slip of 10 ppm or less. When burning low-sulfur coal, SO₂ removal with duct injection of calcium-based sorbents is 40 percent or less, but with sodium-based sorbents, it is near 70 percent at a stoichiometric ratio around 1.8. An increase of NO₂ emissions is observed with the use of sodium compounds. Fortunately, the integration of the urea-based SNCR and sodium-based dry sorbent injection appears to reduce the net stack NH₃ and NO₂ emissions.

Under normal operating conditions, very little NO_x is removed in a spray dryer SO₂ control system. The modified spray drying process was developed specifically for the retrofit of NO_x control to existing commercial spray dryer units. Elevation of the spray dryer exit temperatures and addition of sodium hydroxide (NaOH) to lime slurries can promote significant NO_x removal. Full-scale (20 MW) demonstration of this technology was carried out in two series of tests at Argonne National Laboratory (ANL) using flue gas from the firing of high-sulfur (3.5 percent) coal. The addition of NaOH at 2.5-10 percent by weight of lime improves NO_x removals and reduces the lime requirement for SO₂ control. Most of the NO_x removal occurs in the baghouse, and extended intervals between bag cleanings produce the best performance, with average values of about 35 percent being attained at ANL. With some operating modifications, NO_x removals up to 50 percent should be attainable. Removals also depend strongly on the SO₂:NO_x ratio, being higher for high SO₂ concentrations in the flue gas. In addition to its retrofitability, this process also is a fully integrated SO₂ plus NO_x plus PM control process.

Commercial Applications

Commercial applications of the combined SO₂ and NO_x technologies offer the potential for significant reductions of multiple pollutants with the potential for increasing thermal efficiencies and reduced cost. An example of commercial applications of the combined technology is SNOX™. Ohio Edison is retaining the SNOX™ technology demonstrated under the CCT Program as part of its pollution control system at Niles Station. Commercial SNOX™ plants are operational in

Denmark and Sicily. In Denmark, a 305-MWe plant has been designed, constructed, and operated since 1991. The coal contains 3.0 percent sulfur. The plant in Sicily, operating since March 1991, has a capacity of about 30 MWe and fires petroleum coke.

A number of the combined processes are made up of individual SO_2 , NO_x , and/or particulate control technologies integrated in a combined control system. The individual technologies are in the commercial market. For example, B&W has sold 85 contracts for the DRB-XCL® low- NO_x burner which was used in the Public Service Company of Colorado's demonstration of an integrated dry SO_2/NO_x emissions control system. Further, Illinois Power and City Water, Light and Power are retaining the gas-reburning portion of the combined SO_2 and NO_x control demonstration for NO_x control.

B.3. Coal Processing for Clean Fuels

Physical and chemical processes can be applied to the world's coal resources to transform them to an economic fuel option. In addition, coal processing creates the capability to generate substitute liquid fuels from coal that can replace petroleum and petroleum-derived fuels in a wide range of applications. The solid products are easily transportable fuels, high in energy density, and low in sulfur, ash, and moisture. The liquid fuels are low in sulfur and suitable as feedstock for transportation and stationary power generation fuels and chemicals. Coal processing for clean fuels include physical and chemical coal cleaning ("beneficiation"), mild gasification, and direct and indirect liquefaction.

B.3.1 Coal Preparation

Description

Coal preparation involves the removal of ash-forming mineral matter, sulfur, and trace elements from coal. Reduction in moisture is also a concern with lower-rank coals. These impurities or unwanted constituents vary widely from coal seam to coal seam as well as from coal to coal. As a result, cleaning technology and economics are closely linked to the specific feed coal. Concomitant with removing sulfur, ash, and trace elements, the preparation process crushes and grinds the coal to provide the customer with a product improved in quality and consistency over the as-mined coal. Advanced coal cleaning techniques have the potential to provide a much cleaner coal which could be utilized in new markets, with significant applications additional to the now dominant utility and large industrial markets.

Coal preparation (or beneficiation) processes can be classified into two broad categories: (1) physical preparation and cleaning and (2) chemical/biological cleaning. The commercial practice of coal cleaning currently is limited to physical separation of the impurities based on differences in the specific gravity of coal constituents (e.g., gravity separation processes such as jigs, dense-medium cyclones, tables, etc.) and the differences in surface properties of the coal and its mineral matter content (e.g., froth flotation). Today's physical coal cleaning technology can remove up

to about 50 percent of the total sulfur with thermal (energy) recoveries over 90 percent, depending upon the characteristics of the specific coal being processed.

Physical coal cleaning methods can be very effective in removing pyritic sulfur and mineral matter from coal. The more finely coal is ground, the greater is the liberation of impurities that are not chemically bound to the coal matrix. However, when coal is ground to fine sizes (between 28 and 325 mesh) and ultrafine sizes (finer than 325 mesh), conventional physical cleaning techniques become progressively less effective. Also, physical cleaning methods can not remove the organic, chemically-bound sulfur. Newer approaches to physical cleaning of finely ground coal use special additives and unique flotation cell designs to remove even more mineral matter and pyritic sulfur. Electrostatic techniques to clean dry coal are also under development. This technology relies on inducing charges of opposite polarity on coal particles and particles of mineral matter to accomplish separation.

Both pyritic and chemically bound organic sulfur are converted to the gaseous pollutant sulfur dioxide (SO_2) when coal is burned. Because existing physical cleaning technology removes only the pyritic sulfur contained in the mineral matter, research continues on advanced chemical and biological techniques to remove organically bound sulfur. Chemical treatment has the potential to remove (1) virtually all pyritic sulfur, including finely divided and dispersed pyritic sulfur that may not be removed by physical treatment, (2) a significant portion of the organically bound sulfur, and (3) virtually all of the associated mineral matter. Organic sulfur removal is of particular importance because it represents, on average, about one-third to one-half of the total sulfur in domestic coals. Research on chemical cleaning methods and modification of coal shows considerable technical potential for removing nearly all of the ash and both forms of sulfur. At this stage of development, however, the costs of chemically cleaning coal are much greater per ton of product than costs associated with conventional coal cleaning technology.

Biological treatment of coal is aimed primarily at complete removal of the organic sulfur. It is possible that a biological pretreatment also could make coal more amenable to other cleaning technologies. Biological treatment has the important advantage of requiring much less severe operating conditions than known chemical cleaning methods.

Environmental Characteristics

The application of conventional and advanced coal preparation technologies holds the potential for significant improvements in the environmental performance of coal-based power systems and industries. While conventional coal preparation processes focus on partial ash reduction and removal of portions of the pyritic sulfur, advanced methods will produce clean-coal products with significantly reduced sulfur, ash, and trace element contents. These high-quality coal products can reduce the environmental impacts (e.g., emissions of acid rain precursors and hazardous air pollutants) of current coal-based systems by substituting for lesser-quality feed coals.

Prior to the enactment of environmental regulations, a large segment of utility boilers burned medium- and high-sulfur coals that could produce emissions of up to 4 pounds of SO_2 per million Btu. It was found that over 60 percent of the total sulfur in these coals was in pyritic (inorganic) form. In recent years, several advanced physical coal cleaning technologies have emerged that can

effectively remove a substantial percentage of the pyritic sulfur while achieving high energy recovery.

With the enactment of the SO₂ emission requirements of the 1990 Clean Air Act Amendments, many utilities burning high-sulfur coal have elected to switch to low-sulfur "compliance" coal or install flue gas desulfurization equipment. At the present time, low-sulfur coal is available at a relatively low cost. However, future demand, particularly during Phase II of the Clean Air Act acid rain provision, will likely increase price, while depleting supply. Advanced physical coal beneficiation technology offers the opportunity to extend the availability of compliance fuel. By cleaning high- and moderate-sulfur coals (which represent a significant percentage of existing coal reserves in the United States), additional compliance coal can be made available. Blending a clean-coal product with naturally-occurring, low-sulfur coal would further serve to expand the supply of compliance fuel and would hold down costs compared with cleaning the entire feed stream to compliance levels. In addition, the use of clean coal reduces the volume of flue gas requiring expensive desulfurization. In turn, this reduces the amount of scrubber by-product that would need to be either sold as a by-product or landfilled. Advanced coal preparation technology has also been shown to significantly reduce certain trace-element constituents that contribute to hazardous air pollutant emissions.

Another application of emerging coal cleaning technology has been in the recovery of fine coal from coal-refuse ponds, and as a retrofit to fine-coal cleaning circuits in commercial preparation plants. Direct benefits are a reduction in the amount of refuse material produced as well as the reclamation of land currently lost to refuse ponding. Moreover, given that much of this recovered material is from mines that produce or produced low-sulfur coal, additional compliance fuel is made available for domestic use and export.

Technology Status

Physical coal preparation has been used in commercial practice for a number of years. Further, there are advances in coal processing that are currently being demonstrated. Three advanced processes being demonstrated under the CCT Program are: Custom Coals International Self-Scrubbing Coal™ process; Rosebud SynCoal Partnership advanced coal conversion process; and ABB Combustion Engineering, Inc., and CQ Inc. Coal Quality Expert.

The Custom Coals International project intends to demonstrate an advanced physical coal cleaning and fine magnetite separation technology plus sorbent addition technology. The objective of the project is the design and construction of a 500 ton per hour coal cleaning plant in Somerset County, Pennsylvania, equipped with a unique and innovative coal cleaning technology which will produce competitively priced compliance coals. These coals will be test burned at three commercial utility power plants to demonstrate that these coals can meet or exceed the Clean Air Act Amendments of 1990 sulfur reduction requirements.

The Custom Coals advanced coal cleaning plant has been designed with a unique blending of existing and new processes to produce two types of compliance coals: so-called Carefree Coal™ and Self-Scrubbing Coal™. Carefree Coal™ will be produced by cleaning the coal in a proprietary dense media cyclone circuit utilizing fine magnetite to remove up to 90 percent of the pyritic sulfur

and correspondingly greatly reduce the ash. A patented Self-Scrubbing Coal™ will be produced by taking Carefree Coal™ and pelletizing limestone-based additives with the finest fraction of the clean coal.

The objective of the Rosebud SynCoal Partnership project is to demonstrate an advanced coal conversion process to produce a stable coal product from a high moisture low-rank coal, having a moisture content as low as 1 percent, sulfur content as low as 0.3 percent and heating value up to 12,000 Btu/lb. The facility produces 45 tons/hr of SynCoal® product (300,000 tons/year) and is located adjacent to a unit train loadout facility at Western Energy Company's Rosebud coal mine in Coldstrip, Montana. In 1994, a 50/50 SynCoal® blend test was completed at Montana Power Company's J.E. Corette Plant. Further, Wyoming subbituminous feedstock was tested at the SynCoal® demonstration plant. Over 5,400 tons have been delivered to the J.E. Corette plant. In addition, over 5,700 tons have been delivered to Ash Grove Cement, Bentonite Corporation and Empire Sand and Gravel.

The Coal Quality Expert (CQE) developed under the CCT Program by ABB Combustion Engineering, Inc., and CQ Inc. is an expert computer model that can be run on a personal computer. The model provides coal-burning utilities with a prediction tool to assist in the selection of optimum quality coal for a specific boiler based on operational efficiency, cost, and environmental emissions. The CQE prototype was showcased in September 1993. Emphasis during 1994 was on final model development, prototyping, and validation. A CQE beta version was scheduled for release in early 1995, and the final version is expected in mid-1995.

In addition to the above demonstration, research and development is being pursued by DOE, EPRI, states and the private sector to: (1) improve the environmental performance of coal in current applications; and (2) develop new coal products with greatly enhanced performance capabilities for use in new market applications.

Advanced coal cleaning methods will produce clean coal products with significantly reduced sulfur, ash, and trace element contents. These high-quality coal products hold the potential to: (a) constitute an appropriate feed to advanced power systems (or replace imported petroleum products or natural gas in various markets); and (b) improve the quality of coal-based liquid fuels.

Commercial Applications

A coal preparation plant is normally a stand-alone unit, which can be constructed at mine mouth, at a central processing point, or at a customer's facility. Physically and technically a coal cleaning facility can readily be used to retrofit, repower, or modernize existing facilities, space permitting.

In order to optimize the economic and technical contribution of a planned coal cleaning plant to utility operation, for example, an analysis of the overall cleaning facility plus power plant system is necessary. The feed coal must be considered in selecting the cleaning technology and major pieces of equipment. Also, some assurance is required that the cleaned coal product is a satisfactory fuel for the existing, or planned, combustion equipment. The final emissions of sulfur dioxide and particulates will be controlled by adjusting downstream cleanup to take advantage of the cleaner coal feed. The system's operating cost and/or emissions will be reduced if the

components are properly integrated. These benefits can be achieved with a properly integrated coal cleaning facility providing a fuel of lower ash and sulfur content. Such a clean fuel may reduce transportation costs and will lower erosion and corrosion of boiler tubes, reduce generation of waste on site, and improve efficiency and reliability of the boiler plant. The requirement for post-combustion cleanup will be reduced or possibly eliminated under certain conditions.

Currently, there are about 300 operating coal preparation plants in the United States with the vast majority located in the coal producing states east of the Mississippi. Over 70 percent of the coal mined in this region is cleaned. Total combined U.S. cleaning plant capacity is approximately 180,000 tons-per-hour.

A substantial market for Custom Coals' products is developing in Eastern Europe. The Polish government has requested that a feasibility study be performed to assess the potential for constructing 14 coal cleaning plants with a total capacity of 50 million tons of coal per year. Letters of intent were also received from three Polish coal mines to build two coal preparation plants within the next two years that have a capacity of 10 million tons per year.

Custom Coals is also exploring opportunities with the People's Republic of China, the biggest producer and consumer of coal in the world. Custom Coals would use its advanced coal cleaning technology to clean all or some of the coal currently being burned in the capital city of Beijing. Discussions are also forthcoming on the possibilities of cleaning the rich reserves of Shanxi Province and to eventually transport some of the clean coal product of this northwest province to the more populous and industrial eastern plain of China by pipeline or coal water slurry.

The Rosebud SynCoal Partnership is working on three potential semi-commercial projects located in Wyoming, North Dakota, and Montana. These projects would range in size from 500,000 to 5 million tons/yr. The Wyoming project is a stand-alone mine-mouth design. The North Dakota project is integrated into a mine-mouth power plant with product sales offsite to regional markets. The Montana project is designed either to be integrated into a power plant and fuel user or to expand the existing demonstration facility.

B.3.2 Mild Gasification

Description

Mild gasification, a modification of conventional coal gasification, produces gaseous, solid, and liquid products by heating coal in an oxygen-free reactor. The process takes an alternative approach to complete gasification of coal by driving off the condensable volatile hydrocarbons and leaving behind carbon, in lieu of converting the entire charge of coal to synthesis gas.

Mild gasification processes generate multiple fuels and chemical feedstocks by medium-temperature treatment of coal. The products generated are characterized as coal-derived liquids, gases, and solids, depending on the operating conditions. The solid product can be beneficiated further to remove both ash and pyritic sulfur. A slurry of coal-derived fuel and beneficiated solid has the potential of being a very versatile fuel that can be burned in both coal- and oil-fired boilers.

If the solid product is beneficiated to a high degree, even feedstock coal with a high sulfur content can be used.

Environmental Characteristics

The environmental residuals from the mild gasification process are SO_x , NO_x , particulates and waste liquids. Most of the residual gas from the condensation unit is recycled directly to the pyrolyzer. The remaining gas is burned in a dryer combustor which produces SO_x . The off gas from the dryer is treated in a venturi scrubber and a horizontal scrubber, both using a water-based sodium carbonate solution. The venturi recovers the fine particulates that escape the dryer cyclone, and the horizontal scrubber removes most of the SO_x from the flue gas. The treated gas is vented to a stack. The spent sodium carbonate solution is discharged into a pond for evaporation. NO_x emissions are controlled via staged air injection.

Technology Status

The ENCOAL Corporation is demonstrating the integrated operation of SGI International's novel liquids from coal process to produce two higher ratio fuel forms from mild gasification of low-sulfur subbituminous coal. The CCT project is located in Campbell County, Wyoming, at Triton Coal Company's Buckskin Mine.

The ENCOAL mild coal gasification process involves heating coal under carefully controlled conditions. Coal is fed into a rotary grate dryer where it is heated by a hot gas stream to reduce the coal's moisture content. The solid bulk temperature is controlled so that no significant amounts of methane, carbon monoxide, or carbon dioxide are released from the coal. The solids from the dryer are conveyed to the pyrolyzer where the solids heating rate and residence time are controlled to achieve the desired properties of the fuel products. During processing in the pyrolyzer, all remaining free water is removed, and a chemical reaction occurs that results in the release of volatile gaseous materials. Solids exiting the pyrolyzer are quenched, cooled, and transferred to a surge bin.

The gas produced in the pyrolyzer is then cooled to condense the liquid-fuel products. Most of the gas from the condensation unit is recycled to the pyrolyzer. The rest of the gas is burned in combustors to provide heat for the pyrolyzer and the dryer.

The plant officially entered production in June 1994. Operation has been at a coal feed rate of 500 tons per day (tpd). By year-end 1994, 22 test runs had been completed, representing more than 5,000 hours of operation on coal. Solid and liquid products being produced by the plant have been shipped to industrial and utility customers. In September 1994, approximately 8,000 tons of solid product were shipped as 15-35 percent blends with Powder River Basin coal to the Western Farmer's Cooperative Hugo plant in Oklahoma. This rural electric cooperative used the product successfully in their boilers. ENCOAL also has contracted with Wisconsin Power & Light for the sale of 30,000 tons of solid product. A contract to sell blends of up to 92 percent solid product recently has been signed with Muscatine Power and Water of Muscatine, IA. Other major utility companies have expressed interest in purchasing solid product. Tank cars of liquid product are being shipped on a regular basis to several customers in the Midwest for use in industrial boilers.

The project has been extended for two years in order to resolve problems with the in-process stabilization of the solid product and to conduct and analyze utility test burns of solid product.

Commercial Applications

The liquid products from mild coal gasification can be used in existing markets in place of No. 6 fuel oil. The solid product can be used in most industrial or utility boilers and also shows promise for iron ore reduction applications. The feedstock for mild gasification facilities is being limited to high-moisture, low-heating-value coals.

Attractive features of the ENCOAL mild gasification technology in its commercial configuration include the increased heating value (about 12,000 Btu/lb) and lower sulfur content (per unit of fuel value) of the new solid-fuel product compared to the low-rank coal feedstock, and the production of low-sulfur liquid products requiring no further treatment for the fuel oil market. The product fuels are expected to be used economically in commercial boilers and furnaces and to significantly reduce SO₂ emissions at industrial and utility facilities currently burning high-sulfur bituminous coals or fuel oils.

SGI International and Mitsubishi Heavy Industries are studying the economic and engineering feasibility of developing a 6,000 tpd liquids-from-coal plant in Shandong Province of the People's Republic of China. Feasibility studies have been prepared for projects in Indonesia and Poland.

Implementing a novel process based on mild gasification, Coal Technology Corp. (CTC) is constructing a 65,000 ton-per-year coke plant in Princeton, West Virginia. The CTC process can make coke in one-tenth the time of a traditional process, to the same or higher standards, while using lower grades of coal. Coal gas produced from the process is captured and cleaned, which significantly lowers emissions compared to traditional coke ovens.

B.3.3 Coal Liquefaction

Description

Coal liquefaction technologies produce liquid transportation fuels and chemicals from domestic coal resources (e.g., bituminous coal, subbituminous coal, and lignite). There are two major liquefaction systems for converting coal to such products: (1) indirect liquefaction whereby coal is gasified and the gasifier effluent is converted to liquid products and (2) direct liquefaction whereby the complex organic solid structures in coal are converted directly into liquid products by reaction with hydrogen. These technologies are also capable of converting other carbonaceous feedstocks such as biomass, petroleum coke, municipal wastes, natural gas, etc., to transportation fuels and chemicals either in the presence or absence of coal.

Indirect Liquefaction

In indirect liquefaction, coal is fed to a gasifier where it is partially burned at high temperatures and moderate pressures in the presence of oxygen and steam. This partial combustion of coal generates a gas consisting mainly of carbon monoxide (CO) and hydrogen (H₂), commonly referred to as synthesis gas. The synthesis gas must be cleaned by removing acid gases (CO₂ and H₂S) prior to its conversion to final products.

After being cleaned of impurities, the synthesis gas is sent to a conversion reactor and transformed into desired fuels and chemicals. The products obtained from the conversion reactor depend on the temperature and pressure of operation, the catalyst employed, and the design of the reactor. Typical products include high quality gasoline, premium diesel and jet fuels, oxygenated fuels such as methanol, higher alcohols, dimethyl ether, and high value chemicals and chemical intermediates such as paraffin wax.

Direct Liquefaction

In direct liquefaction, ground coal is slurried with a recirculated process-derived oil and reacted under heat with high pressure hydrogen. The recirculated oil is not only used to transport the feed coal into the reactor(s), but it also plays an important role in the chemistry of coal dissolution, including donation of hydrogen. The liquefaction reactions can be carried out in the presence or absence of catalysts and in a single reactor or in multiple reactor stages. Following coal dissolution and hydrocracking into fragments, mineral matter and unconverted coal solids must be separated and removed. Solids removal technology is an important aspect of liquefaction processing. Liquid products and recycle solvent are recovered by distillation. Middle distillate and heavier liquid products can be used directly as turbine fuel and/or fuel oil. Material that boils in the same temperature range as naphtha has been shown to be an excellent feedstock for petroleum refining to yield high octane gasoline. Middle distillate and heavier liquid products can also be upgraded, using conventional petroleum refining, to a broad spectrum of high quality, specification transportation fuels.

Environmental Characteristics

Indirect Liquefaction

Indirect coal liquefaction technologies can be deployed to produce environmentally superior liquid transportation fuel or high-value chemicals either as independent processes or in coproduction with electricity in an IGCC power plant. Again, these technologies can utilize coal separately or in combination with any other carbonaceous feedstock such as renewable resources or industrial wastes. The environmental characteristics of these technologies are essentially the same as those experienced with coal gasification technologies. The environmental benefit is that the gaseous sulfur (H₂S, COS) and nitrogen (NO_x) compounds produced in the gasifier can be removed from the gasifier stream before combustion or conversion to fuels and chemicals using either wet scrubbing or higher temperature absorption/adsorption processes. Using the higher temperature gas cleaning technologies will make it unnecessary to cool the gas below 500°F, the operating temperature of the indirect liquefaction reactor, thereby increasing the process thermal efficiency.

The principal solid waste from the gasifier is coal ash, which can be disposed of in the same manner as coal-fired boiler ash. When limestone is injected into the gasifier, the solids will contain calcium sulfides, and it will be necessary to convert the sulfides to sulfates. The sulfate compounds are inert and can be disposed of in a landfill.

The transportation fuel products produced from synthesis gas conversion technologies have been shown to be environmentally superior to petroleum-derived fuels and to result in substantially lower emissions in vehicles. In fact, one fuel product has been shown to be capable of meeting California's ultra low emission requirements. These fuels, such as methanol, can also be combusted in turbines by the utility sector for the production of electricity with very low emissions of NO_x and particulates.

Direct Liquefaction

Direct liquefaction technologies require hydrocracking of large coal fragments, either thermally or catalytically, to produce smaller molecules. These smaller molecules can then be upgraded to specification fuels where essentially all heteroatoms (sulfur, nitrogen, and oxygen) are removed by reaction with hydrogen.

Emissions from the liquefaction plants can be minimized through proper design. Sulfur is converted to salable elemental sulfur. Oxygen in the coal is in part rejected as carbon oxides but to a greater extent reacted with hydrogen to form water. Nitrogen is hydrotreated to form salable ammonia. Heavy carbonaceous residue containing the mineral matter is contained in the vacuum bottoms product and can be used to produce hydrogen in a gasifier or burned in a boiler.

In either case, the mineral matter is converted to a refractory-like slag or to fly ash products that are expected to be nonhazardous. Conventional waste water treatment technologies, such as those used in refineries or in coal gasification plants, can be used to eliminate residual phenols, ammonia, and other waste compounds. The plants can be designed to reuse the waste water (zero discharge).

Technology Status

Indirect Liquefaction

The most well known indirect liquefaction technology is the Fischer-Tropsch process. This technology is the basis of the largest commercial coal liquefaction facility in the world and is operated by SASOL in South Africa. These plants employ the dry ash Lurgi Mark IV coal gasifiers and primarily fixed-bed and entrained-bed (Synthol) reactors for synthesis gas conversion. The SASOL process is capable of producing clean fuels, gas, and chemicals. However, 19 percent of the carbon in the coal leaves the dry bottom Lurgi as methane and another 23 percent of the output from the Synthol units is methane. Other light gases are either upgraded to specification fuels or chemicals. As a result, the overall thermal efficiency of the SASOL technologies is about 40 percent. Recent developments at SASOL have led to small scale demonstration of the fixed-fluidized bed and the slurry bed reactor technologies.

Eastman Chemical Company has been operating a coal-to-methanol plant in Kingsport, Tennessee, since 1983. Two Texaco gasifiers, one being used as a backup, process 900 tons of coal per day to produce synthesis gas. The synthesis gas is catalytically converted in a conventional fixed-bed reactor to methanol which is used as an intermediate in the production of methyl acetate and acetic acid.

Similar technologies have been employed for the conversion of natural gas to liquid fuels and chemicals using indirect liquefaction technologies. Mobil designed, built, and operated a natural gas-to-gasoline process in New Zealand; however, most of the plant's output today is methanol. Shell Oil recently started a 12,000 barrel per day Fischer-Tropsch plant in Malaysia from natural gas. Because of the superiority of the diesel fuel (i.e., zero sulfur and high cetane) from this facility compared to that of petroleum-derived diesel, the fuel is being marketed in California.

Air Products Liquid Phase Conversion Company will demonstrate liquid-phase methanol (LPMEOH™) at a 260 tpd facility located at Eastman Chemical Company's Integrated Coal Gasification facility in Kingsport, Tennessee. The objective of the proposed CCT Project is to demonstrate on a commercial scale the production of methanol from a coal-derived synthesis gas using the LPMEOH™ process, and to determine the suitability of methanol produced for use as a chemical feedstock or as a low-SO₂, low-NO_x alternative fuel in stationary and transportation applications. If practical, the production of dimethyl ether (DME) as a mixed co-product with methanol will also be demonstrated.

The indirect liquefaction technology is being advanced through research and development, and testing at proof-of-concept facilities. For example, a pilot plant in Germany employs an advanced fluid-bed reactor system to efficiently convert 100 barrels per day of methanol to high octane gasoline. The unit has also demonstrated the capability to produce light olefins for the conversion to gasoline and/or diesel fuel.

DOE's Alternative Fuels Development Unit (AFDU) at LaPorte, Texas, has been used in the production of methanol from simulated coal-derived synthesis gas using a liquid phase slurry reactor. Recent investigations have included the synthesis of DME, isobutanol for the manufacture of MTBE and high quality transportation fuels via Fischer-Tropsch synthesis.

Direct Liquefaction

Four direct liquefaction processes were tested through the pilot plant stage (up to 250 tons of coal per day) in the mid to late 1970s: (1) Exxon Donor Solvent, (2) H-Coal, (3) Solvent Refined Coal-I (SRC), and (4) SRC-II. Each used a single reactor stage for both coal dissolution and hydrocracking. Depending on operational severity and type catalyst employed, the products ranged from a mostly distillate syncrude, fuel oils containing resid, to a solid de-ashed fuel. Each process utilized a recycled process oil to slurry the feed coal and a hydrogen environment to produce the fuel products.

In addition, advanced novel processes are being pursued with the objective of increasing yields of premium distillation, reducing capital costs and increasing the hydrogen content of the liquid products produced.

These include staged liquefaction and co-processing. Staged liquefaction is an advanced process that provides improved, lower cost technology by the more efficient and specific application in the reaction stage. Higher yields of better quality products are obtained by recovering and recycling heavy intermediate to extinction. In coal-oil coprocessing, coal is slurred in residual fuel oil rather than recycle solvent, and both coal and petroleum residuals are converted to high quality fuels in subsequent processes. This concept offers the potential for significant cost reduction by eliminating or reducing internal recycle oil streams.

Commercial Applications

Indirect Liquefaction

Indirect liquefaction can be easily retrofitted into any facility having existing coal gasification technology, such as an IGCC power plant. The synthesis gas conversion reactors would be added down stream of the synthesis gasifiers and gas cleanup processes and can provide low-cost conversion of coal-derived gas into high quality transportation fuels and chemicals.

Indirect liquefaction technologies can also be readily integrated into existing refineries to convert petroleum-derived coke and residuals into high quality transportation fuels. Because of its high sulfur level, petroleum coke is considered a hazardous waste and has a high disposal cost. Converting such materials to useful fuels is an environmental benefit.

Direct Liquefaction

Coprocessing technology can be used to retrofit existing petroleum refineries, and the economic attractiveness of this option is the main reason why the technology is being developed. In retrofitting, coal and ash handling facilities would be added to existing heavy oil refinery processing equipment. At an appropriate crude oil-to-coal price differential, a refiner could reduce the cost of feedstocks while increasing the production of high-quality liquid fuels from scarce and/or expensive crude oil supplies.

Direct liquefaction is suitable for modernization of existing refinery or chemical processing facilities. The existence of ancillary facilities and utilities at these sites and the elimination or reduction of complex siting and environmental requirements adds to the attractiveness of this approach.

B.4 INDUSTRIAL APPLICATIONS

The industrial application technologies address environmental and energy issues in specific industries such as steel and cement manufacturing industries. Many of the technologies principally identified in other application areas are applicable to the industrial market. These include fluidized bed combustion, advanced combustion, coal gasification, environmental control systems, and coal processing.

B.4.1 Steel Production

Description

The industrial sector has significant potential for innovative techniques to use coal in a more flexible, environmentally responsive manner. In particular, the application of clean coal technologies to steel production, where coal has traditionally been used as a feedstock and/or an energy source, offers opportunities to increase flexibility with respect to coal type, to improve emissions control, and to increase process efficiency. Realization of this potential could significantly improve the competitiveness of U.S. industry and would contribute to efforts to recapture markets recently lost to overseas producers.

Environmental Characteristics

Clean coal technologies applied to U.S. industry can resolve environmental problems similar to those of electric power generators, such as compliance with the 1990 Clean Air Act Amendments, toxic emissions, global climate change issues, and solid waste disposal.

Technology Status

The proposed Clean Power from Integrated Coal/Ore Reduction (CPICOR™) Project would demonstrate, under the CCT Program, the integration of a direct iron-making process with the production of electricity in an efficient and environmentally responsible manner. In July 1994, Air Products and Chemicals, Centerior Energy, and Geneva Steel Company signed an agreement to develop and site the project at Geneva Steel's mill in Vineyard, Utah. The project is currently being negotiated.

The CPICOR™ process integrates two historically distinct processes: iron-making and electric power generation. The Coal/Ore Reduction (COREX®) process is a novel iron-making technology which eliminates the need for coke production. Innovative features of the COREX® process include the reduction shaft furnace, which is used to reduce the iron ore to iron, and the melter-gasifier, which gasifies the coal and melts the iron. The gasification process generates the reducing gas for use in the reduction furnace as well as sufficient heat to melt the resulting iron in the melter-gasifier. Excess reducing gas exiting the reduction furnace is cooled, cleaned, compressed, mixed with air, and burned in a gas turbine generator system capable of combusting low-Btu gas to make electric power. The hot turbine exhaust is then used to raise steam for expansion in a steam turbine, which generates additional electric power. During the demonstration, about 3,400 tpd of a bituminous coal blend containing about 0.5 percent sulfur will be utilized. The project will produce 3,300 tpd of hot metal and 195 MWe.

CPICOR™ technology is less complex and environmentally superior to competing iron-making/power-generating technologies. Criteria air pollutants are reduced substantially largely due to: (1) the inherent desulfurizing capability of the COREX® process, wherein the limestone fed to the reduction furnace captures the sulfur present in the coal, and (2) the efficient control systems within the combined-cycle power generation process. Because coke is not used, coke plants and their associated pollutants can be eliminated.

The energy efficiency of the CPICOR™ technology is much greater than competing commercial technology. The efficiency advantage is gained by more effective use of both the sensible heat in the process and the volatile matter in the coal, as well as by incorporation of the combined-cycle power generation system.

The Blast Furnace Granulated-Coal Injection System Demonstration Project will demonstrate, under the CCT Program, that existing iron-making blast furnaces can be retrofitted with Blast Furnace Granulated-Coal Injection (BFGCI) technology. The project, located in Porter County, Indiana, will retrofit two high-capacity blast furnaces at Bethlehem Steel Corporation's Burns Harbor Plant with BFGCI technology. Each unit has a production capacity of 7,000 net tpd of hot metal. The two units will use about 2,800 tpd of coal during full operation. To date, construction for the project has been completed, and pre-operational tests have been initiated.

In the BFGCI process, both granulated and pulverized coals are used as a blast furnace fuel supplement, replacing natural gas or oil. The coal, along with heated air, is blown into the barrel-shaped section in the lower part of the blast furnace through passages called tuyeres, which creates swept zones in the furnace called raceways. The size of a raceway is important and is dependent upon many factors including temperature. Lowering of a raceway temperature, which can occur with gas injection, reduces blast furnace production rates. Coal, with a lower hydrogen content than either gas or oil, does not cause as severe a reduction in raceway temperatures. In addition to displacing injected natural gas, the coal injected through the tuyeres displaces coke, the primary blast furnace fuel and reducing agent, on approximately a pound-for-pound basis. Because coke production results in significant emissions of NO_x, SO₂, and air toxics, BFGCI technology has significant potential to reduce emissions and enhance blast furnace production.

The gas exiting the blast furnace is clean, containing no measurable SO₂ or NO_x. Sulfur from the coal is removed by the limestone flux and bound up in the slag, which is a salable by-product. In addition to the net emissions reduction realized by coke displacement, blast furnace production is increased by maintaining high raceway temperatures.

Commercial Applications

The CPICOR™ technology is a direct replacement for existing blast furnace and coke-making capacity with the additional benefit of combined-cycle power generation. A full-scale commercial plant based on the CPICOR™ demonstration project would produce nearly 200 MWe (net exportable) and 1,200,000 tons/yr of hot metal, while expanding the type of coals that can be used to produce hot metal into the much larger noncoking range.

The total emissions of NO_x from a future commercial plant are expected to be 0.012 pounds per million Btu of coal, which is a reduction of more than 97 percent from the combination of a comparably sized pulverized coal power plant with flue gas desulfurization. Similarly, the total emissions of SO₂ from the commercial facility are expected to be 0.024 pounds per million Btu, a reduction of more than 90 percent. The net electrical generating efficiency of the commercial facility is estimated to be 47 percent. This compares to a net efficiency of 32 percent for comparably sized conventional facilities.

Overall, a CPICOR™ commercial plant would produce minimal solid or liquid wastes, especially when compared to existing competing facilities. All solid wastes are expected to be exempt from the Resource Conservation and Recovery Act requirements. The majority of solid wastes are beneficially reused, which increases the economic benefit of the technology and avoids burdening landfills. Most of the solid waste is slag from the iron-making process, which is useable in applications such as ballast for road construction and foundation.

BFGCI technology can be applied to essentially all U.S. blast furnaces. The technology should be applicable to any coal commercially available in the United States that has a moisture content no higher than 12 percent. The environmental impacts of commercial application are primarily indirect and consist of a significant reduction of emissions resulting from diminished coke-making requirements.

B.4.2 Cement Manufacture

Description

There are over 250 cement kiln installations in the United States and Canada emitting approximately 230,000 tons/yr. of SO₂. Technologies are necessary to reduce this major cause of transboundary air pollution.

Environmental Characteristics

Technology has been developed and demonstrated that controls SO₂ emissions by 90-95 percent, reduces NO_x emissions 5-15 percent, and eliminates the landfilling of waste cement kiln dust.

Technology Status

A scrubbing system that can reduce SO₂ emissions from coal-burning cement kilns by more than 90 percent using waste kiln dust as a scrubber reagent was demonstrated by the Passamaquoddy Tribe under the CCT Program. The project was located in Thomaston, Maine, at the Dragon Product's 470,000 tons/yr cement plant. The Passamaquoddy Technology Recovery Scrubber™ is a wet flue gas desulfurization process that uses alkaline waste materials as scrubber reagent. The system was able to (1) achieve 90-95 percent SO₂ reduction; (2) reduce NO_x emissions 5-15 percent; (3) produce potassium sulfate and potassium chloride, both highly valued marketable by-products; (4) convert the kiln waste to cement feedstock; and (5) eliminate all waste streams. The technology was operated between August 1991 and September 1993. During the spring and summer of 1993, the unit was on-line approximately 80 percent of the time and recovered 85-90 percent of the cement kiln dust.

Commercial Applications

After completion of the CCT Program demonstration, the scrubber became a permanent part of the Dragon facility. In 1994, a Taiwanese cement company engaged Passamaquoddy Technologies, L.P., to do a preliminary study for the installation of the Passamaquoddy Technology Recovery Scrubber™ on a cement plant in Taiwan.

APPENDIX C

PROJECT SUMMARY SHEETS

Respondent ABB (ASEA Brown Boveri) did not provide a PROJECT SUMMARY form.

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PROJECT SUMMARY

- (1) Technology(ies): Duct Injection
- (2) Federal Incentive: Cooperative Agreement
- (3) Project Title: Duct Injection for the Control of SO₂ and Air
Toxics
- (4) Respondent: Acurex Environmental Corporation - Asea Brown
Boveri Environmental Systems
- (5) Mailing Address: Acurex Environmental Corporation
4915 Prospectus Drive, P.O. Box 13109
- (6) City: Research Tri. Park (7) State: NC (8) ZIP: 27709
- (9) Primary Contact: Wojciech Jozewicz
- (10) Phone No.: (919) 544-4535 (11) Fax No.: (919) 544-5690
- (12) Project Location: Upper Silesia, Poland
- (13) Host Country: Poland
- (14) Applicability: Retrofit in electric utility and/or industrial
sector.
- (15) Source(s) of Coal: Polish hard coal, process tested at SO₂ levels
simulating up to 4% S coal.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: 120 MW_a retrofit

(17) Environmental Performance: CO₂ emission reduced compared to conventional FGD because process does not generate liquid waste, has lower energy consumption, sorbent controls mercury—no need for activated carbon—estimated reduction of CO₂ 30%; over 95% reduction of SO₂; over 95% reduction of mercury; reusable solid waste (concrete, landfill liners).

(18) Project Duration: 3 years

(19) Estimated Total Cost of the Project: \$8,400,000

(20) Government's Incentive Cost: \$4,000,000

(21) Commercialization Potential in Host Country: Hard coal fired capacity in Poland that requires SO₂ reduction is approximately 14,500 MW_a. Potential estimated at 10,000 MW_a (power plants requiring less than 50% SO₂ reduction).

(22) Global Commercialization Potential: Eastern Europe 25,000 MW_a, former Soviet Union 30,000 MW_a, China 40,000 MW_a to the total of approximately 95,000 MW_a.

(23) Notes or Comments (Optional): _____
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Appendix C

PROGRAM ANNOUNCEMENT
for

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PROJECT SUMMARY

- (1) Technology(ies): Pressurized Circulating Fluidized Bed Technology
- (2) Federal Incentive: Cooperative Agreement - Cost Sharing
- (3) Title: Repowering of a Power Station in the Czech Republic with
Ahlstrom Pyropower Pyroflow® PCFB Clean Coal Combustion Technology
- (4) Respondent: Ahlstrom Pyropower, Inc.
- (5) Mailing Address: 8925 Rehco Road
- (6) City: San Diego (7) State: California (8) Zip: 92121
- (9) Primary Contact: William F. Matousek
- (10) Phone No.: (619) 458-3000 (11) Fax No.: (619) 558-0714
- (12) Project Location: Ledvice, Czech Republic (potential)
- (13) Host Country: Czech Republic
- (14) Applicability: PCFB technology is targeted for electric power generation in either the
electric utility or private power sector, for either repowering or new facility applications.
- (15) Source(s) of Coal: Coal for the project will be low to high sulphur bituminous coal.
Sources of coal will be either imported South African or European hard coal. Other potential
sources are the large reserves of low grade coal (brown coal and lignite) indigenous to Central
Europe.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Total installed capacity of 150 MWe (repowering of 125 MWe steam cycle)
- (17) Environmental Performance: Repowering with the PCFB will result in lowering of CO₂ emissions by 15-20%. Other emissions will be SO₂ <200 mg/Nm³, NO_x <150 mg/Nm³ and particulates <10 mg/Nm³ (all PM₁₀), reference 6% O₂. There are no hazardous or toxic wastes. Solid wastes (ash) are inert, with quantities in the range of 12 metric tons/hr.
- (18) Project Duration: The total project duration is expected to be in the range of 42- 48 months including demonstration phase.
- (19) Estimated Total Cost of the Project: Estimated total project cost is in the range of \$225 million.
- (20) Government's Incentive Cost: The government's incentive cost is \$85 to \$110 million.
- (21) Commercialization Potential in Host Country: Commercialization potential in the Czech Republic is high. It is anticipated that there will be 4 to 6 repowering projects in the next five years. Following this period, there is an added potential for several other power projects.
- (22) Global Commercialization Potential: Ahlstrom Pyropower and the ACGIE are actively marketing the PCFB technology in the U.S., Europe, and Pacific Rim (Japan, China, and India). The potential in these markets will grow once the technology is demonstrated.
- (23) Notes or Comments (Optional): Success in marketing of clean coal technologies following demonstration projects such as the AEP Tidd Project is well evidenced. Support for demonstrations in other markets will help to accelerate the deployment of the technology.

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PROJECT SUMMARY

- (1) Technology(ies): Process Monitoring, Modelling, Optimization,
and Control
- (2) Federal Incentive: Cost Share of Initial Demonstration
- (3) Project Title: Emissions Control by Optimization of Plant Operations
Using Advanced Analytical Sensors and Algorithms and Optimization
Technologies Coupled with Supervisory Control Systems
- (4) Respondent: ALIAS Group, Incorporated
- (5) Mailing Address: Post Office Box 11275
- (6) City: Alexandria (7) State: VA (8) Zip: 22312-0275
- (9) Primary Contact: Peter M. Jones, Chairman
- (10) Phone No.: (703) 941-2485 (11) Fax No.: (703) 941-8345
- (12) Project Location: Budapest, Hungary (North Central/South Central)
- (13) Host Country: Hungary
- (14) Applicability: The proposed technology is applicable to all sectors
and to retrofit, repowering, modernizing, extending lifetimes, and to
new facilities.
- (15) Source(s) of Coal: North Central and South Central Hungary;
Central/Eastern Europe. Brown coal is the major type in the region.
Hungary would be the primary source, followed by Poland and the Czech
Republic.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Electric Power Production: 476 - 3,798 GWh; Heat Supply 151 (lignite fired) - 3,361 (coal fired) TJ
- (17) Environmental Performance: Information is being developed. SO₂ emissions for Hungarian brown coal (10 MJ/kg) are 20.0 g/kWh⁻¹, for lignite (6.6 MJ/kg) 18.7 g/kWh; for imported coal (24.0 MJ/kg) 2.1 g/kWh. A minimum of 15% reduction in CO₂ emissions and other noxious gases is anticipated for equivalent energy production.
- (18) Project Duration: One (1) year, under full funding, for a plant retrofit.
- (19) Estimated Total Cost of the Project: \$2.975 million
- (20) Government's Incentive Cost: \$1.4875 million. A loan guarantee may be required for part of the Hungarian contribution.
- (21) Commercialization Potential in Host Country: Approximately twelve (12) plants in Hungary would be subject to this retrofit. In excess of 20,000 GWh capacity should be installed by the year 2030 in fossil fuel fired plants.
- (22) Global Commercialization Potential: The application of this technology is universal and will increase operating efficiencies in virtually all power plants, irrespective of their unit operations.
- (23) Notes or Comments (Optional): A portion of the DOE's investment should be specifically targeted to small, high-technology companies. These companies historically provide the most innovative technical solutions but do not have the capital from revenues to support the development of markets internationally. Technical innovators in small companies can, however, provide enabling technologies "on the margin" which can markedly assist DOE and its CCT Program participants.

