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THRESHOLD EVALUATIONS
OF INDUSTRIAL CONSERVATION
TECHNOLOGIES RUN IN
ISTUM BASE CASE

MASTER

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1. INTRODUCTION

1.1 INTRODUCTION

This report summarizes the results of threshold evaluations performed on several INDUS technologies which were competed with other new and conventional industrial technologies in the Industrial Sector Technology Use Model (ISTUM) developed by EEA. The ISTUM model is briefly described in Section 2 of this report and includes the input technology categories and service sectors treated in the model, and the solution technique used.

Section 3 summarizes the input data specifications for the Industry Conservation technologies run in the ISTUM base case. Included in this section are listings of the technologies run in ISTUM, those not run in ISTUM, and a discussion of the absence of a retrofit algorithm in ISTUM and its resulting impact on conservation technologies. Also included in this section is a discussion of the capital cost variability, maximum market fraction, size and load factors and data quality specifications for the conservation technologies in ISTUM.

Section 4 presents the results of the ISTUM base case run, describing the important limitations and constraints of the base case run, the key assumptions inherent in the base case, and the summarized results of energy savings by year for different generic technology types. Section 5 discusses in detail the technology characterization data developed for each INDUS technology run in the ISTUM base case. The descriptions contained in this section include the calculations and assumptions used in determining the service demand displacement, equipment cost, maximum market fraction, data quality, and size and load range for each technology.

The appendix contains copies of the computer printouts of the threshold evaluation input data and results for each Industry Conservation technology run in ISTUM.

The reader should bear in mind that the ISTUM base case model runs, upon which the results of this analysis are based, are fully described in the four volume set of documentation, which has not yet been released.^{1/} It should also be noted that the ISTUM base case analysis is preliminary, and the results are subject to numerous caveats and qualifications not listed herein, which are described in detail in the full ISTUM documentation.

It is further intended that the acknowledged weaknesses in the current ISTUM model will be removed in subsequent versions. Also, additional Industrial Conservation technologies will be specified for use in later ISTUM runs, along with improved data for technologies run in the current version.

1.2 SUMMARY OF RESULTS

The result of the Base Case runs of the ISTUM model indicate that the 22 industrial conservation technologies offer significant opportunities for energy savings. In 1985 and 2000, the energy savings attributable to these 22 technologies used in 31 separate applications^{2/} is estimated to be .47 and 1.65 quads, respectively.

1/ "Industrial Sector Technology Use Model (ISTUM): Industrial Energy Use in the United States, 1974-2000," Preliminary Draft Report, June 19, 1978, Energy and Environmental Analysis, Inc.

2/ Some technologies, such as High Temperature Recuperators and Boiler Air/Fuel Controls have more than one end-use application area.

The ISTUM effort to model the impact of industrial energy conservation technologies understates their energy savings potential in two ways. First, the current version of ISTUM does not have the capability to account for retrofit technology applications.^{1/} Since several industrial conservation technologies have significant retrofit potential, the energy savings estimates provided by ISTUM are lower than would otherwise be expected. Consequently, the impact of conservation technologies is underestimated to a greater extent in the near term because the opportunities for applications become smaller as old capital stock is replaced. Modifications to the ISTUM model to properly account for retrofit technologies will be added in the future.

A second reason this analysis understates the impact of industrial energy conservation is that not all the conservation technologies were included. Technologies were omitted from the analysis either because they lacked adequate data specifications or because they did not fit into the ISTUM framework. Data collection efforts currently underway, and further disaggregation of industrial sectors and processes represented in the model logic will help rectify these problems and significantly broaden the range of technologies capable of being evaluated in ISTUM.

Table 1-1 summarizes the energy savings estimated by ISTUM for the years 1985 and 2000 by service sector, and Table 1-2 depicts the energy savings by service sector estimated by MOPPS for the same years. Despite the lack of a comprehensive industrial energy conservation portfolio and retrofit logic, the energy savings for the industry conservation technologies are estimated by ISTUM to be .47 and 1.65 quads, respectively. Even though the MOPPS results indicate higher energy savings than ISTUM, the number of technologies competing in MOPPS is more than double the number in ISTUM. Also, recalling that the ISTUM technologies cannot compete for retrofit applications and that the ISTUM data specifications are more conservative than MOPPS, the lower energy savings are not unreasonable.

^{1/} The MOPPS industrial model, which did account for retrofit applications, overstated their potential.

TABLE 1-1
ISTUM RESULTS
CONSERVATION ENERGY SAVINGS IN QUADS
BY SERVICE SECTOR

<u>Sector</u>	<u>Number of Technologies</u>	<u>1985</u>	<u>2000</u>
Steam	9	.145	.549
Direct Heat - Intermediate	4	.059	.254
Direct Heat - Dirty	3	.046	.089
Electrolytic	2	.001	.092
Indirect Heat Non-Coal	2	.023	.104
Calcining	3	.095	.253
Glass Melting	2	.037	.086
Brick Firing	1	.004	.011
Iron Making	2	.021	.049
Steel Reheating	<u>3</u>	<u>.043</u>	<u>.166</u>
TOTAL	31	.474	1.653

TABLE 1-2
MOPPS RESULTS
CONSERVATION ENERGY SAVINGS IN QUADS
BY SERVICE SECTOR

<u>Sector</u>	<u>Number of Technologies</u>	<u>1985</u>	<u>2000</u>
Steam	23	1.594	4.018
Direct Heat - Clean	4	.055	.246
Direct Heat - Intermediate	10	.512	1.163
Direct Heat - Dirty	10	.434	1.099
Indirect Heat	3	.098	.379
Electrolytic	3	.145	.443
Machine Drive	12	.342	1.628
Liquid Feedstock	3	.019	.142
M Gas Feedstock	<u>2</u>	<u>.003</u>	<u>.044</u>
TOTAL	70	3.202	9.162

Table 1-3 lists the industry conservation technologies included in the ISTUM Base Case and the energy savings achieved by each. The technologies that compete in several sectors (such as High Temperature Recuperators) have their individual sector contributions summed and reported as generic technologies. Two of these, Boiler (Heater) Air/Fuel Controls and High Temperature Recuperators account for 78 percent of the total savings in 1985 and 68 percent in 2000.

TABLE 1-3
ISTUM RESULTS
CONSERVATION ENERGY SAVINGS IN QUADS
BY TECHNOLOGY

<u>Technology</u>	<u>1985</u>	<u>2000</u>
Poultry Process Modification Tech	.008	.027
Coal in Aluminum Remelt	-	-
Headbox for Paper	.001	.025
Pulp Paper Characterization	-	.043
Hyperfiltration	.015	.046
Low Level Heat Pumps	-	-
Foam Fiber	.013	.052
High Temperature Recuperator	.215	.587
Paper Pulp Sludge Drying	-	.001
Direct Reduction of Aluminum	-	.058
Aluminum Smelter Modification	.001	.034
Polypropylene to Fuel	.004	.017
Refuse in Cement Kiln	.001	.004
Blended Cement	.054	.148
Flat Glass Energy Reduction	-	.004
Cement Block Drying	.004	.011
Cupola Furnace Modification	-	.005
Blast Furnace Gasifier	.002	.041
Heat Pump - Steam	-	.001
Air/Fuel Controls	.156	.538
Heat Pump - Dry Mill	-	.002
Moving Beam Furnace	-	.009
TOTAL	.474	1.653

2. DESCRIPTION OF THE METHODOLOGY

2.1 INTRODUCTION

The Industrial Sector Technology Use Model (ISTUM) is designed to predict the commercial market penetration of various energy technologies in the industrial sector out to the year 2000. The model represents the refinement and further development of the Industrial Sector Model developed for the Market Oriented Program Planning Study Task Force in 1977.^{1/}

The model assesses the comparative economic competitiveness of each technology. It then uses these assessments to project each technology's anticipated market penetration. Careful accounting of total industrial energy demand forecasts assumes that the total market for all energy technologies is not overstated. Each technology's success is a function of its comparative economics and the total demand for the energy service it provides. All technologies are treated equally with regard to fuel prices and other macro-economic factors. The procedures used to compete the technologies against each other were designed to give an accurate reflection of corporate decision making. In all aspects EEA's strategy was to provide a realistic framework within which energy technologies could be objectively appraised.

Because of the uncertainty that exists in many of the model inputs, the model was designed to allow maximum flexibility in testing alternative scenarios. For example, technology costs are broken down into their major components so that if the cost or necessity of one particular component is in doubt it can easily be changed. Or if an alternative fuel price scenario is of interest each or all fuel price vectors can easily be replaced.

^{1/} "Market Oriented Program Planning Study - Final Report of the Industrial Sector Working Group", prepared for DOE by Energy and Environmental Analysis, Inc., November 30, 1977, unpublished.

In its present state of development, ISTUM is a valuable tool for evaluating:

- The commercial viability of energy technologies in the industrial sector
- The impact of various macro-economic forecasts and fuel price projections on energy use patterns in the industrial sector
- The consequences of various environmental regulatory policies
- The aggregate fuel mix of the industrial sector between now and the end of the century under various economic and policy scenarios
- The commercial potential for certain technologies within specific industries -- e.g., synthetic gas in the petroleum refining industry.

Because of the many dimensions in the ISTUM model this list of possible use for the model is virtually endless.

The primary value of the ISTUM model will be in its systematic use to evaluate either broad economic/policy scenarios or investigation of the factors which determine the commercial potential of emerging energy technologies.

A broad overview of the model will be provided in the next two paragraphs of this section. Paragraph 2.2 will deal with the input requirements of the model; paragraph 2.3 will discuss the solution of the model. The remainder of this volume will include an in-depth discussion of the topics which are briefly described in this chapter. The purpose of this section is to give the reader a quick familiarization with the ISTUM model logic and its special terminology.

2.2 KEY MODEL INPUTS

The three key sets of inputs to the ISTUM model depicted in Figure 2-1, technology data, energy demand data, and fuel prices, will be discussed in this section.

FIGURE 2-1
KEY MODEL INPUTS

2.2.1 Technologies

ISTUM competes the industry conservation technologies together with over 100 other energy technologies. These fall in six primary categories: conventional, fossil energy, conservation, cogeneration, solar and geothermal.

2.2.1.1 Conventional Technologies

Generally these are the technologies which are currently meeting the energy demands in the industrial sector such as conventional oil, gas or coal steam generation. There are a few technologies which are of conventional nature but are as yet untried. In ISTUM all such cases are direct coal firing applications in some direct heat industrial use.

2.2.1.2 Fossil Energy Technologies

These technologies are those which are being developed or studied by the Fossil Energy Division of the Department of Energy (DOE). The ISTUM fossil energy technologies are not an exhaustive sample of the DOE portfolio. The primary technologies are atmospheric fluidized bed combustion (AFB), Low Btu gasification (LBG), and medium Btu gasification (MBG). Each of these technologies actually appears several times depending on how many different service sectors it can compete in. Service sectors are described later in this section.

2.2.1.3 Conservation Technologies

These technologies were all selected from DOE's portfolio of industrial conservation technologies which are currently being developed or studied. The ISTUM conservation technologies were chosen according to how well they fit ISTUM logic, how complete their economic and performance data was, and their potential for significant energy savings.

2.2.1.4 Cogeneration Technologies

ISTUM's portfolio of cogeneration technologies actually includes several self-generation technologies along with various topping and bottoming cycles. These technologies are strictly tied to industrial applications which precludes such utility applications as district heating. There are many intricate dimensions to modeling the commercial penetration of cogeneration in the industrial sector.

2.2.1.5 Solar and Geothermal Technologies

There is much controversy surrounding the commercial potential of these technologies. In the case of solar technologies in the industrial sector this stems from uncertainty over technology cost, and questions about the applicability of solar in high temperature or high capacity factor uses. In the case of geothermal the uncertainty is related more to the spatial location of industrial demand as well as the opportunity for using geothermal resources for central station electric power generation instead of industrial uses.

For all technologies, costs were developed in the systematic way using a framework that allowed breakdown of the technologies into key component costs.

In the case of technologies where there was an abundance of data, costs were broken down into the following major components:

- Site preparation and power house
- Primary system and controls
- Fuel handling
- Utility and feedwater systems
- Indirect capital costs

- Installation costs are included in each component with a separate set of indices to capture regional variability in construction labor costs.