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PROJECT SUMMARY

- (1) Technology(ies): SNRE Technology for combined cleaning of flue gases of SO_x, NO_x and particulate matter
- (2) Federal Incentive: Improvement of flue gas cleaning systems at coal TPSs in Russia
- (3) Project Title: One-unit combined flue gas cleaning: of SO_x by dry method using lime, soda and other reagents; of particulate matter, including that formed in DeSO_x cleaning by filtering via ceramic filters made as tubular elements, and of NO_x by SAR method
- (4) Respondent: Babcock & Wilcox, a McDermott company
- (5) Mailing Address: 20 S. VanBuren Avenue P.O. Box 351
Barberton OH 44203-0351, USA
- (6) City: Barberton (7) State: OH (8) Zip: _____
- (9) Primary Contact: George L. Glessuras, Vice President & General Manager Eastern Europe and C.I.S
- (10) Phone No.: (216) 753-4511 (11) Fax No.: (216) 860-1886
- (12) Project Location: Cherepetskaya TPS, All-Russia Thermal Engineering Institute (VTI)
- (13) Host Country: Russia
- (14) Applicability: The technology is applied for coals with sulfur content of up to 0,05% and combustion product ash content of up to 35-40%
- (15) Source(s) of Coal: Coals from the South Donbass, Kuznetak and some coal-fields of the siberia and Far East

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Construction of large-scale demo FGD plant of
500.10³ m³/h capacity
- (17) Environmental Performance: At CherepetTPS site located in Central
Russia industrial region is characterized by increased atmospheric
content of fly ash, SOx and NOx. Besides, the emissions reach the
State protected "Iasnaya Polyana" reservation
- (18) Project Duration: 1995-1997
- (19) Estimated Total Cost of the Project: 26 mln.USD
- (20) Government's Incentive Cost: 13 mln.USD
- (21) Commercialization Potential in Host Country: Organisation of
manufacture of part of equipment and its sale to interested
enterprises
- (22) Global Commercialization Potential: Use of demo plant results
for further commercial implementation at TPSs of USA and Russia
- (23) Notes or Comments (Optional): _____
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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): PCFB Boiler Based GCP
- (2) Federal Incentive: Improvement of coal firing systems along with reduction of harmful emissions
- (3) Project Title: Construction of 70-100 MWe pilot GCP with PCFB coal-firing boiler
- (4) Respondent: Babcock & Wilcox a McDermott company
- (5) Mailing Address: 20 S. Van Buren Avenue P.O.Box 351
Barberton OH 44203-0351, USA
- (6) City: Barberton (7) State: OH (8) Zip: _____
- (9) Primary Contact: George J. Clessuras, Vice President & General Manager Eastern Europe and U.S.
- (10) Phone No.: (216) 753-4511 (11) Fax No.: (216) 860-1886
- (12) Project Location: Shatura TPS Moscow reg. VTI, TKZ
- (13) Host Country: Russia
- (14) Applicability: Thermal power Stations
- (15) Source(s) of Coal: SSP Kuznetsk. B Near Moscow coal-fields

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: 70-100 MWe COP

(17) Environmental Performance: Reduction of SOx and NOx to 200 mg/m³

(18) Project Duration: 1995-1997

(19) Estimated Total Cost of the Project: 30 mln.USD

(20) Government's Incentive Cost: 5 mln.USD

(21) Commercialization Potential in Host Country: if successful,
over 300 boilers will be modernized by the same technology

(22) Global Commercialization Potential:

(23) Notes or Comments (Optional):

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Atmospheric circulating fluidized-bed combustion-
(ACFB) system
- (2) Federal Incentive: The improvement of the coal combustion technology
with simultaneous reducing of harmful emission into environment
- (3) Project Title: The implementation of advanced ACFB combustion techno-
logy to replace obsolete equipment of Russian TPSS, firing low-grade
with high ash content, such as anthracite culm (AC)
- (4) Respondent: Babcock & Wilcox a McDermott company
- (5) Mailing Address: 20 S. Van Buren Avenue P.O. Box 351
Barberton OH 44203-0351, USA
- (6) City: Barberton (7) State: OH (8) Zip:
- (9) Primary Contact: Richard A. Cavers, General Manager
George J. Clessuras, Vice President & General manager EE and C.I.S.
- (10) Phone No.: (216) 860-1054 (11) Fax No.: (216) 860-1886
216 753-4511 216 860-1886
- (12) Project Location: Nesvatai TPS Rostov reg., Cherepatskaya TPS Tula re.
All-Russia Thermal Engineering Institute (VTI), Taganrog boiler
- (13) Host Country: manufacturer (TJZ) Russia
- (14) Applicability: thermal power stations
- (15) Source(s) of Coal: local anthracite culm, lean kuznetsk coals etc.

Solicitation of Expressions of Interest in Commercial
Clean Coal technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: boiler capacity 230 t/h to replace obsolete equipment
- (17) Environmental Performance: the level of harmful gaseous emissions is provided for EOX and CO about 200 mg/m³; for SOX about 400 mg/m³; flue gases dusting is about 500 mg/m³
- (18) Project Duration: 1995-1997
- (19) Estimated Total Cost of the Project: 20 mln USA
- (20) Government's Incentive Cost: _____
- (21) Commercialization Potential in Host Country: More than 100 boilers in Russia
- (22) Global Commercialization Potential: _____
- (23) Notes or Comments (Optional): _____

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): LIDS DeSOx Technology
- (2) Federal Incentive: Mastering of LIDS Technology of industrial PCS plant of 420 t/h ash-coal fired boiler
- (3) Project Title: LIDS technology is based on boiler furnace limestone injection and integration with SO₂ over boiler path and gas dusts
- (4) Respondent: Babcock & Wilcox a McDermott company
- (5) Mailing Address: 20 S. Van Buren Avenue P.O.Box 351
Barberton OH, 44203-0351, USA
- (6) City: Barberton (7) State: OH (8) Zip: _____
- (9) Primary Contact: George J. Classuras, Vice President & General Manager Eastern Europe and U.S.
- (10) Phone No.: (216) 753-4511 (11) Fax No.: (216) 860-1386
- (12) Project Location: Omsk Cogeneration plant No5 , Omskenergo, VNI Boiler Manufacturer ZIO
- (13) Host Country: Russia
- (14) Applicability: The technology is applied to catch SO₂ by 80-90%
- (15) Source(s) of Coal: middle and low sulfur coals with high initial ash fusion temperature

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Full-scale demo plant at 420 t/h boiler of the
Omsk Cogeneration plant No5
- (17) Environmental Performance: Serious ecological situation due to
the large volume of industrial production in Omsk demand SO2
reduction
- (18) Project Duration: 1995-1996
- (19) Estimated Total Cost of the Project: about 20 mln.USD
- (20) Government's Incentive Cost: _____
- (21) Commercialization Potential in Host Country: Supply of standard
equipment and its sale to interested organizations
- (22) Global Commercialization Potential: The technology is applied
at FPSs of Russia and CIS, and Asia
- (23) Notes or Comments (Optional): _____
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PROGRAM ANNOUNCEMENT
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Clean Coal Technology Projects in Foreign Countries

PUBLIC ABSTRACT

- (1) Technology(ies): Circulating Fluidized Bed Combustion (CFBC)
- (2) Federal Incentive: Low Cost Project Financing
- (3) Title: Plzen District Heating Plant Expansion using brown coal fired CFB
boilers.
- (4) Respondent: Babcock & Wilcox

(5) Abstract:

The Plzen District Heating plant is looking to expand its electrical generation and district heating capacity to meet the demands of a growing Eastern European city. A prefeasibility study of alternative approaches for the plant sponsored by the U.S. AID and U.S. DOE and conducted by Gilbert Commonwealth concluded that Atmospheric Circulating Fluidized-Bed Combustion (CFBC) technology offered the best near-term economic solution for meeting the City's expansion needs. Such a facility would be designed to utilize locally produced brown coal and meet stringent restrictions on environmental emissions for SOx and NOx without separate flue gas control systems. CFBC technology is well suited to meet the emission needs and simplify the processing requirements of low grade coal fuel indigenous to the Czech Republic and much of Eastern Europe. In addition to new construction, CFB technology can be effectively applied to repower aging conventionally fired plants with low emissions, high efficiency, state-of-the-art technology. Babcock & Wilcox's CFB boiler product is especially suited to repowering applications due to its inherently compact configuration which allows a new unit to be installed in the plan area of the existing boiler.

The city of Plzen, like many Eastern European countries is limited in the short term by financial restrictions. Although the Czech economy is rapidly improving, the ability of such smaller organizations to obtain cost effective financing is the primary obstacle to initiating such a project. Many Western European equipment supplying competitors offer eastern European customers attractive financial packages with the supply of their equipment. U.S. companies must meet or exceed this advantage to establish a presence in the Eastern European market. Plzen is an ideal candidate project for U.S. suppliers to gain experience in a developing market. U.S. companies like B&W have limited experience with the brown coals typical in this region and such a project would minimize commercial and technical risk on future projects in that region.

It is estimated that the total cost of the Plzen plant expansion would be \$50 million. B&W believes that the primary obstacle to the project is cost effective financing. If the boiler portion of this project can be financed at 6% below available lending rates, it is estimated that the cost of the Federal incentive would be approximately \$10 million over a 20 year loan term.

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PROJECT SUMMARY

- (1) Technology(ies): Circulating Fluidized Bed Combustion (CFBC)
- (2) Federal Incentive: Direct Subsidy of demonstration unit
- (3) Title: Repowering of 50 MWe Ukrainian high ash anthracite fired plant with CFB technology
- (4) Respondent: Babcock & Wilcox
- (5) Mailing Address: McDermott Inc.
1525 Wilson Blvd. Suite 100
- (6) City: Arlington (7) State: VA (8) Zip: 22209
- (9) Primary Contact: Marshall R. Mazer
- (10) Phone No.: (703) 351-6313 Fax.: (703) 351-6418
- (12) Project Location: Kharkov, Ukraine
- (13) Host Country: Ukraine
- (14) Applicability: CFB technology is best suited for the utility and industrial sectors for repowering aging plants as well as new construction
- (15) Source(s) of Coal: The boiler will burn Ukrainian high ash anthracite coal

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PROJECT SUMMARY CONTINUED

- (16) Project Size: One 50 MWe Boiler and auxiliary equipment required to replace an existing pulverized coal fired boiler system.
- (17) Environmental Performance: Replacement CFB's would reduce SOx emissions by more than 90%, NOx emissions would reduce by 85%, particulate emissions would be reduced by 99% and boiler efficiency is expected to improve as much as 10% which contribute to CO₂ reduction.
- (18) Project Duration: 24-30 months
- (19) Estimated Total Cost of the Project: \$17 Million for all material and construction
- (20) Government's Incentive Cost: \$7-9 Million foreexpected import content
- (21) Commercialization Potential in Host Country: Ukraine has large reserves of low grade coals which need CFB technology - 89 units have been identified as candidates for repowering (approx 14,000 MWe) over the next 10-15 yrs
- (22) Global Commercialization Potential: Many emerging markets are developing for CFB coal firing technology where low cost environmental approaches to are developed, especially in regions where coal quality is poor.
- (23) Notes or Comments (Optional): _____
_____
_____
_____

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PROJECT SUMMARY

- (1) Technology(ies): PRESSURIZED FLUIDIZED BED COMBUSTION (PFBC)
- (2) Federal Incentive: PROJECT COSTS EXCEEDING AN UNCONTROLLED EMISSIONS PLANT
- (3) Project Title: DEMONSTRATING PFBC ADVANCED BOILER TECHNOLOGY AND EMISSIONS CONTROL THROUGH INTERNATIONAL APPLICATIONS.
- (4) Respondent: BABCOCK & WILCOX
- (5) Mailing Address: McDermott Inc.
1525 Wilson Blvd. Suite 100
- (6) City: Arlington (7) State: VA (8) Zip: 22209
- (9) Primary Contact: MARSHALL R. MAZER
- (10) Phone No.: (703) 351-6313 (11) Fax No.: (703) 351-6418
- (12) Project Location: PACIFIC RIM
- (13) Host Country: DEVELOPING COUNTRY
- (14) Applicability: The PFBC technology is applicable to the electric utility sector. This technology lends itself for the construction of new facilities and the repowering of existing facilities.
- (15) Source(s) of Coal: The sources of coal would be in the Pacific Rim countries and could be bituminous coal or lignitic type coal.

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PROJECT SUMMARY CONTINUED

(16) Project Size: The project size is 340 MWe. Main Steam flow will be 782,000 kg per hour and the coal use rate is 101 metric tons per hour.

(17) Environmental Performance: This demonstration of PFBC boiler technology will operate at approximately 10% higher cycle efficiency with the resultant 10% reduction in emissions. The sulfur capture will be about 95% and NOx emissions will be very low at about a 95% capture rate.

(18) Project Duration: The total length of time is projected to be 50 months for project completion.

(19) Estimated Total Cost of the Project: The total cost of the repowering project is estimated to be about \$330,000,000 USD.

(20) Government's Incentive Cost: Estimated cost to the Federal government to range from several millions to \$60,000,000. The latter would cover controlled emissions cost & FOAK development cost & warranty costs.

(21) Commercialization Potential in Host Country: Expand and accelerate the trial of technology elements which will be needed for the next generation of super-high efficiency boiler systems.

(22) Global Commercialization Potential: The long term experience gained will be critical to rapid adoption of technology advances throughout the developing world.

(23) Notes or Comments (Optional): This financial support will have a dramatic effect on making it possible to build large technology demonstrations and will increase the strength and technology competitiveness of U.S. based companies in the international economy.

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PROJECT SUMMARY

- (1) Technology(ies): HIGHER EFFICIENCY COAL FIRED POWER PLANTS
- (2) Federal Incentive: FOAK ENGINEERING & DEVELOPMENT COSTS & WARRANTY COST
- (3) Project Title: DEMONSTRATING ADVANCED BOILER TECHNOLOGY ELEMENTS THROUGH INTERNATIONAL APPLICATIONS.
- (4) Respondent: BABCOCK & WILCOX
- (5) Mailing Address: McDermott Inc.
1525 Wilson Blvd. Suite 100
- (6) City: Arlington (7) State: VA (8) Zip: 22209
- (9) Primary Contact: MARSHALL R. MAZER
- (10) Phone No.: (703) 351-6313 (11) Fax No.: (703) 351-6418
- (12) Project Location: PACIFIC RIM
- (13) Host Country: DEVELOPING COUNTRY
- (14) Applicability: The advanced boiler technology is applicable to the electric utility sector and lends itself for the construction of new facilities. Elements of advanced boiler technology could be installed into existing operating units as a longterm demonstration.
- (15) Source(s) of Coal: The sources of coal would be in the Pacific Rim countries and could be bituminous coal or lignitic type coal.

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PROJECT SUMMARY CONTINUED

(16) Project Size: The project size is 400 MWe. Main Steam flow will be 1,200,000 kg per hour and the coal use rate is 119 metric tons per hour.

(17) Environmental Performance: This demonstration of advanced boiler technology will operate at approximately 10% higher cycle efficiency with the resultant 10% reduction in emissions.

(18) Project Duration: The total length of time is projected to be 40 months for project completion.

(19) Estimated Total Cost of the Project: The total cost of a complete new project is estimated to be about \$320,000,000 USD. An alternate possibility is to run long term tests of elements of the advanced boiler technology in existing units and is estimated to cost about \$50,000,000 USD.

(20) Government's Incentive Cost: Estimated cost to the Federal government would range from a few million to \$20,000,000 USD. The latter would be for FOAK engineering and development cost & warranty costs.

(21) Commercialization Potential in Host Country: Expand and accelerate the trial of technology elements which will be needed for the next generation of super-high efficiency boiler systems.

(22) Global Commercialization Potential: Long term experience gained will be critical to rapid adoption of technology advances throughout the world.

(23) Notes or Comments (Optional): The relatively small investment will have a dramatic (100 plus multiplier) effect on technology demonstrations. Increase in the strength and technology competitiveness of U.S. based companies in the international economy.

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PROJECT SUMMARY

- (1) Technology(ies): Low NO_x Combustion Technology
- (2) Federal Incentive: One million dollars to characterize European bituminous coal & adapt USA burner technology for the Eastern European market.
- (3) Project Title: Implementation Plan for Penetration of the Eastern European Market by Adapting U.S.A. Burner Technology to Foreign Fuels and Boiler Designs
- (4) Respondent: Babcock & Wilcox
- (5) Mailing Address: McDermott Inc.
1525 Wilson Blvd. Suite 100
- (6) City: Arlington (7) State: VA (8) Zip: 22209
- (9) Primary Contact: Marshall R. Mazer
- (10) Phone No.: (703) 351-6313 (11) Fax No.: (703) 351-6418
- (12) Project Location: Alliance, Ohio and Poland or Romania
- (13) Host Country: U.S.A.; Poland or Romania
- (14) Applicability: Electric utility retrofit of existing combustion system.
- (15) Source(s) of Coal: Bituminous coal mined in Poland and adjacent Eastern European countries.

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PROJECT SUMMARY CONTINUED

(16) Project Size: Lab tests at one million Btu/hr heat input in Alliance, Ohio; Field tests at 50 MW. in Poland.

(17) Environmental Performance: NO_x reductions of 40% from baseline conditions; efficiency improvements of 2-5% associated with improved combustion and resultant decreases in CO₂ levels.

(18) Project Duration: 18 months

(19) Estimated Total Cost of the Project: Three million dollars

(20) Government's Incentive Cost: One million dollars

(21) Commercialization Potential in Host Country: Applicable to 40 to 200 different boilers in Poland, Romania and other surrounding Eastern European countries.

(22) Global Commercialization Potential: Application to the world market could increase the market potential to more than 1000 boilers.

(23) Notes or Comments (Optional): _____

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PROJECT SUMMARY

- (1) Technology(ies): Pulverized Coal Reburning/Advanced Overfire Air for NO_x Emission Control
- (2) Federal Incentive: Up-Front Engineering Study, Performance Guarantee Support
- (3) Title: "Pulverized Coal Reburning For Retrofit NO_x Control Applications for the Eastern European Boiler Population"
- (4) Respondent: Babcock & Wilcox (a McDermott company)
- (5) Mailing Address: 1525 Wilson Boulevard, Suite 100
- (6) City: Arlington (7) State: Virginia (8) Zip: 22209
- (9) Primary Contact: Marshall R. Mazer
- (10) Phone No.: (703) 528-6313 (11) Fax No.: (703) 528-6418
- (12) Project Location: Eastern European Utility (Site unspecified at this time)
- (13) Host Country: Eastern Europe/Poland/Romania
- (14) Applicability: Reburn and overfire air technologies is best suited for large scale boilers representative of the utility industry. They lend themselves most readily to retrofit and life-extension of existing pulverized coal facilities.
- (15) Source(s) of Coal: Eastern European bituminous and subbituminous coals mined in countries such as Poland, Romania, etc. would be appropriate.

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PROJECT SUMMARY CONTINUED

(16) Project Size: A potential candidate host site would be in the 100 MW to 250 MW size range, 400,000 to 1 million kg/hr of steam produced, using 50 to 150 Tons/hr of coal depending on coal type and unit size.

(17) Environmental Performance: NO_x emissions reduced by 50 to 60% equivalent to 500 to 1,000 tons/year of reduced emissions. Particulate and CO do not increase significantly. No significant impact on CO₂ emissions. SO₂ emissions are unaffected by reburning; coal switching in combination with reburn address SO₂. Hazardous and toxic pollutants emissions are equal to or slightly improved from baseline conditions by the technology. There is no additional water consumption requirement for reburn. Solid waste quantities should remain unchanged in a PC application.

(18) Project Duration: 2-1/2 years

(19) Estimated Total Cost of the Project: \$15 million based on 100 MW scale.

(20) Government's Incentive Cost: Up-front engineering study - \$300K to \$400K
Performance Guarantee Support - \$1 to \$2 million for \$15 million project.

(21) Commercialization Potential in Host Country: Technology universally applicable to both pulverized coal fired and cyclone fired furnace units subject to economic evaluation versus other technologies. Technically, furnace residence time can be a design constraint. Up-front engineering studies would quantify applicability. Approximately 25,000 MW in Poland to which this could apply

(22) Global Commercialization Potential: Reburning technology with advanced overfire air has been demonstrated as part of CCT's and is expected to achieve market niches pending the particular economics of a given unit. There are 26,000 MW of cyclone fired units in the United States of America to which reburn applies.

(23) Notes or Comments (Optional): _____

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PROJECT SUMMARY

- (1) Technology(ies): Sorbent Injection For SO₂ Removal
- (2) Federal Incentive: \$3,000,000 to demonstrate low capital cost, easily retrofitted, moderate SO₂ emission reduction capabilities for PRC
- (3) Project Title: Moderate SO₂ Emission Reduction Capabilities for the People's Republic of China Power Generation Industry
- (4) Respondent: The Babcock & Wilcox Company
- (5) Mailing Address: McDermott Inc.
1525 Wilson Blvd. Suite 100
- (6) City: Arlington (7) State: VA (8) Zip: 22209
- (9) Primary Contact: Marshall R. Mazer
- (10) Phone No.: (703) 351-6313 (11) Fax No.: (703) 351-6418
- (12) Project Location: Guangdong Province
- (13) Host Country: People's Republic of China
- (14) Applicability: Electric Utility
- (15) Source(s) of Coal: Domestic Chinese Coal

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PROJECT SUMMARY CONTINUED

- (16) Project Size: 2 x 100 MW Boilers
- (17) Environmental Performance: Moderate levels of SO₂ removal
- (18) Project Duration: Three to five years
- (19) Estimated Total Cost of the Project: \$15,000,000
- (20) Government's Incentive Cost: \$3,000,000
- (21) Commercialization Potential in Host Country: Widespread opportunities within the domestic PRC power generation industry
- (22) Global Commercialization Potential: Expansion into neighboring Asia developing countries
- (23) Notes or Comments (Optional):

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PROJECT SUMMARY

- (1) Technology(ies): IGCC and Chemicals Coproduction
- (2) Federal Incentive: Clean Coal Technology International Transfer
- (3) Project Title: Chinese IGCC and Chemical Coproduction Project
- _____
- _____
- (4) Respondent: Bechtel Power Corporation
- _____
- (5) Mailing Address: 9801 Washingtonian Boulevard
- _____
- (6) City: Gaithersburg (7) State: MD (8) Zip: 20878-5356
- (9) Primary Contact: Robert Geosits
- (10) Phone No.: (301) 417-4724 (11) Fax No.: (301) 216-1482
- (12) Project Location: Beijing, China
- (13) Host Country: China
- (14) Applicability: _____
- _____
- (15) Source(s) of Coal: Datong Coal (Chinese)
- _____
- _____
- _____

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PROJECT SUMMARY CONTINUED

(16) Project Size: 250-400 Megawatts plus coproduction

(17) Environmental Performance: Exceeds U.S. Clean Air Standard

(18) Project Duration: 1995 - 2001

(19) Estimated Total Cost of the Project: 500 Million USD

(20) Government's Incentive Cost: 55 million USD

(21) Commercialization Potential in Host Country: Yes

(22) Global Commercialization Potential: Yes

(23) Notes or Comments (Optional):

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PROJECT SUMMARY

- (1) Technology(ies): Coal Log Pipeline
- (2) Federal Incentive: Matching funds to develop U.S. technology for export
- (3) Project Title: Coal Transportation Pipeline for Export
- _____
- _____
- (4) Respondent: Capsule Pipeline Research Center
- _____
- (5) Mailing Address: E2421 EBE, College of Engineering
University of Missouri-Columbia
- _____
- (6) City: Columbia (7) State: MO (8) Zip: 65211
- (9) Primary Contact: Thomas R. Marrero
- (10) Phone No.: (314) 882-3802 (11) Fax No.: (314) 884-4888
- (12) Project Location: Missouri
- (13) Host Country: China (Shanxi Province), pilot plant to be built in the U.S.
- (14) Applicability: Domestic and Foreign (Asia, Eastern Europe, Pacific Rim,
South America)
- _____
- (15) Source(s) of Coal: Domestic: Illinois, Maryland, Missouri, Wyoming and
West Virginia
- _____
- Foreign: Indigenous to Host Countries
- _____

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PROJECT SUMMARY CONTINUED

- (16) Project Size: Large-scale pilot plant, 10 acres on industry donated land.
- (17) Environmental Performance: Excellent (1) allows greater economic use of higher-grade coals that may be located at greater distances from power plants, (2) improves coal transportation aesthetics, reduce air and noise pollution, enhance reliability and safety, (3) permits rapid construction of coal transportation systems where such infrastructure is absent as encountered in third-world nations.
- (18) Project Duration: 2 year design and construction; continued R & D operations after start up.
- (19) Estimated Total Cost of the Project: \$15,000,000
- (20) Government's Incentive Cost: \$7,500,000
- (21) Commercialization Potential in Host Country: At least two, 500-mile pipelines (China)
- (22) Global Commercialization Potential: Great: Applicable in third-world nations that use coal-fired power plants: Asia, Eastern Europe, Pacific Rim, South America
- (23) Notes or Comments (Optional): This facility is critically needed prior to the commercialization of coal log pipeline in the United States and in other nations. Federal matching funds must be obtained to reduce industry risk; without such matching, industry will not embark on the project. These matching funds will be more than off-set by future cost-savings of a domestic demonstration project. Cost of pilot plant is much less than DOE's share of the cost of commercial demonstration.

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PROJECT SUMMARY

- (1) Technology: Slagging Coal Combustion
- (2) Federal Incentive: Federal cost sharing of 33% (\$3 million) on the first 10 MW project. Eximbank financing for manufacturing of US supplied equipment.
- (3) Project Title A 10 MW Steam Power Plant Using an Air Cooled, Slagging Combustor, Fired with Coal or Coal with Waste Fuels
- (4) Respondent: Coal Tech Corp.
- (5) Mailing Address: P.O. Box 154
- (6) City: Merion Station (7) State: PA (8) Zip: 19066
- (9) Primary Contact: Dr. Bert Zauderer
- (10) Phone No.: (610)-667-0442 (11) Fax No.: (610)-667-0576
- (12) Project Location: Hyderabad, India
- (13) Host Country: India
- (14) Applicability: Coal Tech's slagging combustor technology is suitable for steam and electric power production for the industrial, commercial, and utility sectors. Coal Tech performed a number of studies for the US market for this combustor. For example, Coal Tech recently proposed a cogeneration project for 17,500 lb/hr of steam heat and 400 kW electric power for a large industrial park in Pennsylvania. Also, several steam generation projects ranging from 5,000 lb/hr to 150,000 lb/hr of steam for industrial paper mills were proposed using the slagging combustor-boiler system. Also, site specific designs were developed for two projects. One was a 20 MW, greenfield, independent power project consisting of a combined gas turbine-steam turbine power plant with the boilers fired by the slagging coal combustors. The other was a 20 MW repowering project using an existing steam turbine-generator and a coal mine waste fuel for the slagging combustor.

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PROJECT SUMMARY CONTINUED

In all these site specific cases, the Coal Tech system was substantially less costly than other coal fired technologies that meet environmental requirements. Capital cost recovery ranged from 6 months to 7 years using a minimum 20% annual return on capital.

Figure 1 is a schematic drawing of this air cooled, slagging combustor. The combustor is attached to an oil designed package boiler as shown in figure 2. Coal Tech has designed and tested this combustor-boiler system at a 20 MMBtu/hr scale for 2000 hours between 1987 and 1993. The combustor-boiler was located at an industrial plant in Williamsport, PA. Figure 3 shows a schematic plot plan (not to scale) of a power plant utilizing this combustor. Coal Tech is currently installing a 500 kW power demonstration power plant using an advanced version of this combustor at a site in Philadelphia, PA. Referring to figure 1, a brief description of this combustor is as follows: A gas and oil burner, located on the upstream end wall is used to pre-heat the combustor wall. The combustor is then fired with pulverized coal which is injected through the combustor end wall. The swirling combustion gases drive the burning solid fuel particles toward the wall, where the liquid coal ash particles are deposited and drained through a tap at the floor of the combustor. Sulfur emissions are controlled by the injection of a sorbent powder into the combustor. NOx emissions are controlled by operating the combustor fuel rich

- (15) Source(s) of Coal: In all cases, the country's domestic coal supplies will be used. The combustor has been operated on coal with ash concentrations in excess of 50%. For the proposed Indian project, high ash domestic coals will be used. Typical of the very high ash coals is Swang Middling, which has a higher heating value (HHV) of 6,500 Btu/lb, sulfur content of 0.3%, nitrogen content of 1%, a moisture content of 2.43 %, and ash content of 42.24%. At 20% excess air and a combustion temperature of 3090F, the uncontrolled SO₂ emissions are modest, namely, 408 ppm. However, the uncontrolled NO_x emissions are very high, namely, 2760 ppmv. At the other extreme of ash content is a lignite coal with a HHV of 9150 Btu/lb, 1.56 % sulfur, 0.84% nitrogen, 10.2% moisture, and only 9.97% ash. Here at 20% excess air and 3140 F combustion temperature, the uncontrolled SO₂ emissions are 2336 ppmv and the uncontrolled NO_x emissions are 3003 ppmv, both of which are very high. Therefore, the SO₂ and NO_x control technologies provided by the air cooled slagging combustor are a very important additional benefit to burning these high ash coals and/or low HHV Indian coals.
- (16) Project Size: The proposed project is a 10 MW electric power plant. The proposed range of power plant sizes to be marketed initially with this technology is 0.5 to 20 MW electric power. Alternatively, steam generation systems will be offered using this combustor technology with steam generation rates ranging from 20,000 to 200,000 lb/hr.

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PROJECT SUMMARY CONTINUED

(17) Environmental Performance:

SO₂: With sorbent injection into a 20 MMBtu/hr Coal Tech slagging combustor at a Ca/S mol ratio of 3, 70% SO₂ reductions have been measured at the stack gas outlet of the boiler. 2% sulfur Pennsylvania bituminous coals under a wide range of operating conditions were used. Under optimized operation, 85% SO₂ reduction have been measured. Additional SO₂ reductions were measured downstream of the stack particulate collector. In tests with a 1.53% sulfur coal, whose uncontrolled SO₂ level was 2.3 lb/MMBtu, the measured SO₂ level at the stack outlet was 0.048 lb/MMBtu, equal to 98% emission reduction.

NO_x: Using staged combustion only, i.e. the 20 MMBtu/hr combustor operates fuel rich and final combustion air supplied in the boiler, maximum NO_x reductions of two-thirds to under 200 ppmv (about 0.26 lb/MMBtu) were measured.

Particulates: The combustor removes about 70% the coal ash when operating under optimum conditions. A baghouse with polyester bags will remove 99.99% of particulates above 1 micron in diameter. The combustor converts the ash into a chemically inert slag whose metals leach rate with the TCLP test is less than the EPA US Drinking Water Standard. The fly ash collected in the baghouse is reinjected into the combustor for conversion to slag. The slag is an approved product for road and construction use.

Toxics-Metals: Test at high rates of coal ash in the combustor showed that a substantial fraction of volatile metals were trapped in the slag. For example, one third of arsenic and almost one-half of the lead in the ash was retained at an ash injection rate of 700 lb/hr in the 20 MMBtu/hr combustor. Its maximum coal feed rate is 1600 lb/hr using 13,000 Btu/lb HHV coal.

Toxics-Organics: Tests performed by Coal Tech in the 20 MMBtu/hr combustor in 1993 using coal mixed with high chlorine content additives indicate that with proper control of the combustion process, total combined dioxin and furan emissions can be reduced to 1 nanogram per cubic meter of stack gas. This compares with the proposed US standard of 30 ng/cu.m. and it is well below the standards in European countries.

Water Consumption: With the use of a wet cooling tower, the water consumption of the plant would be limited to slightly more than the evaporative loss in the cooling tower. This loss depends on the thermal efficiency of the power plant. For the proposed 10 MW power plant, this water loss is 1.2 gal/kW-hr

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PROJECT SUMMARY CONTINUED

- (18) Project Duration: The total project duration for the first 10 MW plant in India is 2-1/2 years. Subsequent plants in the 0.5 to 20 MW range will have a total project cycle of 1 to 1-1/2 years.
- (19) Estimated Total Cost of the Project: \$10 million for the first 10 MW plant. Subsequent plants of equal size would be at least 1/3 less costly.
- (20) Government's Incentive Cost: \$1/3 of project cost or about \$3 million, and Eximbank financing for the US manufactured and assembled equipment, whose estimated cost is \$5 million.
- (21) Commercialization Potential in Host Country: According to a recent study by RCG/Hagler, Bailly, Inc and American Tractabel (Quoted in Proc.2nd Annual CC Conf, Atlanta, GA, Vol.1 p.104, Sep.8,1993), installed capacity in Asia in 1991 was 534 GW (534×10^9 W). Planned additions between 1991-2000 are 285 GW. China plans 12 GW of annual additions in this decade, equal to 120 GW, or 22% of the Asian total. Assuming the same rate of additions to the year 2030, and that India, which has the second largest population in Asia, will at least add 6 GW annually during that time span, one obtains a 180 GW total in the 30 years of the 21st Century. With its low installed capital cost, use of local coals, and small power plants size, a conservative estimate for the installed slagging combustor would result in a market potential of at least 10% of the total. Therefore, the potential for the slagging combustor system for India would be at least 18 GW over a 30 year span. At a minimum of \$650/kW, this translates to about \$12 billion.
- (22) Global Commercialization Potential: The study cited in Item 22 also provides the worldwide capacity (excluding the US). In 1991, it was 1923 GW, and the planned additions between 1991-2000 were 573 GW. Due to such factors as the state of industrialization and nature of the electric power grid, the nature of domestic coal supply, it will be assumed that only one half of the Indian market estimate is applicable to this technology. Also, it will be assumed that capacity additions, which incidentally included repowering and plant retirements, will remain at 573 GW per decade to 2030. This yields a slagging combustor market potential of 86 GW over the first 30 years of the 21st Century, equal to \$57 billion.

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PROJECT SUMMARY CONTINUED

(23) Comments:

Technical: The above material is based on the current status of the slagging combustor technology. The combustor can also be retrofitted to larger boilers, and Coal Tech has designs for attaching it to multi-100 MW boilers. In that case, the overall cycle efficiency would approach 40%, with consequent reduced environmental impact. Coal Tech has also explored the potential of integrating this combustor in advanced power cycles, using combined gas and steam turbine-generators. In that case, efficiencies approaching 50% are attainable, which would result in further reduced environmental impact, especially in CO₂ gas emissions. In the 35 year span considered in this request, it can be assumed that some of these advanced cycles will enter the marketplace.

Economic: A major impediment to introducing capital intensive technologies, such as electric power plants, is availability of capital. The current financial crisis in Mexico is an example of the results when investors remove their assets from a country. According to the Jan. 12, 1995 issue of the Wall Street Journal, this lack of capital will have a substantial adverse impact on the growth potential of less developed countries. Since energy production is the corner stone of economic growth, means must be found for providing low cost power generation systems. The gas turbine power plant is an example of such a system. However, it depends on natural gas or fuel oil which is not a domestic energy source in many overseas countries. Therefore, the approach taken by Coal Tech of providing a low capital cost, small power system, that operates on low grade domestic coal reserves, should find a ready market. Each plant involves only a modest capital investment, and its limited fuel needs minimize the infrastructure needed to access domestic coal supplies. In addition, subsequent plants can be financed internally by the country with the revenues generated by previous plants.

Federal Incentives: Due to the wide variability of coal supplies, federal incentives are needed to test the applicability of these coal supplies to advanced Clean Coal technologies. In addition, in view of the above comment on investment capital restraints, federal support for small and low cost power systems should be increased in relative to those technologies that focus on large central power plants.

Figure 1: Drawing of the Coal Tech Air Cooled Combustor

Figure 2: Drawing of the 20 MMBtu/hr Coal Tech Combustor Attached to an Oil/Gas Boiler

Figure 3 : TOP VIEW OF BOILER HOUSE

COAL TECH CORP.
MERIDEN STATION, PA

CTI and Penn State have a history of collaboration in international work where the combination of high quality hardware and software along with on-site personnel training are essential to the effective use of any new technology. Existing relationships with companies in both Poland and Mexico have been built upon the team's ability to evaluate the on-site needs, tailor each retrofit to the specific needs, including existing air quality and monitoring in the host country, and to properly train the on-site staff to skillfully use the controls.

The three year project proposed by CTI and Penn State is similar in approach to a project which has been funded by the DOE Krakow Clean Coal Project. The total project cost estimate of \$2.5 million is based on our experience with the Krakow project and also with international installations in Mexico. The Federal share requested is \$1.25 million.

PROJECT SUMMARY

(1) Technology(ies): CCT to be employed is a microprocessor-based combustion control technology. These controls can be retrofitted onto existing boilers and furnaces to provide environmentally clean and reasonably high efficient combustion of coal.

(2) Federal Incentive: A one-half cost share of total project cost will enable Control Techtronics International (CTI) to undertake and complete this project. Dollar value of total project: \$2.5 Million; Dollar value of Federal share: \$1.25 Million

(3) Title: Retrfitting Existing Coal Burning Equipment with Automated Boiler Combustion Controls for Cost Effective Emissions Reduction and effective improvements in China.

(4) Project Location: This project will be undertaken in China. Manufacturing of combustion controls will be completed in the U.S.

(5) Respondent: Control Techtronics International
Pennsylvania State University

(6-12) Mailing Address: Control Techtronics

Mr. John West
99 S. Cameron Strret.
Harrisburg, Pa 17101-2805
Phone: 717-257-5440; FAX: 717-238-4694

Pennsylvania State University

Mr. James Myers
108 Engineering A
University Park, PA 16802
Phone: 814-863-1657; FAX: 814-863-7835

(12) Location: This project will be undertaken in China, the specific location to be determined during discussions with potential joint venture enterprises on-site and with interested facilities which will cost share in the controls and installation expenses. Manufacturing of controls will be completed in the U.S. Supplies for retrofitting will be purchased in the host country whenever possible.

(13) Host Country: China

(14) Applicability: CTI's automated combustion controls are currently in use in industrial and small

utility facilities. In the U.S., controls are installed in hospitals, manufacturing facilities, refineries and the food processing industry, among others. In Poland, controls are installed in a district heating plant, and in Mexico controls are installed in automotive, food processing plants, and health care facilities.

The controls are used both to retrofit existing equipment and in new facilities. Because they are automated, they often represent significant modernization over existing manual control systems.

(15) Sources of Coal: As in previous international projects, coal which is indigenous to the region will be used. Local sources of coal will be used in China.

(16) Project Size: The automated combustion controls can be used in boilers up to 75,000kg steam per hour. These boilers routinely have a coal input of 8 metric tons per hour each.

(17) Environmental Performance: CTI automated combustion controls have been proven to reduce coal use by approximately 20%. This, combined with reductions in excess air velocities at low boiler loads, reduces emission by approximately 75% for particulates, 20% for CO₂, CO and SO₂. No new waste streams are created by the use of these controls.

(18) Project Duration: 36 months

(19) Estimated Total Cost: \$2.5 Million

(20) Government's Incentive Cost: \$1.25 Million

(21) Commercialization Potential in Host Country: We anticipate that successful entry into the Chinese market through this project will result in significant market potential for CTI. Our experiences with the Krakow Clean Fuels Project lead us to project a potential Polish market of 2,000 installations at approximately \$200,000 (U.S.) each, for a total market of \$400 million. Given the difference in populations between Poland and China, where China's population is approximately 30 times larger, this translates into a potential market of somewhere around \$12 billion (U.S.)

(22) Global Commercialization Potential: CTI has already begun to demonstrate the global potential through its installations in Mexico and Poland. Advances in China will further accelerate this growth. China ranks very high among individual country market potential due to their large supplies of indigenous coal and the affordability of CTI's automated combustion controls. Payback periods are commonly between 2-3 years, depending on size and site-specific use characteristics.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: The Ukraine will reduce power production costs and emissions
from existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: _____
The Use of CQE for The Ukraine Power Plants to Reduce Carbon Dioxide, Sulfur
Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: The Ukraine
- (13) Host Country: The Ukraine
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
(2) Federal Incentive: Slovenia will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
(3) Project Title: _____
The Use of CQE for Slovenian Power Plants to Reduce Carbon Dioxide, Sulfur Dioxide,
and Oxide of Nitrogen Emissions
(4) Respondent: CQ Inc.
_____
(5) Mailing Address: One Quality Center, PO Box 280
_____
(6) City: Homer City (7) State: PA (8) zip: 15748-0280
(9) Primary Contact: Jurgen Brat
(10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
(12) Project Location: Slovenia
(13) Host Country: Slovenia
(14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
(15) Source(s) of Coal: Lignite coal
_____
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Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 2,000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
(2) Federal Incentive: the Slovak Republic will reduce power production costs and
emissions from existing power stations and accelerate the deployment of other cost-
(3) Project Title: effective CCTs.
The Use of CQE for Slovak Republic Power Plants to Reduce Carbon Dioxide, Sulfur
Dioxide, and Oxide of Nitrogen Emissions
(4) Respondent: CQ Inc.
(5) Mailing Address: One Quality Center, PO Box 280
(6) City: Homer City (7) State: PA (8) zip: 15748-0280
(9) Primary Contact: Jurgen Brat
(10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
(12) Project Location: Slovak Republic
(13) Host Country: Slovak Republic
(14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
(15) Source(s) of Coal: Domestic brown coal and lignite

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: Rumania will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: _____
The Use of CQE for Rumanian Power Plants to Reduce Carbon Dioxide, Sulfur Dioxide,
and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Rumania
- (13) Host Country: Rumania
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: Poland, will reduce power production costs and emissions from existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: _____
The Use of CQE for Polish Power Plants to Reduce Carbon Dioxide, Sulfur Dioxide,
and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Poland
- (13) Host Country: Poland
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide, the effect of fuel purchase decisions on power plant emissions, performance, and power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal - Silesian coal field hard coal, lignite

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Approximately 4000 MW of identical generating units (boilers)
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- (17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.
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- (18) Project Duration: Six months per power plant
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- (19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.
-
- (20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler
-
- (21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.
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- (22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.
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- (23) Notes or Comments (Optional): _____
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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: Lithuania, will reduce power production costs and emissions
from existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: _____
The use of CQE for Lithuanian Power Plants to Reduce Carbon Dioxide, Sulfur
Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Lithuania
- (13) Host Country: Lithuania
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Imported coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The Use of CQE (one of DOE's Clean Coal Technology products) in
(2) Federal Incentive: Latvia, will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
(3) Project Title: _____
The Use of CQE for Latvian Power Plants to Reduce Carbon Dioxide, Sulfur Dioxide,
and Oxide of Nitrogen Emissions
(4) Respondent: CQ Inc.
(5) Mailing Address: One Quality Center, PO Box 280
(6) City: Homer City (7) State: PA (8) zip: 15748-0280
(9) Primary Contact: Jurgen Brat
(10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
(12) Project Location: Latvia
(13) Host Country: Latvia
(14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
(15) Source(s) of Coal: Imported coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Approximately 1,600 MW of identical generating units (boilers)
- (17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.
- (18) Project Duration: Six months per power plant
- (19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.
- (20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler
- (21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.
- (22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.
- (23) Notes or Comments (Optional): _____
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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products)
- (2) Federal Incentive: in Kyrgyzstan, will reduce power production costs and
emissions from existing power stations and accelerate the deployment of other cost-effective
- (3) Project Title: CCTs.
The Use of CQE for Kyrgyzstan Power Plants to Reduce Carbon Dioxide, Sulfur
Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Kyrgyzstan
- (13) Host Country: Kyrgyzstan
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications in the public
utility sector.
- (15) Source(s) of Coal: Imported coal from Kazakhstan and imported gas from Uzbekistan.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 3000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Minimal. Electricity within Kyrgyzstan is generated by a state-owned entity, so subsequent sales within Kyrgyzstan would be limited.

(22) Global Commercialization Potential: High. Using CQE in Kyrgyzstan can tangibly demonstrate to other countries with centralized electric generation how CQE can be used to minimize both emissions and costs, thereby increasing the commercialization potential of CQE.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: Kazakhstan, will reduce power production costs and emissions
from existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: _____
The Use of CQE for Kazakhstan Power Plants to Reduce Carbon Dioxide, Sulfur
Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Kazakhstan
- (13) Host Country: Kazakhstan
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: China, will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: The Use of CQE for Chinese Power Plants to Reduce Carbon
Dioxide, Sulfur Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: China
- (13) Host Country: China
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
(2) Federal Incentive: Bulgaria, will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
(3) Project Title: The use of CQE for Bulgarian power plants to reduce carbon
dioxide, sulfur dioxide, and oxide of nitrogen emissions.

(4) Respondent: CQ Inc.

(5) Mailing Address: One Quality Center, PO Box 280

(6) City: Homer City (7) State: PA (8) Zip: 15748-0280
(9) Primary Contact: Jurgen Brat
(10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
(12) Project Location: Bulgaria
(13) Host Country: Bulgaria
(14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
(15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4,000 WM of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Advanced Coal Preparation
- (2) Federal Incentive: Support with Polish Government
- (3) Project Title: Self-Scrubbing Coal Technology Utilization in Poland
- (4) Respondent: Custom Coals Corporation
- (5) Mailing Address: 100 First Avenue, Suite
- (6) City: Pittsburgh (7) State: PA (8) Zip: 15222
- (9) Primary Contact: Robin L. Godfrey *Robin L. Godfrey*
- (10) Phone No.: (412) 642-2625 (11) Fax No.: (412) 642-2643
- (12) Project Location: Upper Silesia
- (13) Host Country: Poland
- (14) Applicability: The project involves the construction of new coal preparation plant facilities producing clean coal for power sector and commercial use.
- (15) Source(s) of Coal: CCC has tested multiple Polish coals for washability characteristics to determine the viability of this approach on a meaningful scale.
Based upon the success of this work, the majority of Polish coals from Upper Silesia are excellent candidates for coal preparation as the environmental compliance alternative.
All coal for this and subsequent projects is available within Poland.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: The initial facility would produce 2 million tons per year of clean coal. Two additional facilities of the same size are planned.

(17) Environmental Performance: SEE ATTACHED.

(18) Project Duration: Construction of the first facility is expected to begin in late 1995 and be completed in early 1997.

(19) Estimated Total Cost of the Project: The project cost is expected to be \$30,000,000 per facility with three such facilities planned for Poland.

(20) Government's Incentive Cost: No cash cost. A guarantee against civil penalties might be required which could approximate \$1-2 million.

(21) Commercialization Potential in Host Country: SEE ATTACHED.

(22) Global Commercialization Potential: Custom Coals has specifically studied the application of the technology in China where the potential exist to install 2 billion tons of coal cleaning capacity.

(23) Notes or Comments (Optional):

(17) Environmental Performance:

CO₂ emissions are affected both in an absolute sense and relative to other technology alternatives. By improving coal quality, CO₂ emissions decrease somewhat due to improved power plant efficiency. By comparison to flue gas desulfurization alternatives, CO₂ emissions are reduced due to the decreased generation required to replace the parasitic load of the scrubber. Up to 90% SO₂ removal is possible depending upon particular power station requirements and the combination of CCTs applied. Particulates and toxic pollutants will be reduced by up to 75% due to the pre-combustion removal of non-combustible material.

(21) Commercialization Potential in Host Country:

Currently, less than 30% of Polish steam coal is cleaned to long-term compliance levels. The Polish Power Grid Company has very limited resources to meet system upgrade requirements. CCC's technology offers the opportunity to meaningfully expand the number of power stations which meet forthcoming emissions standards by minimizing Polish investment requirements. Up to 30 million tons per year of additional coal cleaning capacity is possible with 10 million tons to be constructed by Custom Coals seen as realistic.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Advanced Coal Preparation Technology
- (2) Federal Incentive: Matching Funding Grant
- (3) Project Title: China Clean Coal Application Center
- (4) Respondent: Custom Coals Corporation
- (5) Mailing Address: 100 First Avenue, Suite 500
- (6) City: Pittsburgh (7) State: PA (8) Zip: 15222
- (9) Primary Contact: Robin L. Godfrey *Robin L. Godfrey*
- (10) Phone No.: (412) 642-2625 (11) Fax No.: (412) 642-2643
- (12) Project Location: Beijing
- (13) Host Country: China
- (14) Applicability: The CCT technology involved is Custom Coal's proprietary coal cleaning technology. The intended market would be Chinese power plants.
- (15) Source(s) of Coal: The types of coal to be examined would be bituminous coals available in China.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
(2) Federal Incentive: Hungary, will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
(3) Project Title: The Use of CQE for Hungarian Power Plants to Reduce Carbon Dioxide,
Sulfur Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Hungary
- (13) Host Country: Hungary
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: Estonia, will reduce power production costs and emissions from existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: The Use of CQE for Estonian Power Plants to Reduce Carbon Dioxide, Sulfur Dioxide, and Oxide of Nitrogen Emissions.
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Estonia
- (13) Host Country: Estonia
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide, the effect of fuel purchase decisions on power plant emissions, performance, and power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Imported coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 3,000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
- (2) Federal Incentive: the Czech Republic, will reduce power production costs and
issions from existing power stations and accelerate the deployment of other cost-effective CCTs.
- (3) Project Title: The Use of CQE for Czech Republic Power Plants to Reduce Carbon
Dioxide, Sulfur Dioxide, and Oxide of Nitrogen Emissions.
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: Czech Republic
- (13) Host Country: Czech Republic
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic hard and soft coals

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Approximately 4000 MW of identical generating units (boilers)

(17) Environmental Performance: Combustion efficiency improvements of approx. five percent can reduce carbon dioxide and sulfur dioxide emissions by approx. five percent. In addition, efficiency improvements will reduce carbon in fly ash.

(18) Project Duration: Six months per power plant

(19) Estimated Total Cost of the Project: \$250,000 per boiler model. All boilers using identical design can use this model.

(20) Government's Incentive Cost: \$250,000 for a CQE model for use on each boiler

(21) Commercialization Potential in Host Country: Commercial potential can only be expressed indirectly, because CQE is a software tool used for plant modeling and CCT application screening.

(22) Global Commercialization Potential: CCT will tell the user where plant improvements can be made, how much money can be saved, and which technology should be used. Eventually, U.S. equipment worth millions of dollars will be selected.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Quality Expert (CQE) (DE-FC22-PC89663)
The use of CQE (one of DOE's Clean Coal Technology products) in
(2) Federal Incentive: China, will reduce power production costs and emissions from
existing power stations and accelerate the deployment of other cost-effective CCTs.
(3) Project Title: The Use of CQE for Chinese Power Plants to Reduce Carbon
Dioxide, Sulfur Dioxide, and Oxide of Nitrogen Emissions
- (4) Respondent: CQ Inc.
- (5) Mailing Address: One Quality Center, PO Box 280
- (6) City: Homer City (7) State: PA (8) Zip: 15748-0280
- (9) Primary Contact: Jurgen Brat
- (10) Phone No.: (412) 479-6029 (11) Fax No.: (412) 479-4181
- (12) Project Location: China
- (13) Host Country: China
- (14) Applicability: CQE is a single PC-software program that integrates, system-wide,
the effect of fuel purchase decisions on power plant emissions, performance, and
power generation costs. It is an ideal screening tool for CCT applications.
- (15) Source(s) of Coal: Domestic coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: The immediate project is a study that would cover 30 mines
and 30 power plants.

(17) Environmental Performance: Utilization of clean coal in China would permit
some CO₂ emissions reductions through improved power plant performance. A substantial
reduction in particulate emissions, a 50% reduction in SO₂ emissions and a 75% reduction
in air toxics,

(18) Project Duration: Approximately 3 years

(19) Estimated Total Cost of the Project: \$3.4 million over a 3 year period

(20) Government's Incentive Cost: A matching grant of \$1.7 million over a 3
year period.

(21) Commercialization Potential in Host Country: China is in massive need of
affordable environmental control technologies. Custom Coals is pursuing an initial
project for the construction of a 15 million ton per year coal cleaning plant and coal
slurry pipeline.

(22) Global Commercialization Potential: Custom Coals is pursuing similar project
in Poland. Advanced coal cleaning technologies are relevant in any country with
substantial coal reserves and environmental concerns arising from the combustion of coal
to produce electricity.

(23) Notes or Comments (Optional): _____

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Atmospheric Circulating Fluid Bed - Circofluid
- (2) Federal Incentive: \$7 to \$10 Million (10 to 15% of the total turnkey plant cost)
(Based on present 100 MW Plant)
- (3) Project Title: DB Riley International, Inc.
100 MW Circulating Fluid Bed Project in Northeast China
Burning a Waste Coal.
- (4) Respondent: DB Riley International
- (5) Mailing Address: DB Riley International
5 Neponset Street
- (6) City: Worcester (7) State: MA (8) Zip: 01615
- (9) Primary Contact: WilliamJ. Place, Manager, Advanced Technologies
- (10) Phone No.: (508) 852-7100 (11) Fax No.: (508) 852-7548
- (12) Project Location: Northeast China
- (13) Host Country: China
- (14) Applicability: Atmospheric Circulating Fluid Bed for Electric Utility and
Industrial. This is for a new facility producing 100 MW. It could also be applied
in repowering.
- (15) Source(s) of Coal: Northeast China waste coal at 65-70% ash and
approximately 2000 Btu/lb.

**Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries**

PROJECT SUMMARY CONTINUED

- (16) **Project Size:** 100 MW present projects (future projects range from 25 to 125 MW).
- (17) **Environmental Performance:** Atmospheric Circulating Fluid Beds in general due to temperatures, excess air, limestone, as well as staging combustion, high recycle rates, etc. allows NOx levels around 0.2 lb/MMBtu, SO₂ in excess of 90% cyclone and lower CO₂ due to the increased efficiencies over other technologies.
- (18) **Project Duration:** Existing unit expected to startup in 1997. However, follow on 8 to 12 projects could move along quicker than expected with federal incentives.
- (19) **Estimated Total Cost of the Project:** 100 MW turnkey plant at approximately \$70 Million (expect 25 to 125 MW plants to be at \$30 to \$70 Million in the 8 to 12 projects referred to).
- (20) **Government's Incentive Cost:** \$7 to \$10 Million or. 10 to 15% of the turnkey plant cost.
- (21) **Commercialization Potential in Host Country:** Again DB Riley International is looking specifically at 8 to 12 waste coal projects in 25 to 125 MW size ranges over a period of time somewhat dependent on financing.
- (22) **Global Commercialization Potential:** Waste coals and multiple fuels with high efficiency and low emissions can be realized from atmospheric CFB's. China, India, etc. provide this potential for new plants. Europe provides the potential
- (23) ~~XXXXXX Comments XXXXXXXX~~ for repowering using atmospheric CFB's.
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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Pressurized Fluidized Bed Combustor (PFBC)
- (2) Federal Incentive: 10-20% of total turnkey project cost (approx. \$10-20 Million)
- (3) Project Title: DB Riley International Generic 100 to 300 MW
MODular Circulating Pressurized Fluid Bed
- (4) Respondent: DB Riley International
- (5) Mailing Address: DB Riley International
5 Neponset Street
- (6) City: Worcester (7) State: MA (8) Zip: 01615
- (9) Primary Contact: William J. Place, Manager, Advanced Technologies
- (10) Phone No.: (508) 852-7100 (11) Fax No.: (508) 852-7548
- (12) Project Location: Generic - China
- (13) Host Country: China
- (14) Applicability: New units or because of modular design could also be used
for repowering
- (15) Source(s) of Coal: China coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: 100 to 300 MW size using 60 to 125 MW modules.

(17) Environmental Performance: Once again NOx of 0.2 to 0.3 lb/MMBtu will be achieved vs. present NSPS of 0.6, better than 95% sulfur capture and low CO₂ because of the increased efficiency.

(18) Project Duration: This is not presently a real project. Certainly federal incentive is required now to move along in the next few years.

(19) Estimated Total Cost of the Project: \$70 to \$140 Million turnkey in 100 to 300 MW plants.

(20) Government's Incentive Cost: 10 to 20% of total turnkey cost or approximated \$10 to \$20 Million on average size plant.

(21) Commercialization Potential in Host Country: As discussed other places tremendous number of projects potentially. The cost will prohibit quick introduction into China without some help.

(22) Global Commercialization Potential: Other demo projects beginning to show ultimately the major advantages associated with PFBC. Waiting until complete in U.S. will hold up commercialization into areas such as China. First generation

(23) ~~Notes or Comments (Optional):~~ PFBC is ready now.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Flyash Carbon Burnout Cell - Bubbling Bed
- (2) Federal Incentive: \$300,000 to \$700,000
- (3) Project Title: DB Riley International Bubbling Bed Carbon Burnout Cell
- (4) Respondent: DB Riley International
- (5) Mailing Address: DB Riley International
5 Neponset Street
- (6) City: Worcester (7) State: MA (8) Zip: 01615
- (9) Primary Contact: William J. Place, Manager. Advanced Technologies
- (10) Phone No.: (508) 852-7100 (11) Fax No.: (508) 852-7548
- (12) Project Location: China
- (13) Host Country: China
- (14) Applicability: Every coal fired plant running
could potentially use an add on carbon burnout fluid bed.
- (15) Source(s) of Coal: Ash from an existing coal fired plant site.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Can be added on to any coal fired plant - initial costs
are \$1 to \$2 Million per plant on the average:

(17) Environmental Performance: Strictly a decrease incrementally proportionate
to the efficiency increase which is a function of how bad existing performance is.

(18) Project Duration: 1 to 2 years

(19) Estimated Total Cost of the Project: \$1 to \$2 Million

(20) Government's Incentive Cost: \$300,000 to \$700,000

(21) Commercialization Potential in Host Country: Every coal fired plant
with high carbon in the ash is potentially a user.

(22) Global Commercialization Potential: This applied worldwide to coal
plants. Selling the ash as a product in some areas is the additional incentive financially.

(23) Notes or Comments (Optional): _____

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Micronized Coal Reburning Technology
- (2) Federal Incentive: The improvement of the coal combustion technology with simultaneous reduction of harmful emissions
- (3) Project Title: Micronized coal reburning (Three-stage combustion) for NOx control at 230 t/h wall-fired boilers
- (4) Respondent: U.S. Environmental Protection Agency (US EPA)
Air & Energy Engineering Research Laboratory (AEERL)
- (5) Mailing Address: NC 27711, USA
- (6) City: _____ (7) State: NC (8) Zip: _____
- (9) Primary Contact: Richard D. Stern, Senior Technical Advisor
International Technology Liaison
- (10) Phone No.: (919) 541-2973 (11) Fax No.: (919) 541-5227
- (12) Project Location: Verkhnetagil TPS Sverdlovenergo SC, All-Russia
Thermal Engineering Institute (VTI)
- (13) Host Country: Russia
- (14) Applicability: Thermal power Stations
- (15) Source(s) of Coal: mid volatile high-ash bituminous coals

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Capacity of boiler - 230 t/h
- (17) Environmental Performance: NOx emission reduction - 50%
- (18) Project Duration: 3-4 years
- (19) Estimated Total Cost of the Project: \$ 18 M
- (20) Government's Incentive Cost: \$ 9 M
- (21) Commercialization Potential in Host Country: 23 boilers only in Sverdlovenergo JSC
- (22) Global Commercialization Potential: More than 1000 boilers in different countries; more than 100 boilers in Russia
- (23) Notes or Comments (Optional): Successful realization of this project will make it possible to cut NOx emission down and improve the environment not only in Verkhny Tagil but around the Ural; besides, it will be permitted firing high-ash coals instead more expensive natural gas.

Respondent Energy International Corporation did not provide a PROJECT SUMMARY form.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

(1) Technology(ies): Advanced Pressurized Circulating Fluidized Bed (APCFB) Power Generation Process

(2) Federal Incentive: Financial Support

(3) Title: The design & supply of an APCFB Power Generating Facility comprising a coal gasifier, pressurized circulating fluidized bed boiler, gas cleanup equipment, gas and steam turbine generators with heat recovery together with all necessary infrastructure to generate 100 MW of electric power

(4) Respondent: Foster Wheeler Energy International, Inc.

(5) Mailing Address: Suite 460

1701 Pennsylvania Avenue, N.W.

(6) City: Washington (7) State: D. C. (8) Zip: 20006

(9) Primary Contact: Mr. Frank Kelleher

(10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597

(12) Project Location: _____

(13) Host Country: India

(14) Applicability

The Advanced PCFB technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers(even with scrubbers).

In addition to its suitability for grass roots facilities, the Advanced PCFB technology is well suited for repowering applications due to its compact design which results in a boiler island footprint that is 25-30% of that for a comparably sized pulverized coal-fired with a wet flue gas desulfurization unit (PC/FGD).

(15) **Coal Sources**

The main components of the Advanced PCFB technology, namely, the gasifier and the pressurized circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as India, China and Mexico confirms that suitability of applying this technology to the local coals.

16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 300 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) **Environmental Performance**

This technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor and the char in fluidized bed, the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO_2 emissions: The expected net plant thermal efficiency is about 45%. This is substantially higher than those attainable with existing technologies (even current IGCC technology at about 41%). This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO_2 emissions. In addition, of course, all other emissions are proportionately reduced.
- low water consumption and low waste water: The Advanced PCFB plant water consumption rate is nearly 30% lower than a PC fired plant rate and the effluent rate just approximately 43% lower.

Set out below are some typical emission estimates when applying the Advance PFCB technology:

<u>Pollutant</u>	<u>Emission Rate(lb/kwhr)</u>
NO + NO ₂ as NO ₂	1.2 x 10 ⁻³
N ₂ O	0
SO ₂ + SO ₃ as SO ₂	6.1 x 10 ⁻⁴
CO	0
Particulate matter(PM10)	7.6 x 10 ⁻⁶
Air Toxics: As, Pb, Cd, Hg, etc.	all less than 1 x 10 ⁻⁷
solid wastes	0.27
waste water	18

(18) Project Duration

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in India.

(19) Estimated Total Cost of the Project

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 100 MW plant would be about \$160 million as of 1994.

(20) Governments Incentive Cost

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	dependent on extent of (d) and power sales price
(d)	Investment cost share, 35%	\$60,000,000

(21) Commercialization Potential in Host Country

India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal based power of some 140,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Coal represents a major proportion of India's fossil energy reserves.

It is certain that a significant portion of funding will come from multilateral development banks which should put emphasis on efficiency, economics and environmental aspects of the projects. Advanced PCFB technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in India to repower existing plants, or to build new grass roots installations.

India requires enormous additions of power over the next several decades to support the planned development and growth. In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with about 40% being coal based or, by proration, 140,000 MW by the year 2030 using coal as fuel. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology. Indeed, this technology could capture 15% of the market or 20,000 MW.

(22) **Global Commercialization Potential**

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, Indonesia, South and Central America, including Mexico and China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the Advanced PCFB and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

China

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Atmospheric Circulating Fluidized Bed
- (2) Federal Incentive: Financial Support
- (3) Project Title: The Design and Supply of an Atmospheric Circulating
Fluidized Bed Combustion System to Retrofit An Existing 200-MW(e)
Power Plant
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue
- (6) City: Washington (7) State: DC (8) Zip: 20006
- (9) Primary Contact: Mr. Frank A. Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-0597
- (12) Project Location: Lugansk Region of Ukraine
- (13) Host Country: Ukraine
- (14) Applicability: See Attached
- (15) Source(s) of Coal: See Attached

(14) **Applicability**

The ACFB technology provides an effective and environmentally attractive way to burn low-grade fuels such as the coals mined in the eastern part of Ukraine and in other parts of the world. Combustion of these fuels in the presence of sulfur absorbers such as limestone greatly reduces the emission of SO₂ and staged combustion minimizes the NO_x emissions.

This technology can be applied to retrofitting of existing boilers as well as construction of greenfield installation. It is particularly well suited for retrofitting of existing boilers which have limited space for installation of pollution control equipment as sulfur capture and NO_x control are accomplished within the boiler. Furthermore, this technology is well suited for combusting poor quality coals, coal rejects from coal washing, and other materials such as rubber tires, petroleum cokes, sludges and municipal and industrial wastes.

(15) **Coal Sources**

Ukraine possesses vast reserves of poor quality anthracite coal—high in ash (30 to 40% dry basis) and sulfur (2 to 6% dry ash-free basis), and low-volatile matter (5 to 10% dry ash-free basis). This coal cannot be burned in conventional pulverized-coal furnaces without supplemental fuel. Similar coals are available in other parts of the world.

(16) **Project Size**

Foster Wheeler proposes to retrofit an existing 200-MW(e) power plant located in the Lugansk region in Ukraine. The power station has eight boilers, each supplying steam to a 200-MW(e) rated steam turbine. At the present time each of these of these units operates at 131 MW(e). Thus retrofitting one train of the power plant with a new ACFB will increase the output by more than 30%.

(17) **Environmental Performance**

It has been shown that ACFB boilers are very effective in controlling air pollutants.

- SO₂ emissions: By adding limestone to the ACFB boiler together with the coal, sulfur capture in excess of 95% is achievable.

- **NO_x emissions:** Staged combustion in the ACFB boiler will result in NO_x emissions below those recommended by NSPS.
- **CO₂ emissions:** Operating the ACFB boiler more efficiently than the present boiler will result in lower CO₂ emissions.

The quantitative assessment on emissions will be done once the coal and the sorbents are selected.

(18) **Project Duration**

Assuming that the permitting will be done concurrently with the design, we estimate the plant to be operational 36 months after the contract award.

(19) **Estimated Total Cost**

Assuming that the balance-of-plant components will require minimal upgrading, the projected cost of the boiler island with its associated equipment will be approximately \$110 million in 1994. This includes commissioning of the plant estimated to last approximately 6 months.

(20) **Government Incentive Cost**

Government incentives would be required for the following activities:

Feasibility Study	\$250,000
Investment Cost Share	\$40,000,000

(21) **Commercialization Potential in Host Country**

At the present time there are 95 utility boilers in Ukraine in the range from 80 to 300 MW(e). Approximately 50% of them operate on coal, with the balance firing mostly gas. The quality of their coal has significantly deteriorated over the past 10 years. The ash content has greatly increased from the original design of 15 to 32%, with corresponding decrease in calorific value (from 9400 Btu/lb to 7900 Btu/lb) and volatile matter. Also in the most recent years, there were numerous interruptions in

the supply of natural gas, most of which comes from Russia. Great potential for adaptation of this ACFB technology exists in Ukraine for the following reasons:

- ACFB technology is one which effectively can utilize poor-grade Ukrainian coals.
- ACFB technology substantially reduced emissions for SO₂ and NO_x.
- The age of Ukrainian fossil-fired power plants range from 20 to 40 years.
- Ukrainian government has placed top priority on rebuilding their energy sector, especially that of generation of electricity.
- Any conversion of existing or new construction of new power plants is to utilize local coals.

Thus, a successful demonstration of the ACFB project in Ukraine will open considerable opportunities for further application of this technology in Ukraine for repowering of existing plants and construction of new ones.

(22) **Global Commercialization Potential**

This emerging ACFB technology, which already is beginning to take roots in power generation in the U.S.A., has demonstrated its ability to substantially reduce in-situ the emissions of SO₂ and NO_x, has shown good combustion efficiency even with the lowest grade fuels (i.e., coal washery), its versatility to combust other fuels (sludges, tires, wood chips, etc.) together with high availability and 2% higher efficiency than conventional pulverized-coal-fired power plants with scrubbers. It is a front-runner for application in the 21st century.

World power demand in the next 35 years is forecast to increase dramatically, particularly in developing countries such as China, India, South and Central Americas, Indonesia, Eastern Europe, and the newly independent countries. We do believe that the ACFB technology will corner a substantial portion of this market.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): High Efficiency Integration Combined Cycle (HEICC) Technology Repowering
- (2) Federal Incentive: Financial Support
- (3) Title: The design & supply of a coal gasifier, gas cleanup equipment and gas turbine generator to repower a 100 MW atmospheric circulating fluidized bed boiler together with all necessary modifications and additions to existing facilities. The repowered facility would be capable of generating a nominal 180 MW of power.
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: India
- (14) Applicability

The HEICC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers (even with scrubbers).

This technology can be applied in a repowering mode or can form the basis of a grass roots facility. When repowering an existing electricity generating station where, say, the old boiler is being replaced or where the gasifier and gas turbine are integrated with an existing atmospheric fluidized bed boiler power generation facility the use of the HEICC technology will permit a substantial increase in the amount of electricity generated while using much of the existing infrastructure together with marked improved efficiency and reduction in emissions.

(15) **Coal Sources**

The main components of the HEICC technology, namely, the gasifier and the atmospheric circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as China, India and Mexico confirms that suitability of applying the HEICC technology to the local coals.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 250 MW capacity. For this "Expression of Interest" Foster Wheeler proposes repowering an existing facility of 100 MW capacity.

(17) **Environmental Performance**

The HEICC technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition of limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is approaching 40%. This is substantially higher than that attainable with an existing atmospheric fluidized bed boiler power generation system. This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like China and India where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.

- low water consumption and low waste water: The HEICC plant water consumption and effluent rates are considerably lower than for a PC fired plant.

Quantities of pollutants will depend on the coal used as fuel.

(18) Project Duration

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 42 months in India.

(19) Estimated Total Cost of the Project

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of repowering a 100 MW plant to 180 MW would be about \$100 million as of 1994.

(20) Governments Incentive Cost

Government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee]	dependent on extent of (d) and
(d)	Investment cost share]	power sales price

(21) Commercialization Potential in Host Country

India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal based power of some 140,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Coal represents a major proportion of India's fossil energy reserves.

It is certain that a significant portion of funding will come from multilateral development banks which put emphasis on efficiency, economics and environmental aspects of the projects. HEICC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in India to repower existing plants, or to build new grass roots installations.

India requires enormous additions of power over the next several decades to support the planned development and growth. In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with about 40% being coal based or, by proration, 140,000 MW by the year 2030 using coal as fuel. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology. Indeed, this technology could capture 15% of the market or 20,000 MW.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, Indonesia, South and Central America, including Mexico and China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the HEICC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

China

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

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U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Integration Gasification Combined Cycle Power Generation(IGCC)
- (2) Federal Incentive: Financial Support
- (3) Title: The design and supply of an IGCC facility comprising an air blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators together with associated infrastructure to generate 100 MW of power
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: China
- (14) Applicability

The IGCC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers(even with scrubbers).

In addition to its applicability for grass roots installations the IGCC technology is well suited for repowering applications where an existing boiler has reached the end of its life. If the IGCC is sized to match the steam output of the existing boiler, so that the existing steam turbine/generator is used, repowering with this technology results in an increase in the power output from the site. The increase in power results from the power output of the combustion turbine/generator, which can account for as much as two thirds of the total electrical power. Consequently, it is possible to repower an existing conventional coal-fired boiler, and nominally triple the site power production.

(15) **Coal Sources**

The IGCC technology is particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals. Foster Wheeler's knowledge of coals available in countries such as India, China and Mexico confirms that suitability of applying this technology to the local coals.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to about 300 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) **Environmental Performance**

This technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition of limestone in the gasifier and the sorbent based cleanup of the coal gas produced removes up to 99% of the coal sulfur
- low NO_x emissions: Through special combustion techniques of the synthetic gas in the turbine combustor, the NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is over 40%. This is substantially higher than those attainable with conventional technologies. This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like India and China where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.

- solid wastes: the spent limestone and coal ash can be used for certain building activities or landfilled.
- low water consumption and low waste water: The IGCC plant water consumption and effluent rates are considerably lower than for a PC fired plant.

The quantities of pollutants will depend on coal to be used.

(18) **Project Duration**

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in China.

(19) **Estimated Total Cost of the Project**

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 100 MW plant would be about \$160 million as of 1994.

(20) **Governments Incentive Cost**

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	Depending on extent of (d) and power price
(d)	Investment cost share, 35%	\$60,000,000

(21) **Commercialization Potential in Host Country**

China is one of the largest potential markets for clean coal technologies in the world. Coal represent 93% of their proved reserves in millions tons of oil equivalent (TOE) and 25% of the world coal reserves are in China.

Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation.

It is certain that a significant portion of funding will come from multilateral development banks which should put emphasis on efficiency, economics and environmental aspects of the projects. IGCC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, or to build new grass roots installations.

China requires enormous additions of power over the next several decades to support the planned development and growth.

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

In addition, China, in particular, has considerable experience in operating fluidized bed combustion systems and coal gasifiers and is therefore comfortable with this type of technology.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, South and Central America, Indonesia and, obviously, China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the IGCC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

India

In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with nearly half being coal based. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
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Clean Coal Technology Projects in Foreign Countries

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- (1) Technology(ies): Integration Gasification Combined Cycle Power Generation(IGCC)
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- (3) Title: The design and supply of an IGCC facility comprising an air blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators together with associated infrastructure to generate 100 MW of power
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: India
- (14) Applicability

The IGCC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers(even with scrubbers).

In addition to its applicability for grass roots installations the IGCC technology is well suited for repowering applications where an existing boiler has reached the end of its life. If the IGCC is sized to match the steam output of the existing boiler, so that the existing steam turbine/generator is used, repowering with this technology results in an increase in the power output from the site. The increase in power results from the power output of the combustion turbine/generator, which can account for as much as two thirds of the total electrical power. Consequently, it is possible to repower an existing conventional coal-fired boiler, and nominally triple the site power production.

(15) Coal Sources

The IGCC technology is particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals. Foster Wheeler's knowledge of coals available in countries such as India, China and Mexico confirms that suitability of applying this technology to the local coals.

(16) Project Size

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to about 300 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) Environmental Performance

This technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition of limestone in the gasifier and the sorbent based cleanup of the coal gas produced removes up to 99% of the coal sulfur
- low NO_x emissions: Through special combustion techniques of the synthetic gas in the turbine combustor, the NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is over 40%. This is substantially higher than those attainable with conventional technologies. This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like India and China where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.

- solid wastes: the spent limestone and coal ash can be used for certain building activities or landfilled.
- low water consumption and low waste water: The IGCC plant water consumption and effluent rates are considerably lower than for a PC fired plant.

The quantities of pollutants will depend on coal to be used.

(18) **Project Duration**

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in India.

(19) **Estimated Total Cost of the Project**

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 100 MW plant would be about \$160 million as of 1994.

(20) **Governments Incentive Cost**

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	Depending on extent of (d) and power price
(d)	Investment cost share, 35%	\$60,000,000

(21) **Commercialization Potential in Host Country**

India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal based power of some 140,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Coal represents a major proportion of India's fossil energy reserves.

It is certain that a significant portion of funding will come from multilateral development banks which put emphasis on efficiency, economics and environmental aspects of the projects. IGCC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in India to repower existing plants, or to build new grass roots installations.

India requires enormous additions of power over the next several decades to support the planned development and growth. In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with about 40% being coal based or, by proration, 140,000 MW by the year 2030 using coal as fuel. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology. Indeed, this technology could capture 15% of the market or 20,000 MW.

(22) **Global Commercialization Potential**

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, Indonesia, South and Central America, including Mexico and China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the IGCC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

China

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT

for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): High Efficiency Integrated Combined Cycle (HEICC) Technology Repowering
- (2) Federal Incentive: Financial Support
- (3) Title: The Design & Supply of a coal gasifier, gas cleanup equipment and gas turbine generator to repower a 100 MW atmospheric circulating fluidized bed boiler together with all necessary modifications and additions to existing facilities. The repowered facility would be capable of generating a nominal 180 MW of power.
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- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: China
- (14) **Applicability**

The HEICC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers (even with scrubbers).

This technology can be applied in a repowering mode or can form the basis of a grass roots facility. When repowering an existing electricity generating station where, say, the old boiler is being replaced or where the gasifier and gas turbine are integrated with an existing atmospheric fluidized bed boiler power generation facility the use of the HEICC technology will permit a substantial increase in the amount of electricity generated while using much of the existing infrastructure together with marked improved efficiency and reduction in emissions.

(15) **Coal Sources**

The main components of the HEICC technology, namely, the gasifier and the atmospheric circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as China, India and Mexico confirms that suitability of applying the HEICC technology to the local coals.

In particular, Foster Wheeler's data base on significant Chinese coals confirms their suitability for use as fuel for the HEICC technology.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 250 MW capacity. For this "Expression of Interest" Foster Wheeler proposes repowering an existing facility of 100 MW capacity.

(17) **Environmental Performance**

The HEICC technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition of limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is approaching 40%. This is substantially higher than that attainable with an existing atmospheric fluidized bed boiler power generation system. This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like China and India where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x NO_x and greenhouse gases.

- low water consumption and low waste water: The HEICC plant water consumption and effluent rates are considerably lower than for a PC fired plant.

Actual quantities of pollution will depend on the coal used.

(18) **Project Duration**

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 42 months in China.

(19) **Estimated Total Cost of the Project**

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of repowering a 100 MW plant to 180 MW would be about \$100 million as of 1994

(20) **Governments Incentive Cost**

Order of magnitude government incentives would be required for the following activities

Feasibility Study	\$ 250,000
Project Development Work	\$ 500,000
Investment cost share	Dependent on power price

(21) **Commercialization Potential in Host Country**

China is one of the largest potential markets for clean coal technologies in the world. coal represent 93% of their proved reserves in millions tons of oil equivalent (TOE) and 25% of the world coal reserves are in China.

Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation.

It is certain that a significant portion of funding will come from multilateral development banks which should put emphasis on efficiency, economics and environmental aspects of the projects. HEICC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, to retrofit the gasifier and gas turbine system for existing atmospheric circulating fluid bed boilers or to build new grass roots installations.

China requires enormous additions of power over the next several decades to support the planned development and growth.

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of 5% of the market over the period being considered, namely, about 9,000 MW.

In addition, China, in particular, has considerable experience in operating fluidized bed combustion systems and coal gasifiers and is therefore comfortable with this type of technology.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, South and Central America, Indonesia and, obviously, China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

The efficiency of the HEICC, the flexibility in fuels selection and its attractiveness for repowering existing boiler plants will make it one of the technologies of choice.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the HEICC, the flexibility in fuels selection and its attractiveness for repowering existing boiler plants will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

India

In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with nearly half being coal based. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Integration Gasification Combined Cycle Power Generation(IGCC)
- (2) Federal Incentive: Financial Support
- (3) Title: The design and supply of an IGCC facility comprising an oxygen blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators, air separation plant together with the associated infrastructure to generate 300 MW of power
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: India
- (14) Applicability

The IGCC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers(even with scrubbers).

In addition to its applicability for grass roots installations the IGCC technology is well suited for repowering applications where an existing boiler has reached the end of its life. If the IGCC is sized to match the steam output of the existing boiler, so that the existing steam turbine/generator is used, repowering with this technology results in an increase in the power output from the site. The increase in power results from the power output of the combustion turbine/generator, which can account for as much as two thirds of the total electrical power. Consequently, it is possible to retrofit an existing conventional coal-fired boiler, and nominally triple the site power production.

(15) **Coal Sources**

The IGCC technology is particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals. Foster Wheeler's knowledge of coals available in countries such as India, China and Mexico confirms that suitability of applying this technology to the local coals.

In particular, Foster Wheeler's data base on significant Indian coals confirms their suitability for use as fuel for this technology.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to about 300 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 300 MW capacity.

(17) **Environmental Performance**

This technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The sulfur removal processes used achieve a reduction in excess of 99%, depending on the coal used
- low NO_x emissions: Through special combustion techniques of the synthetic gas in the turbine combustor, the NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is over 40%. This is substantially higher than those attainable with conventional technologies. This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like India and China, where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.
- solid wastes: The coal "ash" is produced in the form of a non-leachable "glass" and can be used for certain building activities or landfilled.

- low water consumption and low waste water: The IGCC plant water consumption and effluent rates are considerably lower than a PC fired plant.

The quantities of pollutants will depend on coal to be used.

Set below are some typical emission estimates for a 300 MW oxygen blown IGCC technology:

<u>Pollutant</u>	<u>Emission Rates</u>
NO _x	0.05 lb/MM Btu of coal
SO _x	0.05 lb/MM Btu of coal
Air Toxics	1.1 T/year
Solid Wastes	350 T/day
Waste Water	500 GPM
(Saleable Sulfur	45 T/day)

(18) Project Duration

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in India.

(19) Estimated Total Cost of the Project

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 300 MW plant would be about \$450 million as of 1994.

(20) Governments Incentive Cost

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	Depending on extent of (d) and power price
(d)	Investment cost share	\$150,000,000

(21) Commercialization Potential in Host Country

India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal based power of some 140,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Coal represents a major proportion of India's fossil energy reserves.

It is certain that a significant portion of funding will come from multilateral development banks which put emphasis on efficiency, economics and environmental aspects of the projects. HEICC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in India to repower existing plants, or to build new grass roots installations.

India requires enormous additions of power over the next several decades to support the planned development and growth. In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with about 40% being coal based or, by proration, 140,000 MW by the year 2030 using coal as fuel. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology. Indeed, this technology could capture 15% of the market or 20,000 MW.

(22) **Global Commercialization Potential**

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, Indonesia, South and Central America, including Mexico and China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the IGCC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

China

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT

for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): High Efficiency Integrated Combined Cycle (HEICC)
- (2) Federal Incentive: Financial Support
- (3) Title: The design & supply of HEICC System comprising coal gasifier, atmospheric circulating fluidized bed boiler, gas cleanup equipment, gas & steam turbine generators with heat recovery together with all necessary infrastructure. The facility would be capable of generating 100 MW of power
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: India
- (14) Applicability

The HEICC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers (even with scrubbers).

This technology can be applied in a repowering mode or can form the basis of a grass roots facility. When repowering an existing electricity generating station where, say, the old boiler is being replaced, the use of the HEICC technology will permit a substantial increase in the amount of electricity generated while using much of the existing infrastructure.

(15) **Coal Sources**

The main components of the HEICC technology, namely, the gasifier and the circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as India, China and Mexico confirms that suitability of applying the HEICC technology to the local coals.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 250 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) **Environmental Performance**

The HEICC technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor and the char in fluidized bed, the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is about 42.5%. This is substantially higher than those attainable with existing technologies (even current IGCC technology at about 41%). This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like China and India where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.
- low water consumption and low waste water: The HEICC plant water consumption rate is nearly 40% lower than a PC fired plant rate and the effluent rate just under 35% lower.

Set out below are some typical emission estimates when applying the HEICC technology:

<u>Pollutant</u>	<u>Emission Rate(lb/kwhr)</u>
NO + NO ₂ as NO ₂	2.1×10^{-3}
N ₂ O	$1.0-5.0 \times 10^{-9}$
SO ₂ + SO ₃ as SO ₂	3.21×10^{-3}
CO	7.2×10^{-4}
Particulate matter	7.96×10^{-5}
Air Toxics: As, Pb, Cd, Hg, etc.	all less than 1×10^{-7}
solid wastes	0.226
waste water	0.045 gal/kwhr

(18) Project Duration

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in India.

(19) Estimated Total Cost of the Project

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of say, a 100 MW plant would be about \$150 million as of 1994

(20) Governments Incentive Cost

Government incentives would be required for the following activities

Feasibility Study	\$ 250,000
Project Development Work	\$ 500,000
Generated Power Price Guarantee	to meet Corporate return requirements depending on cost share amount
Investment cost share, 35%	\$50,000,000

(21) Commercialization Potential in Host Country

India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal based power of some 140,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Coal represents a major proportion of India's fossil energy reserves.

It is certain that a significant portion of funding will come from multilateral development banks which put emphasis on efficiency, economics and environmental aspects of the projects. HEICC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in India to repower existing plants, or to build new grass roots installations.

India requires enormous additions of power over the next several decades to support the planned development and growth. In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with about 40% being coal based or, by proration, 140,000 MW by the year 2030 using coal as fuel. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology. Indeed, this technology could capture 15% of the market or 20,000 MW.

(22) **Global Commercialization Potential**

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, Indonesia, South and Central America, including Mexico and China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the HEICC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

China

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT

for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

(1) Technology(ies): Advanced Pressurized Circulating Fluidized Bed (APCFB) Power Generation Process

(2) Federal Incentive: Financial Support

(3) Title: The design & supply of an APCFB Power Generating Facility comprising a coal asifier.

pressurized circulating fluidized bed boiler, gas cleanup equipment, gas and steam turbine generators
with heat recovery together with all necessary infrastructure to generate 100 MW of electric power

(4) Respondent: Foster Wheeler Energy International, Inc.

(5) Mailing Address: Suite 460

1701 Pennsylvania Avenue, N.W.

(6) City: Washington

(7) State: D.C.

(8) Zip: 20006

(9) Primary Contact: Mr. Frank Kelleher

(10) Phone No.: (202) 298-7750

(11) Fax No.: (202) 342-9597

(12) Project Location: _____

(13) Host Country: China

(14) Applicability

The Advanced PCFB technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particularly, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers (even with scrubbers).

The Advanced PCFB technology is well suited for repowering applications due to its compact design which results in a boiler island footprint that is 25-30% of that for a comparably sized pulverized coal-fired with a wet flue gas desulfurization unit (PC/FGD).

(15) **Coal Sources**

The main components of the Advanced PCFB technology, namely, the gasifier and the pressurized circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as China, India and Mexico confirms that suitability of applying this technology to the local coals.

In particular, Foster Wheeler's data base on significant Chinese coals confirms their suitability for use as fuel for this technology.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 300 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) **Environmental Performance**

This technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor and the char in fluidized bed, the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is about 45%. This is substantially higher than those attainable with existing technologies (even current IGCC technology at about 41%). This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like China and India where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.
- low water consumption and low waste water: The Advanced PCFB plant water consumption rate is nearly 30% lower than a PC fired plant rate and the effluent rate just approximately 43% lower.

Set out below are some typical emission estimates when applying the Advance PCFB technology:

<u>Pollutant</u>	<u>Emission Rate(lb/kwhr)</u>
NO + NO ₂ as NO ₂	1.2 x 10 ⁻³
N ₂ O	0
SO ₂ + SO ₃ as SO ₂	6.1 x 10 ⁻⁴
CO	0
Particulate matter	7.6 x 10 ⁻⁶
Air Toxics: As, Pb, Cd, Hg, etc.	all less than 1 x 10 ⁻⁷
solid wastes	0.27
waste water	18

(18) Project Duration

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in China.

(19) Estimated Total Cost of the Project

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 100 MW plant would be about \$160 million as of 1994.

(20) Governments Incentive Cost

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	Dependent on extent of (d) and power sales price
(d)	Investment cost share, 35%	\$60,000,000

(21) Commercialization Potential in Host Country

China is one of the largest potential markets for clean coal technologies in the world. Coal represent 93% of their proved reserves in millions tons of oil equivalent (TOE) and 25% of the world coal reserves are in China.

Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation.

It is certain that a significant portion of funding will come from multilateral development banks which should put emphasis on efficiency, economics and environmental aspects of the projects. Advanced PCFB technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, or to build new grass roots installations.