These capital cost components are in turn broken down into subcases which reflect variability in the component cost due to factors such as sub-surface conditions, multiple unit installations, etc. These subcases are assigned probabilities of occurrence which sum to 1.0 for all subcases within a component. The technology cost inputs are then processed into cumulative frequency distributions which are used in the competition for market shares.

A great deal of time and effort went into the methodology of developing technology costs and the specifications of particular component costs. Due to variability in the amount and quality of the data available, a coding system was set up to grade each technology's inputs. The system gives grades from "A" to "D", with "A" representing a technology with sufficient reliable data to allow a detailed specification of all relevant components. On the other end of the range, a "D" technology is based on sketchy or unsubstantiated data on a technology which presently has no proven commercial applications. In some cases a low grade was also applied to a technology which had economic factors that were not easily modeled in the ISTUM framework.

2.2.2 Energy Demand

This facet of the model actually has three important sub-dimensions:

- Industries
- Equipment sizes (measured in million Btus per hour)
- Equipment load factors (measured in hours of operation per year)

The primary data for ISTUM's energy demand data base comes from the Energy Consumption Data Base (ECDB) which was completed in 1977 for the Federal Energy Administration (FEA) under the management of EEA. The data base is a comprehensive accounting of energy consumption in the industrial sector in 1974.

Considerable effort went into translating the ECDB data base into ISTUM's energy demand data base. Much of this involved allocating the Btus of energy consumption into industry classifications used in ISTUM, and allocating the same energy demands into "service demand" quantities. A service demand is a unit of energy which facilitates the modeling of comparative energy economics. It is defined as the amount of useful energy product required by an energy using industrial process. Thus a boiler with an 80 percent efficiency will convert 100 MMBtu/hr of fuel into 80 MMBtu/hr of service demand - in this case in the form of steam. By converting energy consumption into service demand, technologies with different costs and conversion efficiencies can compete equitably for a given amount of service demand even though they do not use the same fuel/capital-equipment mixes to satisfy the demand.

ISTUM allocates energy demand into 23 different service sectors such as steam, indirect heat, machine drive, etc. Thirteen of these service sectors are actually competed to determine which technologies will "win" the service demand. The other service sectors are maintained to keep accurate accounting of energy consumption. These include such service sectors as natural gas feedstocks, miscellaneous lubes and waxes, etc. Table 2-1 is a complete listing of the service sectors used in ISTUM.

In each of the 13 service sectors where technology competition takes place it is necessary to specify sizes and load factors in order to calculate the economics for each technology on a \$/MMBtu basis. For example,

TABLE 2-1
SERVICE SECTORS USED IN THE ISTUM MODEL

1. Steam*
2. Direct Heat - (Intermediate)*
3. Direct Heat - (Dirty)*
4. Indirect Heat - (coal capable)*
5. Machine Drive*
6. Electrolytic*
7. Liquid Feedstock
8. Natural Gas Feedstock
9. LPG Feedstock
10. Metallurgical Coal
11. Miscellaneous Energy and Lubes
12. Space Heat*
13. Indirect Heat - (not coal capable)*
14. Calcining*
15. Glass Melting*
16. Brick and Clay Firing*
17. Ironmaking*
18. Steelmaking
19. Steel Reheating*
20. Internal Generation
21. Captive Electricity
22. Captive Direct Heat
23. Coke Consumption

*Indicates service sectors in which technologies compete in ISTUM. The remaining service sectors are maintained to keep an accurate accounting of total energy consumption in the industrial sector.

in the steam service sector two sizes and two load factors were chosen giving a total of four size/load factor combinations. The sizes were 50 and 250 MMBtu/hr of service demand; the load factors were 4000 and 7000 hours/yr. Different technologies will dominate different size/load factor cells. Capital intensive technologies will do better with high load factors; technologies with significant economies of scale will do better in large installations.

ISTUM divides energy demand among 26 different Standard Industrial Classifications (SIC's). Twenty-two of these are industrial SIC's at the two, three or four digit level depending on energy consumption patterns. The other four SIC's represent mining and agricultural energy uses. Growth rates of future energy demand are forecast for each SIC. These forecasts were obtained from Data Resources, Inc.'s. most recent "Trendlong" solution of their macro-economic model of the U.S. economy.

2.2.3 Fuel Prices

The third key input to the model is fuel prices. Fuel price inputs for the model were also provided by Data Resources, Inc. They correspond to the same solution of DRI's "Trendlong" macro forecast for the U.S. economy and a coordinated solution of the DRI energy model which actually forecasted the basic fuel prices. The fuel prices were forecast for 13 different regions from which a distribution of national prices for each fuel was generated. Prices were calculated in this fashion out to the year 2000 to match the model's solution horizon. In the actual technology competition these fuel prices were levelized to give a more accurate decision analysis.

2.3 SOLUTION OF THE MODEL

With these three key inputs set, the model is ready for solution to determine the commercial market shares of the competing technologies. There are three key aspects to a solution of the ISTUM model:

- Nominal market shares
- Actual market shares
- Capital stock growth and retirement

2.3.1 Nominal Market Shares

Nominal market shares are calculated assuming rational economic decision making behavior in the private sector. Every decision maker is assumed to always pick the lowest cost technology to meet his energy needs.

Since both the technology cost inputs and the fuel price inputs are ranges (they are inputted as distributions of possible prices rather than single point estimates), the solution of nominal market shares requires a statistical integration procedure to determine how often any given technology will be the lowest cost choice. Thus with Figure 2-2 below, there are four hypothetical technologies competing for the service demand in this particular competitive cell. A competitive cell is a certain size

FIGURE 2-2
HYPOTHETICAL TECHNOLOGY COST DISTRIBUTIONS

and load factor of energy demand in a certain service sector (steam, indirect heat, etc.) in a given year. The distribution for each technology represents the probability of its total cost (capital, fuel and O&M)

equaling any given \$/MMBtu price. The area under a technology's cost distribution represents the total fraction of that particular competitive cell for which that technology can compete. Thus technology "A" has the lowest cost distribution of the four, but the fact that the area under "A's" distribution is relatively small indicates that it is getting blocked out of a part of the market. To do this ISTUM uses what is termed a maximum market fraction. If a particular technology for technical or other reasons can only compete for half of a given market it will receive a maximum fraction of .50. Examples of maximum fraction constraints would include:

- Process steam requirements in some cases are at higher temperatures or load factors than a solar system can provide.
- A conservation technology applicable to one, but not all, direct heat applications in a particular industry.
- Non-attainment regulations effectively blocking coal combustion in some geographical area.

Returning to the example in Figure 2-2, the competition between these four technologies is accomplished by statistical procedure to determine how much nominal market share each technology will get. In this example technology "A" can be expected to get the majority if not all of its maximum market share. Technology "B" will get the next strongest share with "C" next. It is possible that by the time "A", "B", and "C" have taken their shares the entire market will be satisfied and technology "D" will get no share of the market at all. On the other hand, if technologies "A", "B", and "C" have small maximum market fractions there would still be market available to technology "D".

The competitive procedure takes place in each of about 360 competitive cells in the model. The results of this step of the model solution are

the nominal market share for every technology, in every service sector in every industry, in every year of the model. The next step involves determining actual market shares.

2.3.2 Actual Market Shares

For emerging technologies it is assumed that not all industrial energy decisions reflect precision economics. There is great uncertainty surrounding the commercial introduction of new technologies. Some more "risk-prone" decision makers will be likely to respond to the economics of an emerging technology sooner than others. This phenomenon introduces a lag to the commercial acceptance of a new energy technology, causing its actual market in early years. ISTUM has a behavioral lag logarithm that captures this phenomenon with new energy technologies.

Although most analysts agree that a behavioral lag phenomenon exists, no one has developed substantial data to quantify or predict this phenomenon parametrically.

2.3.3 Capital Stock Growth and Retirement

Once actual market shares are calculated for all service sectors and years, it is necessary to determine the size of the service sector demands which apply to these actual market fractions. These demands for energy technologies are a function of two factors -- retirement of existing capacity and new growth. Data Resources, Inc. provided assistance in developing both of these dimensions.

The projections of retirement are based on past capital stock turnover rates in each of the industries we modeled. By looking at historical stocks, we developed a capital stock retirement model based on the philosophy that the amount of retirement of energy stock in any year is a function of the

age of the existing capital stock which is tracked. Coefficients (estimated from historical data) are applied to retire an appropriate portion of the capital stock.

The amount of predicted growth in each industry is then added to this retirement factor to come up with the total incremental demand of energy capacity in each industry in each year. This demand, in turn, is allocated to the appropriate sizes and load factors in each of the service sectors. At this point the energy demands and the actual market shares for all the technologies are on the same basis and the final results are easily calculated.

At their most disaggregated level the model results are measured in annual Btu's of service demand consumption by technology, by industry, by service sector, by fuel, by size. Sorting and displaying these outputs, the model is capable of generating vast quantities of results. Figure 2-3 is a schematic representation of the ISTUM model.

FIGURE 2-3

SCHEMATIC OF INDUSTRIAL SECTOR TECHNOLOGY USE MODEL

3. CONSERVATION TECHNOLOGIES IN ISTUM

3.1 INTRODUCTION

This chapter summarizes the input data specifications for the conservation technologies run in the ISTUM base case. A detailed description of the technology characterization data is included for each technology in Section 5 of this report.

A portfolio of 33 conservation technologies was developed for the ISTUM base case. The majority of these technologies compete in the steam, intermediate direct heat, dirty direct heat, and calcining or steel reheating service sectors.

These conservation technologies, as a group, present a severe test to any comprehensive industrial energy model. Unlike new fossil technologies or ISTUM conventional energy systems the conservation strategies are typically designed for a specific process within a single industry. Many of the conservation technologies incorporate difficult to evaluate but significant non-energy factors, related to environmental control, production capacity, and institutional relationships. In addition, only a handful of conservation technologies were supported by outside documentation. These factors made the specification of conservation technologies in a form compatible with ISTUM very difficult.

The conservation portfolio, listed in Table 3-1, was selected with three guiding criteria. First, conservation technologies had to be reasonably compatible with ISTUM model logic. Second, only DOE projects that were well defined and based upon "hard" data were accepted. Finally, in the limited time available for technology specification, EEA endeavored to include proposals with the potential for major energy impact. The ISTUM conservation portfolio is therefore representative of

TABLE 3-1
CONSERVATION TECHNOLOGIES IN ISTUM

<u>Service Sector</u>	<u>Technology</u>	<u>ISTUM I.D.</u>
Steam	Boiler Air/Fuel Controls	2.11
	Heat Pump for Steam	2.21
	Poultry Process Modification	2.31
	Blast Furnace Conversion for MBG (Steam)	2.41
	Headbox for Paper	2.51
	Pulp Paper Characterization	2.61
	Hyperfiltration	2.71
	Low Level Heat Pump for Steam	2.81
	Foam Fiber Technology	2.91
Clean/Intermediate Direct Heat	Heater Air/Fuel Controls	2.12
	Coal in Aluminum Remelt	2.22
	High Temperature Recuperators	2.32
	Heat Pump - Brayton Cycle	2.92
Dirty Direct Heat	Heater Air/Fuel Control	2.13
	High Temperature Recuperators	2.33
	Paper Pulp Sludge Drying	2.43
Electrolytic	Direct Reduction of Aluminum	2.46
	Aluminum Smelter Modification	2.56
Liquid Feedstocks	Lube Oil Recovery	2.57
Non-Coal Indirect Heat	Heater Air/Fuel Controls	2.113
	Polypropylene Waste to Fuel	2.413
Calcining	High Temperature Recuperators	2.413
	Refuse Derived Fuel in Cement Kilns	2.414
	Blended Cement	2.514

TABLE 3-1 CONTINUED
 CONSERVATION TECHNOLOGIES IN ISTUM

<u>Service Sector</u>	<u>Technology</u>	<u>ISTUM I.D.</u>
Glass Melting	High Temperature Recuperators	2.315
	Glass Conglomerates	2.415
	Flat Glass Energy Reduction	2.515
Brick Firing	Cement Block Drying	2.516
Iron Making	High Temperature Recuperators	2.317
	Cupola Furnace Modification	2.417
Steel Reheating	Blast Furnace Conversion for MBG (Steel Reheat)	2.219
	High Temperature Recuperators	2.319
	Moving Beam Furnace	2.419

DOE sponsored industrial conservation projects, but includes only a part of the entire Federally funded program.