China requires enormous additions of power over the next several decades to support the planned development and growth.

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

In addition, China, in particular, has considerable experience in operating fluidized bed combustion systems and coal gasifiers and is therefore comfortable with this type of technology.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, South and Central America, Indonesia and, obviously, China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the Advanced PCFB and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

India

In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with nearly half being coal based. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT

for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

(1) Technology(ies): Advanced Pressurized Circulating Fluidized Bed (APCFB) Power Generation Process

(2) Federal Incentive: Financial Support

(3) Title: The design & supply of an APCFB Power Generating Facility comprising a coal gasifier, pressurized circulating fluidized bed boiler, gas cleanup equipment, gas and steam turbine generators with heat recovery together with all necessary infrastructure to generate 100 MW of electric power

(4) Respondent: Foster Wheeler Energy International, Inc.

(5) Mailing Address: Suite 460

1701 Pennsylvania Avenue, N.W.

(6) City: Washington (7) State: D. C. (8) Zip: 20006

(9) Primary Contact: Mr. Frank Kelleher

(10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597

(12) Project Location: _____

(13) Host Country: Mexico

(14) Applicability

The Advanced PCFB technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers (even with scrubbers).

In addition to its suitability for grass roots facilities, the Advanced PCFB technology is well suited for repowering applications due to its compact design which results in a boiler island footprint that is 25-30% of that for a comparably sized pulverized coal-fired with a wet flue gas desulfurization unit (PC/FGD).

(15) **Coal Sources**

The main components of the Advanced PCFB technology, namely, the gasifier and the pressurized circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as Mexico, India and China confirms the suitability of applying this technology to the local coals.

(16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 300 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) **Environmental Performance**

This technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor and the char in fluidized bed, the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is about 45%. This is substantially higher than those attainable with existing technologies (even current IGCC technology at about 41%). This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced.

- low water consumption and low waste water: The Advanced PCFB plant water consumption rate is nearly 30% lower than a PC fired plant rate and the effluent rate just approximately 43% lower.

Set out below are some typical emission estimates when applying the Advance PFCB technology:

<u>Pollutant</u>	<u>Emission Rate(lb/kwhr)</u>
NO + NO ₂ as NO ₂	1.2×10^{-3}
N ₂ O	0
SO ₂ + SO ₃ as SO ₂	6.1×10^{-4}
CO	0
Particulate matter(PM10)	7.6×10^{-6}
Air Toxics: As, Pb, Cd, Hg, etc.	all less than 1×10^{-7}
solid wastes	0.27
waste water	18

(18) Project Duration

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in Mexico.

(19) Estimated Total Cost of the Project

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 100 MW plant would be about \$160 million as of 1994.

(20) Governments Incentive Cost

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	dependent on extent of (d) and power sales price
(d)	Investment cost share, 35%	\$60,000,000

(21) Commercialization Potential in Host Country

Mexico requires considerable additions to its power generation capacity over the next several decades and is one of the key potential markets for clean coal technologies in the world, with an expected need for increased coal based power of some 20,000 MW by 2030. The high efficiency, low emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Demonstrated success with this project would open considerable opportunities for further application of this technology in Mexico to repower existing plants, or to build new grass roots installations.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, China, Indonesia, South and Central America, including Mexico.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the Advanced PCFB and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

India

In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with nearly half being coal based. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology.

China

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): High Efficiency Integrated Combined Cycle (HEICC)
- (2) Federal Incentive: Financial Support
- (3) Title: The design & supply of HEICC System comprising coal gasifier, atmospheric circulating fluidized bed boiler, gas cleanup equipment, gas & steam turbine generators with heat recovery together with all necessary infrastructure. The facility would be capable of generating 100 MW of power
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: China
- (14) Applicability

The HEICC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers(even with scrubbers).

This technology can be applied in a repowering mode or can form the basis of a grass roots facility. When repowering an existing electricity generating station where, say, the old boiler is being replaced, the use of the HEICC technology will permit a substantial increase in the amount of electricity generated while using much of the existing infrastructure.

(15) **Coal Sources**

The main components of the HEICC technology, namely, the gasifier and the circulating fluidized bed boiler are particularly versatile with respect to the type of coal to be processed. Units can be designed and built to economically burn a wide variety of coals from lignites to anthracites. Foster Wheeler's knowledge of coals available in countries such as China, India and Mexico confirms that suitability of applying the HEICC technology to the local coals.

In particular, Foster Wheeler's data base on significant Chinese coals confirms their suitability for use as fuel for the HEICC technology.

16) **Project Size**

This technology is intended primarily for repowering existing 50 to 100 MW plants or for new installations of up to 250 MW capacity. For this "Expression of Interest" Foster Wheeler proposes building a new facility of 100 MW capacity.

(17) **Environmental Performance**

The HEICC technology is particularly attractive with respect to its environmental performance compared with conventional PC boilers with scrubbers. Of special note are the following

- low SO_x emission: The addition limestone in the gasifier and circulating fluidized bed removes in-situ over 90% of the coal sulfur
- low NO_x emissions: Through staging combustion of the synthetic gas in the turbine combustor and the char in fluidized bed, the combined NO_x emissions are below those proposed by NSPS, and far superior to existing conventional boiler performance in the countries proposed to use this technology
- low CO₂ emissions: The expected net plant thermal efficiency is about 42.5%. This is substantially higher than those attainable with existing technologies (even current IGCC technology at about 41%). This higher efficiency means that the amount of coal required to be burned per kw hr of power generated is much lower thereby reflecting a corresponding reduction in CO₂ emissions. In addition, of course, all other emissions are proportionately reduced. In the areas like China and India where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x and greenhouse gases.
- low water consumption and low waste water: The HEICC plant water consumption rate is nearly 40% lower than a PC fired plant rate and the effluent rate just under 35% lower.

Set out below are some typical emission estimates when applying the HEICC technology:

<u>Pollutant</u>	<u>Emission Rate(lb/kwhr)</u>
NO + NO ₂ as NO ₂	2.1×10^{-3}
N ₂ O	$1.0-5.0 \times 10^{-9}$
SO ₂ + SO ₃ as SO ₂	3.21×10^{-3}
CO	7.2×10^{-4}
Particulate matter	7.96×10^{-5}
Air Toxics: As, Pb, Cd, Hg, etc.	all less than 1×10^{-7}
solid wastes	0.226
waste water	0.045 gal/kwhr

(18) **Project Duration**

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in China.

(19) **Estimated Total Cost of the Project**

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of say, a 100 MW plant would be about \$150 million as of 1994

(20) **Governments Incentive Cost**

Government incentives would be required for the following activities

Feasibility Study	\$ 250,000
Project Development Work	\$ 500,000
Generated Power Price Guarantee	to meet Corporate return requirements depending on cost share amount
Investment cost share, 35%	\$50,000,000

(21) **Commercialization Potential in Host Country**

China is one of the largest potential markets for clean coal technologies in the world. coal represent 93% of their proved reserves in millions tons of oil equivalent (TOE) and 25% of the world coal reserves are in China.

Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation.

It is certain that a significant portion of funding will come from multilateral development banks which should put emphasis on efficiency, economics and environmental aspects of the projects. HEICC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, to retrofit the gasifier and gas turbine system for existing atmospheric circulating fluid bed boilers or to build new grass roots installations.

China requires enormous additions of power over the next several decades to support the planned development and growth.

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of 15% of the market over the period being considered, namely, about 25,000 MW.

In addition, China, in particular, has considerable experience in operating fluidized bed combustion systems and coal gasifiers and is therefore comfortable with this type of technology.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, South and Central America, Indonesia and, obviously, China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the HEICC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

India

In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with nearly half being coal based. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology.

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Integration Gasification Combined Cycle Power Generation(IGCC)
- (2) Federal Incentive: Financial Support
- (3) Title: The design and supply of an IGCC facility comprising an oxygen blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators, air separation plant together with the associated infrastructure to generate 300 MW of power
- (4) Respondent: Foster Wheeler Energy International, Inc.
- (5) Mailing Address: Suite 460
1701 Pennsylvania Avenue, N.W.
- (6) City: Washington (7) State: D. C. (8) Zip: 20006
- (9) Primary Contact: Mr. Frank Kelleher
- (10) Phone No.: (202) 298-7750 (11) Fax No.: (202) 342-9597
- (12) Project Location: _____
- (13) Host Country: China
- (14) Applicability

The IGCC technology provides an efficient economical and environmentally attractive way to generate electric power and is considered to be eminently qualified to meet the commercial market criteria of the late 1990's and beyond. In particular, the emissions of greenhouse gases, SO₂ and NO_x per kw of power generated are greatly reduced compared with conventional PC boilers(even with scrubbers).

U.S. DEPARTMENT OF ENERGY

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forSolicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): The NOXSO Process: A No-Waste Emission Control Technology
- (2) Federal Incentive: 75% of the project funding; or \$70,171,437.00
- (3) Project Title: Demonstration of the NOXSO Process at China's 300 MW DouBa Power Plant
- (4) Respondent: NOXSO Corporation
- (5) Mailing Address: 2414 Lytle Road
- (6) City: Bethel Park (7) State: PA (8) Zip: 15102
- (9) Primary Contact: John L. Haslbeck
- (10) Phone No.: (412) 854-1200 (11) Fax No.: (412) 854-5729
- (12) Project Location: DouBa Power Plant, Sichuan Province, China
- (13) Host Country: China
- (14) Applicability: NOXSO is applicable to new and retrofit facilities for both the utility and industrial sectors.
- (15) Source(s) of Coal: DouBa's coal is mined within 200 miles of the plant (within China) and contains 4.69% sulfur.

- low water consumption and low waste water: The IGCC plant water consumption and effluent rates are considerably lower than a PC fired plant.

The quantities of pollutants will depend on coal to be used.

Set below are some typical emission estimates for a 300 MW oxygen blown IGCC technology:

<u>Pollutant</u>	<u>Emission Rates</u>
NO _x	0.05 lb/MM Btu of coal
SO _x	0.05 lb/MM Btu of coal
Air Toxics	1.1 T/year
Solid Wastes	350 T/day
Waste Water	500 GPM
(Saleable Sulfur	45 T/day)

(18) **Project Duration**

On the assumption that the permitting process which will run parallel to design activities takes about 18 months, and allowing 6 months for startup and shakedown, the overall project schedule is estimated to be about 48 months in China.

(19) **Estimated Total Cost of the Project**

It is estimated on a basis of average dollars/kw pricing for facilities of this type that the cost of, a 300 MW plant would be about \$450 million as of 1994.

(20) **Governments Incentive Cost**

Order of magnitude government incentives would be required for the following activities

(a)	Feasibility Study	\$ 250,000
(b)	Project Development Work	\$ 500,000
(c)	Generated Power Price Guarantee	Depending on extent of (d) and power price
(d)	Investment cost share	\$150,000,000

(21) **Commercialization Potential in Host Country**

China is one of the largest potential markets for clean coal technologies in the world. Coal represent 93% of their proved reserves in millions tons of oil equivalent (TOE) and 25% of the world coal reserves are in China.

Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Lack of capital is the biggest constraint to growth in electric generation.

It is certain that a significant portion of funding will come from multilateral development banks which should put emphasis on efficiency, economics and environmental aspects of the projects. IGCC technology will be very attractive from each of these points of view.

Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, or to build new grass roots installations.

China requires enormous additions of power over the next several decades to support the planned development and growth.

There have been estimates that China's power requirements could average at least 25,000 MW every five years, based on coal, between now and 2030 or a total of 175,000 MW. The attractiveness of the proposed technology from efficiency and environmental viewpoints could ensure capture of at least 15% of the market over the period being considered, namely, about 25,000 MW.

In addition, China, in particular, has considerable experience in operating fluidized bed combustion systems and coal gasifiers and is therefore comfortable with this type of technology.

(22) Global Commercialization Potential

World power demand in the next thirty five years is forecasted to increase dramatically, particularly in developing countries like India, South and Central America, Indonesia and, obviously, China.

It has been conservatively estimated that coal based power generation capacity could increase at an average rate of 75,000 MW per five year period up to 2030 or 525,000 MW in total.

Of special note are the following markets:

Western Europe

Overall increased power demand of 150,000 MW over the next ten years in Western Europe is expected to be met 50% by combined cycles based on combustion turbines. About 30% of this 50,000 MW will serve industrial applications with an average size of 100 MW. The efficiency of the IGCC and the flexibility in fuels selection will make it one of the technologies of choice.

Eastern Europe

The existing inefficient conventional boilers of Eastern Europe which have a negative impact on the environment will be replaced by repowering the facilities. This market is forecast to be about 200,000 MW over the next 20 or so years with an average size of 100 MW. Most of these repowerings will continue to use coal. An additional demand of some 50,000 MW is expected to be required to meet industrial power demand with an average size of 100 MW.

India

In the next ten years India is expected to increase its power generation capacity by about 100,000 MW with nearly half being coal based. Much of this power will be in the 100 MW - 200 MW range and therefore, offers an appropriate market for this technology.

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): ATMOSPHERIC CIRCULATING FLUIDIZED COMBUSTION (CBC)
- (2) Federal Incentive: Financial Support to Design and Develop the CBC for Helium Gas Turbine Application.
- (3) Project Title: Coal-Fired Fluidized Bed Combustor for High Efficiency Closed Helium Brayton Cycle Power Generation
- (4) Respondent: General Atomics
- (5) Mailing Address: 3550 General Atomics Court, P.O. Box 85608
- (6) City: San Diego (7) State: CA (8) Zip: 92186-9784
- (9) Primary Contact: M. Labar
- (10) Phone No.: (619) 455-3431 (11) Fax No.: (619) 455-2110
- (12) Project Location: Northern Region, India
- (13) Host Country: India
- (14) Applicability: New facility for the generation of base load electric power with high efficiency.
- (15) Source(s) of Coal: Central and Northeastern regions of India; HHV 13,000 BTU/LB, Approx. Analysis: 25-30% ASH, 5-15% Moisture, 1% S

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: 300 MWe, 76 MT/HR Coal Throughout

(17) Environmental Performance: Expected performance typical of that obtained
from demonstrated Atmospheric Fluidized Circulating Bed Combustors

(18) Project Duration: Approximately Six years

(19) Estimated Total Cost of the Project: \$650 Million *

* Budgetary Estimate

(20) Government's Incentive Cost: \$125 Million *

* Budgetary Estimate

(21) Commercialization Potential in Host Country: 72GWe New Capacity
Required in Next 10 years and an additional 150 GWe of new capacity can be projected
by the year 2030. The CBC-PCM should capture 15 to 30% of this market.

(22) Global Commercialization Potential: On a world market, on the order
of 2000 GWe of new capacity is estimated to be required by the year 2030. Again,
the CBC-PCM market share should be in the 15-30% range.

(23) Notes or Comments (Optional): The CBC-PCM offers an excellent opportunity
for a CCT Joint Venture Project with Indian Industry. It provides an opportunity
for significant content by both countries, the CBC Unit from the U.S. and the PCM
Unit from India. The Thapar Group has already expressed their willingness to proceed.

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Overview of existing U.S. technologies
- (2) Federal Incentive: Matching funds up to 50% project total
- (3) Project Title: Training of Earth and Atmospheric Sciences
Graduate Students from Developing Countries in Clean Coal Technologies
- (4) Respondent: Georgia Institute of Technology
- (5) Mailing Address: School of Earth and Atmospheric Sciences,
Georgia Institute of Technology
- (6) City: Atlanta (7) State: GA (8) Zip: 30332-0340
- (9) Primary Contact: Dr. Arthur W. Stelson
- (10) Phone No.: (404) 894-1755 (11) Fax No.: (404) 894-1106
- (12) Project Location: Atlanta, GA, USA
- (13) Host Country: Currently China, Romania, Turkey, India and the Phil
Phillipine
- (14) Applicability: Dissemination of information concernig U.S.
clean coal technologies is a factor limiting utilization.
- (15) Source(s) of Coal: Undetermined but would be governed by the
specific business practices of the developing country from which
the student originates.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Training of 10 students and 1 professor

(17) Environmental Performance: Could have far reaching impact
depending on the developing countries from which the Georgia Tech
Earth and Atmospheric Sciences graduate students originate.

(18) Project Duration: Initially 3 years

(19) Estimated Total Cost of the Project: \$260,000 / year

(20) Government's Incentive Cost: \$120,000 / year

(21) Commercialization Potential in Host Country: Familiarization
with U.S. technologies to students from a specific developing
country should promote business with U.S. companies.

(22) Global Commercialization Potential: Limited by economics and
environmental laws of specific developing country.

(23) Notes or Comments (Optional): This proposal is oriented towards
training; instead of, promotion of one technology in a specific
developing country. Thus, it is more globally oriented.

**Respondent Gilbert/Commonwealth, Inc., did not
provide a PROJECT SUMMARY form.**

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Low Ash Coals to Replace Charcoal Petroleum Coke and Metallurgical Coke.
- (2) Federal Incentive: To create more U.S. Jobs through Low Ash Reductant Exports
- (3) Project Title: Low Ash Coal Reductants (LACR) as a replacement for Charcoal Petroleum Coke and Metallurgical Coke.
- (4) Respondent: The Hiller Group, Inc.
- (5) Mailing Address: 5321 Memorial Highway
- (6) City: Tampa (7) State: Florida (8) Zip: 33634
- (9) Primary Contact: Wesley T. Hiller
- (10) Phone No.: (813) 882-3313 (11) Fax No.: (813) 882-4294
- (12) Project Location: Latin America - Brazil
- (13) Host Country: Brazil
- (14) Applicability: Industrial Consumption - Ferro Alloy and Activated Carbon Industries.
- (15) Source(s) of Coal: United States

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Latin America - Brazil the potential for our technology is
world wide.

(17) Environmental Performance: The reduction in the manufacturing of charcoal
will result in: Less local air pollution, reduction in the deforestation of
local lands local industry will find coal reductant technology will improve air
quality and plant discharge.

(18) Project Duration: _____

(19) Estimated Total Cost of the Project: 1.1M per year for 5 years.

(20) Government's Incentive Cost: 50%

(21) Commercialization Potential in Host Country: Increased production,
New markets for high purity products, less electricity costs, less cost over
charcoal and more consistant carbon charcoal versus Low Ash Coal reductants.

(22) Global Commercialization Potential: 2.4 Billion per year based on 100%
replacement of charcoal, petroleum coke and metallurgical coke.

(23) Notes or Comments (Optional): The situation facing us in the world market
is very similar to that which we found in Brazil. Industry is for the greater part,
underdeveloped and has not been exposed to coal as a carbon replacement for charcoal,
Petroleum and Metallurgical coke. The objective of this program would be to determine
the feasibility and interest of world markets in coal and carbon based technology from
the U.S. as a replacement for less environmentally safe products such as charcoal and

Cont.

to a lesser extent, petroleum and metallurgical coke. The implementation of this program will result in the education of key industries in the use of U.S. coal technology as a viable alternative to the use of local charcoal or other carbon sources. As we have proven in Brazil, action follows education and we would anticipate conversion to U.S. coal as the benefits of this change become evident. The active support of the United States Government is critical to the project's success.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
forSolicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- 1) **Technology:** HYDROCARB^{SM} Process
- 2) **Federal Incentive:** Many countries in the world offer great potential for U.S. firms. There are however, significant additional risks when investing in large projects overseas, especially in newly emerging countries and unstable regions. While Federal Government financial incentives are often necessary, it is equally important that host countries are convinced that the U.S. Government is fully behind and supportive of the activities of its companies that engage in energy projects abroad. This may be accomplished by an informal partnership with these firms that will allow them to avail themselves of Federal Government Offices that can facilitate operations in these countries. For example, there are language and cultural differences that U.S. firms must understand in order to operate effectively. The Government, through its Embassies located within host countries, can easily guide U.S. Firms in interacting with host country business persons, local regulations, etc. Patent protection is always a paramount concern. The U.S. Government can take steps through its high level contacts to insure that Patents are respected.

Financial support is often necessary, particularly where new technologies are concerned. The host country as well as private lenders are also expected to participate. Usually the degree of participation is dependent on the host country, its wealth, critical need, etc. Each situation may differ.
- 3) **Project Title:** Commercialization of the HYDROCARB Process in Eastern Europe (Poland).
- 4) **Respondent:** HYDROCARB Corporation, Dr. Edward W. Grohse, Chairman
- 5-8) **Mailing Address:** 75 Clifton Place, Port Jefferson Station, New York 11776
- 9) **Primary Contact:** HYDROCARB Corporation, Dr. Edward W. Grohse, Chairman, 75 Clifton Place, Port Jefferson Station, New York 11776
- 10) **Phone Number:** (516) 473-0586
- 11) **Fax Number:** (516) 331-0310
- 12) **Project Location:** Eastern Europe (Poland)
- 13) **Host Country:** Poland
- 13a) **Immediate Point of Contact**
Dr. Janusz Rakowski, Director
Institute of Power Engineering
Instytut Energetyki
ul. Mory 8
01-330
Warszawa, Poland
Phone: 011-48-22-366-225
Fax: 011-48-22-366-363
- 14) **Applicability:** It is believed that the HYDROCARB Process is applicable in virtually any situation where a carbonaceous feedstock or waste is available or must be disposed of; in particular coals of any rank or municipal solid waste, respectively. Although the writer is not familiar with the details of the energy and environmental situation in Poland, it is

understood that Poland has the largest coal resources in Europe(excepting perhaps the former Soviet Union). Therefore, it is concluded that with the aid of the HYDROCARB Process, Poland can place itself in the position of supplying the whole of Europe with premium, non-polluting fuels and, hence, enable Europe to become independent of present restrictive fuel suppliers.

- 15) **Sources of Coal:** We are not familiar with this detail at present. However, operation of the HYDROCARB Process is independent of the source of coal to be processed, apart from its effect upon the economics of operation of the Process.
- 16) **Project Size:** The initial project envisioned will entail the design, construction and operation of a 100 tons of coal per day HYDROCARB^{SM} Process demonstration plant. With the present selling price of methanol in particular, a demonstration plant of this relatively small capacity will nevertheless be profitable as well as at the same time providing operating data essential for the reliable design of commercial plants. HYDROCARB Corporation considers it to be a foregone conclusion that operation of the demonstration plant will confirm technical feasibility of the Process. Subsequent projects will involve full-scale commercial plants; probably comprising modules, each module capable of processing approximately 5000 tons per day of coal of any rank.
- 17) **Environmental Performance:** The HYDROCARB^{SM} Process converts coal of any rank (or virtually any carbonaceous material) to non-polluting (sulphur-free, nitrogen-free, ash-free) fuels or chemical commodities: namely, methanol and carbon black. Process gas discharges are negligible. With co-feeding of limestone/dolomite with the coal for major sulfur removal, and subsequent removal of any residual sulphur achieved by conventional gas absorption/adoption procedures, the bulk of the polluting elements originally contained in the coal will be fixed in coal ash and gypsum discharged from the hydrogasifier at approximately 1100 degrees C (2012 degrees F), which may now be landfilled. Nitrogen contained in the coal exits as elemental nitrogen. It is readily conceivable that some form of building construction materials can be fabricated from the coal ash and gypsum (and excess lime) discharged by the HYDROCARB Process.
- 18) **Project Duration:** Approximately two years will be required for the design, construction, and start-up operation of the demonstration plant. Approximately six months to an additional year will be required in order to adequately demonstrate the Process, carry out sensitivity studies, and to determine optimum operating conditions for commercial plants, assuming various feedstocks. Owing to the high value of its products (methanol at its present selling price and the carbon black saleable in this instance at commodity prices), the demonstration plant will be profitable to operate, not typical of small demonstration plants.
- 19) **Total Estimated Cost Of Project:** The estimated total cost of a 100-ton per day demonstration plant in Alaska will be approximately \$35 million or approximately \$25 million in the lower 48 states. The total cost of a 10,000-ton per day commercial plant will be in the neighborhood of \$500 million.
- 20) **Government's Incentive Cost:** Since the projects will be undertaken by foreign countries, the U.S. government's shouldering of up to 25% of the project cost would promote the development and propagation of U.S. technology and provide an incentive for foreign government/industry participation. This would, in turn, create U.S. jobs and allow U.S. industry to participate in profitable foreign projects.
- 21) **Commercialization Potential in Host Countries:** Unlimited
- 22) **Global Commercialization Potential:** Unlimited
- 23) **Notes or Comments(Optional):** Patents have been allowed for issuance in the United States, Poland, and South Africa. Patents are pending in China and all other countries possessing large coal reserves and/or are large energy users.

PROPRIETARY,
HYDROCARB

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT

for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries**PROJECT SUMMARY**

- 1) **Technology:** HYDROCARB^{SM} Process
- 2) **Federal Incentive:** Many countries in the world offer great potential for U.S. firms. There are however, significant additional risks when investing in large projects overseas, especially in newly emerging countries and unstable regions. While Federal Government financial incentives are often necessary, it is equally important that host countries are convinced that the U.S. Government is fully behind and supportive of the activities of its companies that engage in energy projects abroad. This may be accomplished by an informal partnership with these firms that will allow them to avail themselves of Federal Government Offices that can facilitate operations in these countries. For example, there are language and cultural differences that U.S. firms must understand in order to operate effectively. The Government, through its Embassies located within host countries, can easily guide U.S. Firms in interacting with host country business persons, local regulations, etc. Patent protection is always a paramount concern. The U.S. Government can take steps through its high level contacts to insure that Patents are respected.

Financial support is often necessary, particularly where new technologies are concerned. The host country as well as private lenders are also expected to participate. Usually the degree of participation is dependent on the host country, its wealth, critical need, etc. Each situation may differ.
- 3) **Project Title:** Commercialization of the HYDROCARB Process in China.
- 4) **Respondent:** HYDROCARB Corporation, Dr. Edward W. Grohse, Chairman
- 5-8) **Mailing Address:** 75 Clifton Place, Port Jefferson Station, New York 11776
- 9) **Primary Contact:** HYDROCARB Corporation, Dr. Edward W. Grohse, Chairman, 75 Clifton Place, Port Jefferson Station, New York 11776
- 10) **Phone Number:** (516) 473-0586
- 11) **Fax Number:** (516) 331-0310
- 12) **Project Location:** China
- 13) **Host Country:** China

13a) **Immediate Point of Contact**

Xiao Cheng-Ji
Beijing Research Institute of Chemical Industry
PO Box 1442
Beijing 100013

14) **Applicability:** It is believed that the HYDROCARB Process is applicable in virtually any situation where a carbonaceous feedstock or waste is available or must be disposed of, in particular coals of any rank or municipal solid waste, respectively. Although the writer is not familiar with the details of the energy and environmental situation in China it is understood that China has the largest coal resources in Asia. Therefore, it is concluded that with the aid of the HYDROCARB Process, China can place itself in the position of supplying the whole of Asia (with the possible exception of India) with premium, non-polluting fuels and, hence, enable Asia to become independent of present restrictive fuel suppliers.

15) **Sources of Coal:** We are not familiar with this detail at present. However, operation of the HYDROCARB Process is independent of the source of coal to be processed, apart from its effect upon the economics of operation of the Process.

16) **Project Size:** The initial project envisioned will entail the design, construction and operation of a 100 tons of coal per day HYDROCARB^{SM} Process demonstration plant. With the present selling price of methanol in particular, a demonstration plant of this relatively small capacity will nevertheless be profitable as well as at the same time providing operating data essential for the reliable design of commercial plants. HYDROCARB Corporation considers it to be a foregone conclusion that operation of the demonstration plant will confirm technical feasibility of the Process. Subsequent projects will involve full-scale commercial plants; probably comprising modules, each module capable of processing approximately 5000 tons per day of coal of any rank.

17) **Environmental Performance:** The HYDROCARB^{SM} Process converts coal of any rank (or virtually any carbonaceous material) to non-polluting (sulphur-free, nitrogen-free, ash-free) fuels or chemical commodities: namely, methanol and carbon black. Process gas discharges are negligible. With co-feeding of limestone/dolomite with the coal for major sulfur removal, and subsequent removal of any residual sulphur achieved by conventional gas absorption/adsorption procedures, the bulk of the polluting elements originally contained in the coal will be fixed in coal ash and gypsum discharged from the hydrogasifier at approximately 1100 degrees C (2012 degrees F), which may now be landfilled. Nitrogen contained in the coal exits as elemental nitrogen. It is readily conceivable that some form of building construction materials can be fabricated from the coal ash and gypsum (and excess lime) discharged by the HYDROCARB Process.

18) **Project Duration:** Approximately two years will be required for the design, construction, and start-up operation of the demonstration plant. Approximately six months to an additional year will be required in order to adequately demonstrate the Process, carry out sensitivity studies, and to determine optimum operating conditions for commercial plants, assuming various feedstocks. Owing to the high value of its products (methanol at its present selling price and the carbon black saleable in this instance at commodity prices), the demonstration plant will be profitable to operate, not typical of small demonstration plants.

19) **Total Estimated Cost Of Project:** The estimated total cost of a 100-ton per day demonstration plant in Alaska will be approximately \$35 million or approximately \$25 million in the lower 48 states. The total cost of a 10,000-ton per day commercial plant will be in the neighborhood of \$500 million.

PROPRIETARY,
HYDROCARB

20) **Government's Incentive Cost:** Since the projects will be undertaken by foreign countries, the U.S. government's shouldering of up to 25% of the project cost would promote the development and propagation of U.S. technology and provide an incentive for foreign government/industry participation. This would, in turn, create U.S. jobs and allow U.S. industry to participate in profitable foreign projects.

21) **Commercialization Potential in Host Countries:** Unlimited

22) **Global Commercialization Potential:** Unlimited

23) **Notes or Comments(Optional):** Patents have been allowed for issuance in the United States, Poland, and South Africa. Patents are pending in China and all other countries possessing large coal reserves and/or are large energy users.

U.S. DEPARTMENT OF ENERGY

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for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): K-Fuel coal beneficiation technology
- (2) Federal Incentive:
- Support implementation of a model village that will use K-Fuel instead of raw coal for household heating and in industrial/commercial boilers. Model will demonstrate the cost-effective, environmental improvements possible using clean coal initiatives. The model village will build on the work that has already been done in DOE's Krakow Clean Coal project.
  - Educate policy makers in target cities of the Czech Republic on the effectiveness and the cost advantages of using Clean Coal technology for pollution reduction.
  - Educate policy makers on regulatory frameworks with particular focus on life-cycle cost analysis and use of coal.
  - Give DOE sign of approval to K-Fuel technology.
- (3) Project Title: K-Fuel Model Village in the Czech Republic.
- (4) Respondent: KFx, Incorporated: building and operating K-Fuel plants using proprietary technology.
- (5) Mailing Address: 901 North Stuart Street, Suite 750
- (6) City: Arlington (7) State: VA (8) Zip: 22203
- (9) Primary Contact: Robert H. Gentile
- (10) Phone No.: (703) 524-0500 (11) Fax No.: (703) 524-3822
- (12) Project Location: K-Fuel Plant: Bilina, Northern Bohemia, Czech Republic
Model Village: To be determined (Probably in Bohemia)
- (13) Host Country: Czech Republic

- (14) Applicability: Due to heavy use of brown coal, topography, climate and current combustion practices many cities and towns of the Czech Republic face severe air pollution problems similar to the problems faced in Krakow, Poland. As DOE proved in its Krakow study, clean coal technology can significantly reduce pollution from multiple point sources in densely populated urban environments. K-Fuel made from Czech brown coal will be available in 1997 from a plant to be built at the Bílina mine. This K-Fuel is an upgraded fuel that even when burned directly can maximize cost-effective pollution reduction. It is the intent of the K-Fuel Bílina project to provide these Czech municipalities with clean coal that can be burned in existing boilers in order to reduce local, national and trans-boundary air pollution.
- (15) Sources of Coal: Brown coal from the Bílina coal mine owned and operated by Severoceske Doly in Northern Bohemia. KFx and Severoceske Doly have signed a Letter of Intent stating their mutual interest in developing a K-Fuel plant at the Bílina coal mine. KFx chose the site after pre-screening tests were completed on coals from all of the larger brown coal mines in Central Europe.
- (16) Project Size: 2,000,000 metric tons of K-Fuel per year to be developed in phases. The first phase, expected to be operating in 1997, will produce 220,000 metric tons of K-Fuel per year for the industrial boiler market. Future phases will target both the industrial/commercial boiler market as well as the domestic markets using coal for heating. The final phase is expected to be completed by 2006.
- (17) Environmental Performance: 70% of pollution in Czech Republic is produced from small, multiple point sources characterized by small industrial/commercial, district heating, and residential combusters burning raw brown and black coals, coal briquettes and heat coke. The K-Fuel Bílina project will upgrade indigenous Czech brown coal in to a high-energy, clean fuel that, if burned in existing boilers, will significantly reduce local, national and trans-boundary air pollution.
- (18) Project Duration: Two years for the first phase. One year for each additional phase. The first phase should be completed in 1997. The plant will reach total capacity by 2006.
- (19) Estimated Total Cost of the Project: Engineering and construction for the first phase of the project (220,000 tons per year) is estimated to cost \$20 million. The total cost of the plant at full capacity (2,000,000 tons per year) is estimated to be \$160 million.

(20) Government's
Incentive Cost:

Federal aid for implementing a model village program is estimated to be between \$1 million and \$500,000. KFx and Severoceske Doly will cost share over 50% of project.

(21) Commercialization Potential
in Host Country:

All of the phases of the K-Fuel Bílina project will be commercial ventures. In the first phase, over 80% of the 220,000 ton per year production will be placed in competitive contracts with industrial/commercial boilers. The remaining 20% production will be used to demonstrate the advantages to cities and towns of having all the households switch to burning K-Fuel instead of raw coal. The additional phases of the K-Fuel Bílina project will provide K-Fuel to cities that introduce legislation supporting clean air and to industrial/commercial boilers. Currently there is an estimated 3 million ton per year market for upgraded solid fuels in the Czech Republic. This market is expected to grow as environmental regulations increase. The market growth for upgraded coals will be offset by the increased use of natural gas and liquid fuels. However, a 2 million ton per year market for K-Fuel beyond the year 2000 is a conservative estimate.

(22) Global Commercialization Potential:

K-Fuel is a demonstrated commercial technology in the US and in the Czech Republic. In both countries there is an abundance of brown coal and tightening environmental awareness. K-Fuel will be a competitive option in other countries that rely on brown coal for energy and where there is a trend towards reducing air pollution. The application of K-Fuel to reduce household pollution can be extended from the Czech Republic to many countries with large reserves of brown coal including India, China, Turkey, Indonesia, Thailand and others.

(23) Notes or Comments:

This program will support the export of K-Fuel, a US clean coal technology.

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology: Coke Oven Product Recovery Emission Control
- (2) Federal Incentive: Financial Assistance Cooperative Agreement
- (3) Title: Kress Indirect Dry Cooling (KIDC) Pushing and Quenching Emission Control Demonstration
- (4) Respondent: Kress Corporation
- (5) Mailing Address: 227 Illinois Street
- (6) City: Brimfield (7) State: Illinois (8) Zip: 61517
- (9) Primary Contact: H. Dean Forden
- (10) Phone No.: (309) 446-3395 Fax No.: (309) 446-9625
- (12) Project Location: Port Kembla New South Wales
- (13) Host Country: Australia
- (14) Applicability: The KIDC System lends itself in this instance to a retrofit of an industrial steel making plant. The KIDC System can be retrofited on existing coke batteries and can easily be designed to be incorporated for new systems as well.
- (15) Source(s) of Coal: BHP Steel receives it's coal from a local BHP mine west of Port Kembla, NSW.
- (16) Project Size: This project utilizing a single cooling box is expected to process 34 to 50 tons of coke per day. This translates between 43 to 63.5 tons coal per day or 1.8 to 2.6 tons per hour. If the project expands and is put on the

complete battery it would process 38.9 tons of coal per hour 365 days per year.

- (17) Environmental Performance: It has been estimated that during the coke making process, the distribution of PM₁₀ emissions are as follows:

- Leaking doors/lids/offtakes	39%
- Coke Pushing	11%
- Coke Quenching	34%
- Underfired Combustion	16%

Controlling the pushing and quenching emissions with the KIDC System would reduce PM₁₀ emissions by a minimum of 95% and maintaining the 10% opacity limitations upon pushing.

It has been estimated during a regular quench system they use 148 gallons of water per ton of coke and loose approximately 100 gallons of water per ton of coke due to evaporation. The remaining 48 gallons has been contaminated, by coming in contact with the coke. The cooling system used on the KIDC system has an enclosed circulating water system. The water never comes in direct contact with the coke and thus does not become contaminated. Additional water may have to be added to make up the loss due to evaporation. The KIDC system has been estimated at only losing 10 gallons of water per ton of coke.

- (18) Project Duration: Utilizing the existing KIDC carrier and boxes it is estimated that the design and modifications to the carrier and boxes can be completed within six (6) months.

Transportation to Australia and set up would take two (2) months. Modifications to the Coke Oven Battery could be completed within these time periods. The demonstration period

would run a minimum of six (6) months. With the KIDC unit having access to a minimum of 3 ovens we would plan to have between 400 to 500 pushes on one (1) box.

- (19) Estimated Total Cost: The estimated cost for the complete project is broken down as follows:

19.1	Carrier and Box Modifications	\$ 316000.00
19.2	Shipping Cost To Australia	215000.00
19.3	Site Facilities & Modifications	267000.00
19.4	Assembly and Demonstration Expenses	<u>602000.00</u>
19.5	Total	<u>\$ 1400000.00</u>

- (20) Government's Incentive Cost: To help ensure that this project is well received it would be asked that the government's participation would not exceed 50% of the total projects cost. The complete government's incentive cost would be \$ 700000.00.
- (21) Commercialization Potential in Host Country: Within the host country of Australia we feel we have the potential of having the KIDC System running on five (5) recovery type coke oven batteries and one (1) non-recovery type coke oven battery.
- (22) Global Commercialization Potential: Kress Corporation has received inquiries from all parts of the world, USA, England, Sweden, India, and others. An actual number where the KIDC System could be installed is not known at this time.

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PROJECT SUMMARY

- (1) Technology(ies): Global Lowest Cost Clean Energy Delivered
- (2) Federal Incentive: Energy, State, Commerce, EPA, Legal Permits
- (3) Project Title: LIA catalytic coal gasification & IGCC to electric
at one-third capital and one-half product production cost over prior
art for most any grade of coal
- (4) Respondent: Leas Industrial Associates
- (5) Mailing Address: P.O. Box 8084, 122 N. 34th Street
- (6) City: Richmond (7) State: Indiana (8) Zip: 47374
- (9) Primary Contact: Arnold Leas
- (10) Phone No.: (317) 935-2856 (11) Fax No.: (317) 962-7290
- (12) Project Location: As contracted - foreign & domestic
- (13) Host Country: same as item 12
- (14) Applicability: to most any grade of coal at mine-site or use
point via negotiations
- (15) Source(s) of Coal: same as item 14

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: 50 to 100 MWe Electric delivered net
- (17) Environmental Performance: to meet USA-EPA standards and no
liquid or solids waste products
- (18) Project Duration: about 5 year pursuant negotiations and
contractual agreements
- (19) Estimated Total Cost of the Project: 60 to 80 million 1994
dollar values contingent negotiations
- (20) Government's Incentive Cost: Assistance to procure construction
and operating permits
- (21) Commercialization Potential in Host Country: to meet National
electric demand via LIA coal processes
- (22) Global Commercialization Potential: Economic benefits and
growth potential could represent gain in millions of jobs
- (23) Notes or Comments (Optional): See enclosed letter to
Dr. Howard Feibus and summary drawing

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PROJECT SUMMARY

- (1) Technology(ies): Core Separator for Particulate Emissions
- (2) Federal Incentive: Reduction of Particulate Air Emissions
- (3) Project Title: "Particulate Emission Abatement for Low Emission
Sources in the People's Republic of China"
- (4) Respondent: LSR Technologies, Inc.
- (5) Mailing Address: 898 Main Street
- (6) City: Acton (7) State: MA (8) Zip: 01720-5808
- (9) Primary Contact: S. Ronald Wysk
- (10) Phone No.: (508) 635-0123 (11) Fax No.: (508) 635-0058
- (12) Project Location: Hangzhou, Zhenjiang Province, PRC
- (13) Host Country: People's Republic of China
- (14) Applicability: Coal-fired industrial boilers providing heat and steam;
strong candidate for retrofit and modernizing existing facilities.
- (15) Source(s) of Coal: (1) Kailin, (2) Kew Loong Kieng, and (3) Kiaping Mines

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Demonstration unit rated at 11.6 MW_T, 124,000 kilograms
steam per hour, and 2,560 kilograms coal per hour.
- (17) Environmental Performance: Overall particulate collection efficiency - 94-98%,
PM10 collection efficiency - 90-93%, cost, \$/(M³/h) - 2.20, cost, \$/(Kg/h)
solids removal - 126., and cost, \$/Kg/h) PM10 solids removal - 803
- (18) Project Duration: Approximated 6 months to design, build, install and test.
- (19) Estimated Total Cost of the Project: Total estimated cost is
approximately \$130,000.
- (20) Government's Incentive Cost: Approximately \$100,000 with \$30,000
cost shared by Chinese affiliate.
- (21) Commercialization Potential in Host Country: This technology is
badly needed in PRC. This demonstration project will mark the beginning of
many more commercial sales.
- (22) Global Commercialization Potential: By the year 2030, another
10,000 units could be in operation with a combined gross output of 100,000 MW_T.
- (23) Notes or Comments (Optional): Market acceptance of this product will
depend heavily on government enforcement of environmental laws.

U.S. DEPARTMENT OF ENERGY

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forSolicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): The NOXSO Process: A No-Waste Emission Control Technology
- (2) Federal Incentive: 75% of the project funding; or \$70,171,437.00
- (3) Project Title: Demonstration of the NOXSO Process at China's 300 MW DouBa Power Plant
- _____
- _____
- (4) Respondent: NOXSO Corporation
- _____
- (5) Mailing Address: 2414 Lytle Road
- _____
- (6) City: Bethel Park (7) State: PA (8) Zip: 15102
- (9) Primary Contact: John L. Haslbeck
- (10) Phone No.: (412) 854-1200 (11) Fax No.: (412) 854-5729
- (12) Project Location: DouBa Power Plant, Sichuan Province, China
- (13) Host Country: China
- (14) Applicability: NOXSO is applicable to new and retrofit facilities for both the utility and industrial sectors.
- (15) Source(s) of Coal: DouBa's coal is mined within 200 miles of the plant (within China) and contains 4.69% sulfur.
- _____
- _____
- _____

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: The project will be located at the 300 MW DouBa Power Plant which
uses 165 tons per hour high sulfur coal.

(17) Environmental Performance: The NOXSO Process is a high efficiency, dry, post-
combustion flue gas technology that uses a regenerable sorbent to simultaneously remove 95% SO₂
and 82% NO_x from flue gas with no increase in CO₂. The process has no impact on boiler
performance. It is compact, easy to retrofit, generates a saleable by-product, and creates no waste
discharge, a distinct advantage over conventional FGD scrubber and SCR processes.

(18) Project Duration: 39 months

(19) Estimated Total Cost of the Project: \$93,561,916

(20) Government's Incentive Cost: 75% of the project funding; or \$70,171,437.00

(21) Commercialization Potential in Host Country: NOXSO expects to attain 2%
of the retrofit and new Chinese installed capacity: between 1999 and 2030 this equates to approximately
19,200 MW, or 64 total facilities.

(22) Global Commercialization Potential: Over the next 34 years, NOXSO anticipates
building the no-waste technology on 60,000 MW of installed capacity, or 200 total facilities worldwide.

(23) Notes or Comments (Optional):

First, the DOE must help with protecting intellectual property when it is installed in other countries.

Second, DOE can help with financing projects abroad both with grants, low-interest loans and/or
identifying funds in the guest country.

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PROJECT SUMMARY

- (1) Technology(ies): Advanced Coal Cleaning & Conversion
- (2) Federal Incentive: Differential Cost Financing
- (3) Project Title: Indonesia SynCoal Development Project
- (4) Respondent: Rosebud SynCoal Partnership
- (5) Mailing Address: 490 North 31st Street, Suite 308
P.O. Box 7137
- (6) City: Billings (7) State: MT (8) Zip: 59103
- (9) Primary Contact: Ray Sheldon
- (10) Phone No: 406/252-2277 (11) Fax No: 406/252-2090
- (12) Project Location: Tanjung Enim, Sumatera Selatan, Indonesia
- (13) Host Country: Indonesia
- (14) Applicability: Improve combustion efficiency and make an exportable low sulfur fuel from an abundant low rank indigenous resource for fuel switching applications requiring high quality fuel.
- (15) Source(s) of Coal: Indonesian low rank coal mines in Sumatera Selatan operated by PT Tambang Batubara Bukit Asam

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: 1.0 million metric ton per year or 115 metric tons per hour of SynCoal® product

(17) Environmental Performance: The use of SynCoal® in a conventional combustion technology would reduce CO₂ emissions by about 10%, SO₂ emissions by about 24%, and should provide some reductions in NO_x, particulate and PM₁₀. No impact on the hazardous and toxic pollutants or water requirement are known at this time. The SynCoal® cleaning process will segregate about 7000 metric tons per year of solid inert mineral waste from the upgraded coal. This waste would be dry land filled locally.

(18) Project Duration: Construction would commence in 1996 concluding in 1999 with initial operation

(19) Estimated Total Cost of the Project: \$65 million U.S. dollars

(20) Government's Incentive Cost: \$30 million U.S. Differential Cost Financing

(21) Commercialization Potential In Host Country: Indonesia has 36 billion metric tons of recoverable coal and lignite resources, 70 percent is low rank reserves in Sumatra and requires upgrading for export or remote use within Indonesia. Indonesia is strategically located within the south central Pacific Rim coal market which is growing rapidly.

(22) Global Commercialization Potential: SynCoal® is produced from abundant low cost resources such as those found in Indonesia, Alaska, India, China and elsewhere. SynCoal® has the potential to supply clean solid fuel for a significant percentage of the growth in energy consumption necessary to support the anticipated world economic growth.

(23) Notes or Comments (Optional): None

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Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) **Technology:** SGI International's Liquid From Coal (LFC) Process
- (2) **Federal Incentive:** 50% Cost Sharing of the LFC Engineering & Economic Feasibility Proposal for a Clean Coal Refinery.
- (3) **Project Title:** Indonesia One Clean Coal Refinery Project
- (4) **Respondent:** SGI International
- (5) **Mail Address:** 1200 Prospect Street, Suite 325
- (6) **City:** La Jolla   (7) **State:** California   (8) **Zip:** 92037
- (9) **Primary Contact:** Scott A. van Hoften, Manager of International Projects
- (10) **Phone No.:** (619) 551-1090   (11) **FAX No.:** (619) 551-0247
- (12) **Project Location:** P.T. Tambang Batubura Bukit Asam (PT TBBA) Mine in the Tanjung Enim District in South Sumatra, Indonesia.
- (13) **Host Country:** Indonesia
- (14) **Applicability:** The LFC Process is primarily suited for a stand alone Clean Coal Refinery (CCR) to be built at or near the mouth of a subbituminous or lignite mine. The solid, Process Derived Fuel (PDF) product can be the directly consumed by an electrical power plant where an LFC Clean Coal Refinery is coupled with a coal-fired power plant co-located at the mine-mouth. However, the LFC Process is not limited to the utility sector and the process can be utilized for the commercial and industrial sectors such as cement or aluminum plants.
- (15) **Source(s) of Coal:** Generally, the run-of-mine coals that are the most attractive candidates for LFC Process upgrading have high moisture (greater than 20%); low ash content (less than 15%); an H/C ratio of 0.8, or greater, and a fuel ratio of 1.4, or smaller. Typical ideal coal candidates are usually subbituminous or lignite in rank. Indonesia has significant reserves that meet these criteria and the P.T. Tambang Batubara Bukit Asam

mine in the Tanjung Enim District of South Sumatra has an immediate need to employ such an upgrading technology.

- (16) **Project Size:** Conducting an LFC Engineering & Economic Feasibility Study is the initial step in developing an LFC Clean Coal Refinery. The LFC processing plant is designed to be modular. A base plant is designed to process 5,000 metric tons of coal or lignite per day (208 metric tons per hour). This plant also includes a 40 MW cogeneration facility capable of providing 20 MW for sale to a local utility grid. This request seeks 50% funding of the LFC Engineering and Economic Feasibility Study which would determine specifically the required size of the stand alone Clean Coal Refinery.
- (17) **Environmental Performance:** A significant portion of existing electrical power plants and over 80% of the new electrical power generating capacity in Asia and the Pacific Rim will be fueled by coal. The LFC Process offers a method that can markedly reduce the environmentally damaging SO₂ emissions from such coal-fired power plants. The upgrading or drying of low-rank coals and lignites in a Clean Coal Refinery removes most of the moisture, thereby increasing the heating value of the solid product and, therefore, decreasing the transportation costs and infrastructure impact. The mild pyrolysis (or mild gasification) removes a significant fraction of the organic sulfur. The use of the Process Derived Fuel (PDF) or clean coal, such as produced in an LFC Clean Coal Refinery, will significantly reduce the SO₂ emissions of electrical power plants or commercial facilities. The LFC technology is currently employed at the ENCOAL LFC Demonstration Plant in Gillette, Wyoming. ENCOAL Corporation owns the plant and licenses the LFC Process from the TEK-KOL Partnership, jointly owned by SGI International and SMC Mining Company. The U.S. Department of Energy and ENCOAL are co-funding this \$72 million project under Round Three of the government's Clean Coal Technology Demonstration Program. In September 1994, the program was extended for two years, bringing the overall project cost to \$90 million. The ENCOAL Plant has been demonstrating the effectiveness of this sulfur reduction at near-commercial scale since it began operation in June of 1992.
- (18) **Project Duration:** The LFC Engineering and Economic Feasibility Study is expected to take 6 to 9 months to complete depending upon the time it takes to ship the 500 kg run-of-mine coal sample from Indonesia to the SGI Development Center in Perrysburg, Ohio. The actual construction of an LFC processing plant is expected to take 24 to 36 months from the onset of design and permitting to the completion of construction and startup.
- (19) **Estimated Total Cost of the Project:** The cost to conduct an LFC Engineering and Economic Feasibility Study of a 5,000 metric ton per day LFC processing plant is \$400,000 US dollars. This request seeks \$200,000 to cover the Indonesian half of the Feasibility Study. SGI International intends to fund the remaining cost. Note that the cost to design and construct a stand alone 5,000 tonne-per-day LFC Clean Coal Refinery Plant is expected to be \$125 million US dollars.
- (20) **Government's Incentive Cost:** The \$400,000 cost to perform the LFC Engineering and Economic Feasibility Study is normally shared by SGI International and the prospective joint venture partner. However, in the case of a developing nation such as Indonesia, funds for feasibility study are extremely limited. In this case, the Indonesian government has requested that SGI International find partners that would fund their 50%. Therefore, the cost to the US Government is \$200,000 to fund one-half the feasibility study. The financial benefit to the United States in return for such a \$200,000 commitment is potentially very large. Providing the LFC Engineering and Economic Feasibility Study is positive, it is expected that commercial and private funding support for a stand alone project will be available. As the estimated unit cost of one 5,000

tonne-per-day module is \$125 million, a stand alone Clean Coal Refinery project then would result in significant equipment and service contracts to U.S. firms.

- (21) **Commercialization Potential in the Host Country:** One of the world's most attractive regions for pursuing SGI's business strategy is Indonesia. Indonesia has ample natural resources, including an estimated 32 billion tons of coal resources with an estimated reserve life of several hundred years. This is considerably longer than its oil and gas resources of 19 and 42 years, respectively. Indonesia also has a large population and an emerging industrial infrastructure. Industrialization and improvements in the standard of living depend, in large measure, on the ability of the nation to generate hard currency through export of a portion of its natural resources. In the past, Indonesia relied on petroleum for export and to generate local energy. Coal now is planned to supplement petroleum for both functions. This need to export coal is coupled with a need to meet a 17% annual increase in electric power usage — one of the world's highest growth rates. The country's leadership is committed to limiting the environmental impact of its energy policies. All these factors were considered in evaluating SGI's business opportunities in Indonesia based on the use of the proprietary LFC Process for upgrading coal and producing petroleum substitutes. Should only a small portion of all the new electrical generating plants in Indonesia between now and 2030 employ Process Derived Fuel (PDF), the total number of LFC Clean Coal Refineries could total more than 100.
- (22) **Global Commercialization Potential:** The global commercialization potential is nearly unlimited. There are vast quantities of low-grade, sub-bituminous and lignite coals around the world and these coals are disadvantaged in the marketplace because their high water content which makes them very expensive to transport to distant markets, and their low heat value makes them an inefficient boiler fuel. The transportation cost component of the coal's delivered price can be over 3-5 times the cost of the coal at the mine. More importantly, many of the world's low-rank coals are also relatively high in sulfur which results in unacceptable sulfur dioxide emissions when burned. The world-wide potential to reduce sulfur dioxide emissions through use of the solid Process Derived Fuel (PDF) is environmentally very important. An LFC Clean Coal Refinery, in addition to producing a low sulfur, high heating value, premium quality Clean Coal, also produces a valuable liquid co-product with characteristics similar to a number 6, low-sulfur fuel oil. However, the Coal Derived Liquid (CDL) is of better quality than a number 6 fuel oil and with a very slight amount of dewaxing can produce other extremely attractive, value-added products.

- (23) **Notes of Comments:**

LFC DEMONSTRATION PLANT

In 1990, ENCOAL Corporation and the U.S. Department of Energy (DOE) negotiated a cooperative agreement to construct and operate for two years, a Clean Coal Demonstration Plant using the LFC Process at the Buckskin Mine near Gillette, Wyoming. Under this cooperative agreement, the DOE is sharing 50% of the allowable project costs. The LFC technology was licensed to ENCOAL by TEK-KOL. TEK-KOL is owned by SGI International and SMC Coal Company. ENCOAL's project was selected for co-funding by the DOE in December 1989, under Round Three of the U.S. Government's Clean Coal Technology Demonstration Program. After completion, the DOE approved funding for an extension of the operational phase. The total cost for design, construction and the first two years of operation was less than the estimated \$72.6 million. In September 1994, the program was extended for two years, bringing the overall project cost to \$90 million.

Construction of the LFC Clean Coal Demonstration Plant began in October 1990 and was completed in June 1992 with an announcement by the DOE that ENCOAL had met its construction and start-up goals for the plant successfully. In May, June and July of 1994, with only minor interruptions, the plant operated for 68 consecutive days at more than 90% availability — more than 600,000 gallons of specification CDL was produced and sold, and more than 12,000 short tons of PDF was stored following stabilization for two months with no significant self-heating observed.

The experience gained from plant operations has allowed ENCOAL to modify plant components and complete installation of additional equipment intended to bring the plant up to continuous, optimum production of deliverable products for shipment to its customers. At this time, most of the components of the LFC Technology as applied in the ENCOAL plant have been demonstrated. The integrated operation of all plant equipment using advanced computer control techniques has been very successful. The following unique process steps have been demonstrated at the ENCOAL plant: coal drying on a rotary grate using convective heating; coal devolatilization on a rotary grate using convective heating; hot particulate removal with cyclones; combustors operating on low BTU gas from internal streams; solids stabilization for storage; computer control of a mild coal gasification process; and dust suppression of the PDF solids.

REQUIREMENT FOR FEASIBILITY STUDY

The successful completion of an LFC Engineering and Economic Feasibility Study is required to reliably establish that a stand alone Clean Coal Refinery Project is desirable, practical and suitable from both an economic as well as an engineering and technical standpoint. A successful study which results in the design and construction of one or more 5,000 tonne-per-day LFC Clean Coal Refineries would greatly benefit the United States economy in several ways. With the anticipated unit cost of one 5,000 tonne-per-day LFC Clean Coal Refinery module being approximately \$125 million, there would generate significant U.S. based goods and service contracts in support of design, equipment provisioning and construction. Additionally, it would meet the intent of Congress in exporting the fruits of the U.S. Clean Coal Technology to the benefit of developing economies and countries. However, in the case of Indonesia, as with other developing economies, the funding for half of the LFC Engineering and Economic Feasibility Study is not available. Consequently, we seek U.S. Government assistance in providing the portion of the expense of the study which would otherwise be paid by Indonesia. Such a relatively small contribution to the overall project could have a large multiplying effect in the return of goods and service contracts to the U.S.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT

for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) **Technology:** SGI International's Liquid From Coal (LFC) Process
- (2) **Federal Incentive:** 50% Cost Sharing of the LFC Engineering & Economic Feasibility Proposal for a Clean Coal Refinery.
- (3) **Project Title:** CHINA TWO Clean Coal Refinery Project
- (4) **Respondent:** SGI International
- (5) **Mail Address:** 1200 Prospect Street, Suite 325
- (6) **City:** La Jolla   (7) **State:** California   (8) **Zip:** 92037
- (9) **Primary Contact:** Scott A. van Hoften, Manager of International Projects
- (10) **Phone No.:** (619) 551-1090   (11) **FAX No.:** (619) 551-0247
- (12) **Project Location:** Zhalainguoer Mining area near the city of Manzhouli in the Inner Mongolia Autonomous Region of the People's Republic of China
- (13) **Host Country:** People's Republic of China
- (14) **Applicability:** The LFC Process is primarily suited for a stand alone Clean Coal Refinery (CCR) to be built at or near the mouth of a subbituminous or lignite mine. The solid, Process Derived Fuel (PDF) product can be directly consumed by an electrical power plant where an LFC Clean Coal Refinery is coupled with a coal-fired power plant co-located at the mine-mouth. However, the LFC Process is not limited to the utility sector and the process can be utilized for the commercial and industrial sectors such as cement or aluminum plants.
- (15) **Source(s) of Coal:** Generally, the run-of-mine coals that are the most attractive candidates for LFC Process upgrading have high moisture (greater than 20%); low ash content (less than 15%); a hydrogen to carbon (H/C) ratio of 0.8, or greater; and a fuel

ratio (fixed carbon to volatile matter) of 1.4, or smaller. Typical ideal coal candidates are usually subbituminous or lignite in rank. The Zhalainguoer Coal Mine Administration has significant reserves that meet these criteria and China has an immediate need to employ such an upgrading technology.

- (16) **Project Size:** Conducting an LFC Engineering & Economic Feasibility Study is the initial step in developing an LFC Clean Coal Refinery. The LFC processing plant is designed to be modular. A base plant is designed to process 5,000 metric tons of coal or lignite per day (208 metric tons per hour). This plant also includes a 40 MW cogeneration facility capable of providing 20 MW for sale to a local utility grid. This request seeks 50% funding of the LFC Engineering & Economic Feasibility Study which would determine specifically the required size of the stand alone Clean Coal Refinery.
- (17) **Environmental Performance:** A significant portion of existing electrical power plants and the majority of the new electrical power generating capacity worldwide will be fueled by coal. The LFC Process offers a method that can markedly reduce the environmentally damaging SO₂ emissions from such coal-fired power plants. The upgrading or drying of low-rank coals and lignites in a Clean Coal Refinery removes most of the moisture, thereby increasing the heating value of the solid product and, therefore, decreasing the transportation costs and infrastructure impact. The mild pyrolysis (or mild gasification) removes a significant fraction of the organic sulfur. The use of the Process Derived Fuel (PDF) or clean coal, such as produced in an LFC Clean Coal Refinery, will significantly reduce the SO₂ emissions of electrical power plants or commercial facilities. The LFC technology is currently employed at the ENCOAL LFC Demonstration Plant in Gillette, Wyoming. ENCOAL Corporation owns the plant and licenses the LFC Process from the TEK-KOL Partnership, jointly owned by SGI International and SMC Mining Company. The U.S. Department of Energy and ENCOAL are co-funding this \$72 million project under Round Three of the government's Clean Coal Technology Demonstration Program. In September 1994, the program was extended for two years, bringing the overall project cost to \$90 million. The ENCOAL Plant has been demonstrating the effectiveness of this sulfur reduction at near-commercial scale since it began operation in June of 1992.
- (18) **Project Duration:** The LFC Engineering & Economic Feasibility Study is expected to take 6 to 9 months to complete depending upon the time it takes to ship the 500 kg run-of-mine coal sample from Zhalainguoer to the SGI Development Center in Perrysburg, Ohio. The actual construction of an LFC processing plant is expected to take 24 to 36 months from the onset of design and permitting to the completion of construction and startup.
- (19) **Estimated Total Cost of the Project:** The cost to conduct an LFC Engineering & Economic Feasibility Study of a 5,000 metric ton per day LFC processing plant is \$400,000 US dollars. This request seeks \$200,000 to cover the Chinese half of the Feasibility Study. SGI International intends to fund the remaining cost. Note that the cost to design and construct a stand alone 5,000 tonne-per-day LFC Clean Coal Refinery Plant is expected to be \$125 million US dollars.
- (20) **Government's Incentive Cost:** The \$400,000 cost to perform the LFC Engineering & Economic Feasibility Study is normally shared by SGI International and the prospective joint venture partner. However, in the case of a developing nation such as China, funds for feasibility study are extremely limited or non-existent. In this case the Zhalainguoer Coal Mine Administration and the Chinese government have requested that SGI International find partners that would fund their 50%. Therefore, the cost to the US Government is \$200,000 to fund one-half the feasibility study. The financial benefit to the United States in return for such a \$200,000 commitment is potentially very large. Providing the LFC Engineering & Economic Feasibility Study is positive, it is expected

that commercial and private funding support for a stand alone project will be available. As the estimated unit cost of one 5,000 tonne-per-day module is \$125 million, a stand alone Clean Coal Refinery project then would result in significant equipment and service contracts to U.S. firms.

- (21) **Commercialization Potential in the Host Country:** One of the world's most attractive regions for pursuing SGI's business strategy is China. China has between 160 billion and 185 billion tonnes of proven coal reserves, of which over 71 billion are classified as subbituminous or lignite. China is also the world's largest producer and user of coal, with 1992 production being nearly 1.1 billion tonnes. Approximately 74% of China's electricity is generated from coal-fired plants. Even at current rates of production and growth, these reserves are sufficiently ample to supply China with hundreds of years of energy. China also has a large population and an emerging industrial infrastructure. Industrialization and improvements in the standard of living depend, in large measure, on the ability of the nation to generate hard currency through export of a portion of its natural resources. Export of a clean coal product also contributes to cleaner, more environmentally favorable power production in the Pacific Rim. The country's leadership is committed to limiting the environmental impact of its energy policies. All these factors were considered in evaluating SGI's business opportunities in China based on the use of the proprietary LFC Process for upgrading coal and producing petroleum substitutes. Should only a small portion of all the new electrical generating plants in China between now and 2030 employ Process Derived Fuel (PDF), a vast number of LFC Clean Coal Refineries could be designed and constructed.
- (22) **Global Commercialization Potential:** The global commercialization potential is nearly unlimited. There are vast quantities of low-grade, sub-bituminous and lignite coals around the world and these coals are disadvantaged in the marketplace because their high water content which makes them very expensive to transport to distant markets, and their low heat value makes them an inefficient boiler fuel. The transportation cost component of the coal's delivered price can be over 3-5 times the cost of the coal at the mine. More importantly, many of the world's low-rank coals are also relatively high in sulfur which results in unacceptable sulfur dioxide emissions when burned. The world-wide potential to reduce sulfur dioxide emissions through use of the solid Process Derived Fuel (PDF) is environmentally very important. An LFC Clean Coal Refinery, in addition to producing a low sulfur, high heating value, premium quality Clean Coal, also produces a valuable liquid co-product with characteristics similar to a number 6, low-sulfur fuel oil. However, the Coal Derived Liquid (CDL) is of better quality than a number 6 fuel oil and with a very slight amount of dewaxing can produce other extremely attractive, value-added products.

- (23) **Notes of Comments:**

LFC DEMONSTRATION PLANT

In 1990, ENCOAL Corporation and the U.S. Department of Energy (DOE) negotiated a cooperative agreement to construct and operate for two years, a Clean Coal Demonstration Plant using the LFC Process at the Buckskin Mine near Gillette, Wyoming. Under this cooperative agreement, the DOE is sharing 50% of the allowable project costs. The LFC technology was licensed to ENCOAL by TEK-KOL. TEK-KOL is owned by SGI International and SMC Mining Company. ENCOAL's project was selected for co-funding by the DOE in December 1989, under Round Three of the U.S. Government's Clean Coal Technology Demonstration Program. After completion, the DOE approved funding for an extension of the operational phase. The total cost for design, construction and the first two years of operation was less than the estimated \$72.6 million. In

September 1994, the program was extended for two years, bringing the overall project cost to \$90 million.

Construction of the LFC Clean Coal Demonstration Plant began in October 1990 and was completed in June 1992 with an announcement by the DOE that ENCOAL had met its construction and start-up goals for the plant successfully. In May, June and July of 1994, with only minor interruptions, the plant operated for 68 consecutive days at more than 90% availability — more than 600,000 gallons of specification CDL was produced and sold, and more than 12,000 short tons of PDF was stored following stabilization for two months with no significant self-heating observed.

The experience gained from plant operations has allowed ENCOAL to modify plant components and complete installation of additional equipment intended to bring the plant up to continuous, optimum production of deliverable products for shipment to its customers. At this time, most of the components of the LFC Technology as applied in the ENCOAL plant have been demonstrated. The integrated operation of all plant equipment using advanced computer control techniques has been very successful. The following unique process steps have been demonstrated at the ENCOAL plant: coal drying on a rotary grate using convective heating; coal devolatilization on a rotary grate using convective heating; hot particulate removal with cyclones; combustors operating on low BTU gas from internal streams; solids stabilization for storage; computer control of a mild coal gasification process; and dust suppression of the PDF solids.

REQUIREMENT FOR FEASIBILITY STUDY

The successful completion of an LFC Engineering & Economic Feasibility Study is required to reliably establish that a stand alone Clean Coal Refinery Project is desirable, practical and suitable from both an economic as well as an engineering and technical standpoint. A successful study which results in the design and construction of one or more 5,000 tonne-per-day LFC Clean Coal Refineries would greatly benefit the United States economy in several ways. With the anticipated unit cost of one 5,000 tonne-per-day LFC Clean Coal Refinery module being approximately \$125 million, there would generate significant U.S. based goods and service contracts in support of design, equipment provisioning and construction. Additionally, it would meet the intent of Congress in exporting the fruits of the U.S. Clean Coal Technology to the benefit of developing economies and countries. However, in the case of China, as with other developing economies, the funding for half of the LFC Engineering & Economic Feasibility Study is not available. Consequently, we seek U.S. Government assistance in providing the portion of the expense of the study which would otherwise be paid by the Zhalainguoer Coal Mine Administration or China. Such a relatively small contribution to the overall project could have a large multiplying effect in the return of goods and service contracts to the U.S.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) **Technology:** SGI International's Liquid From Coal (LFC) Process
- (2) **Federal Incentive:** 50% Cost Sharing of the LFC Engineering & Economic Feasibility Proposal for a Clean Coal Refinery.
- (3) **Project Title:** POLAND ONE Clean Coal Refinery Project
- (4) **Respondent:** SGI International
- (5) **Mail Address:** 1200 Prospect Street, Suite 325
- (6) **City:** La Jolla   (7) **State:** California   (8) **Zip:** 92037
- (9) **Primary Contact:** Scott A. van Hoften, Manager of International Projects
- (10) **Phone No.:** (619) 551-1090   (11) **FAX No.:** (619) 551-0247
- (12) **Project Location:** Belchatów and other Mine-Power Plants in Poland
- (13) **Host Country:** Poland
- (14) **Applicability:** The LFC Process is primarily suited for a stand alone Clean Coal Refinery (CCR) to be built at or near the mouth of a subbituminous or lignite mine. The solid, Process Derived Fuel (PDF) product can be directly consumed by an electrical power plant where an LFC Clean Coal Refinery is coupled with a coal-fired power plant co-located at the mine-mouth. However, the LFC Process is not limited to the utility sector and the process can be utilized for the commercial and industrial sectors such as cement or aluminum plants.
- (15) **Source(s) of Coal:** Generally, the run-of-mine coals that are the most attractive candidates for LFC Process upgrading have high moisture (greater than 20%); low ash content (less than 15%); a hydrogen to carbon (H/C) ratio of 0.8, or greater; and a fuel ratio (fixed carbon to volatile matter) of 1.4, or smaller. Typical ideal coal candidates are usually subbituminous or lignite in rank. The Belchatów Lignite Mine has significant

reserves that meet these criteria and Poland has an immediate need to employ such an upgrading technology.

- (16) **Project Size:** Conducting an LFC Engineering & Economic Feasibility Study is the initial step in developing an LFC Clean Coal Refinery. The LFC processing plant is designed to be modular. A base plant is designed to process 5,000 metric tons of coal or lignite per day (208 metric tons per hour). This plant also includes a 40 MW cogeneration facility capable of providing 20 MW for sale to a local utility grid. This request seeks 50% funding of the LFC Engineering & Economic Feasibility Study which would determine specifically the required size of the stand alone Clean Coal Refinery.
- (17) **Environmental Performance:** A significant portion of existing electrical power plants and the majority of the new electrical power generating capacity worldwide will be fueled by coal. The LFC Process offers a method that can markedly reduce the environmentally damaging SO₂ emissions from such coal-fired power plants. The upgrading or drying of low-rank coals and lignites in a Clean Coal Refinery removes most of the moisture, thereby increasing the heating value of the solid product and, therefore, decreasing the transportation costs and infrastructure impact. The mild pyrolysis (or mild gasification) removes a significant fraction of the organic sulfur. The use of the Process Derived Fuel (PDF) or clean coal, such as produced in an LFC Clean Coal Refinery, will significantly reduce the SO₂ emissions of electrical power plants or commercial facilities. The LFC technology is currently employed at the ENCOAL LFC Demonstration Plant in Gillette, Wyoming. ENCOAL Corporation owns the plant and licenses the LFC Process from the TEK-KOL Partnership, jointly owned by SGI International and SMC Mining Company. The U.S. Department of Energy and ENCOAL are co-funding this \$72 million project under Round Three of the government's Clean Coal Technology Demonstration Program. In September 1994, the program was extended for two years, bringing the overall project cost to \$90 million. The ENCOAL Plant has been demonstrating the effectiveness of this sulfur reduction at near-commercial scale since it began operation in June of 1992.
- (18) **Project Duration:** The LFC Engineering & Economic Feasibility Study is expected to take 6 to 9 months to complete depending upon the time it takes to ship the 500 kg run-of-mine coal sample from Poland to the SGI Development Center in Perrysburg, Ohio. The actual construction of an LFC processing plant is expected to take 24 to 36 months from the onset of design and permitting to the completion of construction and startup.
- (19) **Estimated Total Cost of the Project:** The cost to conduct an LFC Engineering & Economic Feasibility Study of a 5,000 metric ton per day LFC processing plant is \$400,000 US dollars. This request seeks \$200,000 to cover the Polish half of the Feasibility Study. SGI International intends to fund the remaining cost. Note that the cost to design and construct a stand alone 5,000 tonne-per-day LFC Clean Coal Refinery Plant is expected to be \$125 million US dollars.
- (20) **Government's Incentive Cost:** The \$400,000 cost to perform the LFC Engineering & Economic Feasibility Study is normally shared by SGI International and the prospective joint venture partner. However, in the case of a nation such as Poland, funds for feasibility study are extremely limited. Therefore, the cost to the US Government is \$200,000 to fund one-half the feasibility study. The financial benefit to the United States in return for such a \$200,000 commitment is potentially very large. Providing the LFC Engineering & Economic Feasibility Study is positive, it is expected that commercial and private funding support for a stand alone project will be available. As the estimated unit cost of one 5,000 tonne-per-day module is \$125 million, a stand alone Clean Coal Refinery project then would result in significant equipment and service contracts to U.S. firms.

- (21) **Commercialization Potential in the Host Country:** Of the approximately 16.7 billion tonnes of hard coal that are classified as available for mining, about 15.7 billion tonnes are located in the Upper Silesia coal fields in 65 operating mines. This resource includes subbituminous coals that may be suitable for upgrading through the use of mild gasification technology, such as the LFC Process. LFC Clean Coal Refineries also may be appropriate for upgrading some of the lignite reserves located in southwestern Poland (Turow, 1 billion tonnes of reserves), western Poland (Scinawa, Legnica, Cybinka, and Gubin, a total of 4.9 billion tonnes), or central Poland (Konin, Adamow, and Belchatów). The Belchatów mine alone produces some 40 million tonnes per year of lignite at the present time, all of which is dedicated to a nearby 4,320 MWe power station. All these factors were considered in evaluating SGI's business opportunities in Poland based on the use of the proprietary LFC Process for upgrading coal and producing petroleum substitutes. Should only a small portion of all the new electrical generating plants in Poland between now and 2030 employ Process Derived Fuel (PDF), a vast number of LFC Clean Coal Refineries could be designed and constructed.
- (22) **Global Commercialization Potential:** The global commercialization potential is nearly unlimited. There are vast quantities of low-grade, sub-bituminous and lignite coals around the world and these coals are disadvantaged in the marketplace because their high water content which makes them very expensive to transport to distant markets, and their low heat value makes them an inefficient boiler fuel. The transportation cost component of the coal's delivered price can be over 3 – 5 times the cost of the coal at the mine. More importantly, many of the world's low-rank coals are also relatively high in sulfur which results in unacceptable sulfur dioxide emissions when burned. The world-wide potential to reduce sulfur dioxide emissions through use of the solid Process Derived Fuel (PDF) is environmentally very important. An LFC Clean Coal Refinery, in addition to producing a low sulfur, high heating value, premium quality Clean Coal, also produces a valuable liquid co-product with characteristics similar to a number 6, low-sulfur fuel oil. However, the Coal Derived Liquid (CDL) is of better quality than a number 6 fuel oil and with a very slight amount of dewaxing can produce other extremely attractive, value-added products.

(23) **Notes of Comments:**

LFC DEMONSTRATION PLANT

In 1990, ENCOAL Corporation and the U.S. Department of Energy (DOE) negotiated a cooperative agreement to construct and operate for two years, a Clean Coal Demonstration Plant using the LFC Process at the Buckskin Mine near Gillette, Wyoming. Under this cooperative agreement, the DOE is sharing 50% of the allowable project costs. The LFC technology was licensed to ENCOAL by TEK-KOL. TEK-KOL is owned by SGI International and SMC Mining Company. ENCOAL's project was selected for co-funding by the DOE in December 1989, under Round Three of the U.S. Government's Clean Coal Technology Demonstration Program. After completion, the DOE approved funding for an extension of the operational phase. The total cost for design, construction and the first two years of operation was less than the estimated \$72.6 million. In September 1994, the program was extended for two years, bringing the overall project cost to \$90 million.

Construction of the LFC Clean Coal Demonstration Plant began in October 1990 and was completed in June 1992 with an announcement by the DOE that ENCOAL had met its construction and start-up goals for the plant successfully. In May, June and July of 1994, with only minor interruptions, the plant operated for 68 consecutive days at more than 90% availability — more

than 600,000 gallons of specification CDL was produced and sold, and more than 12,000 short tons of PDF was stored following stabilization for two months with no significant self-heating observed.

The experience gained from plant operations has allowed ENCOAL to modify plant components and complete installation of additional equipment intended to bring the plant up to continuous, optimum production of deliverable products for shipment to its customers. At this time, most of the components of the LFC Technology as applied in the ENCOAL plant have been demonstrated. The integrated operation of all plant equipment using advanced computer control techniques has been very successful. The following unique process steps have been demonstrated at the ENCOAL plant: coal drying on a rotary grate using convective heating; coal devolatilization on a rotary grate using convective heating; hot particulate removal with cyclones; combustors operating on low BTU gas from internal streams; solids stabilization for storage; computer control of a mild coal gasification process; and dust suppression of the PDF solids.

REQUIREMENT FOR FEASIBILITY STUDY

The successful completion of an LFC Engineering & Economic Feasibility Study is required to reliably establish that a stand alone Clean Coal Refinery Project is desirable, practical and suitable from both an economic as well as an engineering and technical standpoint. A successful study which results in the design and construction of one or more 5,000 tonne-per-day LFC Clean Coal Refineries would greatly benefit the United States economy in several ways. With the anticipated unit cost of one 5,000 tonne-per-day LFC Clean Coal Refinery module being approximately \$125 million, there would generate significant U.S. based goods and service contracts in support of design, equipment provisioning and construction. Additionally, it would meet the intent of Congress in exporting the fruits of the U.S. Clean Coal Technology to the benefit of developing economies and countries. However, in the case of Poland, as with other developing/recovering economies, the funding for half of the LFC Engineering & Economic Feasibility Study is not available. Consequently, we seek U.S. Government assistance in providing the portion of the expense of the study which would otherwise be paid by Poland. Such a relatively small contribution to the overall project could have a large multiplying effect in the return of goods and service contracts to the U.S.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): FlueSorbent Duct-Injection Process for SO₂/Particulates Control
Potential for increased U.S. Exports of goods and services,
- (2) Federal Incentive: good relationships with emerging East European countries, *
- (3) Project Title: A 30-60 MWe Demonstration of a New, Low-Cost, High-Efficiency
Duct-Injection Process for SO₂ Control.
- (4) Respondent: Sorbent Technologies Corporation
- (5) Mailing Address: 1935 East Aurora Road
- (6) City: Twinsburg (7) State: Ohio (8) Zip: 44087
- (9) Primary Contact: Sid Nelson Jr.
- (10) Phone No.: (216) 425-2354 (11) Fax No.: (216) 425-3983
- (12) Project Location: Czech Republic (Near Prague)
- (13) Host Country: Czech Republic
- (14) Applicability: Worldwide, applicable to electric utility and industrial
sectors. It lends itself best to retrofit applications.
- (15) Source(s) of Coal: The Czech Republic has significant coal reserves.
Coals may also be imported from Poland, Germany and elsewhere. Bituminous
coals, sub-bituminous coals, and lignites; all levels of sulfur.

*mitigation of potential global climate change.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: 30 to 60 MWe

(17) Environmental Performance: No significant SO₂ control exists today in the Czech Republic. There is also a significant lack of control of particulates, particularly PM₁₀ particulates. Approximately 80 percent SO₂ control and high control of particulates (large and small) are achieved with the new low-cost technology. Also, there are no environmental wastes produced whatsoever with the new technology; a valuable by-product soil amendment is produced, instead.

(18) Project Duration: 36 Months

(19) Estimated Total Cost of the Project: \$20 Million

(20) Government's Incentive Cost: \$10 Million

(21) Commercialization Potential in Host Country: Very high. There are more than a dozen boilers in this range in the Czech Republic. Applicable larger boilers, of course, also exist.

(22) Global Commercialization Potential: Extremely high.....potentially hundreds.....in the U.S. also.

(23) Notes or Comments (Optional): The Czech Republic, like many developing countries, have little hard cash to put into environmental control facilities. This new technology requires a minimum of capital investment for equipment. Agriculture plays an important part in the economy of the Czech Republic. The fertilizer/soil conditioner by-products of the new technology are very attractive to the Czech Republic.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): E-SO_x Technology for moderate flue Gases
Desulfurization
- (2) Federal Incentive: The Improvement of the Coal Combustion Technology
with simultaneous reducing Emission into Environment
- (3) Project Title: Simultaneous wet-dry limestone desulfurization
installation in ESP prechamber
- (4) Respondent: Air & Energy Engineering Research Laboratory (AEREL)
US EPA, South research Institute (SRI), USA
- (5) Mailing Address: NC, 27711, USA
- (6) City: _____ (7) State: NC (8) Zip: _____
- (9) Primary Contact: Richard D. Stern, Senior Technical Advisor
International Technology Liaison
- (10) Phone No.: (919) 541-2973 (11) Fax No.: (919) 541-5227
- (12) Project Location: Dorogobuzh TPP, Smolenskenskaya, All-Russia
Thermal Engineering Institute (VTI)
- (13) Host Country: Russia
- (14) Applicability: Thermal Power Stations
- (15) Source(s) of Coal: mid- and low-sulfur coals of Russia

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: Full-scale demo ESP plant with 12m-high electrodes
and cleaning gases expenditure 500 m³/h

(17) Environmental Performance: Near Dorogobuzh TPP there is fertilizers
manufacturer, Therefore environmental protection at this region is
one of actual problems

(18) Project Duration: 1995-1996

(19) Estimated Total Cost of the Project: 3 mln USD

(20) Government's Incentive Cost: 1,5 mln USD

(21) Commercialization Potential in Host Country: The TPSs firing
mid- and low-sulfur coals in Russia

(22) Global Commercialization Potential: The technology is applied
at TPSs of Russia and CIS, and at TPSs of USA, Canada and Europe

(23) Notes or Comments (Optional):

**U.S. DEPARTMENT OF ENERGY
PROGRAM ANNOUNCEMENT**

**For
Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries**

PROJECT SUMMARY

- (1) **Technology:** Integrated Gasification Combined Cycle (IGCC)
- (2) **Federal Incentive:**
  - A. Facilitate access to foreign markets; (i.e., technically-capable staff in U.S. embassies; entree to energy ministries or departments of host government).
  - B. Support in pre-feasibility stage (i.e., funding through TDA)
  - C. Improved coordination of U.S. government support by various departments and agencies (i.e., among Departments of Energy, Commerce and State, Export-Import Bank, OPIC, Trade and Development Agency, AID, etc.)
  - D. Closer cooperation with private industry in assembling financing package to compete with non-U.S. competitors.
  - E. Providing assistance to host countries and sponsoring industries in resolving issues of contract development, risk, currency convertability and repatriation of revenue.
- (3) **Title:** Gujarat Gasification Project
- (4) **Respondent:** Texaco Inc.
Alternate Energy Group
- (5) **Mailing Address:** 2000 Westchester Avenue
- (6) **City:** White Plains   (7) **State:** New York   (8) **Zip:** 10650
- (9) **Primary Contact:** Chris Gidez
- (10) **Phone:** (914) 253-6170   (11) **Fax:** (914) 253-7744
- (12) **Project Location:** Gujarat

- (13) **Host Country:** India
- (14) **Applicability:** This technology is best suited for the electric utility or industrial sectors and should be considered for the construction of new facilities.
- (15) **Sources of Coal:** The State of Orissa, India
- (16) **Project Size:** 300 - 400 MW
- (17) **Environmental Performance:**

Integrated Gasification Combined Cycle (IGCC) is widely recognized as the cleanest, most efficient and versatile technology for the production of electricity from coal and other "dirty" hydrocarbon feedstocks containing sulfur, metals and other potential pollutants.

Compared to conventional coal-fired boiler systems, IGCC can reduce sulfur dioxide (SO₂) emissions by more than 99 percent; nitrogen oxides (NO_x) emissions reductions by up to 85 percent; and carbon dioxide (CO₂) emissions by 15 percent or more. IGCC achieves an equally impressive performance in particulates emissions, waste water discharge and solid waste generation. In fact, the only two solid byproducts of IGCC, sulfur and non-leachable slag, both have market value: sulfur for fertilizer production and slag for use as an aggregate, roadbed base or abrasive.

In India, new national policies have been adopted to combat industrial pollution through both increased regulation and some fiscal incentives. In addition in 1994 the government strengthened regulation governing environmental assessments, requiring, among other things, broad consultation and public participation. Many Indian states have adopted participatory approaches that utilize economic incentives to protect forests and preserve biodiversity.

- (18) **Project Duration:** Development, engineering and construction phase is estimated at 3-5 years; nominal plant life is 30 years.
- (19) **Estimated Total Cost of Project:** \$365 million

In fully assessing the cost of power generation using different technologies, it is critical to understand the environmental costs (i.e., externality costs) associated with each. Externality costs are a means of monetarily quantifying the relative impact of controlling production of emissions of various elements into the environment. By calculating the value of the "avoided" emissions of SO₂, NO_x and CO₂ by installing

IGCC versus conventional coal technologies (using a 250 megawatt case), the developer can realize a \$16-18MM annual environmental cost savings, equivalent to approximately 1.0¢ per kilowatt hour advantage. Additional savings are achieved by IGCC's reduced solids discharge. Assuming a \$10/ton solids disposal cost, and considering that other coal technologies (including PC w/FGD and AFBC) generate between 300-400 thousand tons per year more solids than IGCC (250MW case), the IGCC facility would enjoy an annual cost savings of between \$1.7-3.9MM. Altogether, these environmental cost benefits can be equated to an environmental capital value in excess of \$500/kilowatt capital cost reduction relative to other technologies.

(20) Government's Incentive Cost:

Cost to the U.S. government to provide project support as outlined above would be minimal. No direct funding is requested nor required. The bulk of the support requested is in the form of political, coordinating, technical and financial expertise. Existing authority within TDA, Ex-Im, OPIC and AID would be sufficient.

(21) Commercialization Potential in Host Country:

The annual power growth is 8,000 MW per year through the year 2000. About 65% of these additions will be coal-fired plants.

(22) Global Commercialization Potential:

According to widely accepted estimates, the potential market for Clean Coal Technologies (CCT) in developing and transitional economies is projected to be \$600-800 billion between 1993-2010, with an export potential of approximately \$200 billion for exporting nations. This translates to up to 70,000 new jobs in exporting nations. Of this, IGCC could capture 80 percent of the global clean coal market, according to Market Potential for Clean Coal Technologies (U.S. DOE, 9/92).

Since IGCC is regarded as among the most advanced and commercially proven CCT, it is frequently cited by host countries as a preferred technology, assuming issues of risk and financing can be resolved.

(23) Comments:

In the near-term, the large bulk of new, grassroots coal-fueled power projects will be constructed outside the U.S., primarily in developing nations or those nations in transition to market-based economies. Hence, the primary markets for U.S. companies are overseas.

At present, the United States is considered the world leader in Clean Coal Technology. However, other countries, including Japan and Germany, represent a significant threat to the U.S. leadership position; due in large part to the support being provided to industry by their respective governments. For host countries making a CCT selection, support in the financing and commercial structure of the project is often as important as the technology itself. Without coordinated, aggressive support by the U.S. government, as described above, U.S. companies can be expected to lose out in the competition for the lucrative and strategically critical project opportunities.

An added incentive for the U.S. government to take a project proactive role in supporting CCT export is the potential for Joint Implementation credits.

While technologies such as IGCC may be considered "commercial" in OECD countries, the financial community is hesitant to provide typical financing packages in developing countries or countries with market economies in transition without substantial political and coordinating support from both the host government as well as the government of the project developers or technology providers. Hence, the U.S. government must recognize the greater complexities involved in developing CCT projects in these regions; just as it recognizes that it is in these regions where the greatest environmental benefit can be achieved.

Wide Product Slate and Feedstock Flexibility

Two added benefits of IGCC, versus other Clean Coal Technologies, are its flexibility in both feedstock acceptance and product slate.

A Texaco IGCC facility, in a cogeneration or trigeneration mode, can produce a number of valuable products simultaneously, including steam, town gas and industrial gases. In one scenario, an IGCC could generate both electricity and town gas, thereby supplanting direct burning of coal in homes as well as old, inefficient and dirty coal utility boilers.