Incompatibilities with ISTUM model logic caused some technologies to be removed from the conservation portfolio. For example, Petroleum Refinery Energy Audits, a non-hardware DOE demonstration, could not be accurately modeled. The proposed Sterile Fluid Milk technology claimed energy benefits outside of the industrial sector (energy savings in retail and wholesale facilities) and was not suitable for ISTUM, an industrial sector model. The lack of appropriate competitive technologies prevented the inclusion of the Coal to Acetylene.

Numerous other DOE conservation proposals are in an early stage of development and lack adequate technical specification for ISTUM. DOE proposals for Waste Tire Energy Recovery, CO Conversion to Methanol, and Freeze Crystallization are some of the technologies that were not included in the ISTUM base case for this reason.

Table 3-2 identifies the conservation technologies not included in the ISTUM base case, and the reasons why they were not modeled. Future development and refinement of the ISTUM model, coupled with the ongoing EEA research in technology specification and project evaluation will strengthen the conservation portfolio of the continuing ISTUM analysis.

3.2 THE CONSERVATION RETROFIT ISSUE

The previous formulation of the MOPPS industrial sector model evaluated incremental demand (a combination of growth and normal capital retirement) and included a crude algorithm for estimating the pure retrofit applications of conservation technologies. Because of limited time and resources and the weakness of the original retrofit analysis, EEA limited the development of the ISTUM model to incremental demand. The lack of a retrofit algorithm understates the potential impact of conservation technologies.

TABLE 3-2
MAJOR CONSERVATION TECHNOLOGIES NOT INCLUDED IN ISTUM^{1/}

<u>Reason for Omission</u>	<u>Technologies</u>
Insufficient technical data because proposal is being redefined or is in pre- liminary stages	O ₂ Enrichment CO Conversion to Methanol N ₂ Based Carberrization CO as Feedstock Freeze Crystallization Irrigation Water Conservation Waste Heat from Slag
Non-hardware project, incompatible with ISTUM	Refinery Energy Monitor
Current ISTUM technology port- folio lacks appropriate competitors	Coal to Acetylene Heat Pump Grain Drying High Efficiency Arc Welding
Non-industrial energy savings are not compatible with ISTUM model structure	Sterilized Fluid Milk
Data quality of technology docu- mentation is marginal, or technology could not be accurately specified in limited time	Electric Arc Furnace Glass Composite Pipes Slot Forge Furnace Textile Process Modification Food Sterilization (GASPAK) Low Energy Fluid Food

^{1/} This list is representative of the projects omitted from the ISTUM base case. Many relatively new conservation proposals will not appear on either this page or in Table 3-1.

The importance of this ISTUM limitation is illustrated by Figure 4. At time T_0 , all service demand is satisfied by the ongoing capital stock. Future service demand in the ISTUM model, at T_1 , is composed of three categories. The first is new demand (region A on Figure 4) required by industrial growth. The second demand category (Region B) is created by the normal retirement of old capital equipment. The remaining service demand is supplied by the ongoing capital stock (Region C) until time T_j when all capital equipment existing at time T_0 has been replaced. Under the current ISTUM model structure, technologies may only compete for incremental demand, the sum of regions A and B on Figure 2-1. The ISTUM model provides no information for Region C which represents the potential market for retrofit technologies or premature retirement.

Normal retirement of old capital stock in ISTUM is determined by a capital turnover function. Premature retirement is the additional early replacement of existing equipment because of the availability of an economically superior technology. The superior technology shifts forward the optimal replacement age for the older combustion equipment. The current ISTUM model structure does not evaluate the potential market from premature retirement.

Since old industrial plants incur only variable costs once the capital investment has been paid, firms have an incentive to keep an existing plant in operation. This economic barrier is strong enough to minimize error in ISTUM projections of most major combustion equipment markets. However, a positive case can be made for retrofit applications of some conservation technologies. The excellent economics of Boiler Air/Fuel Controls combined with the simple "bolt on" character of these devices is stimulating retrofit applications. Because this monitoring technology operates virtually parallel to primary combustion equipment, the retirement economics of the existing capital stock may be only a minor influence on the retrofit investment decision. Other technologies with good economics, but with stronger links to the special characteristics of a particular

FIGURE 3-1

COMPONENTS OF ISTUM SERVICE DEMAND

Region A = Service Demand from New Growth.

Region B = Service Demand from Normal Retirement

Region C = Service Demand Satisfied by Ongoing
Capital Stock (the potential retrofit
market)

}
ISTUM
Incremental
Service
Demand

production process, such as High Temperature Recuperators, still may have some potential as retrofit applications. ISTUM provides no clues as to the extent of the bias against these and other conservation technologies. Resolution of the premature retirement or conservation retrofit issue must wait for the planned extension of the current model.

3.3 CONSERVATION TECHNOLOGY SPECIFICATION -- CAPITAL COST VARIABILITY

The capital cost specifications of the conservation technologies was almost invariably weaker than the specifications of new and conventional technologies. None of the conservation proposals included detailed breakdowns of equipment components or the capital cost distributions essential for ISTUM technology specifications. EEA was supplied with only point estimates for capital costs of each conservation technology, generally based upon a proposer's preliminary estimate of the technology's lowest cost in an ideal application.

To specify the conservation technologies in the ISTUM format, EEA constructed a single primary equipment building block with a probability distribution based upon three points. The lowest capital cost represents the ideal application, generally assumed to be the proposer's point estimate. Two additional capital cost estimates and a probability distribution were added by EEA staff. The three points and probability distribution, in combination, express the subjective assessment of the equipment cost variations of all technically possible applications of the conservation device.

Since none of the conservation technologies were specified for different service demand sizes, linear multipliers were employed to scale the capital cost distributions up and down to correspond to ISTUM levels. The final cost distribution incorporated the installation variability index and indirect capital costs (components "I" and "H", common to all ISTUM technologies), which are explained in detail in the Technology Appendix.

The simple "bolt on" technologies, such as Boiler Air/ Fuel Controls, Blended Cement, and Pulp Paper Characterization, may have been reliably modeled by this method of capital cost specification. For these technologies, the expected cost distributions are fairly narrow. Some of the more complicated process modifications, such as Direct Reduction of Aluminum, Moving Beam Furnace, or Paper Pulp Sludge Drying, could not be modeled accurately by capital cost distributions supported only by a point estimate. The available technology data for these complex conservation systems provided little insight as to the cost range for potential applications. In addition the lack of detailed component breakdown increased the possible errors from partial or inconsistent specification of the primary combustion equipment costs of the technology.

3.4. CONSERVATION MAXIMUM MARKET FRACTIONS

The maximum market fraction represents the potential service demand share for which conservation technologies may compete. Although ISTUM service demand is segmented by industry and service sector, additional factors provide technical bounds for conservation technologies. The maximum market fraction for conservation strategies is limited by the maximum service displacement of the technology, such as the 2 percent average energy savings of Boiler Air/Fuel Control. The availability of suitable waste heat (such as restricting high temperature recuperators) or waste material (limiting lube oil recovery) are additional factors which may constrain maximum market fractions. Conservation proposals that are technically applicable to a process subcategory within a single industry (such as Poultry Process Modification) are subject to a restriction based upon the ratio of the applicable process service demand to the service demand for the entire industry.

Multiple technical limits of the maximum market fraction for conservation strategies are common. For example, the Refuse Derived Fuel in Cement Kilns technology is restricted by three factors. First, the service demand displacement is limited for technical reasons to 30 percent, the

maximum substitution of refuse fuel for conventional energy sources in the Portland Cement process. In addition, EEA estimates that only half of the cement plants in the United States could secure an adequate supply of waste fuel because of geographic or institutional reasons. Finally, the Portland Cement process is only a little more than half of the service demand in calcining service sector. The multiplicative combination (.30 x .50 x .52) of the three restrictions - maximum service demand displacement, limited availability of waste fuel, and service sector subcategory - yields a maximum market fraction of .078 for Refuse Derived Fuel in Cement Kilns.

Due to the generally favorable economics of many conservation technologies, the accurate calculation of a maximum market fraction is extremely important. If the cost distribution for a conservation proposal is below the range of new and conventional technologies, the maximum market fraction is the only reason why the technology gets less than a 100 percent market penetration. Although this component of technology specification is important, the data supporting the calculations was often weak. For most conservation technologies, the proposer's data on technical limits or potential applicable units were the principle sources for maximum market calculations. Only limited number of calculations were supplemented by outside documentation and technical evaluations by EEA staff. Continued effort by EEA in this area will yield improved maximum market data for the entire conservation portfolio for use in subsequent refinements of the ISTUM model. Complete documentation of maximum market fractions for each conservation proposal can be found in Section 5.

3.5. SIZE AND LOAD FACTORS

Other factors that constrained the applicability of conservation technologies were size and capacity utilization specifications. Typically size or load ranges were restricted when scale-up or scale-down factors were not known or did not seem reasonable. For example, Poultry Processing

Modification was restricted to the 50 MMBtu/hr and 4000 hr/yr size and load factor categories because USDA documents indicated that virtually no plants operated beyond these limits. Headbox for Paper was restricted to the largest size and load factor in the steam sector, the only applicable paper making processes according to the proposers of this technology. These restrictions may actually improve the ISTUM market projection for a technology by placing the entire maximum market fraction in the logical model subcategory, which is probably the best market for the technology.^{1/} Distortions of ISTUM market projections from inappropriate competition amongst non-compatible technologies are thereby eliminated.

3.6 DATA QUALITY CODES

The data quality codes for conservation technologies in ISTUM are low for two reasons, weak technology documentation and conflicts with ISTUM model logic. As noted above, much of the technology specification for conservation proposals is based upon proposer data. Often the technology is in an early stage of development and neither "bench scale" tests nor engineering calculations have been completed. As a result of prior experience, EEA has concluded that the proposer data, especially estimates of expected capital costs, energy savings and potential markets, for technologies are generally very optimistic. Conservation technology specifications that were not based upon existing hardware development or could not be verified by EEA review or outside sources, received low data quality codes.

The "D" quality code is related to the second major technology specification problem, conflicts with ISTUM model logic. The current formulation

^{1/} The maximum market fraction of a conservation technology that is restricted by size or load will shift upward to compensate for reduced service demand for which it will compete. The size of the shift is based upon the size and load specifications of the particular service sector. Full explanations of these calculations for specific technologies can be found in Section 5.

of ISTUM was designed to accommodate major conservation or combustion equipment. The conservation portfolio includes several technologies with environmental control credits, material savings, production capacity changes and other non-energy related characteristics. Although some technologies were not included in the conservation portfolio because of significant conflicts with ISTUM model logic, EEA included a number of technologies with a "D" quality code to assure reasonable representation of conservation for the base case.

4. RESULTS

4.1 INTRODUCTION

This section summarizes the results of the ISTUM base case run. This section begins with a general discussion of the important limitations of the model. It then lists the characteristics of the base case run emphasizing the distinguishing features of this run compared with other policy scenarios.

4.2 IMPORTANT LIMITATIONS AND BOUNDARIES OF ISTUM

This section describes the limitations and boundaries of ISTUM. It is meant to serve as an introduction and warning when interpreting the results. Due to the depth and breadth of the ISTUM analysis, certain aspects of the model are naturally stronger than others. Also, certain considerations were ignored due to the purpose and/or scope of ISTUM.

4.2.1 Dependency Of Results On Base Case Assumptions

It should be noted that several assumptions specific to the base case scenario significantly affect the results. For example, it is perfectly possible that the government policies modeled in the base case scenario will not reflect actual future policy. Thus, the reader should refer to the key assumptions characterizing the base case which are contained in Section 4.3 of this chapter.

4.2.2 Distinction Between Energy and Non-Energy Service Demands

The purpose of ISTUM is to determine the industrial demand for technologies and fuels to meet industrial energy demands. However, a substantial portion of industrial demands for fossil fuels is for non-energy and

miscellaneous energy purposes. The major uses for fuels in the industrial sector has been presented previously in Table 2-1. The service sectors with asterisks are those that ISTUM considered for competing technologies.

The remaining service sectors generally include those that use energy products in non-energy uses (e.g., feedstocks, lubricants, etc.) or service sectors which are maintained for energy accounting purposes only.

Feedstock demands were calculated by maintaining constant feedstock mixes for each industry and using DRI industry growth rates. The resulting feedstock values are added to the energy demands calculated by ISTUM to project total industrial demands for fossil fuels for the remainder of the century.

4.2.3 Inability to Treat Interdependencies Adequately in the Base Case

The ISTUM base case run upon which these results are based was able to only partially handle interdependencies. Interdependencies are broadly defined as the covariance of cost components within a technology or among competing technologies. Those cost components covarying within a technology were assumed to be perfectly dependent and were combined accordingly. In effect, this served to reduce the variability of the cost of a technology.

Interdependencies across competing technologies were not treated adequately in the base case run. Dependent and independent cost variations were not distinguished. However, cost data were structured to identify dependent cost variations and model logic to treat interdependencies will be integrated into ISTUM in the future.

4.2.4 Omission of the Retrofit Market

Potentially economic retrofit applications were not considered in the base case ISTUM run. The major reason for their exclusion is the difficulty which ISTUM would have in reassessing the potential market for each year given the penetration of retrofit applications in prior years. In effect, the potential market would decrease as retrofit applications penetrated the market in prior years. Furthermore, remaining lifetimes of existing equipment bear heavily on the comparative economies of retrofit applications. These would require even more detailed modeling to be accurately captured.

4.2.5 Inaccurate Projection of MBG Penetration Resulting from Retrofit Omission

Medium Btu Gasification (MBG) captures no market, according to the ISTUM results. However, other studies conducted have demonstrated a potential market for MBG, mainly in retrofit applications. The combustion properties of MBG allow it to be burned in conventional natural gas boilers with only slight equipment modification. If the economics or regulatory environment favor a switch from natural gas and oil to coal fueled systems, it may be cheaper to use MBG rather than replace existing equipment with direct coal capable or low Btu gas (LBG) capable combustors. Since the present version of ISTUM does not deal with retrofit applications the potential market for MBG is considerably understated.

4.2.6 Understated Projection of Conservation Technology Penetration

The market shares that conservation technologies capture represent energy that would otherwise be required if conservation technologies were not available. The aggregate statistics on the group understate the total potential for conservation in the industrial sector for three reasons. First, not all conservation technologies comprising the DOE portfolio

were included since technical and/or cost information could not be obtained. Second, it is likely that many process changes will occur in the future that are presently unforeseeable. Thus, overall energy consumption, as projected by ISTUM, is probably overstated. Unfortunately, there are no means of determining the extent to which conservation has been understated, short of identifying and costing out all prospective conservation technologies. Third, the largest market for many conservation technologies is the retrofit market, which is not modeled.

4.2.7 Omission of Nuclear Power as an Industrial Technology Option

Nuclear power had been considered in MOPPS but was not considered in ISTUM. The main reason for its exclusion from ISTUM is its inability to achieve economies of scale at sizes industrial demands warrant. This is not considered a limitation of ISTUM since it is believed that nuclear power would not have penetrated the industrial sector where it did not penetrate in MOPPS. Instead, the technology was omitted to keep modeling costs to a minimum given reasonable industrial sector technologies.

4.2.8 Technology Uncertainty

Some of the technologies included in ISTUM are not technically proven. EEA attempted to make realistic estimates of their performance and costs. But they may not turn out in the manner estimated. If not, their performance will be different than projected.

4.3 KEY ASSUMPTION ON THE BASE CASE RUN^{1/}

The base case run possessed the following distinguishing characteristics:

- The Energy Supply and Environmental Coordination Act (ESECA) provision was assumed instituted, which prohibited the burning of oil or gas under boilers exceeding 100 MMBtu/hr of rated capacity.

^{1/} The base case in this initial ISTUM run refers to the April 4, 1978 run. Additional base case runs are anticipated in the future.

- An average electric utility declining block rate price was considered representative of the electricity price industry pays for electricity.
- Natural gas prices were assumed deregulated in 1985.
- Natural gas was assumed supply constrained in the 1980's - it was assumed that 25 percent of all new industrial requests for natural gas would be honored in 1980, 50 percent in 1981 to 1985 and 100 percent in 1986 and later years.
- An investment tax credit of 10 percent was assumed for all capital investments. This corresponds to current law (May 1978).
- A 13 percent nominal cost of capital was assumed as a result of an assumed debt/equity ratio of 35:65 and the nominal cost of equity and debt equaling 15 percent and 9 percent respectively.
- A "middle-of-the-road" economic growth rate was assumed which affected the assumed inflation, energy demand, and fuel price growth rates.
- The New Source Performance Standards currently under consideration or already being applied were assumed to prevail throughout the time period studied.

The results of the base case run are highly dependent on the above assumptions. During the course of the next few months, several policy alternatives will be considered in ISTUM which might dramatically affect the resulting fuel balances. The above assumptions should be kept in mind when interpreting the results presented in this volume.

4.4 CONSERVATION TECHNOLOGIES

The market shares that conservation technologies win represent energy that would otherwise be required if conservation technologies were not available. Air/fuel controls (boiler and heater) save 0.1 quads in 1985 and 0.38 quads in the year 2000. Air/fuel controls compete in four service sectors and conserve the following amounts of energy and percent of each service sector in 1985 and 2000:

Table 4-1
PROJECTED ENERGY CONSERVED BY AIR/FUEL
CONTROLS: 1985 and 2000

<u>Service Sector</u>	<u>1985</u>		<u>2000</u>	
	<u>Quads</u>	<u>Percent</u>	<u>Quads</u>	<u>Percent</u>
Steam	0.1	1.4%	0.3	2.6%
Direct Heat - Intermediate	0.004	0.5%	0.024	1.8%
Direct Heat - Dirty	0.005	2.8%	0.009	3.1%
Indirect Heat (not coal capable)	0.012	1.0%	0.058	2.9%

While air/fuel controls save a greater percentage of direct heat - dirty energy demand than of steam demand, air/fuel controls conserve the greatest quantities of energy in the steam sector due to this service sector's large energy consumption.

Heat Pumps compete in the steam, direct heat - intermediate, and space heat service sectors. Overall, Heat Pumps save 0.07 quads and 0.1 quads in 1985 and 2000 respectively. They save the following quantities and percentages of energy demand in the three service sectors:

TABLE 4-2
PROJECTED ENERGY CONSERVED BY HEAT
PUMPS: 1985 and 2000

<u>Service Sector</u>	<u>1985</u>		<u>2000</u>	
	<u>Quads*</u>	<u>Percent</u>	<u>Quads</u>	<u>Percent</u>
Steam	0.000	0.002%	0.004	0.039%
Direct Heat - Intermediate	0.001	0.058%	0.005	0.350%
Space Heat	0.074	16.5	0.098	13.4%

The Heat Pump is most economic as a space heater.

*Zero indicates energy savings less than .001 Quads saved.

High Temperature Recuperators conserve 0.07 quads in 1985 and 0.19 quads in the year 2000. They compete in the following service sectors with the results as shown:

TABLE 4-3
PROJECTED ENERGY CONSERVED BY HIGH TEMPERATURE
RECUPERATORS: 1985 and 2000

<u>Service Sector</u>	<u>1985</u>		<u>2000</u>	
	<u>Quads</u>	<u>Percent</u>	<u>Quads</u>	<u>Percent</u>
Direct Heat - Intermediate	0.015	1.8%	0.061	4.6%
Direct Heat - Dirty	0.010	5.4%	0.019	7.1%
Calcining	0.013	4.1%	0.033	6.8%
Glass Melting	0.012	11.7%	0.027	16.1%
Ironmaking	0.007	14.9%	0.014	21.9%
Steel Reheating	0.014	7.0%	0.038	14.1%

High Temperature Recuperators save the most energy in the direct heat - intermediate service sectors. Recuperators save large percentages of energy in the glass melting, ironmaking, and steel reheating service sectors.

The following technologies are "industrial waste" conservation technologies and compete in the following service sectors with results as presented:

TABLE 4-4
PROJECTED ENERGY CONSERVED BY INDUSTRIAL WASTE:
1985 and 2000

<u>Service Sector</u>	<u>1985</u>		<u>2000</u>	
	<u>Quads</u>	<u>Percent</u>	<u>Quads</u>	<u>Percent</u>
Direct Heat - Dirty				
Paper Pulp Sludge Drying	0.000	0.1%	0.001	0.4%
Indirect Heat (Not coal				
capable) Propylene Fuel	0.003	0.2%	0.012	0.6%
Calcining				
Refuse - Cement Kilns	0.000	0.1%	0.001	0.2%

Overall, this technology group saves 0.003 quads and 0.014 quads in 1985 and 2000 respectively.

"Other process changes" include several technologies that compete in the steam, calcining, brick firing, and glass melting service sectors. These technologies combine to save 0.05 quads and 0.20 quads in 1985 and 2000 respectively. Individually, the technologies perform as follows:

TABLE 4-5
PROJECTED ENERGY CONSERVATION BY "OTHER PROCESS CHANGES"
1985 and 2000

<u>Service Sector</u>	<u>1985</u>		<u>2000</u>	
	<u>Quads</u>	<u>Percent</u>	<u>Quads</u>	<u>Percent</u>
<u>Steam</u>				
Foam Fiber Tech	0.010	0.2%	0.042	0.4%
Pulp Paper Characterization	0.000	0.002%	0.036	0.32%
Poultry Process Modification	0.005	0.08%	0.016	0.15%
Headbox for Paper	0.001	0.01%	0.021	0.2%
Hyperfiltration	0.012	0.2%	0.038	0.3%
<u>Calcining</u>				
Blended Cement	0.016	5.0%	0.044	9.0%
<u>Glass Melting</u>				
Flat Glass Energy Red.	0.000	0.1%	0.001	0.7%
<u>Brick Firing</u>				
Cement Block Drying	0.001	3.2%	0.003	6.0%

Primary Metals Process Changes conserve 0.002 quads and 0.124 quads in 1985 and 2000 respectively. Technologies include Coal in Aluminum Remelt, Aluminum Smelter Modifications, Direct Reduction of Aluminum, Cupola

Furnace Modification, Moving Beam Furnace, Blast Furnace - MBG. They compete in the following service sectors and perform as follows:

TABLE 4-6
PROJECTED ENERGY CONSERVED BY PRIMARY METALS PROCESS CHANGES:
1985 and 2000

<u>Service Sector</u>	<u>1985</u>		<u>2000</u>	
	<u>Quads</u>	<u>Percent</u>	<u>Quads</u>	<u>Percent</u>
Direct Heat - Intermediate				
Coal Aluminum Remelt	0.000	0.000%	0.000	0.000%
Electrolytic				
Aluminum Smelter Modifications	0.001	0.182%	0.034	2.809%
Direct Reduction of Aluminum	0.000	0.000%	0.073	5.958%
Ironmaking				
Cupola Furnace Modification	0.000	0.078%	0.002	2.395%
Steel Reheating				
Moving Beam Furnace	0.000	0.000%	0.003	1.12%
Blast Furnace - MBG	0.000	0.231%	0.012	4.28

5. TECHNOLOGY CHARACTERIZATION DATA

5.1 INTRODUCTION

This section contains detailed descriptions of the technology characterization data for the conservation technologies run in the ISTUM base case.

Included in the characterization data are descriptions of the calculations and assumptions used in determining the service demand displacement, equipment cost, maximum market fraction, data quality and size and load range for each technology.

5.2 POULTRY PROCESS MODIFICATION TECHNOLOGY I.D.: 2.31

The conservation measures for the poultry processing industry that are supported by this DOE project include energy audits, simple housekeeping measures, and capital investments for heat recovery equipment. The major investments for a poultry plant would include modification of the scald tank, installation of heat recuperators on hot process water overflows, and adapting a heat exchanger to the refrigerator units to preheat water. The overall impact of this DOE program would be a reduction in the service demand for steam in the food industry (SIC 20).

Approximately 90 percent of all poultry processing is concentrated in 250 dual eviscerating plant modules located in the 175 largest plants in the United States. USDA data indicates that only 50 of these production modules operate for two shifts a day, or about 4,000 hours/year. Since the smallest load range for steam in ISTUM is 4,000 hours/year, EEA used the double shift poultry module for technology specification.