With minimal if any additional capital requirement, a Texaco IGCC can accept a wide variety of feedstocks, including petroleum residues, petroleum coke, low-grade, high-sulfur coals, bitumen emulsions and even hydrocarbonaceous wastes, such as used oils, scrap tires, municipal and industrial sludge and plastics. The result is that relatively inexpensive fuels sources can be used to augment coal, reducing fuel costs. In certain instances, waste products will command a tipping fee, further reducing power generation costs. Thus, the IGCC facility can serve not only as a provider of reliable, cost-effective and clean energy products, but can also provide innovative waste management solutions for communities and industries.

An IGCC in a refinery/utility mode can accept both coal and "bottom-of-the-barrel" crude slates and residues to produce electricity and steam heat for a local utility, as well as power, steam and hydrogen for the refinery, improving utility emissions and refinery emissions (by allowing for the shutdown of inefficient, dirty boilers) and improve the productivity of the refinery -- providing more reliable and cleaner transportation fuels along with electricity.

Texaco's Alternate Energy Group is a world leader in the development and commercialization of gasification technology. Worldwide, more than 45 Texaco-licensed gasification facilities are in operation or in design/construction for the production of chemicals, fertilizer, town gas and power.

Texaco has expertise in the development, design, construction and operation of power generation facilities (currently with 1100 MW of natural gas-fired cogeneration capacity in operation). This includes participation in the Cool Water Coal Gasification Program, the first commercial demonstration of IGCC technology (1984-89). Texaco owned or licensed IGCC facilities are currently under development in Florida, Kansas and Italy (including the 260 MW Polk Power Project being developed by Tampa Electric Co. with DOE support through its Clean Coal Technology Program). However, IGCC has yet to be deployed in non-OECD countries, where the technology can achieve the greatest environmental benefits.

Among the Texaco expertise which may be drawn upon in this project are an engineering staff of over 100 highly skilled specialists, as well as an experienced project development and marketing staff.

**U.S. DEPARTMENT OF ENERGY
PROGRAM ANNOUNCEMENT**

**For
Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries**

PROJECT SUMMARY

- (1) **Technology:** Integrated Gasification Combined Cycle (IGCC)
- (2) **Federal Incentive:**
- A. Facilitate access to foreign markets; (i.e., technically-capable staff in U.S. embassies; entree to energy ministries or departments of host government).
  - B. Support in pre-feasibility stage (i.e., funding through TDA).
  - C. Improved coordination of U.S. government support by various departments and agencies (i.e., among Departments of Energy, Commerce and State, Export-Import Bank, OPIC, Trade and Development Agency, AID, etc.)
  - D. Closer cooperation with private industry in assembling financing package to compete with non-U.S. competitors.
  - E. Providing assistance to host countries and sponsoring industries in resolving issues of contract development, risk, currency convertibility and repatriation of revenue.
- (3) **Title:** Eastern Europe Clean Energy Project.
- (4) **Respondent:** Texaco Inc.
Alternate Energy Group
- (5) **Mailing Address:** 2000 Westchester Avenue
- (6) **City:** White Plains   (7) **State:** New York   (8) **Zip:** 10650
- (9) **Primary Contact:** Chris Gidez
- (10) **Phone:** (914) 253-6170   (11) **Fax:** (914) 253-7744
- (12) **Project Location:** Eastern Europe
- (13) **Host Country:** Eastern Europe

- (14) **Applicability:** The proposed IGCC facility would be a "grassroots" electric power plant.
- (15) **Sources of Coal:** Indigenous Eastern European Coals
- (16) **Project Size:** The IGCC plant(s) would produce approximately 200 to 400 MW from approximately 1400 to 2800 MTPD coal respectively.
- (17) **Environmental Performance:**

Integrated Gasification Combined Cycle (IGCC) is widely recognized as the cleanest, most efficient and versatile technology for the production of electricity from coal and other "dirty" hydrocarbon feedstocks.

Compared to unscrubbed conventional boiler systems, IGCC achieves sulfur dioxide (SO₂) emissions reductions of up to 99 percent; nitrogen oxides (NO_x) emissions reductions of up to 85 percent; and carbon dioxide (CO₂) emissions reductions of up to 15 percent. IGCC achieves an equally impressive performance in particulates emissions, waste water discharge and solid waste generation. In fact, the only two solid byproducts of IGCC, sulfur and non-leachable slag, both have market value: sulfur for fertilizer production and slag for use as an aggregate, roadbed base or abrasive.

The existing outmoded power plants in the region, considered to be among the most inefficient and to have the worst air quality levels in eastern Europe, could be replaced by IGCC. In addition, with an efficiency of approximately 43% the project(s) will be significantly more efficient than conventional plants now operating in eastern Europe, leading to significant reduction in CO₂ emissions.

- (18) **Project Duration:** 3-4 years for project development, engineering and construction; 30 year nominal plant life.
- (19) **Estimated Total Cost of Project:**

\$275-560 million U.S. dollars (U.S. Gulf Coast basis).

This estimate is a bare contract cost and does not include the following: Design allowance, license fees, owner's cost, spare parts, operation and maintenance cost.

In fully assessing the cost of power generation using different technologies, it is critical to understand the environmental costs (i.e., externality costs) associated with each. Externality costs are a means of monetarily quantifying the relative impact of controlling production of emissions of various elements into the environment. By calculating the value of the "avoided" emissions of SO₂, NO_x, CO₂ & particulates, by

installing IGCC versus conventional unscrubbed coal technologies (using a 250 megawatt case), the developer can realize a \$16-18MM annual environmental cost savings, equivalent to approximately 1.0¢ per kilowatt hour advantage. Additional savings are achieved by IGCC's reduced solids discharge. Assuming a \$10/ton solids disposal cost, and considering that other coal technologies (including PC w/FGD and AFBC) generate between 300-400 thousand tons per year more solids than IGCC, the IGCC facility would enjoy an annual cost savings of between \$3-4 MM.

Altogether, these environmental cost benefits can be equated to an environmental capital value in excess of \$500/kilowatt capital cost reduction relative to other technologies.

(20) Government's Incentive Cost:

Cost to the U.S. government to provide project support as outlined above would be minimal. No direct funding is requested nor required. The bulk of the support requested is in the form of political, coordinating, technical and financial expertise. Existing funds within TDA, Ex-Im, OPIC and AID would be sufficient.

(21) Commercialization Potential in Host Country:

According to widely accepted estimates, the potential market for Clean Coal Technologies (CCT) in Eastern Europe is projected to be \$100-200 billion between 1993-2010, with an export potential of approximately \$50-100 billion for exporting nations. This translates to up to 15,000 new jobs in exporting nations.

(22) Global Commercialization Potential:

According to widely accepted estimates, the potential market for Clean Coal Technologies (CCT) in developing and transitional economies is projected to be \$600-800 billion between 1993-2010, with an export potential of approximately \$200 billion for exporting nations. This translates to up to 70,000 new jobs in exporting nations.

Since IGCC is regarded as among the most advanced and commercially proven CCT, it is frequently cited by host countries as a preferred technology, assuming issues of risk and financing can be resolved.

IGCC could capture 80% of the global clean coal technology market, according to Market Potential for Clean Coal Technology Exports (U.S. DOE, 9/92).

(23) Comments:

In the near-term, the large bulk of new, grassroots coal-fueled power projects will be constructed outside the U.S., primarily in developing nations or those nations in transition to market-based economies. Hence, the primary markets for U.S. companies are overseas.

At present, the United States is considered the world leader in Clean Coal Technology. However, other countries, including Japan and Germany, represent a significant threat to the U.S. leadership position; due in large part to the support being provided to industry by their respective governments. For host countries making a CCT selection, support in the financing and commercial structure of the project is often as important as the technology itself. Without coordinated, aggressive support by the U.S. government, as described above, U.S. companies can be expected to lose out in the competition for the lucrative and strategically critical project opportunities.

An added incentive for the U.S. government to take a project proactive role in supporting CCT export is the potential for Joint Implementation credits.

While technologies such as IGCC may be considered "commercial" in OECD countries, the financial community is hesitant to provide typical financing packages in developing countries or countries with market economies in transition without substantial political and coordinating support from both the host government as well as the government of the project developers or technology providers. Hence, the U.S. government must recognize the greater complexities involved in developing CCT projects in these regions; just as it recognizes that it is in these regions where the greatest environmental benefit can be achieved.

Wide Product Slate and Feedstock Flexibility

Two added benefits of IGCC, versus other Clean Coal Technologies, are its flexibility in both feedstock acceptance and product slate.

A Texaco IGCC facility, in a cogeneration or trigeneration mode, can produce a number of valuable products simultaneously, including steam, district heat, town gas and industrial gases. In one scenario, an IGCC could generate both electricity and town gas, thereby supplanting direct burning of coal in homes as well as old, inefficient and dirty coal utility boilers.

With minimal if any additional capital requirement, a Texaco IGCC can accept a wide variety of feedstocks, including petroleum residues, petroleum coke, low-grade, high-sulfur coals, bitumen emulsions and even hydrocarbonaceous wastes, such as used oils, scrap tires, municipal and industrial sludge and plastics. The result is that

relatively inexpensive fuels sources can be used to augment coal, reducing fuel costs. In certain instances, waste products will command a tipping fee, further reducing power generation costs. Thus, the IGCC facility can serve not only as a provider of reliable, cost-effective and clean energy products, but can also provide innovative waste management solutions for communities and industries.

An IGCC in a refinery/utility mode can accept both coal and "bottom-of-the-barrel" crude slates and residues to produce electricity and steam heat for a local utility, as well as power, steam and hydrogen for the refinery, improving utility emissions and refinery emissions (by allowing for the shutdown of inefficient, dirty boilers) and improve the productivity of the refinery -- providing more reliable and cleaner transportation fuels along with electricity.

Qualifications

Texaco's Alternate Energy Group is a world leader in the development and commercialization of gasification technology. Worldwide, more than 49 Texaco-licensed gasification facilities are in operation or in design/construction for the production of chemicals, fertilizer, town gas and power.

Texaco has expertise in the development, design, construction and operation of power generation facilities. This includes participation in the Cool Water Coal Gasification Program, the first commercial demonstration of IGCC technology (1984-89). Approximately 1800 MW of Texaco owned or licensed IGCC facilities are currently under development in Florida, Kansas and Italy (including the 260 MW Polk Power Project being developed by Tampa Electric Co. with DOE support through its Clean Coal Technology Program). However, IGCC has yet to be deployed in non-OECD countries, where the technology can achieve the greatest environmental benefits.

The Texaco Gasification Process and Texaco Gasification Power Systems technologies have been licensed in western Europe (22 projects in operation and/or under design/construction) for the production of chemicals, hydrogen and electrical power. It has yet to be applied in eastern Europe in an IGCC mode, where it could achieve emissions reductions of over 99% sulfur dioxide and 85% nitrogen oxides, as well as increased reductions in carbon dioxide of about 15% as compared to conventional unscrubbed coal burning technologies.

Texaco is prepared to offer its expertise which may be drawn upon in this project including, an engineering staff of over 100 highly skilled specialists, as well as an experienced project development and marketing staff.

Respondent Thermal Organic Recycling
Equipment Corporation did not provide a
PROJECT SUMMARY form.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Slagging Coal Combustion Technology
Support first demonstration project in China by providing dollars for a
(2) Federal Incentive: portion of the U.S.-based support services and specialty equipment
- (3) Project Title: 25 MW_e Greenfield Clean Coal Power Plant in China using Slagging Coal
Combustion and Back-End Spray Dryer Absorber Technologies
- (4) Respondent: TRW Space & Technology Division (Primary), China International Thermal
Energy Engineering Corp, Foster Wheeler Corporation and Joy Technologies, Inc.
- (5) Mailing Address: Mail Stop 01/1081, One Space Park
- (6) City: Redondo Beach (7) State: CA (8) zip: 90278
- (9) Primary Contact: Dr. Shiva Ubhayakar
- (10) Phone No.: (310) 813-9296 (11) Fax No.: (310) 814-5288
- (12) Project Location: Ling Shi, Shan Xi Province, People's Republic of China
- (13) Host Country: People's Republic of China
- (14) Applicability: New Electric Utility Power Plant for this project; but can be used as retrofit
of other existing coal, oil or gas-fired boilers.
- (15) Source(s) of Coal: Shan Xi Province, China Type: Bituminous
(middling coal)

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: 25 MW_e
- (17) Environmental Performance: Emissions goals of 0.2 lb/MMBTU NO_x, over 95% SO₂ removal and 0.15 lb/MMBTU of PM-10. Overall CO₂ emissions will be reduced by reducing use of low efficiency home-furnaces fired by coal. Solid wastes will be primarily nontoxic slag and spent limestone/ash material.
- (18) Project Duration: 3 years
- (19) Estimated Total Cost of the Project: \$150 million Renminbi + \$5 million = \$23 million (equivalent)
- (20) Government's Incentive Cost: \$5 million
- (21) Commercialization Potential in Host Country: China is projecting a total of 17,000 MW_e per year for 10 years. Potential market for slagging coal combustion technology is 340 to 1700 MW_e per year for 10 years (2% to 10% share)
- (22) Global Commercialization Potential: A total of about 6000 MW_e in Eastern Europe, Russia, Korea, Ukraine and India over next ten years
- (23) Notes or Comments (Optional): Data provided by CITEEC:
- (1) China's State Science and Technology Commission (SSTC) has decided that this project is an important part of its plan for 1995-2000 period, and has proposed this to DOE as a cooperative project between DOE & SSTC.
- (2) Acid rain is a very serious problem in China and covers 29% of the total area. The south and Southwestern part of China is one of the three highest acid rain polluted areas in the world. This project will provide means of retrofitting boilers to mitigate the acid rain problem at relatively low costs.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Slagging Coal Combustion Technology
- (2) Federal Incentive: \$5 to 6 Million
- (3) Project Title: Retrofit Demonstration of Clean Coal Slagging Combustor
Technology in Ukraine/Ladyzen Power Plant
- (4) Respondent: TRW Space & Technology Division (Primary), Vinnitsaenergo Utility,
Ukraine
- (5) Mailing Address: Mail Stop 01/1070, One Space Park
- (6) City: Redondo Beach (7) State: California (8) Zip: 90278
- (9) Primary Contact: Dr. Gregory Listvinsky
- (10) Phone No.: (310) 813-9275 (11) Fax No.: (310) 814-8290
- (12) Project Location: Ladyzen Power Plant, Vinnitsa Oblast, Ukraine
- (13) Host Country: Ukraine
- (14) Applicability: Retrofit of existing boilers, can be used for new boilers.
- (15) Source(s) of Coal: Lvov - Volyn Basin, Ukraine
High ash, Bituminous Coal

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: Retrofit 300 MWe Boiler, Phase One, 200 Mwt Slagging Combustion
System integrated with existing boiler
- (17) Environmental Performance: Emissions goals of 0.2 lb/MMBTU NO_x, over 95%
SO₂ removal and 0.015lb/MMBTU of PM-10. CO₂ emissions will also be lower than existing
Ukraineian pulverized coal plants due to higher carbon conversion efficiency.
Solid wastes will be primarily usable environmentally neutral construction material.
- (18) Project Duration: 4 years.
- (19) Estimated Total Cost of the Project: \$35 Million equivalent total with
Phase One \$15 Million (equivalent)
- (20) Government's Incentive Cost: \$5 - 6 Million
- (21) Commercialization Potential in Host Country: _____
200 to 300 MW_e per year for over 20 years to retrofit the existing power plant.
- (22) Global Commercialization Potential: _____
A total of about 6000 MW_e in Eastern Europe, Russia, Ukraine, India and Korea
over next twenty years.
- (23) Notes or Comments (Optional): Particularly attractive technology for Ukraine.
Allows to eliminate gas/oil assist while meeting environmental standards. Cost effective
way to retrofit the existing plants and bring power output to rated capacity
Consistent with the the US Government pledge to reduce Ukraine dependence on
nuclear power.

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Coal Preparation
- (2) Federal Incentive: Need for financial incentives in a new developing market.
- (3) Project Title: Coal Preparation, an idea whose time has come. utilizing
prepared coal in Power Plants in India.
- (4) Respondent: Viking Systems International
- (5) Mailing Address: 2070 William Pitt Way
- (6) City: Pittsburgh (7) State: PA (8) Zip: 15238
- (9) Primary Contact: Jack Saluja
- (10) Phone No.: (412) 826-3355 (11) Fax No.: (412) 826-3353
- (12) Project Location: West Bengal
- (13) Host Country: India
- (14) Applicability: Power Generation Sector
- (15) Source(s) of Coal: Eastern Coal Fields Ltd.

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

(16) Project Size: A plant to prepare over 5 million tons of coal per year.

(17) Environmental Performance: Improved Power Plant Performance; reduced
CO₂ and particulates; Increased life & operating efficiency of boilers.

(18) Project Duration: Two and one-half years.

(19) Estimated Total Cost of the Project: 40 million dollars

(20) Government's Incentive Cost: Availability of guaranteed low interest
loans.

(21) Commercialization Potential in Host Country: At least six to eight
similar size plants.

(22) Global Commercialization Potential: Considerable.

(23) Notes or Comments (Optional): _____

U.S. DEPARTMENT OF ENERGY

PROGRAM ANNOUNCEMENT
for

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY

- (1) Technology(ies): Utilization of ash from Power Plants.
- (2) Federal Incentive: Need for financial incentives in a new developing market.
- (3) Project Title: Utilization of combustion ash for useful products.
- _____
- _____
- (4) Respondent: Viking Systems International
- _____
- (5) Mailing Address: 2070 William Pitt Way
- _____
- (6) City: Pittsburgh (7) State: PA (8) Zip: 15238
- (9) Primary Contact: Jack Saluja
- (10) Phone No.: (412) 826-3355 (11) Fax No.: (412) 826-3353
- (12) Project Location: Site to be determined after initial feasibility study.
- (13) Host Country: India
- (14) Applicability: Commercial Sector
- _____
- (15) Source(s) of Coal: Dependent on the site chosen after the initial feasibility study is completed.
- _____
- _____
- _____

Solicitation of Expressions of Interest in Commercial
Clean Coal Technology Projects in Foreign Countries

PROJECT SUMMARY CONTINUED

- (16) Project Size: To process 500,000 tons of ash per year.
- (17) Environmental Performance: Presently ash is dumped into ash ponds and has posed considerable environmental problems & land use problems throughout the country.
- (18) Project Duration: 12 months
- (19) Estimated Total Cost of the Project: Between \$5*10⁶ and \$6*10⁶.
- (20) Government's Incentive Cost: Need for guaranteed low interest loans
- (21) Commercialization Potential in Host Country: Considerable - feasibility study has not been started & already many requests have been obtained to put up such plants.
- (22) Global Commercialization Potential: Tremendous; Need in Kazakhstan, Bulgaria, Hungary & many other countries.
- (23) Notes or Comments (Optional): _____

APPENDIX D

ADDITIONAL MATERIALS RECEIVED

Bharat Heavy Electricals Limited

High Pressure Boiler Plant, Tiruchirappalli-620014,
Tamil Nadu, India.

Phone: Office: 63338

Grams: BHARATELEC

Telex: 0485 211 & 0485 212 (BHHP IN)

Fax: 91-(0431)-87710

91-(0431)-83353

N. KRISHNAMURTHI
Additional General Manager

NO. BHE:R&D:NM:

DT. 13-01-1995

FAX NO. 412-892-4736

Dear Dr. Rao,

Kindly refer to the discussions we had with you during your visit to BHEL/Tiruchi on 27.01.94. Please find enclosed Solicitation of expressions of interest in Ruppert - 11 plant coal technology projects in foreign countries for further processing at your end.

With kind regards,

Yours sincerely,

N. Krishnamurthi
(N. KRISHNAMURTHI)

ENCL: AS STATED

TO
DR. S. N. RAO,
ASSISTANT TECH. SUPPORT MANAGER,
GURNG & ROE SERVICES CORPORATION,
P.O. BOX NO. 18284,
PITTSBURGH,
PA 15236

Regd. Office: BHEL HOUSE, Sin Fort, New Delhi-110 048

SOLICITATION OF EXPRESSIONS OF INTEREST IN COMMERCIAL CLEAN
COAL TECHNOLOGY PROJECTS IN FOREIGN COUNTRIES.

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1. TECHNOLOGY	:	CONTROL OF AIR TOXIC
2. TITLE	:	CONTROL OF AIR TOXIC METALS IN INDIAN HIGH ASH COAL FIRED BOILERS.
3. PROJECT LOCATION	:	INDIA
4. CONTACT PERSON & ADDRESS	:	SHRI N.KRISHNAMURTHI, ADDL. GENERAL MANAGER RESEARCH & DEVELOPMENT BHEL, TIRUCHIRAPALLI, INDIA 620 014 PHONE NO. 91-0431-4- 553203 & 553338 FAX NO. 91-0431-553333
5. HOST COUNTRY	:	INDIA
6. SOURCES OF COAL	:	DIFFERENT MINES / POWER STATIONS
7. POSSIBLE COLLABORATING AGENCY IN USA	:	DR. STEVEN A.BENSON DIRECTOR CENTER FOR AIR TOXIC METALS ENERGY & ENVIRONMENTAL RESEARCH CENTRE, P.O. BOX 9018 GRAND FORKS, ND 58202 - 9018

**EXPRESSIONS OF INTEREST IN COMMERCIAL CLEAN COAL TECHNOLOGY
PROJECTS IN FOREIGN COUNTRIES.**

1. TECHNOLOGY : CONVERSION TECHNOLOGIES

2. TITLE : DEMONSTRATION OF COAL WATER SLURRY AND
HYDROTHERMALLY DEWATERED LIGNITE
SLURRY FIRING SYSTEMS IN BOILERS.

3. PROJECT LOCATION : DHUL / INDIA

4. CONTACT PERSON : N.KRISHNAMURTHI

5. ADDRESS : ADDL. GENERAL MANAGER/R&D
BHARAT HEAVY ELECTRICALS LTD.,
TIRUCHIRAPALLI, TAMIL NADU
INDIA PIN CODE: 620 014
PHONE NO. 91-0431-553203
FAX NO. 91-0431-053323

6. HOST COUNTRY : INDIA

7. SOURCES OF COAL : LOW ASH/BENEFICIATED COALS
LIGNITE FROM NEYVELI IN TAMIL NADU

8. POSSIBLE COLLABORATING
AGENCY CENTER FOR ENVIRONMENTAL & ENERGY
R&D COMMERCIALISATION SERVICES
ENVIRONMENTAL & ENERGY RESEARCH
INTERNATIONAL LIMITED
BOX 8103, UNIVERSITY STATION
GRAND FORKS, NORTH DAKOTA
58202, USA.

ATTN.: MR. BHASKAR PATEL
CO-CHAIRMAN

9. ABSTRACT 1

In Indian context low ash coal reserves are very low and the low ash coal available is of high sulphur in Assam which is very much away from the major user centers. In Southern India, lignite reserves are available considerably in Tamilnadu. If the moisture content is reduced and a slurry is prepared economically then this technology is applicable for retrofitting numerous smaller capacity oil fired boilers to substitute oil, for reburning to reduce NOx and for load regain in coal lignite fired boilers.

The objective of this project is to demonstrate this technology. This will facilitate soliciting demonstration opportunities and implementing at a few locations.

BHEL has carried out earlier a project on Development of Coal Water Slurry Project under USAID. It has a fully equipped laboratory for slurry characterisation, slurry preparation, handling, combustion and has carried out successful studies on atomised combustion of slurry and combustion of slurries in fluid bed.

Now it is also equipped to study heat transfer aspects on slag depositions.

APPLICABILITY 1

Demo Scale Thermal dewatering of Lignite and combustion have been demonstrated by Environmental and Energy Research International Ltd. in USA.

COMMERCIAL POTENTIAL1

- * Already ATIRA (Ahmedabad Textile Industries Research Association) and CERA have proposed joint work in Gujarat, India. Further commercial potential is dependent on techno-economic viability of the system.

budget duration

FOUR YEARS.

8. ABSTRACT :-

The mineral content associated with Indian coal is very high varying from 25 to 50%. The coals and lignites are distributed over 58 coal fields and over 450 coal seams. Very limited studies have been made on air toxic metals and control of them.

In this project, it is intended to carry out the following:

- Analysis of trace metals in fly ashes from various power stations and create a data base - mine and power station wise.
- Identify installations with respect to severity of air toxic metals.
- Test and demonstrate the technologies for control of Air Toxic Metals in the Fuel Evaluation Test Facility (FETF) constructed by BHEL with USAID.

9.   **APPLICABILITY & COMMERCIAL POTENTIAL**   :   **LIKELY TO HAVE GOOD POTENTIAL IN INDIAN CONTEXT.**
11.   **PROJECT DURATION**   :   **AROUND 3 YEARS.**
12.   **BENEFITS**   :   **Centre for Air Toxic Metals, Grand Ford N.D. USA will have valuable information based on which adequacy or applicability of various technologies developed can be evaluated for commercialisation.**

SOLICITATION OF EXPRESSIONS OF INTEREST IN COMMERCIAL CLEAN
COAL TECHNOLOGY PROJECTS IN FOREIGN COUNTRIES.

-----

1. TECHNOLOGY : CONTROL OF AIR TOXIC
2. TITLE : CONTROL OF AIR TOXIC METALS IN
INDIAN HIGH ASH COAL FIRED BOILERS.
3. PROJECT LOCATION : INDIA
4. CONTACT PERSON &
ADDRESS : SHRI N.KRISHNAMURTHI,
ADDL. GENERAL MANAGER
RESEARCH & DEVELOPMENT
BHEL, TIRUCHIRAPALLI, INDIA
620 014
PHONE NO. 91-0431-4- 553203 & 553338
FAX NO. 91-0431-553333
5. HOST COUNTRY : INDIA
6. SOURCES OF COAL : DIFFERENT MINES / POWER STATIONS
7. POSSIBLE COLLABORATING
AGENCY IN USA : DR. STEVEN A.BENSON
DIRECTOR
CENTER FOR AIR TOXIC METALS
ENERGY & ENVIRONMENTAL RESEARCH
CENTRE,
P.O. BOX 9018
GRAND FORKS, ND 58202 - 9018

January 9, 1995

DESTEC ENERGY, INC.
2500 CITYWEST BLVD., SUITE 150
P.O. BOX 4411
HOUSTON, TEXAS 77210-4411
(713) 735-4000

Dr. Howard Feibus, Director
Office of Clean Coal Technology
Fossil Energy, FE-221 (270 CC)
U.S. Department of Energy
Washington, D.C. 20585

Dear Dr. Feibus:

I am writing to you with regards to the Request for "Expressions of Interest" solicited by your department. As you know, Destec Energy has a strong and continued interest in the global promotion, development and commercialization of clean coal technologies, specifically coal gasification combined cycle (CGCC).

On page ten of the solicitation is a paragraph which describes specific Congressional guidance by the House Report No. 103-551. It states that the Committee does not support construction of showcase facilities in international markets "to prove large gasifiers in power plants". You and I discussed this potential limitation and ways the government can help us develop or commercialize CGCC overseas.

The U.S. Government might be of great assistance to support applications. Developing countries without strong environmental regulations have little incentive to apply CGCC or other clean coal technologies. These developing countries are not willing to pay any premium for CCTs when they are allowed to build unscrubbed pulverized coal units. Destec Energy sees this as the greatest barrier for commercialization of CGCC and other clean coal technologies.

Although Destec Energy would like to be responsive to the solicitation by proposing a potential overseas CGCC project, we do not see how that is possible given the Congressional Committee guidance and the lack of stringent environmental regulations in developing countries. Please understand that Destec Energy wishes to continue development and use of clean coal technologies like CGCC and we stand behind our commitment to support The U.S. Department of Energy and your office towards that objective.

Sincerely yours,

A handwritten signature in cursive script that reads 'Mark W. Roll'.

Mark W. Roll
Market Manager/Coal Gasification

January 11, 1995

Dr. Howard Feibus
Director, Office of Clean Coal Technology
Fossil Energy, FE-221 (270 CC)
U.S. Department of Energy
Washington, D.C., 20585

Subject: International Commercial Clean Coal Technology Projects

Dear Howard:

I'm writing in response to the November 18, 1994 Federal Register Notice (p. 59759 ff) seeking expressions of interest in a potential program to disseminate Clean Coal Technologies (CCTs) to foreign countries. Since we are neither process developers nor implementers, our response is more general than requested in the Federal Register Notice.

As you know, EPRI has supported and actively participated in the CCT program, and we view its possible extension to deploy CCTs internationally as an opportunity not only to benefit U.S. industry but also to help address global environmental issues. Thus, we are interested in partnering with DOE and/or others on future programs to disseminate CCTs into developing countries. We see this opportunity as a logical next step in CCT development; in fact, we are already partnering with our members and the World Bank to work in developing countries such as India and China, as well as with U.S. AID in Mexico. We also have continuing projects in Russia and Lithuania, and eleven of our member utilities have partnering programs with former Eastern bloc countries.

EPRI's participation in the CCT program has focused on our expertise in technology selection, demonstration, and assessment. Through our participation in these CCT projects and other EPRI-sponsored demonstrations, we have developed an in-depth understanding of the plant upgrading and environmental management options available to planners and developers as they seek the least cost solutions for their site-specific conditions. These skills are relevant and essential to developing nations, which must balance their huge demand for electrification with limited capital resources and growing international expectations to protect the global environment.

Dr. Howard Feibus
January 11, 1995
Page 2

The attached table illustrates EPRI's long and broad involvement in the CCT program. If the CCT program extends abroad, we are interested in participating in projects that play on the strengths of our past experience with CCTs and our knowledge, skills, and products aimed at performance and emission improvements in older plants.

Thank you for the opportunity to express our interest in this initiative and comment on our international experiences. If you have any questions, please don't hesitate to call me.

Sincerely,

A handwritten signature in cursive script, appearing to read "George Heston".

9829L.GTP.dvh

EPRI Role in DOE CCT Projects

<u>Utility</u>	<u>CCT Round</u>	<u>Project</u>	<u>EPRI Participation (\$M)</u>
Alabama Power Duquesne Light Mississippi Power NSP Penn. Elect. Co. New York St. E&G PS of Oklahoma	1	CQ Inc Coal Quality Expert computer model	7
Tri-State G&T	1	Nucla CFB Demonstration Plant	11
Wisconsin P&L	2	Coal Reburning for Cyclone Boiler	1
Ohio Edison	2	B&W SO _x ,NO _x ,RO _x Box	0.5
North. Indiana PS	2	Advance Flue Gas Desulfurization	0.2
Georgia Power/SCS	2	CT-121 FGD Process Demo	7
Gulf Power/SCS	2	SCR for NO _x Control on High S Coals	2
Gulf Power/SCS	2	Advanced T-Fired NO _x Control	2
Midwest Power	3	PCFB Demo	1
Public Service of Colorado	3	Gas Reburning & Low NO _x Burners on a Wall Fired System	0.7
Richmond Power & Light	3	LIFAC Sorbent Injection Desulfurization	0.5
Ohio Edison	3	NOXSO SO ₂ -NO _x Removal Flue Gas Cleanup System	0.5
Tampa Electric	3	Tampa Electric IGCC (Texaco)	5
New York State Electric & Gas	4	Formic Acid Enhanced wet Limestone Scrubbing+NALCO NO _x out	5.5
Sierra Pacific Power	4	MW Kellogg IGCC Demo	0.5 (in kind)
PSI Energy, Inc	4	Destec Coal Gasification Repowering	5
EPRI Total			49.4

Prof. Bolesław Zaporowski
Poznań University of Technology
Piotrowo 3A
P.O.Box 1
60-965 Poznań
Poland
tel: (48-61)782277
fax: (48-61)782280

Poznań, January 13, 1995

Dr. Howard Feibus
Director of Office of Clean Coal Technologies
Fossil Energy, FE-221 (270 CC)
U.S. Department of Energy
WASHINGTON, D.C. 20585
Fax: (0-01-301) 903-0243

With reference to the Announcement of Department of Energy referring to Commercial Projects of Clean Coal Technologies for international market I am sending you the information referring to Poland. I am the scientific worker of Poznań University of Technology and my answer on your announcement has only general meaning.

In Poland 98.5% of electric energy is generated from hard coal and brown coal. In 1993 there were used for this goal about 35 mln tons of hard coal and 05 mln tons of brown coal with high content of ash. This coal is burned in power plants in pulverized-fuel boilers with no desulphurizing utilities. It causes the emission of great amount of dust, SO_2 and NO_x . I think that in Poland in the nearest future the decision will be taken to construct the power plant with the system IGCC. Nowadays in some power plants there are introduced the utilities for desulfurization of combustion gases with the help of wet and dry method and it is proposed the change of some pulverized-fuel boilers with fluidized bed boilers.

In our University there are conducted theoretical works on the system IGCC. We will deliver the results of this work to Department of Commerce and Trade of Poland, in which are subjected power plants, in a few months and we will suggest the co operation with the program Clean Coal Technology realised in USA. For Poland the most important will be possibility to buy gas generators for total, pressure gasification of coal and gas desulphurizing equipment.

Nowadays we are not able to propose particular project of power plant in Poland that can use Clean Coal Technology. We will send to you the documents for such project as it will be possible.

I would like to ask you to enter Poland on a list of countries that will develop Clean Coal Technology, particularly IGCC system.

Thank you for sending information about the program Clean Coal Technology and I would like to ask you to send us further information about the development of these technologies in USA.

Yours Sincerely

prof. B. Zaporowski

NATIONS UNIES
COMMISSION ECONOMIQUE
POUR L'EUROPE

ОБЪЕДИНЕННЫЕ НАЦИИ
ЭКОНОМИЧЕСКАЯ КОМИССИЯ
ДЛЯ ЕВРОПЫ

UNITED NATIONS
ECONOMIC COMMISSION
FOR EUROPE

Tel: +41 22 917 2444/2445 (direct)
+41 22 917 1234 (Palais des Nations)
Fax: +41 22 917 0038/36 (short messages)
+41 22 917 0123 (longer messages)

Telegram: UNATIONS, GENEVE
Telex: 41 29 62 UNO CH
Palais des Nations
CH-1211 GENEVA 10

Ref.:

Dear Mr. Feibus,

9 January 1995

Subject: Statement of Interest in US Clean Coal Technology Programme

The United Nations Economic Commission for Europe has recently created a Meeting of Experts on Clean Coal Technologies, under the Chairmanship of Mr. Theodore Atwood, Project Manager of your Department. The Meeting of Experts exchanged information on policies and technologies and through its regular programme promote technology transfer to/and business opportunities with the central and eastern European countries in transition.

At its last meeting in April 1994, the Meeting of Experts decided to develop a particular project on "Implementation Programme on Accelerating Clean Coal Technology" (IMPACCT).

The Project was designed with a purpose of promoting the application of economic (smaller-size capacities at more reasonable cost) coal technologies in the countries of central and eastern Europe and CIS members (see attached document)

The IMPACCT project has been endorsed by UN/ECE Energy Committee and strongly supported by the countries in transition. Through a special questionnaire recently circulated to these countries, we have identified several projects under different stages of development, which need to upgrade their commercial viability before being proposed to financial institutions and investors.

Mr. Howard Feibus
Director
Office of Clean Coal Technology
Fossil Energy, FE-221 (270 CC)
US Department of Energy
Washington DC 20585
United States of America

The duration of the Project is supposed to be 5 years and its execution requires approximately 1-1.2 million dollars, an amount which will mainly be used for advisory assistance and project-site demonstration workshops in the countries in transition. ECE Energy Division will prepare the programmes, organize participation of experts, identify projects, using its networks in the countries in transition. Our work will be closely coordinated with the activities related to environmental protection in which ECE has a long-standing experience.

We are aware of the DOE's Clean Coal Technology Demonstration Programme and we would like to explore the possibilities of establishing mutually supportive arrangements. We are enclosing to this letter a short information on IMPACCT in the hope that we shall be receiving your comments as well as your views on the possibilities to cooperate in this important area. If you need more information, please do not hesitate to contact me.

Looking forward to hearing from you, and wishing you a Happy and Prosperous New Year.

Yours sincerely,

Dunja Pastizzi-Ferencic
Deputy Executive Secretary

Economic and Social
Council

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ENERGY/WP.1/GE.3/6/Add.1
29 April 1994

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

COMMITTEE ON ENERGY

WORKING PARTY ON COAL

Meeting of Experts on Clean Coal Technologies
Second session, 11-13 April 1994

IMPLEMENTATION PROGRAMME ON ACCELERATING
CLEAN COAL TECHNOLOGY (IMPACCT)

Terms of reference - draft document**

(Prepared by the secretariat)*

1. Purpose of the programme

(a) The purpose of the programme is to promote the implementation of economic "clean coal technologies" by means of:

- (i) determining how to access available technologies, and how to negotiate their availability on a least cost basis;
- (ii) learning how to structure projects with a view to reducing capital costs, reducing foreign exchange costs, accelerating cash flow, identifying collateral revenue sources and facilitating financing;

---

*/ In accordance with the decision of the Meeting of Experts at its second session, held in April 1994 (ENERGY/WP.1/GE.3/6, para. 26).

**/ This document will be subsequently elaborated and completed after receiving replies and comments by Central/Eastern European Governments.

- (iii) negotiating with potential Western partner organizations (including the European Union), commercial partners (engineering and equipment supply and countertrade) and lending institutions to improve the commercial viability of the proposed projects;
- (iv) training responsible government and industry leaders from the economies in transition in project identification, development, structuring and negotiation, as well as in development and improvement of national projects engineering and project finance skills;
- (v) assisting the economies in transition to set up a legal and market economy framework with regard to the clean recovery and use of coal, including recovery and use of coal tips, methane and ash.

(b) In the selection of projects, the following criteria can be considered in addition to economic and environmental viability:

- (i) "repeatability" use of a project as a model for other urgent and economic projects;
- (ii) utilization of publicly available technologies with minimum royalties and foreign engineering and equipment costs;
- (iii) utilization, when competitive, of engineering and equipment provided from within the UN-ECE economies in transition;
- (iv) cooperation among UN/ECE member countries and enterprises, including exchange of information and skills and cross-border tendering, rather than single country projects;
- (v) ongoing cross-national training to implement project repetition.

2. Work methods: The programme should be carried out through project-site demonstration workshops, task-force meetings and case studies to discuss and to review economic, environmentally beneficial demonstration projects (regardless by whom developed) with the purpose of:

- (i) analysing how to improve the economic, financial and commercial viability of similar or related projects in the same or other countries;
- (ii) encouraging dissemination and implementation of skills learned in each project to persons responsible for similar or related projects in the same or other countries;
- (iii) encouraging cooperation aimed at project leaders, suppliers of skills and equipment, project clients, financial institutions, official and professional bodies of the market and transitional economy members of the UN/ECE.

3. The expected output is to facilitate financing and commercialization of viable projects in economies in transition by providing an expression of confidence in their technical and economic aspects from financial institutions and companies, and thus, to catalyse self-sufficiency in the implementation of clean coal technologies.

4. Proposed technico-economic project areas:

- (i) from coal mine stage (e.g. improved techniques, multiple seam exploitation, reworking mine tips, methane recovery and use);
- (ii) through coal preparation and handling before combustion and other end-uses (e.g. ash, sulphur, metals reduction, coal and coal fines briquetting for smokeless fuels; coal storage and transport economies; pre-combustion preparation processes such as lignite drying and grinding techniques);
- (iii) clean coal combustion and ash utilization (e.g. developing of FBC; retrofitting of small and medium coal-fired boilers for home, collective, industrial and municipal purposes, heat recovery, ash utilization).

5. Duration of the programme: five years.

6. Funding: to be identified by the Working Party on Coal and the Committee on Energy.

**Economic and Social
Council**

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ENERGY/WP.1/GE.3/7
29 July 1994

Original: ENGLISH

**ECONOMIC COMMISSION FOR EUROPE
COMMITTEE ON ENERGY**

WORKING PARTY ON COAL

Meeting of Experts on Clean Coal Technologies

Third session, 3-4 April 1995

Szczyrk near Bielsko, Upper Silesia (Poland)

PROVISIONAL AGENDA FOR THE THIRD SESSION*/

to be held in Szczyrk, Poland
starting on Monday, 3 April 1995 at 10 a.m.

1. Adoption of the agenda
2. Election of Officers
3. Decisions of the Working Party on Coal and the Committee on Energy concerning the work of the Meeting of Experts (ENERGY/WP.1/8 and ECE/ENERGY/25)
4. Implementation programme on accelerating clean coal technology - IMPACCT (ENERGY/WP.1/GE.3/6, Add 1 and 2)
5. Government policies and incentives, strategies and financing of national research programmes, harmful gas emission standards regarding further application of clean coal technologies.
Coordinator: Finland. General report: ENERGY/WP.1/GE.3/R.4

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*/ Simultaneous interpretation in English, French and Russian will be provided during the session.

6. Public acceptance of coal use. Coordinator: Czech Republic.
General report: ENERGY/WP.1/GE.3/R.3
7. Fuel and technology choice adapted to specific requirements domestic regulations and international conventions. Coordinator: Poland.
General report: ENERGY/WP.1/GE.3/R.7
8. Fluidized-bed combustion technologies (FBC) and integrated gasification combined cycle (IGCC), based on coal gasification: recent project demonstration achievements. Co-originators: Czech Republic and Sweden. General report: ENERGY/WP.1/GE.3/R.6
9. Coal preparation and smokeless fuel production for non-power markets and associated combustion technology. Coordinator: United Kingdom.
General report: ENERGY/WP.1/GE.3/R.5
10. Methodology for assessing the urgent needs of clean coal technology in central and eastern Europe, case study: Czech Republic. Document: (ENERGY/WP.1/GE.3/R.9 and Add 1)
11. Evaluation of three success/failure projects commercially developed in central and eastern Europe
12. Technology transfer and cooperation, joint-venture opportunities and business climate in central and eastern Europe
13. Information exchange programme at middle managerial level between experts from western, central and eastern Europe
14. Work programme
15. Date and venue of the next session
16. Other Business
17. Adoption of the report

* * * *

ANNOTATIONS

Item 3: Decisions of the Working Party on Coal and the Committee on Energy concerning the work of the Meeting of Experts

The secretariat will introduce the decisions of the Working Party on Coal and-of the Committee on Energy related to the activities of the Meeting of Experts (ENERGY/WP.1/8 and ECE/ENERGY/26).

Item 4: Implementation programme on accelerating Clean Coal technology - IMPACCT

- At its second session held in April 1994, the Meeting of Experts decided to launch a programme for accelerating the application of clean coal technology in the European and CIS countries in transition. The purpose of the programme, of its first stage, is to promote the implementation of economic, clean coal technologies by means of determining how to access available technologies, how to negotiate their availability on a least cost basis; learning experts from the ECE countries in transition how to structure projects; negotiating with potential partners how to improve the commercial viability of the proposed projects.
- The working methods and the proposed scope of projects is described in the document ENERGY/WP.1/GE.3/6/Add 1).
- The ECE Executive Secretary circulated an inquiry to all ECE member countries in transition asking them to describe all projects developed at different stages which can be a subject of assessment prior to commercial application;
- The ECE Working Party on Coal, at its session in October 1994 should discuss how to raise fundings with a view to carry out this programme over the next 5 years;
- A follow-up will be considered by the Meeting of Experts at its session in April 1995. A paper prepared by the Secretariat will summarize the developments related to the future of this programme.

Items 5 to 9: The Coordinators should prepare and send to the ECE secretariat before the end of this year the general reports, which will be submitted for consideration and discussion at the next session. Countries which have not yet sent their replies to the questionnaires under the respective subjects are requested to do so by 15 October 1994; Participants

who wish to make presentations under topics 5 to 9 are requested to indicate it in the registration form. Under agenda item 8, a part of the general report, presentations will be made only on the recent project demonstration achievements.