Service Demand Displacement

EEA estimated the following energy savings and capital cost break down for double shift poultry plants:

<u>Component</u>	<u>Cost</u>	<u>Energy Savings 10⁹ Btu/year</u>
Initial housekeeping	\$10,000	19.2
Modified scalding tank	\$35,000	7.5
Heat recuperators	\$35,000	8.9
Modified cleaning system	<u>\$ 7,000</u>	<u>3.6</u>
TOTAL	\$87,000	39.2

Based upon a 39.2×10^9 Btu/year energy savings in the poultry industry the steam service demand displacement at 4000 hours/year is:

$$\frac{\text{energy savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \frac{\text{service demand}}{\text{displacement}}$$

$$\frac{39.2 \times 10^9 \text{ Btu/year} \times .82}{4000 \text{ hr/year}} = 8.036 \text{ MMBtu/hr}$$

Equipment Cost

The equipment cost for modifying the poultry process is based upon the proposer's component breakdown identified in the table above. The proposer indicated that the cost for scalding modification could be lower for some plant configurations. EEA assumed the ideal application would cost \$80,000, and that 30 percent of all plants would be modified for a cost of \$80,000 to \$87,000. An additional 50 percent of all applications would face a total charge of \$87,000 to \$94,000. This relatively tight distribution of cost is supported by the simple nature of the proposed modifications.

Operating and maintenance costs were anticipated to be about 5 percent of installed capital cost. A linear scale factor of 6.25 was used to match the technology cost distribution to the 50 MMBtu/hr ISTUM steam size category.

Size and Load Ranges

Detailed information on the operating characteristics of poultry processing plants indicated that placing this technology package in the largest steam size and load categories was inappropriate. EEA therefore restricted the competition of poultry process modification to the ISTUM 50 MMBtu/hr size and 4000 hour/year load range.

Maximum Market Fraction

The 50 double shift modules can each save 39.2×10^9 Btu/year by adopting this technology package. The 200 single shift modules are incorporated into the maximum service demand displacement calculation by counting them as 100 double shift plants. The maximum annual displacement of steam service demand is therefore:

$$\left(\left(.5 \times \begin{array}{c} \text{single} \\ \text{shift} \\ \text{modules} \end{array} \right) + \begin{array}{c} \text{double} \\ \text{shift} \\ \text{modules} \end{array} \right) \times \begin{array}{c} \text{module} \\ \text{energy} \\ \text{savings} \end{array} \times \begin{array}{c} \text{fuel} \\ \text{efficiency} \end{array} = \begin{array}{c} \text{maximum} \\ \text{service} \\ \text{demand} \\ \text{displacement} \end{array}$$

$$((.5 \times 200) + 50) \times 32.9 \times 10^9 \times .82 = 4.8 \times 10^{12}$$

The ISTUM allocation of size and load ranges for the food industry limits the competition of poultry process modification (specified at only 50 MMBtu/hr and 4000 hr/year) to only 45 percent of the steam service demand in the food industry. Since the calculation of maximum service demand displacement was based upon specific plant data that already considered size and load constraints, the final maximum market calculation must be adjusted accordingly.

$$\frac{\text{maximum service demand displacement}}{\text{size/load factor} \times \text{industry service demand constraint}} = \text{maximum market fraction}$$

$$\frac{4.8 \times 10^{12} \text{ Btu/year}}{.45 \times 329.0 \times 10^{12} \text{ Btu/year}} = .0324$$

Data Quality

The technical specification of poultry process modification was supported by detailed component cost breakdowns and engineering calculations of energy savings. EEA was able to verify this data using our own engineering calculations. Although the USDA data on the market for this technology was very good, the modeling problems associated with converting single shift facilities into ISTUM compatible units indicated that a "C" quality code for maximum market fraction was appropriate.

5.3 COAL IN ALUMINUM REMELT TECHNOLOGY I.D.: 2.22

This technology was competed in the ISTUM base case and failed to capture a portion of the intermediate heat service demand. Consequently, a threshold evaluation is not included for this technology. It should be pointed out that the data quality codes for this technology are low and the results should not be considered an accurate representation of commercial potential.

Conventional remelt furnaces in the aluminum industry are fired using oil or natural gas. This technology specification is based upon a 300×10^6 lb/year aluminum remelt plant that uses coal. The coal remelt process competes in the clean direct heat service sector for SIC 3334, the aluminum industry.

Service Demand Displacement

The proposer of this DOE sponsored project indicates that a 300×10^6 lb/year plant may consume 320×10^9 Btu/year. The service demand displacement of the coal remelt process may be calculated as follows:

$$\frac{\text{fuel savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \frac{\text{service demand}}{\text{displacement}}$$

$$\frac{32 \times 10^{10} \times .4}{6500} = 19.69 \text{ MMBtu/hr.}$$

Equipment Cost

The project data for this technology revealed a range of capital costs from \$10 to 13 million. EEA estimated that half of all applications would cost between \$10 and \$11.6 million, with an additional 40 percent of all applications costing from \$11.6 to 13.8 million.

The operating and maintenance charge was estimated to be \$.83/MMBtu or about two percent of total capital costs. The coal in aluminum remelt cost was linearly scaled to the ISTUM clean direct heat service sector size categories.

Maximum Market Fraction

The DOE project manager estimated a potential market for 200 aluminum remelt plants. Based upon the hourly rating, the maximum service displacement is as follows:

$$\text{hourly rating} \times \text{hours/year} \times \text{units} = \text{maximum service demand displacement}$$

$$\begin{array}{l} 19.69 \times 10^6 \times 6500 \times 200 = 25.6 \times 10^{12} \\ \text{Btu/hr} \quad \quad \text{hr/yr} \quad \text{units} \quad \text{Btu/year/unit} \end{array}$$

The maximum market fraction is therefore:

$$\frac{\text{maximum service demand displacement}}{\text{ISTUM Direct Heat Service Demand in SIC 3334}} = \text{maximum market fraction}$$

$$\frac{25.6 \times 10^{12}}{38.7 \times 10^{12}} = .66$$

Data Quality

The energy savings, capital cost, and potential market for this technology was not verified by outside review or detailed engineering calculations. Energy savings and cost data were considered "C" quality data, while the lack of corroborating data on the maximum market fraction indicated a "D" quality code was appropriate.

5.4 HEADBOX FOR PAPER TECHNOLOGY I.D.: 2.51

This technology is based upon a modification to the headbox in the papermaking process. The goal of the process change is to increase the solid content of paper slurry from .5 to 2.0 percent, which would decrease the steam service demand in the drying cycle. The project data is based upon paper making units over 200 inches, accounting for approximately 75 percent of total production.

Service Demand Displacement

The proposer claims the headbox modification can save $.1 \times 10^{12}$ Btu/year. Using ISTUM assumptions about hours of operation and fuel efficiencies for the steam service sector in the paper industry, the hourly service demand displacement is:

$$\frac{\text{energy savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$
$$\frac{.1 \times 10^{12} \times .82}{7000} = 11.7 \text{ MMBtu/hr.}$$

Equipment Cost

The ISTUM equipment cost distribution was based upon the proposer's point estimate for retrofit applications. Since the DOE project manager indicated that this technology would be applicable to only 250 existing facilities, EEA assumed the modification costs would depend upon unique plant designs. Under the circumstances, total costs might rise significantly beyond the proposer's estimate for an ideal application. EEA estimated that 50 percent of all applications (Block A 2.51) would cost between \$700,000 and \$900,000. An additional 40 percent of the applications would cost \$900,000 to \$1,200,000. Operating and maintenance charges were anticipated to be equal to the conventional system. A linear scale factor of 21.37 was employed to match the 250 MMBtu/hr ISTUM size category in the steam service sector.

Size and Load Range

The improved headbox is designed for only the largest paper forming facilities. Since equipment cost and technical performance at the 50 MMBtu/hr size and the 4000 hours/year load range was not appropriate, EEA restricted this technology to steam demand at 250 MMBtu/hr, operating 7000 hours/year.

Maximum Market Fraction

The proposer indicated that the current total market for this headbox modification was 250 paper forming units. The maximum service demand displacement in 1978 is therefore:

$$\begin{array}{rclclcl} \text{energy} & \times & \text{fuel} & \times & \text{total} & = & \text{maximum service} \\ \text{savings} & & \text{efficiency} & & \text{units} & & \text{demand displacement} \\ \\ .1 \times 10^{12} & \times & .82 & \times & 250 \text{ units} & = & 20.5 \times 10^{12} \\ \text{Btu/unit/yr} & & & & & & \text{Btu/year} \end{array}$$

When size and load restrictions are used in technology specification, the maximum market fraction calculation may need to be adjusted. Due to ISTUM size and load assumptions, the restricted headbox technology can compete for only 56 percent of the steam service demand in the paper industry. Since the prior maximum service demand displacement already recognized the technical limitations for this process modification, the ISTUM maximum market must be increased to compensate for the restriction:

$$\frac{\text{Maximum service demand displacement}}{\text{size/load restriction}} \times \frac{\text{industry service demand}}{\text{demand}} = \text{maximum market fraction}$$

$$\frac{20.5 \times 10^{12} \text{ Btu/year}}{.56 \times 937.4 \times 10^{12} \text{ Btu/year}} = .039$$

Data Quality

Since this technology was not supported by equipment component breakdowns or any fuel scale demonstration, EEA gave the cost and energy savings a "C" quality code. The maximum market fraction is supported by slightly better data on existing paper making facilities and was rated as a "B".

5.6 PULP PAPER CHARACTERIZATION TECHNOLOGY I.D.: 2.61

This project is based upon the development by the National Bureau of Standards of an image analysis device to characterize pulp paper. The benefits of this technology are predicted to be: (1) increased recycling of poorly utilized mixed pulp papers, (2) the optimization of existing recycling processes by accurately measuring the pulp quality prior to paper making, and (3) increased control and better utilization of materials in the virgin pulp industry.

Service Demand Displacement

The energy savings claimed by the proposer include 45×10^9 Btu/year of oil or coal and 27×10^9 Btu/year of electricity. EEA made numerous phone calls to the proposer to try and document the sources of claims but was unable to determine their origin. Based upon an average consumption of 20 to 30 million Btu/ton for paper, the proposer claims a 10-12 percent energy savings for this paper technology. Assuming the energy savings are obtained by (1) eliminating test runs to verify paper quality and (2) minimizing resident time in pulp baths, the service demand displacement for the image analysis equipment is:

$$\frac{\text{fuel efficiency} \times \text{steam demand} + \text{fuel efficiency} \times \text{electric energy savings}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{(.82 \times 45 \times 10^9) + (.285 \times 27 \times 10^9)}{7000} = 6.37 \text{ MMBtu/hr}$$

Equipment Cost

The proposer of this technology expressed considerable uncertainty about the eventual cost for a fiber characterization unit. Virtually no analysis or engineering calculations of cost have been performed. The proposer indicated a target capital cost of \$110,000 for one image analysis unit. EEA guessed that installed costs (Block A2.61) for the full spectrum of applications could range from \$110,000 to \$160,000.

Operating and maintenance was estimated to be 5 percent of capital costs. The 6.35 MMBtu/hr service demand displacement required that the pulp characterization capital cost be linearly scaled to ISTUM steam service sector sizes, 50 and 250 MMBtu/hr.

Maximum Market Fraction

The proposer estimated a market for 500 pulp image analysis devices. Based upon the hourly service demand displacement and this market estimate, the maximum service demand relief is:

units sold x hourly service demand displacement x hours of operation displacement = maximum service demand displacement

$$500 \text{ units} \times 6.37 \text{ MMBtu/hr} \times 7000 \text{ hrs/yr.} = 22.3 \times 10^{12} \text{ Btu/yr.}$$

The ISTUM maximum market fraction is therefore:

$$\frac{\text{maximum service demand displacement}}{\text{industry service demand}} = \text{maximum market fraction}$$

$$\frac{22.3 \times 10^{12} \text{ Btu/yr}}{937.4 \times 10^{12} \text{ Btu/yr}} = .0238$$

Data Quality

Up to this time, the work on this DOE project has been directed at technical issues and has not included an explicit analysis of market potential, equipment cost, or energy savings. The proposer could not document the early estimates in these areas. Because of this lack of supporting documentation, the data quality for maximum market fraction and cost were coded as "C". The poorly documented energy savings of this technology, possibly involving multiple service sectors, presents difficult modeling problems and is coded as a "D".

5.7 HYPERFILTRATION TECHNOLOGY I.D.: 2.71

The technology data for HYPERFILTRATION is drawn from a joint DOE/EPA project for the closed cycle operation of textile plants. With this technology, hot process water is cleaned and reused many times, reducing the demand for steam. In addition, the filtration process can reduce pollution control costs, decrease water consumption, and provide an opportunity to recover chemicals and dyes.

Service Demand Displacement

The ISTUM specification is based upon a 30 gallon/minute filtration unit recycling 90 percent of 180°F water. For a unit operating at 7,000 hours/year, the fuel savings is expressed as follows:

process bath recycling efficiency	x	filter capacity	x	temperature difference of water	x	energy consumption = to heat water	=	energy savings per unit
.9		x 1.26 x 10 ⁶		x 130		x 8.34	=	13 x 10 ⁹
		gal/yr/unit				°F		Btu/yr/unit

The service demand of this unit is 1.5 MMBtu/hr based upon 7000 hr/year and an 82 percent efficiency in raising steam. To account for the electricity consumption of pumps, this service demand rating was lowered to 1.2 MMBtu/hr.

Equipment Cost

The capital cost frequency of the hyperfiltration unit (building block A 2.71) was based upon a revised point estimate from the DOE project manager.

EEA assumed that the project manager's estimate of \$133,000 for a hyperfiltration unit reflected a favorable application. For the entire textile industry, EEA estimate that 50 percent of the applications would fall between \$133,000 and \$150,000 and about 40 percent of the applications would cost between \$150,000 and \$180,000. The non-energy costs are reflected in the annual operating and maintenance charge. EEA estimates the annual chemical recovery and water pollution control benefits to range between \$26,000 and \$41,000 or 17 to 30 percent of the capital costs of an average hyperfiltration unit. With a typical O&M charge of \$20,300 or 13 percent of the average unit cost, the hyperfiltration unit provides an average non-fuel savings of \$16,000 or 11 percent of the capital cost each year.

Although the filtration unit has a 1.2 MMBtu/hr service demand rating, it will compete with other technologies to displace steam demand in either the 50 or 250 MMBtu/hr categories. Based upon the modular nature of the technology, EEA assumed that a linear scaling of the capital costs to these sizes was appropriate.

Maximum Market Fraction

The maximum market fraction for the hyperfiltration technology could only be estimated indirectly with poorly documented data. EEA assumed that one third of all water consumed in the textile industry (100×10^9 gallons per year in one EPA estimate) was at 180°F . The total number of filtration units required to handle this water is:

$$\frac{\text{hot water in textile industry}}{\text{hyperfiltration unit capacity}} = \text{Total Units}$$
$$\frac{.33 \times (100 \times 10^9 \text{ gallons/year})}{30 \text{ gal/min} \times 60 \text{ min/hr} \times 7000 \text{ hr/yr.}} = 2645 \text{ units}$$

The maximum service demand displacement for the entire textile industry is:

$$2645 \text{ units} \times 1.2 \text{ MMBtu/hr} \times 7000 \text{ hr/yr} = 22 \times 10^{12} \text{ Btu/yr}$$

The ISTUM maximum market fraction is therefore:

$$\frac{\text{maximum technology service demand displacement}}{\text{applicable industry service demand}} = \text{maximum market fraction}$$

$$\frac{22 \times 10^{12}}{93.6 \times 10^{12}} = .237$$

Data Quality

The energy savings of this technology could be partially verified by an engineering calculation of the waste water stream. However the equipment costs and maximum market fraction were based upon more questionable data. The capital cost specification relies heavily on the point estimates provided by the proposer and project managers point estimates, and the ISTUM logic must be stretched to incorporate non-energy credits. The capital costs in ISTUM were not supported by data from a full scale demonstration unit or engineering cost calculations. The maximum market fraction relies on questionable assumptions about the volume and temperature distribution of process water in the textile industry. Therefore this technology was given a "D" code for maximum market fraction and a "C" code on costs. The energy savings was classified as "B" quality data.

5.8 LOW LEVEL HEAT PUMPS TECHNOLOGY I.D.: 2.81

This reverse ranking cycle heat pump, designed to reclaim waste heat from industrial processes was included in the ISTUM base case, but failed to capture a portion of the steam service demand. Therefore no threshold evaluation was performed on this technology.

Service Demand Displacement

The proposer indicated a potential fuel savings of 198×10^9 Btu/year with this low level heat pump. Based upon this data, the ISTUM service demand displacement is:

$$\frac{\text{fuel savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{198 \times 10^9 \text{ Btu/yr} \times .82}{7000 \text{ hr/yr}} = 23.2 \text{ MMBtu/hr}$$

Equipment Cost

The proposer provided the following breakdown of costs for the low level heat pump:

power recovery system	\$303,000
pipng, steam evaporator	\$448,000
installation	<u>\$195,000</u>
TOTAL	\$846,000

EEA assumed that this cost represented an ideal application and that unique circumstances in some plants would almost double total cost. One half of all applications were estimated to fall between \$750,000 and \$950,000. An additional 40 percent of all applications were expected to cost from \$950,000 to \$1,300,000.

Operating and maintenance charges were estimated to annually cost about 7 percent of total capital cost. The 23.2 MMBtu/hr unit was linearly scaled to the ISTUM steam service sector size categories.

Maximum Market Fraction

The potential market for this technology is limited by the availability of waste heat sources and not potential applications of low temperature steam. EEA estimated that the low level heat pump was best suited for non-corrosive and high volume waste heat sources. Since very little documentation of waste streams is currently available, EEA conservatively estimated a five percent maximum market fraction. This represents the fraction of steam service demand for which an adequate waste heat source is available.

Data Quality Code

Since very little data is currently available on the characteristics of waste heat sources, and the market limits for the low level heat pump could not be accurately defined, EEA considered maximum market fraction to be a "D" data quality code. The energy savings of this technology while based upon engineering calculations was not verified by outside reviewers and was classed as "C" quality data. Due to the limited component breakdown of cost provided by the proposer, EEA judged the cost data was code "B".

Qualifications

The DOE project manager estimated a COP of 60 is technically feasible for this heat pump when the unit is driven by a waste heat turbine. Heat pumps without the turbine, operated with purchased electricity, may exhibit a COP of 15. The current ISTUM specification for the low level heat pump erroneously assumes a COP of 2.5. This error increases the charge for electricity consumed, resulting in an understatement of the true market potential for this heat pump.

5.9 FOAM FIBER TECHNOLOGY I.D.: 2.91

The energy conservation potential of the DOE sponsored project is based upon a process change in the textile industry that will reduce the hot water required in fabric finishing. The conventional pad bath would be replaced with a novel foam process that could decrease the demand for steam.

Service Demand Displacement

Based upon the proposer's estimate of 25×10^9 Btu/year in energy savings, the service demand displacement of a foam fiber unit is:

$$\frac{\text{annual energy savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{25 \times 10^9 \text{ Btu/yr} \times .82}{7000 \text{ hr/yr}} = 2.93 \text{ MMBtu/hr}$$

Equipment Cost

The ISTUM capital cost distribution for this technology is based entirely upon the proposer's point estimate of the cost of an ideal application. EEA estimated that 90 percent of all applications would cost between \$65,000 and \$600,000. No differences were anticipated between operating and maintenance costs of the conventional and new system. The capital cost distribution (Block A2.91) was linear scaled to match the ISTUM sizes of 50 and 250 MMBtu/hr in the steam service sector.

Maximum Market Fraction

The market analysis for this technology is based upon an A.D. Little study which estimated that 674 technically compatible applications exist in the textile industry. Using this estimate, EEA calculated the maximum service demand displacement as follows:

Total	Unit	Steam		Maximum
Market X	Energy	X Fuel	=	Service Demand
Units	Savings	Efficiency		Displacement

$$674 \text{ units} \times 25 \times 10^9 \text{ Btu/unit/yr} \times .82 = 13.82 \times 10^{12} \text{ Btu/yr.}$$

The ISTUM maximum market fraction is therefore:

$$\frac{\text{maximum service demand displacement}}{\text{textile steam service demand}} = \text{maximum market fraction}$$

$$\frac{13.82 \times 10^{12} \text{ Btu/yr}}{93.6 \times 10^{12} \text{ Btu/yr.}} = .1476$$

Data Quality

Since EEA was unable to confirm the technology specification through engineering calculations or an outside data source, the foam fiber project was given "C" quality codes.

5.10 HIGH TEMPERATURE RECUPERATOR TECHNOLOGY I.D.: 2.32, 2.33, 2.314, 2.315, 2.317, 2.319

Gases exiting high temperature industrial processes may be used to preheat incoming combustion air, saving as much as 30 percent of total fuel. The waste heat recovery research sponsored by DOE includes numerous high temperature recuperator projects. The ISTUM specification of recuperators is based upon a technical analysis of energy saving investments by the American Iron and Steel Institute.^{1/}

High temperature recuperators were placed in six ISTUM service sectors: clean/intermediate direct heat, dirty direct heat, calcining, glass melting, ironmaking and steel reheating. The ISTUM specification is based upon AISI data on a soaking pit recuperator that uses a 1800°F waste gas stream to preheat combustion air from 70°F to 800°F.

Service Demand Displacement

The AISI report indicated that the soaking pit recuperator would save 24.03×10^9 Btu/year of fuel, assuming a 30 percent savings over a cold air condition. The service demand displacement of this recuperator is therefore:

$$\frac{\text{fuel savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$
$$\frac{24.03 \times 10^9 \text{ Btu/yr} \times .33}{5500} = 1.5 \text{ MMBtu/hr}$$

^{1/} Handbook on Energy Conservation in the Steel Industry, American Iron and Steel Institute (AISI), May 26, 1976.

Equipment Cost

The equipment cost of the AISI recuperator was based upon an ideal application, involving no unusual installation costs. The total installed cost of \$62,200 included the following components:

Radiation recuperator	\$41,500
Piping	6,500
Installation crane rental	2,000
Engineering	1,700
<u>Labor</u>	<u>10,500</u>
TOTAL	\$62,200

EEA assumed that 50 percent of all recuperators would cost between \$62,200 and \$114,400. An additional 40 percent of all recuperators would cost between \$114,400 to \$167,000. This capital cost frequency is common to all cost building blocks (A2.32, A2.33, A2.314, A2.315, A2.317, A2.319) for recuperators in ISTUM.

Operating and maintenance charges are estimated by AISI at \$4,000 per year, or 6.4 percent of installed cost. The recuperator cost, based upon a 1.5 MMBtu/year unit, was scaled to the ISTUM service demand sizes in each service sector.

Maximum Market Fraction

The maximum market fraction for recuperators is based upon a survey of waste heat recovery in 73 industry groups by Garrett Airesearch^{1/}. The energy savings potential for 3-digit SIC using 85 percent effective recuperators was aggregated for each ISTUM service sector as follows.

Service Sector 14 - Calcining

Garrett estimated a potential energy savings of 5.4 percent in calcining. Although this estimate was based only upon oil and gas fired kilns,

^{1/} "Survey of Potential Energy Savings Using High Effectiveness Recuperators from Waste Heat Recovery from Industrial Flue Gases", Garrett Airesearch Manufacturing Company, October 15, 1977.

about 30 percent of the calcining service sector. EEA assumed a maximum market fraction of .05 was reasonable.

Service Sector 15 - Glass Melting

The Garrett survey identified the following fuel savings potential in glass melting:

<u>SIC</u>	<u>Fuel Saving Potential</u>	<u>10¹² Btu</u>
3211	Flat Glass	9.39
3222	Glass Containers	13.19
3229	Pressed and Blown	6.00
3231	Products of Glass	2.39
<u>GLASS MELTING</u>		<u>30.97</u>

The maximum market fraction of recuperators in glass melting is therefore:

$$\frac{\text{Garrett estimated fuel savings}}{\text{ISTUM Glass melting fuel}} = \frac{30.97}{237.8} = .13$$

Service Sectors 17 - Ironmaking and 19 - Steel Reheating

The Garrett Survey estimates the potential energy savings of recuperators in the steel industry. The industry could use recuperators for five different service sectors: intermediate direct heat, dirty direct heat, ironmaking, steelmaking, and steel reheating. Since Garrett does not estimate potential energy savings by service sector, EEA assumed that energy savings from recuperators could be proportionally allocated to ISTUM service sectors based upon total service demand in each service sector.