Item 10: Methodology for assessing the urgent needs of clean coal technology in central and eastern Europe, case study in Czech Republic

- A methodology will be prepared by the Russian Federation for consideration at the next session. A consultancy group will present and discuss independently its views on this issue, including the consideration of a case study: the criteria uses to assess the needs of clean coal technologies in the Czech Republic.

Item 11: Evaluation of three success/failure projects commercially developed in central and eastern Europe

- The Meeting of Experts will analyze the success or failure of three commercial projects developed in the ECE countries in transition. The projects should be of different nature. The ECE countries in transition are invited to make project proposals before the end of December 1994 for consideration at the next session.

Item 12: Technology transfer and cooperation, joint-venture opportunities and business climate in central and eastern Europe

- This agenda item will be carried out by panel discussion in which will take part experts from manufacturing companies, technology recipients, different energy companies in central/eastern Europe, banks. The main subjects of discussion will be the promotion of direct investments, partnerships, technology cooperation, conditions and obstacles.

Item 13: Information exchange programme at middle managerial level between experts from western, central and eastern Europe

- At the last session in April 1994, the Meeting of Experts requested the Swedish delegation and ECE secretariat to cooperate and prepare a programme for that purpose, which should be considered at its next session.

Item 14: Work programme

The Meeting of Experts will discuss and adopt its short-term programme of work. The ECE member countries may address written proposals to the secretariat before the next session.

Item 15: Date and venue of the next meeting

The delegations are invited to make proposals for hosting the 1996 session of the Meeting of Experts. Otherwise, the session will be held in Geneva.

* * * *

ANNEX

REGISTRATION FORM

MEETING OF EXPERTS CLEAN COAL TECHNOLOGIES

Szczyrk, near Bielsko, Poland, 3-4 April 1995

This form should be returned to the following
addresses by 31 December 1994:

United Nations Economic
Commission for Europe
Energy Division
Mr. Slav Slavov
Palais des Nations
CH-1211 Geneva 10
Switzerland

and

Central Mining Institute
Mr. Jerzy Prus
Head of Department
of International Relations
Plac Gwarówl, P.O. Box 3672
40-166 Katowice
Poland

Telephone: ++41 22 9172444

++41 22 9172404

Telefax: ++41 22 9170038

or ++41 22 9170036

Telex: 412962 ONU CH

Telephone: ++48 32 583022

Telefax: ++48 32 596533

Telex: 0313713/0315500

Surname:(Mr.Mrs.Ms.)..... First name:.....

Country or Organization:.....

Professional address:.....

Telephone:..... Telefax:.....

I wish to make presentation under item:.....

I shall/shall not* participate in the Workshop succeeding the Meeting of
Experts:.....

Arrival at Katowice/Flight number:.....

Departure from/flight number:.....

Please arrange accommodation at Hotel "Orle Gniazdo" in Szczyrk
from:..... to:..... for:..... nights
in single bed room:..... double bed room:.....

I wish to use a special bus between Katowice and Szczyrk:.....

*/ Delete what is not applicable

APPENDIX E

SUMMARIES OF EOIs

This Appendix includes detailed write-ups of each EOI, as discussed in Chapter 4, including: **Proposal No., Proposer, Project/Technology Description, Technology Status, Environmental Performance, Economics, and Market Potential.** Information is included to the extent to which it was provided in each EOI. If no information is available, the category is omitted from the summary.

Table E-1
Guide to Appendix E

Region/Country	Page Number	EOI Respondent Number(s)
E.1 Asian and Pacific Rim Countries (grouped together)		
E.1.1 China	E-2	2, 19, 21, 24, 26, 27, 40, 42, 45, 46, 47, 48, 50, 51, 58, 59, 63, 66, 73, 76
E.1.2 India	E-15	6, 7, 15, 16, 18, 20, 22, 23, 43, 54
E.1.3 Other Asian/Pacific Rim Countries Australia Indonesia Pakistan Pacific Rim	E-22	60 4, 52 55 65, 69, 70
E.2 Newly Independent States		
E.2.1 Russia	E-26	9, 10, 11, 12, 13, 14
E.2.2 Ukraine	E-29	17, 28, 53, 67
E.2.3 Other Newly Independent States Estonia Kazakhstan Kyrgyzstan Latvia Lithuania	E-32	38 36 35 34 33
E.3 Eastern and Central European Countries		
E.3.1 Poland	E-33	32, 57, 61, 62, 75
E.3.2 Czech Republic	E-37	3, 39, 64, 68, 77
E.3.3 Other Eastern & Central European Countries Bulgaria Hungary Romania Slovenia Slovak Republic Eastern Europe	E-40	41 37, 49 31 29 30 44, 56, 71, 72
E.4 Latin America		
Brazil and Mexico	E-43	8, 25
E.5 Country Unspecified	E-45	1, 5, 74

E.1 ASIAN AND PACIFIC RIM COUNTRIES

E.1.1 CHINA

This section contains a brief summary of each of the 20 EOIs submitted for China. Information is included to the extent to which it was provided in the EOIs. EOI summaries are listed in the order in which they appear on Table 4-2.

Proposal No.: 73

Proposer: The Babcock & Wilcox Company

Project/Technology Description: The requestor proposes to demonstrate LIMB and Coolside technology in China. These technologies involve moderate SO₂ emission reduction with concomitant moderate costs associated with capital requirements.

Technology Status: These technologies have been demonstrated under the auspices of the DOE Clean Coal Technology Program.

Environmental Performance: The LIMB and Coolside processes are expected to reduce SO₂ emissions by 60-70 percent.

Economics: The proposal indicates that the capital costs of these systems would be moderate. Definitive cost requirements would be established after preliminary design at a 2 x 100-MWe site.

Market Potential: Widespread opportunities are anticipated within the Peoples Republic of China power generation industry.

Proposal No.: 42

Proposer: Bechtel Power Corporation

Project/Technology Description: The proposed project is a 250- to 400-MWe IGCC plant, with co-production of chemicals (e.g., methanol or fertilizer), for the Beijing area.

Technology Status: Even though the specific technology was not described, this is probably a first-generation IGCC, which is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC systems release less SO₂ (over 90 percent), NO_x (below those proposed by NSPS), air toxics, and particulate matter per megawatt of power generated

compared with traditional technologies. In addition, their higher efficiency when compared with conventional pulverized-coal boilers ensures commensurate reductions in the release of greenhouse gases. In areas like China, where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO₂, NO_x, and greenhouse gases.

Economics: The estimated total cost of the proposed project is about \$500 million, for which \$55 million in Federal financial support is sought.

Market Potential: IGCC systems offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing and underdeveloped countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 40

Proposer: CQ Inc.

Project/Technology Description: The Coal Quality Expert (CQE) would be demonstrated by evaluating the performance of a power plant boiler in China. CQE is an integrated model that can be used to make fuel switching and blending, natural gas co-firing and scrubber retrofit decisions.

Technology Status: CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based upon several highly successful models, such as the Electric Power Research Institute Coal Quality Impact Model and FGDCOST, both of which have gained widespread industrial acceptance.

Environmental Performance: Plant improvements/modifications suggested from CQE modelling will result in combustion efficiency improvements, which will raise plant efficiency. Improved plant efficiency will reduce SO₂ and CO₂ emissions, while reducing carbon in fly ash. CQE can aid in the identification of the most cost-effective options for reducing NO_x and SO₂ emissions.

Economics: CQE would be used to identify the cost-effective improvements in power plant operations and/or modifications. The total project cost is \$250,000; the Federal government is being asked to fund the entire cost of the project.

Market Potential: CQE could be applied in any utility situation worldwide where coal firing is practiced. Plant modifications or retrofits suggested by CQE modelling could result in identifying new technology requirements that could be supplied by U.S. firms.

Proposal No.: 66

Proposer: Capsule Pipeline Research Center (University of Missouri)

Project/Technology Description: The project seeks to construct a pilot plant facility in Missouri to test and demonstrate a complete coal-log pipeline system for transporting coal.

Technology Status: Laboratory and bench-scale development of the coal-log pipeline system has been completed with funding from 14 private companies, DOE, the National Science Foundation, and the state of Missouri. The technology is ready for testing on a "short-track" system using near full-scale components.

Environmental Performance: Pipeline transport of coal as logs would allow the use of cleaner, higher-grade coal at greater distances from the mine in areas where there is limited transportation infrastructure and where water resources required for slurry pipelines are limited. The ultimate result of clean coal use will be a reduction in SO₂, particulate, trace element, and CO₂ emissions.

Economics: Pipeline transport of coal is thought to be less costly than alternative transport means in some situations. The total project cost is estimated at \$15 million with the government's share at 50 percent of the total (\$7.5 million).

Market Potential: The application of low-cost coal transport technology, such as coal-log pipeline, in developing nations that have poor transportation infrastructures and limited water resources for transporting coal from mine or preparation plant to end-user, might be very attractive.

Proposal No.: 51

Proposer: Control Techtronics International

Project/Technology Description: The proposed project would retrofit existing coal-burning equipment with automated boiler combustion controls. The three-year project would introduce in China microprocessor-based combustion controls, which are a software and hardware solution that can be tailored to individual boiler needs.

Technology Status: These automated combustion controls are currently in use in industrialized, institutional, and small utility facilities.

Environmental Performance: Automated controls have been proven to reduce coal use by about 20 percent. This, combined with reductions in excess air velocities at low boiler loads, reduces emissions by approximately 75 percent for particulates, 20 percent for CO₂, CO, and SO₂.

Economics: Payback periods are commonly two to three years, depending on size and site-specific use characteristics. The proposed effort is estimated to cost \$2.5 million; Federal financial support is sought for 50 percent.

Market Potential: The respondent has already begun to demonstrate the global potential through its installations in Mexico and Poland. China ranks very high in terms of market potential due to its large supplies of indigenous coal and the affordability of automated combustion controls.

Proposal No.: 58

Proposer: Custom Coals Corporation

Project/Technology Description: The project seeks support to implement a Clean Coal Application Center in Beijing, China, to develop a database of information on Chinese power plants and available coal supplies. The initial study would include up to 30 power plants and 30 coal mines. The Coal Quality Expert (CQE) would be used to evaluate various fuel switching and blending, natural gas co-firing, and scrubber retrofit options.

Technology Status: The project would collect coal samples for detailed analysis using standard methods and power plant design information. The CQE will be used to model clean coal use in typical Chinese power plants. CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based on several highly successful models, such as the Electric Power Research Institute's Coal Quality Impact Model and FDGCOST, which have gained widespread industrial acceptance.

Environmental Performance: The use of clean coal in China would result in significant reductions in SO₂ (50 percent), air toxics (75 percent), and a reduction in CQ due to power plant performance improvements.

Economics: This project should be considered as up-front analysis to justify the erection of conventional or advanced coal cleaning plants in China. Such a model is the most accurate and cost-effective means to assess the economics of clean coal use in power plants. The total project cost is \$3.4 million over 3 years with a proposed government share of 50 percent.

Market Potential: The project will provide the necessary information to support construction of a preparation plant in China to clean 15 million tons per year of coal. Similar efforts are under way in Poland and other coal-dependent countries.

Proposal No.: 46

Proposer: DB Riley International, Inc.

Project/Technology Description: Proposed for northeast China is a 100-MWe atmospheric circulating fluidized-bed plant, which would burn a waste coal.

Environmental Performance: Atmospheric circulating fluid beds (AFB) in general, due to lower temperatures, excess air, limestone, as well as staging combustion, and high recycle rates, have very good environmental performance, e.g., NO_x levels around 0.2 lb/million Btu, SO₂ capture in excess of 90 percent, and lower CO₂ levels.

Economics: Fluidized-bed combustor systems produce a dry ash that is a salable by-product, *in-situ* removal of sulfur oxides eliminates the need for post-combustion flue gas desulfurization.

Market Potential: The AFBs are targeted for waste coals and in sizes ranging approximately 25-125 MWe. There are at least 8-12 of these projects taking place in China. Fluidized-bed combustor systems offer an option for meeting increasing demand for electric power without relying on high-cost fuels while meeting international demands for protecting the environment.

Proposal No.: 47

Proposer: DB Riley International, Inc.

Project/Technology Description: Proposed is a pressurized fluidized-bed power generating facility in the 100- to 300-MWe range using 60- to 125-MWe modules.

Technology Status: Second-generation pressurized fluidized-bed combustor (PFB) systems have been demonstrated at the pilot-plant scale.

Environmental Performance: Due to lower temperatures, excess air, limestone, as well as staging combustion, and high recycle rates, PFB generally has very good environmental performance, e.g., NO_x levels around 0.2 to 0.3 lb/million Btu, SO₂ capture in excess of 95 percent, and lower CO₂ levels.

Economics: PFB systems produce a dry ash that is a usable by-product, and *in-situ* removal of sulfur oxides eliminates the need for post-combustion flue gas desulfurization. The first cost

would exceed the numbers for atmospheric circulating fluid bed technologies, the efficiency would be higher, and the resulting emissions lower.

Market Potential: This technology is ready to be offered to the Chinese market based on extensive pilot-plant development work. PFB systems offer an option for meeting increasing demand for electric power without relying on high-cost fuels while meeting international demands for protecting the environment.

Proposal No.: 48

Proposer: DB Riley International, Inc.

Project/Technology Description: The proposed project would be a bubbling-bed carbon burnout cell for adding onto an existing plant. The bubbling-bed combustor burns out carbon from fly ash, which improves unit efficiency and lowers emissions.

Proposal No.: 48

Proposer: DB Riley International, Inc.

Technology Status: The carbon burnout cell utilizes existing bubbling fluidized-bed technology.

Environmental Performance: Emissions reductions are directly proportional to the increase in plant efficiency achieved by installing the carbon burnout cell.

Economics: A cell would cost \$1-2 million and would provide plant efficiency increases of about 0.5 percent. The cell also produces a salable by-product and eliminates or reduces disposal costs. The proposer is recommending U.S. government cofunding of \$300,000 to \$700,000.

Market Potential: The potential market for this technology is worldwide. It is currently being marketed to U.S. utilities and is applicable to any existing coal-fired plants with high carbon in the ash.

Proposal No.: 19

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of an IGCC facility comprising an air-blown coal gasifier, coal gas cleaning equipment, and

combustion and steam turbine generators, together with associated infrastructure to generate 100 MWe of power.

Technology Status: This first generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC systems release less SO₂ (over 90 percent), NO_x (below those proposed by New Source Performance Standards (NSPS)), air toxics, and particulate matter per megawatt of power generated compared with traditional technologies. In addition, their higher efficiency when compared with conventional pulverized-coal boilers ensures commensurate reductions in the release of greenhouse gases. In areas like China where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO₂, NO_x, and greenhouse gases.

Economics: This technology is intended primarily for repowering existing 50-100 MWe plants or for new installations of up to 250 MWe capacity. The expected net plant thermal efficiency is approaching 40 percent. The estimated total cost of a 100-MWe plant is about \$160 million, for which Federal financial support for 35 percent is sought.

Market Potential: China is one of the largest potential markets for clean coal technologies in the world. Coal represent 93 percent of their proven reserves in millions tonnes of oil equivalent and 25 percent of the world coal reserves are in China. Coal will be the primary source of electric power generation. IGCC systems offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing countries an option for meeting their increasing demand for electric power without relying on high cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 21

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves repowering a 100-MWe atmospheric circulating fluidized-bed boiler, using high-efficiency integrated combined-cycle (HEICC) technology. The HEICC system involves partial gasification of coal, with cleaned low-Btu gas going to a gas turbine generator and char, along with particulates and reacted and unreacted sorbent, conveyed to an atmospheric circulating fluidized-bed boiler. The repowered facility would be capable of generating a nominal 180 MWe of power.

Technology Status: First-generation atmospheric circulating fluidized bed (AFB) is commercially available. The coal gasifier, gas cleanup equipment, and gas turbine generator to repower an atmospheric circulating fluidized-bed boiler have been demonstrated.

Environmental Performance: It has been shown that AFB boilers are very effective in controlling air pollutants. By adding limestone to the AFB boiler together with coal, sulfur capture in excess of 90 percent is achievable. Staged combustion in the AFB boiler will result in NO_x emissions below those recommended by NSPS. The AFB boiler operates more efficiently than the present boiler and emits less CO₂.

Economics: The expected net plant thermal efficiency is approaching 40 percent. This is substantially higher than that attainable with an existing atmospheric fluidized-bed boiler power generation system. The estimated total cost of repowering a 100-MWe plant to 180 MWe would be about \$100 million. Federal financial support is requested, although the amount is not specified.

Market Potential: China is one of the largest potential markets for clean coal technologies in the world. Coal represents 93 percent of their proven reserves in millions of tons of oil equivalent and 25 percent of the world coal reserves are in China. Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, to retrofit the gasifier and gas turbine system for existing AFB boilers, or to build new grassroot installations.

Proposal No.: 24

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of an advanced pressurized circulating fluidized-bed facility comprising a coal gasifier, pressurized circulating fluidized-bed boiler, gas cleanup equipment, gas and steam turbine generators with heat recovery, together with all necessary infrastructure to generate 100 MWe of power.

Technology Status: Second-generation pressurized fluidized-bed combustor (PFB) systems have been demonstrated at the pilot-plant scale. The coal gasifier, gas cleanup equipment, and gas turbine generator have been demonstrated at the pilot scale.

Environmental Performance: PFB systems, in general, due to lower temperatures, excess air, limestone, as well as staging combustion, and high recycle rates, have very good environmental performance, e.g., NO_x levels around 0.2 to 0.3 lb per million Btu, SO₂ capture in excess of 95 percent, and lower CO₂ levels.

Economics: PFB systems produce a dry ash that is a usable by-product, in-situ removal of sulfur oxides eliminates the need for post-combustion flue gas desulfurization. The first cost would exceed the numbers for atmospheric circulating fluid bed technologies, the efficiency would be higher, and the resulting emissions lower.

Market Potential: This technology is ready to be offered to the Chinese market based on extensive pilot-plant development work. PFB systems offer an option for meeting increasing demand for electric power without relying on high-cost fuels while meeting international demands for protecting the environment.

Proposal No.: 26

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed new, 100-MWe power plant would employ high-efficiency integrated combined-cycle (HEICC) technology. The HEICC system involves partial gasification of coal, with cleaned low-Btu gas going to a gas turbine combustor and char, along with particulates and reacted and unreacted sorbent, conveyed to an atmospheric circulating fluidized-bed boiler.

Technology Status: First-generation atmospheric circulating fluidized-bed (AFB) is commercially available. The coal gasifier, gas cleanup equipment, and gas turbine generator have been demonstrated at the pilot scale.

Environmental Performance: It has been shown that AFB boilers are very effective in controlling air pollutants. By adding limestone in the gasifier and the AFB boiler, sulfur capture in excess of 90 percent is achievable. Staged combustion in the AFB boiler will result in NO_x emissions below those recommended by NSPS. Improvements in efficiency using HEICC technology also will result in lower CO₂ emissions.

Economics: The expected net plant thermal efficiency is approaching 42.5 percent. This is substantially higher than that attainable with an existing atmospheric fluidized-bed boiler power generation system. The proposed plant would cost about \$150 million; Federal financial support is sought for 35 percent of this cost.

Market Potential: China is one of the largest potential markets for clean coal technologies in the world. Coal represents 93 percent of their proven reserves in millions of tons of oil equivalent and 25 percent of the world coal reserves are in China. Coal will be the primary source of electric power generation since the government has allocated oil and gas to other uses. Demonstrated success with this project would open considerable opportunities for further application of this technology in China to repower existing plants, to retrofit the gasifier and gas turbine system for existing AFB boilers or to build new grassroots installations.

Proposal No.: 27

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of an IGCC facility comprising an oxygen-blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators, air separation plant, together with infrastructure to generate 300 MWe of power.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC systems release less SO₂ (over 90 percent), NO_x (below those proposed by NSPS), air toxics, and particulate matter per megawatt of power generated compared with traditional technologies. In addition, their higher efficiency when compared with conventional pulverized-coal boilers ensures commensurate reductions in the release of greenhouse gases. In areas like China where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO₂, NO_x, and greenhouse gases. Some typical emission estimates for a 300-MWe oxygen-blown IGCC unit are: NO_x—0.05 lb/million Btu, SO₂ —0.05 lb/million Btu, air toxics—1.1 tons per year, solid wastes—350 tons per day, and waste water—500 gallons per minute.

Economics: This technology is intended primarily for repowering existing 50- to 100-MWe plants or for new installations of up to 300 MWe capacity. The expected net plant thermal efficiency is approaching 40 percent. The estimated cost of the proposed 300-MWe facility is about \$450 million, for which government financial support is sought for 30 percent.

Market Potential: China is one of the largest potential markets for clean coal technologies in the world. Coal represent 93 percent of their proven reserves in millions tons of oil equivalent and 25 percent of the world coal reserves are in China. Coal will be the primary source of electric power generation. IGCC systems offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 76

Proposer: HYDROCARB Corporation

Project/Technology Description: The HYDROCARB™ Process is an innovative technology that converts coal of all grades (as well as other carbonaceous material such as biomass and municipal solid waste) to fuels and chemical commodities. The heart of the process involves hydro-gasification, methane pyrolysis, and methanol synthesis process units. Products from the process are anticipated to consist of carbon black and methanol. The proposed project in China would be a 100-ton-per-day demonstration, approximately one-fiftieth of the size envisioned for commercial facilities. Production rates from the demonstration are estimated at 37 tons per day of carbon black and 6,700 gallons per day of methanol.

Technology Status: The process relies predominantly on conventional technology and involves no new chemistry. Experimental design testing has been completed for most process steps. The demonstration is, however, considered vital to the reliable design of commercial plants.

Environmental Performance: Pollutant control efficiency from process gases are not quantitatively stated in the Expression of Interest but are expected to be high. Removal of sulfur in the feedstock is accomplished with calcium sorbents. It is anticipated that basic solid waste (consisting of ash, gypsum, and unconverted lime) will be suitable for landfill or may potentially be converted to a marketable building construction material.

Economics: Although the capital requirement for the process is significant, it is believed that product sales will provide a profitable operation over the life-cycle of the plant. The expression of interest includes a recommendation for U.S. government funding up to 25 percent of the demonstration cost. Estimated project cost is provided but is indicated as proprietary.

Market Potential: No limit for the market potential was specified. However, marketing analysis would be required for large-scale development of the technology. For instance, the U.S. capacity for methanol is about 5 million tons per year. A commercial plant (5,000 tons of coal per day) would have an estimated capacity of about 3 million tons per year.

Proposal No.: 50

Proposer: LSR Technologies, Inc.

Project/Technology Description: The respondent proposes to demonstrate use of a core separator for dust collection at an 11.6-MWt coal-fired industrial boiler in Hangzhou in the Zhenjiang Province of China.

Technology Status: The proposer describes the core separator as an advanced technology developed through research sponsored by the Department of Energy and the Environmental Protection Agency. It utilizes a highly efficient collector, which functions on the principle of inertial separation.

Environmental Performance: This project would address airborne dust and particulate emissions from coal-fired boilers. Overall particulate collection efficiency is 94-98 percent. The PM10 collection efficiency is 90-93 percent.

Economics: The proposer indicates the cost would be \$2.20 per cubic meter per hour, with solids removal costing \$126 per kilogram per hour and PM10 solids removal costing \$803 per kilogram per hour. The expression of interest includes a recommendation for U.S. government funding of \$100,000, with the remaining \$30,000 from the Chinese affiliate.

Market Potential: The technology is applicable to coal-fired industrial boilers providing heat and steam. It is a candidate for retrofitting and modernizing existing facilities. The proposer indicates that market acceptance of this technology will depend heavily on government enforcement of environmental laws. By the year 2030, another 10,000 units could be in operation, with a gross output of 100,000 MWt.

Proposal No.: 63

Proposer: NOXSO Corporation

Project/Technology Description: The NOXSO process is a dry, post-combustion process that uses a regenerable sorbent to simultaneously adsorb SO₂ and NO_x from the flue gas. The NO_x is recycled into the flame of the coal combustor where it is reduced to N₂ and H₂O. The SO₂ is ultimately converted to elemental sulfur. The proposed demonstration is on China's 300-MWe DouBa power plant.

Technology Status: A 5-MWe proof-of-concept test was conducted on a slipstream at Ohio Edison's Toronto power plant.

Environmental Performance: The NOXSO process is expected to reduce SO₂ emissions by 95 percent and NO_x emissions by 82 percent, and does not generate waste.

Economics: The proposal indicates that a limestone scrubber/SCR technology would have higher capital and operating costs than the NOXSO process.

Market Potential: The proposer expects to install NOXSO on 19,200 MWe in China (1999-2030) and globally on 60,000 MWe (in the next 34 years).

Proposal No.: 59

Proposer: SGI International

Project/Technology Description: The project seeks to construct a clean coal refinery at the Zhalainguoer mining area in Inner Mongolia. The refinery would use SGI International's liquid

from coal (LFC) process, which upgrades low-rank coal using mild gasification technology and produces liquid and solid products. A base plant is designed to process 5,000 metric tons of coal or lignite per day. This plant includes a 40-MW cogeneration facility capable of providing 20-MWe for sale to a local utility grid.

Technology Status: One mild gasification demonstration plant is operational under DOE's Clean Coal Technology Program. Liquid products are sold to a fuel broker, and solid products are sold to a local utility for power generation.

Environmental Performance: A significant portion of existing electrical power plants and over 80 percent of the new electrical power generating capacity in Asia and the Pacific Rim will be fueled by coal. This process offers a method that can markedly reduce the environmentally damaging SO₂ emissions from such coal-fired power plants. The upgrading or drying of low-rank coals and lignites in a clean coal refinery removes most of the moisture, thereby increasing the heating value of the solid products and, therefore, decreasing the transportation costs and infrastructure impact. The mild pyrolysis removes a significant fraction of the organic sulfur.

Economics: Mild gasification provides an economic option for upgrading high-moisture, low heating value coals. Proposed as the first step is a \$400,000 LFC engineering and economic feasibility study, for which 50 percent of government financial support is sought.

Market Potential: The Zhalainguo area of China has coal reserves of over 10 billion tons of proven lignite and subbituminous coal with minable reserves of 8.4 billion tons. Because of the high moisture levels and low heating value, there currently exists a very limited demand for these coals. The Zhalainguo Coal Mine Administration is eager to explore ways in which these extensive coal reserves can be upgraded to become more acceptable. Liquid products can be used in existing markets for No. 6 fuel oil. Solid products can be used in most industrial and utility boilers. Mild gasification provides an economic option for upgrading high-moisture, low heating value coals.

Proposal No.: 2

Proposer: TRW Space & Technology Division

Project/Technology Description: A 25-MWe greenfield power plant in China based on TRW's slagging coal combustion technology is proposed with the cooperation with China International Thermal Energy Engineering Corporation. The demonstration would prove the viability of TRW's technology for both industrial and utility sectors to Chinese plant developers.

Technology Status: TRW's slagging combustor technology should be considered as technically mature in the development process but not commercial as it has not yet been integrated onto a full-scale boiler. The technology was developed and demonstrated in part through a DOE CCT III project.

Environmental Performance: With lime spray dryer technology, over 90 percent SO₂ reduction can be achieved. NO_x emissions are projected at less than or equal to 0.2 lb/million Btu or more than 50 percent lower than conventional burner technology. Particulates emissions are very low because about 80 percent of the coal's ash is converted to a solid slag, which has significant market use. The remaining ash is collected in a baghouse, thereby achieving ash emissions of less than or equal to 0.015 lb/million Btu.

Economics: Economics of this project are uncertain but claimed by TRW to be less than competing IGCC or AFB technologies. Government support for \$5 million of the total project costs of \$23 million is sought for the procurement of goods and services from the United States.

Market Potential: If TRW's slagging combustion technology is proven for industrial and utility boilers, the market potential could be significant, both in retrofit and greenfield applications. TRW identified a 6,000-MWe market in Eastern Europe, Russia, Ukraine, India, and Korea over the next 20 years.

Proposal No.: 45

Proposer: Texaco Inc.

Project/Technology Description: The proposed project is a grassroots IGCC facility of about 400 MWe in size.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC is widely recognized as the cleanest, most efficient, and most versatile technology for the production of electricity from coal and other "dirty" hydrocarbon feedstocks containing sulfur, metals, and other potential pollutants. Compared to conventional coal-fired boiler systems, IGCC can reduce SO₂ emissions by more than 99 percent, NO_x emissions reductions by up to 85 percent, and CO₂ emissions by 15 percent or more. IGCC achieves an equally impressive performance in particulates emissions, wastewater discharge, and solid waste generation. The only two solid by-products of IGCC, sulfur and non-leachable slag, both have market value; sulfur for fertilizer production and slag for use as an aggregate, roadbed base, or abrasive.

Economics: This technology is intended primarily for new installations to produce 400 MWe. The operator of the IGCC could realize a \$16- to \$18-million annual environmental cost savings, equivalent to an advantage of approximately one cent per kilowatt-hour. Assuming a \$10-per-ton solids disposal cost and considering that the other coal technologies generate between 300-400 thousand tons per year more solids than IGCC (250-MWe case), the IGCC plant also would have an annual solid discharge cost savings of \$1.7-3.9 million. Altogether, these environmental cost

benefits can be equated to an environmental capital value in excess of \$500 per kilowatt capital cost reduction relative to other technologies.

Market Potential: The potential market for clean coal technologies in developing and transitional economies is projected to be \$600-800 billion between 1993 and 2010, with an export potential of approximately \$200 billion for exporting nations. This translates to up to 7,000 new jobs in exporting nations. IGCC systems also offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing and underdeveloped countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

E.1.2 INDIA

This section contains a brief summary of each EOI for India. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 54

Proposer: Coal Tech Corporation

Project/Technology Description: The proposed project is a 10-MWe steam power plant using an air-cooled, slagging combustor, fired with coal or coal with waste fuels.

Technology Status: Coal Tech's slagging combustor technology should be considered as technically mature in the development process but not commercial. The technology was developed and demonstrated in part through a CCT I project.

Environmental Performance: With sorbent injection, 98 percent SO₂ reduction can be achieved. NO_x emissions are potentially up to 80 percent lower than conventional burner technology. Particulates emissions are very low because about 70 percent of the ash from coal is converted to a solid slag, which has significant market use. The remaining ash is collected in a baghouse for an overall ash collection of 99.99 percent. Trace organic emissions are very low because of high combustion temperatures; metal emissions are generally lower than conventional burner technology because of metal entrapment in the slag.

Economics: Economic performance is unknown, but is expected to be higher than oil- or gas-fired boilers or coal-fired stokers at the industrial scale. Federal financial support for one-third of the total project costs of \$10 million is sought, along with Ex-Im Bank financing for the U.S.-manufactured and assembled equipment.

Market Potential: The worldwide market for a small combustion system, particularly in developing countries, is very large. The Asian market for small systems in the 5- to 10-MWe range is estimated at several \$100 million over the next 5 years.

Proposal No.: 16

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of a 100-MWe advanced pressurized circulating fluidized-bed power generating facility. The facility comprises a coal gasifier, pressurized circulating fluidized-bed boiler, gas cleanup equipment, gas and steam turbine generators with heat recovery, together with all necessary infrastructure.

Technology Status: Second-generation pressurized circulating fluidized-bed (PFB) combustion has been demonstrated in pilot plants. This project applies a PFB combustor in conjunction with a coal gasifier, gas cleanup equipment, and gas and steam turbine generators with heat recovery.

Environmental Performance: This technology is particularly attractive with respect to environmental performance compared to conventional pulverized coal boilers with scrubbers. The addition of limestone in the gasifier and circulating fluidized bed removes *in-situ* over 90 percent of the sulfur through staging combustion of the synthetic gas in the turbine combustor and the char in fluidized bed. The combined NO_x emissions are below those proposed by NSPS and are far superior to existing conventional boiler performance in the countries proposed to use this technology. The high efficiency reflects a corresponding reduction in CO₂ emissions. In addition, all other emissions are proportionately reduced. The advanced PFB plant water consumption rate is nearly 30 percent lower than the pulverized coal-fired plant rate, and the effluent rate is approximately 43 percent lower.

Economics: The expected net plant thermal efficiency of 45 percent, which means that the amount of coal required to be burned per kilowatt hour of power generated will decrease.

Market Potential: India requires enormous additions of power over the next several decades to support the planned development and growth. In the next 10 years, India is expected to increase its power generation by about 100,000 MWe, with about 40 percent being coal-based. Therefore, India offers an appropriate market for this technology, which could capture 15 percent of the market, or 20,000 MWe.

Proposal No.: 18

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project would repower a 100-MWe atmospheric circulating fluidized-bed boiler using high-efficiency integrated combined-cycle (HEICC) technology. At full load, the repowered plant would generate a normal 180 MWe. The project involves the design and supply of a coal gasifier, gas cleanup equipment, and gas turbine generator, with all necessary modifications and additions to existing facilities.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC systems releases less SO₂ (over 90 percent), NO_x (below those proposed by NSPS), air toxics, and particulate matter per megawatt of power generated compared with traditional technologies. In addition, its higher efficiency when compared with conventional pulverized-coal boilers ensures commensurate reductions in the release of greenhouse gases. In areas like India, where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO₂, NO_x, and greenhouse gases.

Economics: This technology is intended primarily for repowering existing 50- to 100-MWe plants or for new installations of up to 250 MWe capacity. The expected net plant thermal efficiency is approaching 40 percent. The estimated total project cost is about \$100 million. Financial support is requested; the share is unspecified.

Market Potential: IGCC systems offer developing countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 20

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of an IGCC facility to generate a nominal 100 MWe of power. The IGCC facility comprises an air-blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators, and the associate infrastructure.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC releases less SO₂ (over 90 percent), NO_x (below those proposed by NSPS), air toxics, and particulate matter per megawatt of power generated compared with traditional technologies. In addition, its higher efficiency when compared with conventional pulverized-coal boilers ensures commensurate reductions in the release of greenhouse gases. In areas like India, where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO₂, NO_x, and greenhouse gases.

Economics: This technology is intended primarily for repowering existing 50- to 100-MWe plants or for new installations of up to 250-MWe capacity. The expected net plant thermal efficiency is approaching 40 percent. The total project cost is estimated at \$160 million. Federal financial support is sought for 35 percent of this total.

Market Potential: India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal-based power of some 140,000 MWe by 2030. Coal represents a major proportion of India's fossil energy reserves. IGCC systems offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems also offer developing countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 22

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of a 300-MWe IGCC facility comprising an oxygen-blown coal gasifier, coal gas cleaning equipment, combustion and steam turbine generators, and air separation plant, together with the associated infrastructure.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC releases less SO_x (over 90 percent), NO_x (below those proposed by NSPS), air toxics, and particulate matter per megawatt of power generated compared with traditional technologies. In addition, its higher efficiency, when compared with conventional pulverized-coal boilers, ensures commensurate reductions in the release of greenhouse gases. In areas like India, where scrubbers are generally not in use, the application of this technology will bring about even greater reductions in overall emissions of SO_x, NO_x, and greenhouse gases. Some typical emission estimates for a 300-MWe oxygen-blown IGCC facility are: NO_x—0.05 lb per million Btu; SO_x—0.05 lb per million Btu; air toxics—1.1 tons per year; solid wastes—350 tons per day; and wastewater—500 gallons per minute.

Economics: This technology is intended primarily for repowering existing 50- to 100-MWe plants or for new installations of up to 300 MWe capacity. The expected net plant thermal efficiency is approaching 40 percent.

Market Potential: India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal-based power of some 140,000 MWe by 2030. Coal represents a major proportion of India's fossil energy reserves. IGCC systems offer an

economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing and underdeveloped countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 23

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of a new 100-MWe power plant using a high-efficiency integrated combined-cycle (HEICC) system. The HEICC system comprises a coal gasifier, atmospheric circulating fluidized-bed boiler, gas cleanup equipment, and gas and steam turbine generators with heat recovery, together with all necessary infrastructure.

Technology Status: First-generation atmospheric circulating fluidized-bed (AFB) technology is commercially available. The coal gasifier, gas cleanup equipment, and gas turbine generator have been demonstrated at the pilot scale.

Environmental Performance: It has been shown that AFB boilers are very effective in controlling air pollutants. By adding limestone in the gasifier and the AFB boiler, sulfur capture in excess of 90 percent is achievable. Staged combustion in the AFB boiler also will result in NO_x emissions below those recommended by NSPS. Improvements in efficiency using the HEICC technology also will result in lower CO₂ emissions.

Economics: The expected net plant thermal efficiency is approaching 42.5 percent. This is substantially higher than that attainable with an existing atmospheric fluidized-bed boiler power generation system. The proposed plant would cost about \$150 million; Federal financial support is sought for 35 percent of this cost.

Market Potential: India is one of the largest potential markets for clean coal technologies in the world, with an expected need for coal-based power of some 140,000 MWe by 2030. The high-efficiency, low-emission characteristics of this technology can be expected to enable it to capture a significant portion of this market. Coal represents a major portion of India's fossil energy reserves. The HEICC technology offers an economic and environmentally acceptable option for meeting increased demand for power.

Proposal No.: 15

Proposer: General Atomics

Project/Technology Description: The proposed project is a new 300-MWe power plant using a coal-fired atmospheric circulating fluidized-bed combustor for high-efficiency, closed helium Brayton-cycle power generation.

Environmental Performance: Expected performance is typical of that obtained from atmospheric circulating fluidized-bed combustors. *In-situ* removal of sulfur oxides eliminates the need for post-combustion flue gas desulfurization. Lower combustor temperatures reduce nitrogen oxides emissions. Fluidized-bed combustion systems produce a dry ash that is a usable by-product.

Economics: Because of the higher temperature, the closed helium Brayton-cycle plant is projected to be more efficient than conventional fluidized-bed steam cycle plants, making this an ideal process for India, a water-constrained country where industrial water availability is both limited and controlled.

Market Potential: India has embarked on a major industrialization program with economic liberalization. The core of this industrial boom will depend on the electric power sector; 72,000 MWe is anticipated to be added in the next 10 years. AFB systems offer an economic and environmentally acceptable option for meeting increased demand for power. These systems offer an option for meeting increasing demand for electric power without relying on high-cost fuels, while meeting international demands for protecting the environment. AFB systems offer countries in need of hard currency an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 43

Proposer: Texaco Inc.

Project/Technology Description: The proposed project is a 300- to 400-MWe IGCC power plant in Gujarat, India. The plant would use the Texaco gasification power system.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC is widely recognized as the cleanest, most efficient, and most versatile technology for the production of electricity from coal and other "dirty" hydrocarbon feedstocks containing sulfur, metals, and other potential pollutants. Compared to conventional coal-fired boiler systems, IGCC systems can reduce SO₂ emissions by more than 99 percent, NO_x emissions reductions by up to 85 percent, and CO₂ emissions by 15 percent or more. IGCC achieves an equally impressive performance in particulates emissions, waste water discharge, and solid waste generation. The only two solid by-products of IGCC, sulfur and non-leachable slag, both have market value: sulfur for fertilizer production and slag for use as an aggregate, roadbed base, or abrasive.

Economics: This technology is intended primarily for new installations to produce 300-400 MWe. The operator of the IGCC facility could realize a \$16-18 million annual environmental cost savings, equivalent to an advantage of approximately one cent per kilowatt-hour. Additional savings from reduced solid discharge, assuming a \$10-per-ton solids disposal cost, and considering that the other coal technologies generate between 300-400 thousand tons per year more solids than IGCC (250-MWe case), would amount to an annual cost savings of \$1.7-3.9 million. Altogether, these environmental cost benefits can be equated to an environmental capital value in excess of \$500 per kilowatt capital cost reduction, relative to other technologies.

Market Potential: The potential market for clean coal technologies and in developing and transitional economies is projected to be \$600-800 billion between 1993 and 2010, with an export potential of approximately \$200 billion for exporting nations. This translates to up to 7,000 new jobs in exporting nations. IGCC systems also offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 6

Proposer: Viking Systems International

Project/Technology Description: Proposed is construction of a coal preparation plant in India to clean five million tons per year of high ash coal (864-ton-per-hour plant, assuming 5,782 operating hours per year).

Technology Status: The specific coal-cleaning technology to be deployed is not described, but it is likely to be conventional coal preparation technology, which has been practiced commercially for decades worldwide. However, the proposed plant could include advanced technology for cleaning fine coal.

Environmental Performance: The use of clean coal by the utility/industrial/commercial/residential sectors will result in a reduction in SO₂ and particulates. Small reductions in CO₂ emissions are possible with coal cleaning because of small improvements in power plant heat rate.

Economics: Although the economics of the proposed technology are not addressed, coal cleaning is generally the most cost-effective way (dollars per ton) to achieve modest reductions in sulfur dioxide emissions from coal combustion. The total project cost is \$40 million, with low-interest guaranteed loans requested from the Federal government.

Market Potential: The market potential for conventional and advanced coal cleaning plants worldwide, particularly in many developing countries with poor quality coals, is substantial. The proposer anticipates the need for an additional six to eight plants in India.

Proposal No.: 7

Proposer: Viking Systems International

Project/Technology Description: The respondent proposes to erect one or more plants in India to produce a variety of commercially marketable products utilizing waste coal ash from power plants.

Economics: The total project cost is estimated to be \$5-6 million. Guaranteed low-interest loans are sought.

E.1.3 OTHER ASIAN AND PACIFIC RIM COUNTRIES

This section contains a brief summary of each EOI for other Asian and Pacific Rim countries. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 65

Proposer: ABB (ASEA Brown Boveri) Inc.

Project/Technology Description: The respondent submitted comments on two key questions: what are the greatest opportunities for commercialization (regions and technologies) and what role can DOE and the Federal government play to facilitate commercialization. The response highlighted the importance of pressurized fluidized-bed combustion, particularly in the Pacific Rim and Asia.

Environmental Performance: PFB is very efficient (less carbon dioxide), provides excellent and naturally low NO_x and SO₂ values, and is very fuel flexible, providing adaptability to local coals.

Economics: Modest government incentives, such as low-cost financing and/or loan guarantees, would help to cover or offset any perceived financial risk related to the project.

Market Potential: Countries such as China, India, Taiwan, Indonesia, the Philippines, and Korea represent enormous growth opportunities for coal technologies due to the substantial economic growth and vast indigenous coal reserve of these areas. There is a need for significant emission reduction while improving the electric output/efficiency of existing plants by using indigenous coal reserves. There is also a possibility for greenfield capacity.

Proposal No.: 69

Proposer: Babcock & Wilcox

Project/Technology Description: The proposed project is a 340-MWe pressurized fluidized-bed boiler for an unspecified Pacific Rim country.

Technology Status: Pressurized fluidized-bed combustion (PFB) has been demonstrated at pilot plants.

Environmental Performance: This demonstration of PFB boiler technology will operate at approximately 10 percent higher cycle efficiency with the resultant 10 percent reduction in emissions. The sulfur capture will be about 95 percent and the NO_x emissions will be very low at about a 95 percent capture rate.

Economics: The total cost of a repowering project is estimated to be about \$330 million. Federal government financial support is sought to cover controlled emissions costs, first-of-a-kind development cost, and warranty costs.

Market Potential: Advanced PFB boiler technology and emissions control in the Pacific Rim is applicable to new facilities, as well as the repowering of existing facilities.

Proposal No.: 70

Proposer: Babcock & Wilcox Company

Project/Technology Description: The respondent proposes to conduct full-scale demonstrations of new unspecified components of advanced coal-fired boiler designs that will be deployed after the turn of century.

Technology Status: The technical status is unknown because the components to be evaluated and/or developed were not specified.

Environmental Performance: The proposed components would be part of an advanced boiler design that has a 10 percent higher cycle efficiency and resultant 10 percent decrease in emissions.

Economics: Support from the U.S. government of up to \$20 million is requested to cover first-of-a-kind engineering and warranty costs.

Market Potential: Potentially very large if technology is proven to be technically and economically sound.

Proposal No.: 55

Proposer: Energy International Corporation

Project/Technology Description: The proposed project would comprise the generation of fuel gas via the oxygen-blown underground gasification of coal, coupled with the generation of electricity via integrated gas turbine/steam turbine combined-cycle. The proposed site is the Thar Desert of Pakistan where there are estimated to be in excess of 100 billion tons of lignite in seams over 30 feet thick and depths in the range of 300-600 feet.

Technology Status: Underground coal gasification has been demonstrated and is considered ready for commercial use.

Environmental Performance: Because underground coal gasification is a highly efficient gasification process, the overall conversion of carbon to CO₂ will keep the emission of greenhouse gases to acceptable low levels. The ash generated remains primarily underground and, therefore, the particulate emissions and ash disposal will not be significant issues. The low-sulfur coal will produce low sulfur-bearing gases that can be readily cleaned from the feed stream to the power plant so that sulfur emissions will be very low.

Economics: A project to produce 350 MWe would be expected to cost about \$120 million and would generate markets for about \$60 million for U.S.-made power generation, oxygen plant, well field, piping, and other equipment, in addition to \$30-40 million in engineering and construction services.

Market Potential: Without the underground coal gasification, the billion tons of lignite in the Thar Desert would appear to have no commercial value within the next 50 years; these deposits appear to have premium applicability for underground gasification.

Proposal No.: 60

Proposer: Kress Corporation

Project/Technology Description: The proposed project is a demonstration of coke oven product recovery emission control technology by applying the Kress indirect dry cooling (KIDC) system on a by-product recovery coke oven battery located at Port Kembla, New South Wales, Australia.

Technology Status: The KIDC carrier and boxes were first used at Bethlehem Steel's coke plant at Sparrows Point, Maryland, and were to be demonstrated under the CCT Program. However, the project was terminated, due to cold shutdown of the coke oven battery in response to unrelated economic decisions, prior to completing the system as a finished production tool. Although the primary objective of the KIDC test was accomplished, insufficient time was available with the rapidly disintegrating battery to fashion the system to its ultimate goal. The

carrier and boxes would be modified and shipped to Australia for use in the proposed demonstration. The proposed project would be second application and would be a full-scale demonstration in a commercially operating facility. The technology has been patented by Kress Corporation.

Environmental Performance: The system, by controlling both coke pushing and quenching, would reduce PM10 emissions by a minimum of 95 percent and maintain the 10 percent opacity limitation upon pushing. Moreover, unlike traditional coke cooling, with its direct application of large amounts of cooling water, water usage is practically nil. The cooling system has an enclosed circulating water system, so the water never comes in direct contact with the coke and thus does not become contaminated.

Economics: The 12-15 month demonstration project (6 months of operation) involving a single cooling box, which is expected to process 34-50 tons of coke per day, would cost about \$1.4 million, including modification and shipping of the carrier and boxes from Maryland. The U.S. government is asked to codfund up to 50 percent.

Market Potential: The global market potential is unknown, although the proposer indicates it has received inquiries from all parts of the world. The proposer believes the potential in Australia is five recovery-type and one nonrecovery-type coke oven batteries.

Proposal No.: 52

Proposer: Rosebud SynCoal Partnership

Project/Technology Description: The project would erect a SynCoal® facility at the P.T. Tambang Batubara Bukit Asam mine near Tanjung Enim District in South Sumatra, Indonesia. The plant would upgrade one million metric tons per year of low-rank coal for domestic use and export.

Technology Status: The technology is being demonstrated in the CCT Program and is technically ready for commercialization.

Environmental Performance: The use of SynCoal® in conventional combustion technology would reduce CO₂ emissions by about 10 percent and SO₂ emissions by about 24 percent; and it should provide some NO_x, particulate, and trace element emissions reductions. Dry waste from the process may be used as landfill.

Economics: The economics of upgrading low-rank coal with the SynCoal® or other process is largely contingent upon local competition from other domestic or imported high-rank coals. The total project cost is about \$65 million, with \$30 million being sought from the Federal government for differential costs between the SynCoal® technology and other conventional technologies.

Market Potential: Indonesia has 36 billion tons of recoverable coal and lignite resources; 70 percent of the total is low-rank reserves in Sumatra that require upgrading for export and domestic use. The SynCoal® technology is applicable to low-rank coals found in Alaska, India, Indonesia, China, and elsewhere.

Proposal No.: 4

Proposer: SGI International

Project/Technology Description: The proposed project is an application of the liquid from coal (LFC) process at the P.T. Tambang Batubara Bukit Asamto mine in the Tanjung Enim District in South Sumatra, Indonesia.

Technology Status: One mild gasification demonstration plant is operational under DOE's Clean Coal Technology Program. Liquid products are sold to a fuel broker and solid products are sold to a local utility for power generation.

Environmental Performance: A significant portion of existing electrical power plants and over 80 percent of the new electrical power generating capacity in Asia and the Pacific Rim will be fueled by coal. This process offers a method that can markedly reduce the environmentally damaging SO₂ emissions from such coal-fired power plants. The upgrading or drying of low-rank coals and lignites in a clean coal refinery removes most of the moisture, thereby increasing the heating value of the solid products, which, in turn, decreases the transportation costs and infrastructure impact. Mild pyrolysis removes a significant fraction of the organic sulfur.

Economics: A base plant is designed to process 5,000 tonnes of coal or lignite per day. This plant includes 40-MWe cogeneration facility capable of providing 20 MWe for sale to a local utility grid. Financial support is sought for 50 percent of the estimated \$400,000 engineering and economic feasibility study.

Market Potential: The Suralaya Power Plant supplies over 40 percent of the baseload generating capacity on the Java-Bali grid, which comprises the bulk of the Indonesia's demand for power. The state coal-mining company has determined the need to seriously consider upgrading options, which would create export potential into the Pacific Rim steam coal market in order to generate much needed revenue. Liquid products can be used in existing markets for No. 6 fuel oil. Solid products can be used in most industrial and utility boilers. Mild gasification provides an economic option for upgrading high-moisture, low heating value coals.

E.2 NEWLY INDEPENDENT STATES

E.2.1 RUSSIA

This section contains a brief summary of each EOI for Russia. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 9

Proposer: Babcock & Wilcox

Project/Technology Description: The proposed project involves the application of SNRB technology in Russia.

Technology Status: SNRB technology has been successfully demonstrated under the CCT Program.

Environmental Performance: The proposers do not indicate the actual performance of the system except to state that it removes SO₂, NO_x, and particulates. The SNRB process is a high-temperature baghouse, which essentially integrates SCR (for NO_x removal) with dry scrubbing for SO₂ removal. The 5-MWe demonstration indicated 80-95 percent SO₂ removal depending on what type of sorbent is used (sodium bicarbonate or calcium hydroxide), stoichiometric ratio, and other operating conditions (i.e., temperature). The NO_x removal was consistently above 90 percent. The particulate emissions were consistently below 0.03 lb/million Btu.

Economics: Federal government support is sought for 50 percent of the \$25 million estimated as the total project cost.

Market Potential: The proposers indicate U.S. and Russia as the potential market.

Proposal No.: 10

Proposer: Babcock and Wilcox

Project/Technology Description: The proposed project is a pressurized circulating fluidized-bed combustion system in Russia.

Technical Status: Second-generation pressurized circulating fluidized-bed (PFB) combustors have been demonstrated in pilot plants.

Environmental Performance: This technology is particularly attractive with respect to its environmental performance compared with conventional pulverized coal boilers with scrubbers.

The addition of limestone in the PFB reflects a corresponding reduction of CO₂ emissions and other pollutants.

Economics: Babcock & Wilcox is seeking \$5 million of the total project cost of \$30 million from the U.S. government.

Market Potential: If the demonstration is successful, there is a possibility of modernizing over 300 boilers with this technology.

Proposal No.: 12

Proposer: Babcock & Wilcox

Project/Technology Description: The proposed project involves retrofitting Omsk Cogeneration plant No. 5 in Russia with LIDS DeSO_x technology. LIDS technology is based on boiler furnace limestone injection and integration with the SO₂ over-boiler path and gas ducts.

Technology Status: Technology status is not discussed in the proposal.

Environmental Performance: The technology removes 80-90 percent of the SO₂.

Economics: The total cost of the project is estimated to be about \$20 million.

Market Potential: The technology is applicable in Russia, the Newly Independent States, and Asia.

Proposal No.: 11

Proposer: Babcock & Wilcox

Project/Technology Description: A 70- to 100-MWe pilot combined-cycle plant equipped with pressurized circulating fluidized-bed combustion technology is proposed for construction in Russia. Babcock & Wilcox will team with a Russian design institute, VTI, and a boiler manufacturer, Taganrog (TKZ).

Technology Status: PFB technology is under development in the DOE CCT Program and is not considered commercial.

Environmental Performance: The environmental performance of PFB technology is substantially better than modern pulverized coal-fired power plants equipped with scrubbers because of the higher plant efficiency of the PFB technology. NO_x and SO₂ emissions are projected at 200 mg/m³.

Economics: The total estimated cost is \$20 million.

Market Potential: There are about 140 boilers (170-230 tons of steam per hour) that have reached or exceeded their design lives and require replacement.

Proposal No.: 14

Proposer: EER and U.S. EPA (AEERL)

Project/Technology Description: The respondent proposes to demonstrate micronized coal reburning technology in a Russian boiler fired with 230 tonnes per hour of coal. Coal reburning is a technically proven technology that is capable of reducing NO_x emissions from coal-fired boilers by 50-60 percent. Micronized coal reburning is an extension of the base technology to achieve improved NO_x and combustion performance.

Technology Status: Conventional coal reburning technology was proven in a DOE CCT II project at the Wisconsin Power & Light Company Nelsen Dewey Generating Station. Micronized coal reburning was selected as a CCT V project but the demonstration has not occurred because of withdrawal of the proposed site.

Environmental Performance: NO_x reductions of 50-60 percent have been proven in a full-scale boiler. Small reductions in other emissions (SO₂, CO₂, and particulates) are possible if coal reburning is installed as part of overall plant upgrade.

Economics: Coal reburning economics are very site specific but are comparable to competing technologies for some boilers. Total project costs are \$18 million; the proposed government share is \$9 million.

Market Potential: Coal reburning has a significant worldwide market potential, but it must compete against other technologies including gas reburning, selective noncatalytic reduction, and selective catalytic reduction. Twenty-three boilers in one Russian utility have been identified as candidates for retrofitting with micronized coal reburning. The proposer claims that the market for the technology is more than 100 boilers in Russia and 1,000 boilers worldwide.

Proposal No.: 13

Proposer: SRI and U.S. EPA (AEERL)

Project/Technology Description: The proposed project is a Russian demonstration of E-SO_x technology for moderate flue gas desulfurization. Fine water/limestone slurry is injected into the entrance of an ESP. The slurry scrubs SO₂ and the dry waste is collected in the ESP. The proposed size is a full-scale demonstration ESP with 12-meter-high electrodes.

Environmental Performance: The proposed process is described as having moderate SO₂ removal capabilities.

Economics: The estimated total project cost is about \$3 million; government support is sought for 50 percent of this cost.

Market Potential: Thermal power systems firing medium- to low-sulfur coals.

E.2.2 UKRAINE

This section contains a brief summary of each EOI for Ukraine. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 67

Proposer: Babcock & Wilcox

Project/Technology Description: The proposed project involves repowering a 50-MWe boiler at the Kharkov GRES-2 power plant in Ukraine with a circulating fluidized-bed demonstration unit to prove the commercial application of the technology for high-ash anthracite coal.

Technology Status: Atmospheric circulating fluidized-bed (AFB) combustion is commercially available.

Environmental Performance: Replacement AFBs would reduce SO₂ emissions by more than 90 percent, NO_x emissions would be reduced by 85 percent, particulate emissions would be reduced by 99 percent, and boiler efficiency is expected to improve as much as 10 percent, which contributes to CO₂ reduction.

Economics: Financial support is sought for \$8 million of the total project cost of \$17 million.

Market Potential: Ukraine is facing difficult economic conditions resulting from its dependence upon foreign energy sources. Prior to the breakup of the Soviet Union, Ukraine generated nearly 50 percent of its electrical power from natural gas and oil imported from Russia and other former Soviet territories. Ukraine now must maximize its use of indigenous fuels, which are primarily low-quality, high-ash anthracite coals, in order to minimize tensions resulting from trade imbalances with Russia.

Proposal No.: 28

Proposer: CQ Inc.

Project/Technology Description: The proposed project would demonstrate the Coal Quality Expert (CQE) by evaluating the performance of a power plant boiler in Ukraine. CQE is an integrated model that can be used to make fuel switching and blending, natural gas co-firing, and scrubber retrofit decisions.

Technology Status: CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based upon several highly successful models, such as the Electric Power Research Institute Coal Quality Impact Model and FGDCOST, both of which have gained widespread industrial acceptance.

Environmental Performance: Plant improvements/modifications suggested from CQE modelling will result in combustion efficiency improvements, which will raise plant efficiency. Improved plant efficiency will reduce SO₂ and CO₂ emissions, while reducing carbon in fly ash. CQE can aid in the identification of the most cost-effective options for reducing NO_x and SO₂ emissions.

Economics: CQE would be used to identify the cost-effective improvements in power plant operations and/or modifications. The total project cost is \$250,000; the government is being asked to fund the entire cost of the project.

Market Potential: CQE could be applied in any utility situation worldwide where coal firing is practiced. Plant modifications or retrofits suggested by CQE modelling could result in identifying new technology requirements that could be supplied by U.S. firms.

Proposal No.: 17

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves repowering a 200-MWe power plant in the Lugansk region of Ukraine with an atmospheric circulating fluidized-bed boiler. The power station has eight boilers, each supplying steam to a 200-MWe rated steam turbine. At the present time, each of these units operates at 131 MWe. Thus, retrofitting one train of the power plant a new AFB will increase the output by more than 30 percent.

Technology Status: First-generation atmospheric circulating fluidized-bed (AFB) is commercially available.

Environmental Performance: It has been shown that AFB boilers are very effective in controlling air pollutants. By adding limestone to the AFB boiler together with coal, sulfur capture in excess of 95 percent is achievable. Staged combustion in the AFB boiler will result in NO_x emissions below those recommended by NSPS. The AFB boiler operates more efficiently than the present boiler and will result in lower CO₂ emissions.

Economics: Financial support is requested for \$40 million of the total project cost of \$110 million.

Market Potential: There are 95 utility boilers in Ukraine in the range of 80- to 300-MWe. Approximately 50 percent of them operate on coal, with the balance firing mostly gas. Coal quality has significantly deteriorated over the past 10 years. The ash content has greatly increased from the original design of 15-20 percent, with a corresponding decrease in calorific value (from 9,400 Btu per pound to 7,900 Btu per pound) and volatile matter. Also, in the most recent years there were numerous interruptions in the supply of natural gas. AFB technology is one that effectively can utilize poor-grade Ukrainian coals. The age of Ukrainian fossil-fired power plants ranges from 20 to 40 years. The Ukrainian government has placed top priority on rebuilding the energy sector, especially that of electric generation. Any conversion of existing units or new construction would utilize local coals.

Proposal No.: 53

Proposer: TRW Space & Technology Division

Project/Technology Description: The proposed project is a retrofit demonstration of TRW's slagging combustor utilizing a 300-MWe boiler at Ladyzen Power Plant in Vinnitsa Oblast, Ukraine. A two-phase approach is proposed. The first phase involves integrating two 100-MWt, TRW-designed slagging coal combustors with an existing 800-MWt boiler, and using this partial retrofit as an optional demonstration of the technology. The second phase involves completely retrofitting the boiler with a slagging combustor system.

Technology Status: TRW's slagging combustor technology is considered as technically mature in the development process but not commercial as it has not yet been integrated onto a full-scale boiler. The technology was developed and demonstrated in part through a DOE CCT III project.

Environmental Performance: With addition, at a later date, of flame spray dryer technology, over 90 percent SO₂ reduction can be achieved. NO_x emissions are projected at less than or equal to 0.2 lb per million Btu, or more than 50 percent lower than conventional burner technology. Particulate emissions are very low because about 80 percent of the coal's ash is converted to a solid slag, which has significant market use. The remaining ash is collected in a baghouse, thereby achieving ash emissions of less than or equal to 0.015 lb per million Btu.

Economics: The economics are uncertain but are claimed by TRW to be less than competing IGCC or AFB technologies. TRW is seeking \$5-6 million of the total project costs of \$35 million for the procurement of goods and services from the United States.

Market Potential: If TRW's slagging combustion technology is proven on high-ash coals such as those found in Ukraine, the market potential could be significant, both in retrofit and greenfield applications. TRW identified a market of 6,000-MWe in Eastern Europe, Russia, Ukraine, India, and Korea over the next 20 years. Where reductions or elimination of oil or gas occurs, such as in Ukraine, the economics will be more attractive, and thus the market should be brighter.

E.2.3 OTHER NEWLY INDEPENDENT STATES

This section contains a brief summary of EOIs submitted for Estonia, Latvia, Lithuania, Kazakhstan, and Kyrgyzstan. Information is included to the extent it was included in the EOIs.

Proposal No.: 33, 34, 35, 36, 38

Proposer: CQ Inc.

Project/Technology Description: The project proposes to demonstrate the Coal Quality Expert (CQE) by evaluating the performance of a power plant boiler in Estonia, Kazakhstan, Kyrgyzstan, Latvia, and Lithuania. CQE is an integrated model that can be used to make fuel-switching and blending, natural gas co-firing, and scrubber retrofit decisions.

Technology Status: CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based upon several highly successful models, such as the Electric Power Research Institute's Coal Quality Impact Model and FDGCOST, that have gained widespread industrial acceptance.

Environmental Performance: Plant improvements/modifications suggested from CQE modelling will result in combustion efficiency improvements, which will raise plant efficiency. Improved plant efficiency will reduce SO₂ and CO₂ emissions, while reducing carbon in fly ash. CQE can aid in the identification of the most cost-effective options for reducing NO_x and SO₂ emissions.

Economic Performance: CQE will be used to identify the cost-effective improvements in power plant operations and/or modifications. The total project cost is \$250,000; the government is being asked to fund the entire cost of the project.

Market Potential: CQE could be applied in any utility situation worldwide where coal firing is practiced. Plant modifications or retrofits suggested by CQE modelling could result in identifying new technology requirements that could be supplied by U.S. firms.

E.3 EASTERN AND CENTRAL EUROPEAN COUNTRIES

E.3.1 POLAND

This section contains a brief summary of each EOI for Poland. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 62

Proposer: Acurex Environmental Corporation and ABB Environmental Systems

Project/Technology Description: The proposed project involves retrofitting a 120-MWe boiler in Upper Silesia, Poland, with duct injection technology. The ADVACATE/MDI integrates two duct injection technologies: preparation of a highly reactive sorbent (ADVACATE) and humidification by moist duct injection (MDI) process for SO₂ removal. An advanced silicate (ADVACATE) sorbent uses flyash to increase the reactivity of calcium-based sorbents. The sorbent is injected into the duct as a moist, free-flowing powder between the air preheater and the particulate collection system.

Technology Status: The ADVACATE/MDI duct injection process has been demonstrated at a 10 MWe scale and at the 105-MWe Edgewater Plant (Ohio Edison).

Environmental Performance: The ADVACATE/MDI process is capable of achieving 90 percent SO₂ removal. The sorbents have been shown to capture 99 percent of mercury present in flue gas. The process would lower CO₂ emissions relative to commercial wet FGD systems. The solid waste generated is reusable as low-strength concrete or as a material for landfill liners.

Economics: Duct injection is a low capital-cost technology, with possible application in plants with limited space, and potential reuse of solid waste. Government financial support for \$4 million of the total project cost of \$8.4 million.

Market Potential: The ADVACATE/MDI technology is applicable to low- and medium-sulfur coals. The respondent estimates a global potential of 95,000 MWe, of which 25,000 MWe is in Eastern Europe.

Proposal No.: 32

Proposer: CQ Inc.

Project/Technology Description: The Coal Quality Expert (CQE) would be demonstrated by evaluating the performance of a power plant boiler in Poland. CQE is an integrated model that can be used to make fuel switching and blending, natural gas cofiring, and scrubber retrofit decisions.

Technology Status: CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based upon several highly successful models, such as the Electric Power Research Institute's Coal Quality Impact Model and FGDCOST, which have gained widespread industrial acceptance.

Environmental Performance: Plant improvements/modifications suggested from CQE modelling will result in combustion efficiency improvements, which will raise plant efficiency. Improved plant efficiency will reduce SO₂ and CO₂ emissions, while reducing carbon in fly ash. CQE can aid in the identification of the most cost-effective options for reducing NO_x and SO₂ emissions.

Economics: CQE would be used to identify the cost-effective improvements in power plant operations and/or modifications. The total project cost is \$250,000; the government is being asked to fund the entire cost of the project.

Market Potential: CQE could be applied in any utility situation worldwide where coal firing is practiced. Plant modifications or retrofits suggested by CQE modelling could result in identifying new technology requirements that could be supplied by U.S. firms.

Proposal No.: 57

Proposer: Custom Coals Corporation

Project/Technology Description: The project involves construction of a coal preparation plant in Poland to clean two million tons per year of coal using the self-scrubbing coal technology (coal preparation plus sorbent addition for sulfur control).

Technology Status: Conventional and advanced coal cleaning equipment, both of which are available commercially, would be used in the preparation plant. The technology is being demonstrated under the CCT Program.

Environmental Performance: Improved coal quality will lead to improved power plant performance, which will ultimately lead to reduced CO₂ emissions. Also, a significant reduction

in SO₂ emissions will result from burning the clean coal product that incorporates a limestone sorbent.

Economics: The economics of the self-scrubbing coal technology will be site-specific. Coal cleaning is generally the most cost-effective means (\$/ton) to reduce sulfur dioxide emission from coal combustion. Incorporating the sorbent into clean coal form produced from moderate sulfur coal will significantly increase the amount of "compliance" coal that could be marketed. The total project cost is estimated at \$30 million with only \$1-2 million requested from the government as a guarantee against civil penalties.

Market Potential: Currently, less than 30 percent of Polish coal is cleaned to long-term compliance levels. The application of Custom Coal's technology will expand the number of power stations that can meet forthcoming emissions standards. Three facilities are planned for Poland.

Proposal No.: 75

Proposer: HYDROCARB Corporation

Project/Technology Description: The proposed project in Poland involves construction of a 100-ton-of-coal-per-day demonstration plant, which is approximately one-fiftieth of the size envisioned for commercial facilities. Production rates from the demonstration are estimated at 37 tons per day of carbon black and 6,700 gallons per day of methanol. The HYDROCARB™ process converts coal of all grades (as well as other carbonaceous material such as biomass and municipal solid waste) to fuels and chemical commodities. The heart of the process involves hydrogasification, methane pyrolysis, and methanol synthesis process units.

Technology Status: The process relies predominantly on conventional technology and involves no new chemistry. Experimental design testing has been completed for most process steps. The demonstration, however, is considered vital to the reliable design of commercial plants.

Environmental Performance: Pollutant control efficiency from process gases is not quantitatively stated in the EOI but is expected to be high. Removal of sulfur in the feedstock is accomplished with calcium sorbents. It is anticipated that basic solid waste (consisting of ash, gypsum, and unconverted lime) will be suitable for landfill or may potentially be converted to a marketable building construction material.

Economics: Although the capital requirement for the process is significant, it is believed that product sales will provide a profitable operation over the life-cycle of the plant. The EOI includes a recommendation for U.S. government funding up to 25 percent of the demonstration cost. Estimated project cost is provided but is indicated as proprietary.

Market Potential: No limit for the market potential was specified. However, marketing analysis would be required for large-scale development of the technology. For instance, the U.S. capacity for methanol is about 5 million tons per year. A commercial plant (5,000 tons of coal per day) would have an estimated capacity of about 3 million tons per year.

Proposal No.: 61

Proposer: SGI International

Project/Technology Description: The project seeks to construct a clean coal refinery in Belchatów, Poland and other power plants. The refiner would use SGI International's liquid from coal (LFC) process, which upgrades low-rank coal using mild gasification technology and produces liquid and solid products. A base plant is designed to process 5,000 metric tons of coal or lignite and solid products. A base plant is designed to process 5,000 metric tons of coal or lignite per day. This plant includes a 40-MW cogeneration facility capable of providing 20 MWe for sale to a local utility grid.

Technology Status: One mild gasification demonstration plant is operational under DOE's Clean Coal Technology Program. Liquid products are sold to a fuel broker and solid products are sold to a local utility for power generation.

Environmental Performance: This process offers a method that can markedly reduce the environmentally damaging SO₂ emissions from coal-fired power plants. The upgrading or drying of low-rank coals and lignites in a clean coal refinery removes most of the moisture, thereby increasing the heating value of the solid products, also decreasing the transportation costs and infrastructure impact. The mild pyrolysis removes a significant fraction of the organic sulfur.

Economics: Government financial support for 50 percent of the total project costs of \$400,000 is requested.

Market Potential: Poland is among the world's leaders in both hard coal and lignite/brown coal production. The Belchatów mine in south-central Poland produces some 40 million metric tons of lignite per year, all of which is dedicated to a nearby 4,320-MWe power station. Because of its high moisture content and high volatile matter, the heating value and coal rank are low. This technology could help reduce the SO₂ emissions by upgrading the lignite and removing most of the moisture and by using mild pyrolysis, which removes a significant fraction of the volatile matter and sulfur. Liquid products can be used in existing markets for No. 6 fuel oil. Solid products can be used in most industrial and utility boilers. Mild gasification provides an economic option for upgrading high-moisture, low heating value coals.

E.3.2 CZECH REPUBLIC

This section contains a brief summary of each EOI for the Czech Republic. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 64

Proposer: Ahlstrom Pyropower, Inc.

Project/Technology Description: The proposed project involves repowering a 125-MWe boiler in Ledvice, Czech Republic, using pressurized circulating fluidized-bed technology.

Technology Status: Second-generation pressurized circulating fluidized-bed (PFB) technology has been demonstrated at the pilot plant.

Environmental Performance: Repowering with the PFB would result in lowering of CO₂ emissions by 15-20 percent. Other emissions will be SO₂ less than 200 mg/Nm³; NO_x less than 150 mg/Nm³; and particulates less than 10 mg/Nm³ (reference 6 percent O₂). There are no hazardous or toxic wastes. Solid wastes (ash) are inert, with quantities in the range of 12 metric tons per hour.

Economics: Government support is sought for \$85-110 million of the total project cost of about \$225 million.

Market Potential: The commercialization potential in the Czech Republic is high. It is anticipated that there will be four to six repowering projects in the next five years.

Proposal No.: 68

Proposer: Babcock & Wilcox

Project/Technology Description: The proposed project involves the expansion of the district heating plant in Plzeň, Czech Republic, using brown-coal-fired atmospheric circulating fluidized-bed boilers. A 175-ton-per-hour boiler and cogeneration turbine plant expansion is proposed.

Technology Status: Atmospheric circulating fluidized-bed (AFB) combustion is commercially available.

Environmental Performance: Replacement AFBs would reduce SO₂ emissions by more than 90 percent, NO_x emissions would be reduced by 85 percent, particulate emissions would be reduced by 99 percent and boiler efficiency is expected to improve as much as 10 percent, which contributes to CO₂ reduction.

Economics: Government financial support for \$10 million of the total project cost of \$50 million is requested.

Market Potential: The Plzeň district heating plant (Czech Republic) is looking to expand its electrical generation and district heating capacity to meet the demands of a growing Eastern European city. Such a facility would use locally produced brown coal and meet stringent restrictions on environmental emissions for SO₂ and NO_x without separate flue gas control systems. In addition to new construction, AFB technology can be effectively applied to repowering aging, conventionally fired plants.

Proposal No.: 39

Proposer: CQ Inc.

Project/Technology Description: The Coal Quality Expert (CQE) will be demonstrated by evaluating the performance of a power plant boiler in the Czech Republic. CQE is an integrated model that can be used to make fuel-switching and blending, natural gas cofiring, and scrubber retrofit decisions.

Technology Status: CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based upon several highly successful models, such as the Electric Power Research Institute's Coal Quality Impact Model and FGDCOST, both of which have gained widespread industrial acceptance.

Environmental Performance: Plant improvements/modifications suggested from CQE modelling will result in combustion efficiency improvements, which will raise plant efficiency. Improved plant efficiency will reduce SO₂ and CO₂ emissions, while reducing carbon in flyash. CQE can aid in the identification of the most cost-effective options for reducing NO_x and SO₂ emissions.

Economics: CQE would be used to identify the cost-effective improvements in power plant operations and/or modifications. The total project cost is \$250,000; the government is being asked to fund the entire cost of the project.

Market Potential: CQE could be applied in any utility situation worldwide where coal firing is practiced. Plant modifications or retrofits suggested by CQE modelling could result in identifying new technology requirements that could be supplied by U.S. firms.

Proposal No.: 77

Proposer: KFx, Incorporated

Project/Technology Description: The project proposes to construct a K-Fuel plant in Bilina, Northern Bohemia, Czech Republic, to produce 220,000 tons of upgraded, clean fuel for industrial and commercial boilers and home use. A model village would be constructed to demonstrate the advantages of clean fuel use.

Technology Status: The K-Fuel process has been under development since 1975 and is currently commercializing two of the principal methods to produce a clean fuel.

Environmental Performance: About 70 percent of pollution in the Czech Republic is produced from small, multiple point sources, such as residential and small commercial/industrial boilers. Conversion of brown coal to K-Fuel for use in these units will reduce local, national, and transboundary pollution.

Economics: The total project cost for a 2-million-ton-per-year plant is estimated at \$160 million, with engineering and construction of the first phase (220,000 tons per year) costing \$20 million. Federal support between \$500,000 and \$1 million is sought to implement the model village.

Market Potential: A 2-million-ton-per-year market in the Czech Republic by the year 2000 for upgraded brown coal is estimated. K-Fuel could be a competitive option in other countries that have low-rank coal, such as India, China, Turkey, Indonesia, and Thailand.

Proposal No: 3

Proposer: Sorbent Technologies Corporation

Project/Technology Description: Proposed is a demonstration of a duct injection process using "supported sorbents" on a 30- to 60-MWe boiler in the Czech Republic. The proposed process would inject supported sorbent into a duct between existing ESP and a COHPAC microbaghouse. Supported sorbents are moist, granular sorbents consisting of hydrated lime coated onto the large internal and external surface areas of mineral supports, such as exfoliated vermiculite and perlite.

Technology Status: Currently, this process is being tested on a 2-MWe (6,500 acfm) slipstream at Ohio Edison's R.E. Burger station.

Environmental Performance: The proposer indicates over 80 percent SO₂ removal with utilizations over 55 percent. The process (with the additional baghouse) would increase

particulate collection and would remove significant quantities of mercury. The spent sorbent would be relatively free of flyash and has shown promise as a fertilizer.

Economics: Although duct injection processes generally are low capital cost systems, the proposed process would have a higher capital cost (due to the equipment installed after the ESP) than earlier duct injection processes. However, it would have lower operating costs due to higher sorbent utilizations (if the cost of the sorbent is not significantly greater than hydrated lime) and a salable by-product. Also, the higher SO₂ removals (relative to earlier duct injection processes) would also influence the cost (based on \$/ton of SO₂ removed). Government financial support is sought for 50 percent of the total project cost of \$20 million.

Market Potential: There are more than a dozen boilers in the proposed size range in the Czech Republic. The process also would be applicable to boilers globally (including the United States).

E.3.3 OTHER EASTERN AND CENTRAL EUROPEAN COUNTRIES

This section contains a brief summary of each EOI for other Eastern and Central European countries. Information is included to the extent it was provided in the EOIs.

Proposal No.: 49

Proposer: ALIAS Group, Incorporated

Project/Technology Description: The proposed project involves retrofitting advanced sensors and combustion/emission control technology onto existing utility and industrial coal-fired boilers to provide improved efficiency and environmental performance. The demonstration is proposed for an unspecified industrial plant in Hungary. Through existing relationships with Hungarian companies, the respondent seeks to develop an organization in Hungary to sell and service the automated controls.

Technology Status: Similar control systems are being developed and marketed in the United States, Canada, and the United Kingdom, including several demonstration projects funded by DOE (CCT and Small Business Innovative Research (SBIR) Programs). The advanced sensor technology is not specified.

Environmental Performance: Although specific to each boiler application, emissions will be reduced via improved control of the combustion process. In general, modest NO_x, CO, and particulate emissions reductions will be achieved for most installation.

Economics: The economics would be very site-specific. In general, payback would be achieved in a few years through improved plant efficiency. The total project cost is \$2.975 million; the proposed federal share is 50 percent of the total.

Market Potential: In developing countries, there is tremendous need for modern control systems. Therefore, the market potential for the proposed systems, which carry little or no technical risk, is likely very large. Twelve plants in Hungary have been identified for potential retrofit.

Proposal No.: 71

Proposer: Babcock & Wilcox Company

Project/Technology Description: The respondent proposes to promote its DRB-XCL burner technology, which was developed with DOE support as a CCT Round I project, in Eastern Europe, where there is a large population of older boilers in need of low-cost NO_x control approaches. Support is requested to adapt the technology to foreign boiler designs by collecting detailed plant design information. The modified technology would be developed in a 1-million-Btu-per-hour pilot-scale combustion facility and demonstrated in a 50-MWe boiler in Poland.

Technology Status: Babcock & Wilcox's low-NO_x burner technology is considered commercial.

Environmental Performance: NO_x reductions are typically 40-60 percent. Power plant efficiency improvements, which are gained primarily through parallel plant upgrades, are typically 2-5 percent.

Economics: Low-NO_x burners generally are the most cost-effective NO_x abatement technology for pulverized coal-fired boilers. The respondent seeks \$1 million to support an initiative, costed at a total \$3 million, to sell burners in Eastern Europe.

Market Potential: Babcock & Wilcox identified a total of approximately 3,500 burners in just two countries: Poland and Romania. With completion of the proposed effort, Babcock & Wilcox should be able to garner a significant market share. Babcock & Wilcox states that the total worldwide boiler market is more than 1,000 boilers.

Proposal No.: 72

Proposer: Babcock & Wilcox

Project/Technology Description: The respondent proposes to demonstrate the technology in Eastern Europe, where there is a large population of older boilers in need of low-cost NO_x control approaches.

Technology Status: Coal reburning technology is technically proven. It was demonstrated in a DOE CCT Round II project at the Wisconsin Power & Light Company's Nelsen Dewey Generating Station.

Environmental Performance: NO_x reductions of 50-60 percent have been proven in a full-scale boiler. Small reductions in other emissions (SO₂, CO₂, and particulates) are possible if coal reburning is installed as part of overall plant upgrade.

Economics: The proposal seeks funding for up-front engineering studies (\$300-400 thousand) and performance guarantees (\$1-2 million) to remove barriers to commercial deployment of the technology. Coal reburning economics are very site-specific but are comparable to competing technologies for some boilers.

Market Potential: Coal reburning has a significant worldwide market potential, but it must compete against other technologies including gas reburning, selective catalytic reduction, and selective catalytic reduction.

Proposal No.: 29, 30, 31, 37, 41

Proposer: CQ Inc.

Project/Technology Description: The Coal Quality Expert (CQE) would be demonstrated by evaluating the performance of a power plant boiler in Bulgaria, Hungary, and Romania. CQE is an integrated model that can be used to make fuel-switching and blending, natural gas co-firing, and scrubber retrofit decisions.

Technology Status: CQE is a new model, which is being developed in the CCT Program, for making fuel decisions by integrating the system-wide effects of fuel purchase decisions on power plant emissions, performance, and power generation costs. The model is based upon several highly successful models, such as the Electric Power Research Institute's Coal Quality Impact Model and FGDCOST, both of which have gained widespread industrial acceptance.

Environmental Performance: Plant improvements/modifications suggested from CQE modelling will result in combustion efficiency improvements, which will raise plant efficiency. Improved plant efficiency will reduce SO₂ and CO₂ emissions, while reducing carbon in fly ash. CQE can aid in the identification of the most cost-effective options for reducing NO_x and SO₂ emissions.

Economics: CQE would be used to identify the cost-effective improvements in power plant operations and/or modifications. The total project cost is \$250,000; the government is being asked to fund the entire cost of the project.

Market Potential: CQE could be applied in any utility situation worldwide where coal firing is practiced. Plant modifications or retrofits suggested by CQE modelling could result in identifying new technology requirements that could be supplied by U.S. firms.

Proposal No.: 56

Proposer: Gilbert/Commonwealth, Inc.

Economics: The performance of evaluations and other studies, e.g., evaluation of supply-side options, emissions compliance/life extension, evaluation of heating systems, can have far reaching implications for better understanding the needs of host countries with respect to clean coal technologies.

Market Potential: There will be a continuous need for studies and evaluations of current systems prior to the construction and use of clean coal technologies.

Proposal No.: 44

Proposer: Texaco, Inc.

Project/ Technology Description: The proposed project is a grassroots, 200-400 MWe IGCC power plant.

Technology Status: This first-generation IGCC is at the commercial demonstration stage of development. U.S. technology developers are marketing first-generation IGCC systems worldwide.

Environmental Performance: IGCC is widely recognized as the cleanest, most efficient, and versatile technology for the production of electricity from coal and other "dirty" hydrocarbon feedstocks containing sulfur, metals, and other potential pollutants. Compared to conventional coal-fired boiler systems, IGCC can reduce SO₂ emissions by more than 99 percent, NO_x emissions by up to 85 percent, and CO₂ emissions by 15 percent or more. IGCC achieves an equally impressive performance in reducing particulates emissions, wastewater discharge, and solid waste generation. The only two solid by-products of IGCC, sulfur and non-leachable slag, both have market value; sulfur for fertilizer production and slag for use as an aggregate, roadbed base, or abrasive.

Economics: This technology is intended primarily for new installations to produce 200-400 MWe. The operator of the IGCC could realize a \$16-18 million annual environmental cost savings, equivalent to an advantage of approximately one cent per kilowatt-hour. Assuming a \$10-per-ton solids disposal cost, and considering that the other coal technologies generate 300-400 thousand tons per year more solids than IGCC (250-MWe case), the IGCC plant also would have an annual solid discharge cost savings of \$1.7-3.9 million. Altogether, these environmental cost benefits can be equated to an environmental capital value in excess of \$500 per kilowatt capital cost reduction, relative to other technologies.

Market Potential: The potential market for clean coal technologies in developing and transitional economies is projected to be \$600-800 billion during 1993 to 2010, with an export potential of approximately \$200 billion for exporting nations. This translates to up to 7,000 new jobs in exporting nations. IGCC systems also offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems also offer developing and underdeveloped countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

E.4 LATIN AMERICA

This section contains a brief summary of each EOI for Latin America. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 25

Proposer: Foster Wheeler Energy International, Inc.

Project/Technology Description: The proposed project involves the design and supply of a 100-MWe advanced pressurized circulating fluidized-bed power generating facility in Mexico. The system comprises a coal gasifier, pressurized circulating fluidized-bed boiler, gas cleanup equipment, and gas and steam turbine generators with heat recovery, together with all the necessary infrastructure.

Technology Status: First-generation pressurized fluidized bed (PFB) is commercially available. The coal gasifier, gas cleanup equipment, and gas turbine generator have been demonstrated at the pilot scale. The facility would be capable of generating nominal 100 megawatt electric (MWe) of power.

Environmental Performance: It has been shown that PFB boilers are very effective in controlling air pollutants. By adding limestone to the PFB boiler together with coal, sulfur capture in excess of 90 percent is achievable. Staged combustion in the PFB boiler will result in NO_x emissions below those recommended by NSPS. The PFB boiler operates more efficiently than the present boiler and will result in lower CO₂ emissions.

Economics: Government financial support is sought for \$60 million of the estimated total project cost of \$160 million.

Market Potential: Mexico requires considerable additions to its power generation capacity over the next several decades and is one of the key potential markets for clean coal technologies in the world, with an expected need for increased coal-based power of some 20,000 MWe by 2030. The

high-efficiency, low-emission characteristics of this technology can be expected to enable it to capture a significant portion of this market.

Proposal No.: 8

Proposer: The Hiller Group, Inc.

Project/Technology Description: The respondent proposes to export to Brazil low-ash coal reductants to replace charcoal, petroleum coke, and metallurgical coke.

Environmental Performance: The reduction in the manufacturing of charcoal will reduce local air pollution, reduce deforestation, and provide more efficient coking process, which should reduce plant emissions.

Economics: The process is expected to open new markets for high-purity alloy products, and should reduce electricity costs. Government financial support is sought for 50 percent of the estimated total project cost of \$1.1 million annually for five years.

Market potential: There is a large global market because industries in the underdeveloped countries have not been exposed to coal as a carbon replacement for charcoal, petroleum, and metallurgical coke.

E.5 COUNTRY UNSPECIFIED

This section contains a brief summary of each EOI that did not specify a country or region. Information is included to the extent to which it was provided in the EOIs.

Proposal No.: 5

Proposer: Georgia Institute of Technology

Project/Technology Description: The respondent proposes to train earth and atmospheric sciences graduate students from developing countries in clean coal technologies.

Environmental Performance: The training with respect to the clean coal technologies for foreign nationals from developing countries will provide a better understanding of the technical considerations, which should have positive impact on host countries selecting clean coal technologies.

Economics: Financial support is sought for 50 percent of the total project cost of \$260,000 per year.

Proposal No.: 1

Proposer: Leas Industrial Associates

Project/Technology Description: The proposed project is a grassroots 50- to 100-MWe IGCC plant using catalytic coal gasification.

Technology Status: Applied for patent (08-352833).

Environmental Performance: The use of this novel gasification technology is projected to meet U.S. EPA standards. Using a U.S. coal, the technology reduces CO₂ emissions by 35.8 percent, NO_x emissions by 90 percent, SO₂ emissions by 99 percent, and process water cooling by 90 percent. In addition, there are no liquid or solid waste products.

Economics: Although the economics of the proposed technology are addressed using a U.S. coal, substantial savings in coal transportation: \$500 per ton from metal recovery from coal, by-product credit value of purified ash of \$20 per ton, and by-product credit value of purified gypsum of \$10 per ton. In addition, the overall efficiency of the LIA-IGCC is 44 percent.

Market Potential: IGCC systems offer an economic and environmentally acceptable option for meeting increased demand for power. IGCC systems offer developing and underdeveloped countries an option for meeting their increasing demand for electric power without relying on high-cost fuels, while meeting the international demands for protecting the environment. That is, IGCC systems offer countries rich in coal an option to reduce their reliance on oil and natural gas for power generation.

Proposal No.: 74

Proposer: Thermal Organic Recycling Equipment Inc.

Project/Technology Description: The thermal organic reactions (THOR) process is a closed-loop oxygen-free process that decomposes organic material into hydrocarbon vapors, some of which are condensed into various hydrocarbon liquids similar to distillate and heavy oil. Although many organic materials (plastics, oil shale, sewage sludge, chicken litter, hospital/medical wastes, spilled/waste oil, coal) have been evaluated, a THOR unit to process discarded or waste tires is proposed for commercialization. By-products from tire processing include high-grade carbon black and clean nylon and/or steel cord. A commercial unit would process 6,000 tires per day and could be integrated into a large facility capable of coprocessing municipal solid waste and other wastes, such as animal waste and sewage sludge.

Technology Status: A small pilot reactor of unspecified scale has been operated on a variety of organic materials to develop and validate the THOR process.

Environmental Performance: The THOR process operates as a closed system. Most organics are recovered as valuable products. The remaining waste gases are utilized within the process to generate necessary heat to operate the unit. When processing tires, the nylon and/or steel cords are recovered as clean recyclable by-products.

Economics: Unknown. No specific request for financial assistance was stated.

Market Potential: The worldwide market is potentially very large if the process is technically and economically proven.