SIC	Fuel Savings Potential	10^{12} Btu/yr
3312	Blast Furnace & Steel Mills	191.7
3315	Steel Wire	.75
3316	Cold Finished	--
3317	Steel Pipes & Tubes	2.73
Total Potential Energy Savings		195.18
Energy savings in service sector 2 or 3		-48.53
Combined Service Sectors 17, 18, 19		146.65

The maximum market fraction for the combined service sectors is as follows:

combined fuel savings			maximum
iron	steel	steel	market
making	making	reheating	fraction
fuel	fuel	fuel	
	+	+	
146.64×10^{12} Btu/year			=
$(141 + 115 + 577.9) \times 10^{12}$ Btu/yr.			.1758

Service Sector 2 - Clean/Intermediate Direct Heat and 3 - Dirty Direct Heat

To obtain the maximum market fraction for service sectors 2 and 3, the Garrett energy savings had to be proportionally scaled between the service sectors and 4 applicable industrial groups. Table 5-1 summarizes the results of these calculations. The Garrett data is listed in Tables 5-2, 5-3, and 5-4.

Data Quality

The overall quality of data on high temperature recuperators was very good. The ISTUM technical specification was supported by Garrett and AISI research. The energy savings potential in glass melting, calcining, iron-making, steel reheating and the direct heats could be generally verified by engineering calculations.

TABLE 5-1

POTENTIAL FUEL SAVINGS IN DIRECT HEAT (10^{12} Btu/yr)

ISTUM Industry Classification	Service Sector 2	Service Sector 3	
	Clean/Intermediate Direct Heat	Dirty Direct Heat	
331	23.8	24.73	Proportionally allocated first from service sector 17 and 19 then between service sector 2 and 3
3334	24.6	3.79	From Table 2, proportionally allocated between service sectors 2 and 3
334	52.0	4.16	From Table 3, proportionally allocated between service sectors 2 and 3
34	17.69	--	From Table 4
TOTAL	118.09	32.68	POTENTIAL FUEL DISPLACEMENT
	680.2	183.8	ISTUM FUEL CONSUMPTION FOR THESE INDUSTRIES
	.1736	.1778	MAXIMUM MARKET FRACTION

TABLE 5-2

SIC-3334 COMPONENTS

SIC	Fuel Savings Potential 10^{12} Btu
3334 Primary Aluminum	28.39
TOTAL 28.39	

TABLE 5-3

SIC 334 COMPONENTS

SIC	Fuel Savings Potential 10^{12} Btu
3321 Gray Iron Foundries	2.77
3322 Malleable Iron Foundries	2.49
3324 Steel Investment Foundries	0.70
3325 Steel Foundries	1.21
3331 Primary Copper	6.80
3332 Primary Lead	0.84
3333 Primary Zinc	4.04
3351 Copper Rolling	8.54
3353 Aluminum Sheet	11.10
3354 Aluminum Extruded	2.96
3356 Nonferrous Rolling	3.79
3361 Aluminum Foundries	6.45
3362 Brass, Bronze, Copper Foundries	0.70
3369 Nonfer- Foundries	1.25
3398 Metal Heat Transfer	2.52
3399 Prim. Metal Products, NEC	--
TOTAL 56.16	

TABLE 5-4

SIC 34 COMPONENTS

Sic		Fuel Savings Potential 10^{12} Btu
3432	Plumbing fittings	0.73
3443	Fab. Plate work Boiler	0.53
3462	Iron & Steel Forgings	12.50
3463	Non-Ferrous Forgings	1.39
3493	Steel springs, except wire	0.67
3631	Household cooking equip.	0.86
3728	Aircraft equip., NEC	1.01
TOTAL		17.69

5.11 PAPER PULP SLUDGE DRYING TECHNOLOGY I.D.: 2.43

Pulp sludges from a paper making plant are often disposed of by a two step process that includes mechanical dewatering and fuel-oil assisted incineration in hog fuel boilers. The pulp paper sludge drying alternative includes three steps: (1) sludge thickening, (2) solvent drying, and (3) steam recovery combustion. The benefits of this technology include a decrease in fuel oil consumption; the recovery of steam, and a reduction in the need for landfilling.

Service Demand Displacement

The service demand displacement for this technology was derived from the proposer's data for the new and conventional sludge drying process based upon a 50 ton/day dry weight plant. The conventional process consumes 3.63×10^9 Btu/yr of electricity in dewatering and 127.46×10^9 Btu/year of fuel in incineration. The new sludge drying system consumes 35.9×10^9 Btu/year of electricity but then produces steam, an equivalent of 20.40×10^9 Btu/year of fuel oil. The service demand displacement for this technology is the net energy savings for the 4 fuels:

$$\frac{115.8 \times 10^9 \text{ Btu/year}}{7500 \text{ Hours/Year}} = 15.44 \text{ MMBtu/hr}$$

Equipment Cost

The proposer estimated a total installed cost of \$3 million for a 50 ton/day plant. EEA assumed this represented ideal circumstances, and expected that for some pulp plant configurations this cost could be as high as \$5 million.

No incremental operating or maintenance costs were expected compared with the conventional system. The equipment cost were linearly scaled to match the ISTUM dirty direct heat size categories.

Maximum Market Fraction

The potential market size for this technology was not clearly identified by the proposer. EEA estimated the technology might compete for 1 percent of the dirty direct heat in paper making.

Data Quality

The ISTUM technology specification for this process modification is hindered due to the early stages of development of this project and the difficulty of modeling a four fuel technology. For these reasons, EEA gave the pulp sludge drying technology a "C" data quality code.

5.12 DIRECT REDUCTION OF ALUMINUM TECHNOLOGY I.D.: 2.46

The direct reduction method of making aluminum is a radical process change, from the conventional Hall cell technology. The new aluminum technology would save 50,000 Btu/lb over conventional electrolytic production.

The technology data supplied by the DOE project manager was based upon a 300,000 ton/year direct heat process that could potentially displace 38×10^{12} Btu/year of electric energy. Although the ISTUM specification is based upon this data, the final technology specification was scaled to one third this size to avoid a technical computer modeling problem associated with the size specification of this technology. The following table compares the two aluminum technologies:

	<u>Direct Reduction</u>	<u>Conventional Electrolytic</u>
Plant Size	300,000 tons/year	300,000 tons/year
Btus of Fuel Consumed	38×10^{12} Btu/year	38×10^{12} Btu/year
Service Sector	Direct Heat ^{1/}	Electrolytic
Fuel Use Efficiency	.8 ^{2/}	1.0
Hours of Operation	6500	6500
Service Demand	$\frac{(38 \times 10^{12}) \times 8}{6500}$	$= \frac{(48 \times 10^{12}) \times 1.0}{6500} =$
	4676 MMBtu/hr	7384 MMBtu/hr

1/ Since the direct reduction process is a substitute for the electrolytic service sector, the technology is actually placed in the electrolytic service sector.

2/ The DOE project manager states that this efficiency is the result of capturing off gases from the blast furnaces.

Service Demand Displacement

The service demand displacement for the direct reduction process is based upon the service demand of the conventional system. One direct reduction unit is equal to a 7384 MMBtu/hr electrolytic plant. Since this size exceeded ISTUM model limits, EEA scaled this technology specification to one third size or 2462 MMBtu/hr. To reflect the efficiency improvements of this process, the final fuel use efficiency was made 1.58, based upon the ratio of electrolytic service demand to direct reduction service demand.

$$\frac{\text{electrolytic service demand}}{\text{direct reduction service demand}} = \frac{7384}{4676} = 1.58$$

Equipment Cost

The DOE project manager indicated a capital cost of \$150 million dollars. Based upon the one third scaledown, EEA estimated 20 percent of all direct reduction plants would cost from \$50 to \$60 million. An additional 60 percent of all facilities would cost from \$60 to \$100 million.

Operating and maintenance costs were estimated at 12 percent of capital cost. The one third scale direct reduction was linearly sized to the ISTUM 600 MMBtu/hr electrolytic size category.

Maximum Market Fraction

Due to the early development stage of this technology, the maximum market fraction is surrounded by uncertainty. The chemical properties of the new aluminum might limit the market for direct reduction to aluminum used in casting, about 15 percent of total aluminum production in 1976.

Data Quality

Due to the difficulties of modeling direct reduction, the lack of outside documentation, and some of the technical uncertainties about the new process, EEA considered the data quality to be code "C".

5.13: ALUMINUM SMELTER MODIFICATION TECHNOLOGY I.D.: 2.56

The aluminum smelter modification specification in ISTUM is based upon an improved cathode for the basic Hall cell. Although primarily conceived as a retrofit technology, this process modification would also apply to new aluminum facilities. The smelter modification would not be applicable for Direct Reduction of Aluminum (ISTUM technology 2.46).

Service Demand Displacement

With a 25 percent savings of electrical energy over the existing Hall cell process, the service demand displacement in the electrolytic service sector is as follows:

$$\begin{array}{lcl} \text{fuel efficiency} & \times & \frac{\text{annual energy consumption} \times \text{fraction saved}}{\text{hours of operation}} = \text{ISTUM Service Demand Displacement} \\ 1.0 & \times & \frac{22.75 \times 10^9 \text{ Btu/cell/yr.} \times .25}{6500 \text{ hr/yr.}} = .88 \text{ MMBtu/hr.} \end{array}$$

Equipment Cost

The DOE project manager estimates a capital cost of \$165,000 including a \$40,000 installation charge for an ideal application of this technology. EEA assumed that half of all aluminum cells could be modified for a cost (block A 2.56) between \$165,000 and \$185,000 based upon a 50 percent increase in installation cost. Another 40 percent of all applications would face installation charges between 50 and 100 percent greater than the ideal modification cost.

EEA assumed that the operating and maintenance charge of the new technology would equal the conventional system, so no incremental O&M was reported in the ISTUM specification. The cathode modification cost was linearly scaled up to the ISTUM electrolytic service sector size of 600 MMBtu/hr.

Maximum Market Fraction

This technology is applicable to all existing and new aluminum production facilities based upon the Hall cell. With a 25 percent savings in

electrolytic energy, the ISTUM maximum market fraction is 0.25. The current formulation of the ISTUM model logic does not adjust for the presence of a mutually exclusive aluminum technology, direct reduction. Nor does the model provide any information about attractiveness of premature retirement and retrofit applications of the cathode modification.

Data Quality

The cost and energy savings of this technology received a "C" data quality code because no component break down of cost or supporting technical documentation of energy savings was provided by either the proposer or the DOE project manager. The maximum market fraction received a quality "C" code because of the ISTUM model's inability to consider the interaction of the Aluminum Smelter Modification with the Direct Reduction of Aluminum technology.

5.14 LUBE OIL RECOVERY TECHNOLOGY I.D.: 2.57

This DOE sponsored research project is directed at the development of an improved process for recovering lube oil. The ISTUM specification is based upon a 10×10^6 gallon/year re-refining plant. The lube oil recovery technology competes for liquid feedstock service demand in SIC-29 petroleum refining and related industries.

Lube Oil Recovery

Because the Lube Oil Recovery technology competes in the Liquid Feedstock service sector which did not have any other technologies specified, it was decided that the service sector would not be run in the ISTUM base case. Consequently, a threshold evaluation was not performed for this technology.

Service Demand Displacement

The DOE project manager indicated that the proposed rerefining plant would process 10×10^6 gallons per year with a 70 percent efficiency. Since the re-refined oil would consume 1.28×10^6 Btu/Bbl compared to 2.2×10^6 Btu/Bbl for virgin lube oil, this technology would save about

21,900 Btu/gallon of lube oil. Based upon this data, the service demand displacement for this technology is:

$$\frac{\text{plant capacity} \times \text{efficiency} \times \text{energy savings}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{10 \times 10^6 \text{ gal/yr} \times .7 \times 21,900 \text{ Btu/gal}}{8000 \text{ hours/year}} = 19 \text{ MMBtu/hr.}$$

Equipment Cost

The proposer identified a capital cost of \$3 million for a re-refining facility. EEA assumed this cost represented an ideal application, and that only 50 percent of all lube oil recovery plants would be built at a cost of 3 to 3.6 million dollars. Another 40 percent of all applications were expected to cost from 3.6 to 5 million dollars. Operating and maintenance charges were expected to annually total 12 percent of the total installed capital cost. The 19 MMBtu/hr unit was linearly scaled to 250 MMBtu/hr size category in the liquid feedstock service sector.

Maximum Market Fraction

EEA calculated that 25 percent of annual consumption of 1.35×10^9 gallons of lube oil in the United States could be collected from fleet maintenance yards, gasoline stations, and lube oil recycling centers (such as sponsored by states under EPCA). Based upon a 10×10^6 gallon/year facility, the total market for re-refining plants is:

$$\frac{1.35 \times 10^9 \text{ gallon/year} \times .25}{10 \times 10^6 \text{ gallon/year/plant}} = 34 \text{ plants}$$

Using a 34 plant market the maximum service demand displacement is:

number of plants	x hourly service demand	x hours of operation	=	maximum service demand displacement
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$$34 \text{ plants} \times 19 \times 10^6 \text{ Btu/hr} \times 8000 \text{ hr/yr} = 5.168 \times 10^{12} \text{ Btu/hr}$$

The maximum market fraction is therefore:

$$\frac{\text{maximum service demand displacement}}{\text{liquid feedstock service demand}} = \frac{\text{maximum market}}{\text{fraction}}$$

$$\frac{5.168 \times 10^{12}}{736.4 \times 10^{12}} = .007$$

Data Quality

The primary weakness in the data supporting this technology was the energy savings calculation. Because the energy savings was not verified by engineering analysis or by an outside reviewer, EEA gave the lube oil recovery technology a "C" quality code.

5.15 POLYPROPYLENE TO FUEL TECHNOLOGY I.D.: 2.413

The focus of this proposed DOE project is the thermal cracking of waste atactic polypropylene into a low sulfur #6 fuel oil. The ISTUM technology specification is based upon a 200 million lb/year plant. EEA placed the polypropylene technology in the non-coal indirect heat service sector.

Service Demand Displacement

The 200 million pound per year plant could create 3.46×10^{12} Btu/year of #6 fuel oil according to the proposer. The plant would consume 2.4×10^6 kWh/year of electricity. Based upon this data, the service demand displacement would be:

$$\frac{(3.46 \times 10^{12} \text{ Btu/year}) \times .7 - (2.4 \times 10^6 \text{ kWh/yr} \times 3413 \times .9)}{8300 \text{ hr/yr.}} = 291 \text{ MMBtu/hr}$$

Equipment Cost

The proposer identified a \$2 million dollar capital cost for a polypropylene cracking plant. EEA assumed that this represented an ideal application, and that some applications might face a cost 50 percent higher, or \$3 million.

The proposer indicated that operating and maintenance would include a \$3.5 million cost for atactic polypropylene collection and a \$300,000 credit for avoided landfilling costs. This resulted in a net O&M of 1.5 percent.

Maximum Market Fraction

The calculation of a maximum market fraction for this technology is hindered by significant lack of information. No reliable prediction of future production of atactic polypropylene exists today. In addition, the economics of recovering previously landfilled polypropylene have not been determined. EEA conservatively estimated a market for two 200×10^6 lb/year plants in 1978. Based upon a 291 MMBtu/hr service demand displacement and 8300 hr/year operation, the maximum market fraction is:

$$\frac{\text{maximum service demand displacement}}{\text{ISTUM service sector service demand}} = \text{maximum market fraction}$$

$$\frac{2 \times 291 \times 10^6 \times 8300}{286.7 \times 10^{12}} = .0168$$

Data Quality

The use of a very conservative maximum market fraction made a "B" data quality code. However the difficulties of modeling the energy savings of this technology, essentially involving a new product and uncertain costs for waste material, indicated a "C" quality code for energy savings was appropriate.

5.16 REFUSE IN CEMENT KILN TECHNOLOGY I.D.: 2.414

Refuse derived fuel (RDF) is a combustible material extracted from municipal solid waste. The goal of this DOE sponsored project is the 30 percent substitution of RDF for conventional fuels in the calcining service sector for SIC 32, the cement industry. Approximately two thirds of all cement is produced in coal fired kilns. Therefore in most plants, implementing this technology would substitute one relatively dirty fuel for another.

Service Demand Displacement

Data from the Portland Cement Association^{1/} suggests that new dry-process cement kilns will consume approximately 6×10^6 Btu/ton. The

^{1/} Energy Conservation Potential in the Cement Industry, FEA Conservation - Paper 26, June 1975 and 1974 Energy Report for the U.S. Portland Cement Industry: Summary Analysis, Portland Cement Association, May 1975.

DOE project data assumes an energy savings of 550×10^9 Btu/year for a 305,000 ton/year kiln. The hourly rating for this example is therefore:

$$\begin{array}{ccccccc} \text{Combustion} & \times & \text{Percent} & \times & \text{Energy} & \times & \text{capacity} = \text{service} \\ \text{efficiency} & & \text{RDF} & & \text{Consumption} & & \text{demand} \\ & & \text{substitution} & & \text{per ton} & & \text{displacement} \end{array}$$

$$.33 \quad \times .3 \quad \times 6 \text{ MMBtu/ton} \times \frac{305,000 \text{ ton/yr}}{7000 \text{ hr/yr}} = 25.9 \text{ MMBtu/hr}$$

Equipment Cost

The DOE technology documentation reported a \$2 million capital cost for a modification of a 305,000 ton/day cement kiln, but provided no breakdown of the components of the charge. EEA assumed this data was based upon an ideal application and specific circumstances at some plants could increase this cost to \$3 million (block 2.414). Operating and maintenance charges were estimated to be 5 percent of capital costs. A linear scaling factor of 1.54 was used to match the ISTUM size category of 40 MMBtu/hr. in the calcining service sector.

Fuel Used

A market price for RDF does not exist in the United States at this time. The handful of demonstration programs in solid waste combustion identified significant technical obstacles in the preparation and combustion of refuse fuels. If these hurdles could be passed and a viable market for RDF created, EEA assumes the fuel price would generally track the price of coal. Since ISTUM does not have an RDF price, the "fuel" for this technology was therefore specified as coal.

Maximum Market Fraction

The potential market for this technology theoretically includes 385 kilns which annually produce 85×10^6 tons of cement. However, many of these kilns are located far from urban areas and a reliable source of refuse fuel. EEA assumed that about half of the U.S. production would face this restriction. The maximum service demand displacement for a 100 percent penetration of the remaining market would be:

U.S. Pro- duction	Unit x Energy Consumption	x	Combustion Efficiency	x	Maximum RDF Sub- stitution	x	RDF Availa- bility Restric- tion	=	maximum service demand displace- ment
85x10 ⁶ ton/yr	x 6x10 ⁶ Btu/yr	x	.33	x	.3	x	.5	=	25.2x10 ¹² Btu/yr.

The ISTUM maximum market fraction is :

$$\frac{\text{maximum technology service demand displacement}}{\text{applicable industry service demand}} = \text{maximum market fraction}$$

$$\frac{25.2 \times 10^{12}}{324.7 \times 10^{12}} = .078$$

Data Quality

The energy savings and potential market for a RDF system could be calculated from the Portland Cement Association data. However, the costs of this technology are based upon poorly documented equipment costs and considerable uncertainty about the market price for RDF. The ISTUM quality codes reflect the reliability of technology specification from this data. Cost is considered "C" quality data, while maximum market fraction and energy savings are rated as "B" quality data.

5.17 BLENDED CEMENT TECHNOLOGY I.D.: 2.514

The blending of pozzolanic material, such as blast furnace slag or fly ash into Portland cement can reduce the overall energy consumption in cement production. According to Portland Cement Association data^{1/}, approximately 7 percent of current United States cement production is blended with pozzolanic material. This DOE project aims at increasing

^{1/} Energy Conservation Potential in the Cement Industry, FEA Conservation Paper 26, June 1975.

the market for blended cement by overcoming existing institutional and technical barriers. The ISTUM technology specification is based upon a 250,000 ton/year cement kiln using a 30 percent substitution of fly ash or slag. The impact of the DOE program supporting this process change in the calcining service sector is expected to have its initial impact in 1980.

Service Demand Displacement

The energy consumption of new cement kilns utilizing the dry process averages about 6×10^6 Btu/ton. The service demand displacement for a 250,000 ton/year blended cement plant using a 30 percent substitution of pozzolanic material is:

Hourly Capacity	x	Percent Energy Savings	x	Energy Consumption	x	Fuel Efficiency	=	Service Demand Displacement
$\frac{250,000 \text{ ton/yr}}{7000 \text{ hr/yr.}}$	x	.30	x	6×10^6 Btu/ton	x	.33	=	21.2 MMBtu/ hr.

Equipment Cost

Based upon the proposer's estimate of \$5.00 per ton of capacity for a blended cement facility, the minimum cost (Block A 2.514) for a 250,000 ton/year plant is \$1.25 million. EEA assumed that half of all potential applications would fall between this minimum cost and \$1.45 million. Only 10 percent of all cement plants were expected to incur equipment and installation costs greater than \$7.00 per ton of capacity, or \$1.75 million for a 250,000 ton/year facility.

Operating and maintenance charges for blended cement equipment were estimated to be 5 percent of capital costs. The additional electricity costs of this technology were considered minor and are included in the O&M charge.

Maximum Market Fraction

The 385 kilns in the United States currently produce 85 million tons of cement each year. EEA conservatively estimated that overcoming technical hurdles and relaxing institutional barriers could potentially increase the market from 7 to 50 percent of total production. Based upon a 30 percent substitution of pozzolanic material, the maximum service demand displacement of the technology is:

Energy consump- tion/ton	x	Percent Savings	x	U.S. Pro- duction	x	Fuel Effi- ciency	x	Technical Limitations	=	Maximum service demand displacement
6×10^6	x	.30	x	85×10^6	x	.33	x	.5	=	25.2×10^{12}
Btu/ton				tons/yr.						Btu/year

The ISTUM maximum market fraction is:

$$\frac{\text{maximum service demand displacement}}{\text{industry service sector demand}} = \text{maximum market fraction}$$

$$\frac{25.2 \times 10^{12}}{324.7 \times 10^{12}} = .078$$

Data Quality

The ISTUM specification for blended cement is based on data from the Portland Cement Association, the DOE project manager, and the proposer. The technical data is supported by operating characteristics of blended cement facilities in Japan, Germany, Italy, and the United States. Therefore EEA rated the data quality for all categories in blended cement as "B".

5.18 GLASS CONGLOMERATE TECHNOLOGY I.D.: 2.415

Because the technology characterization data for glass conglomerates is based upon data acknowledged by the proposer to be preliminary, this technology was not included in the ISTUM base case run.

The glass conglomerate technology is a method for preheating pelletized glass container batch (with potential applications in other glass processes) to save melting energy, increase furnace life expectancy, and reduce air pollution. Under some circumstances this technology could significantly increase the capacity of an existing furnace. However, the ISTUM specification is based upon a 150 ton/day glass regenerative furnace operated at a 80° C lower temperature. In addition to energy savings and pollution control, a furnace operated in this manner would require less frequent furnace wall rebuilds.

Service Demand Displacement

The service demand displacement calculation is based upon a 150 ton/day furnace operating 7920 hours/year.^{1/} The conventional furnace consumes 328×10^9 Btu/year but the pelletized preheating glass furnace consumes 307×10^9 Btu/year. Based upon a 21×10^9 Btu/year fuel savings, the service demand displacement is:

$$\frac{\text{Incremental Fuel Savings} \times \text{Fuel Efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{21 \times 10^9 \times .3}{7920} = .795 \text{ MMBtu/hr}$$

Equipment Cost

The proposer estimated a capital cost of \$1 million for this technology. EEA assumed this represented an ideal application and that 50 percent of all applications would cost between \$1 and 1.3 million. EEA estimated that another 40 percent of all applications would cost between \$1.3 and 1.8 million.

The proposer did not identify the operating costs for this technology. However, operating the furnace at an 80°C lower temperature would extend

^{1/} The proposers documentation is based upon 7920 hour/year operation. The ISTUM assumption for glass melting is 7000 hours/year.

the wall liner life from 3 to 5 years. The proposer estimated this could annually save \$133,000 in maintenance. The glass conglomerate technology might also reduce the need for pollution control equipment. For the ISTUM specification of this technology, EEA assumed a net operating and maintenance savings of 12 percent.

Maximum Market Fraction

The pelletizing preheat technology is currently being tested on a glass container furnace, but could potentially be adapted to flat glass production. The proposer's data indicate an energy savings of slightly higher than 6 percent. Based upon this data, EEA assumed that glass conglomerates could compete for 6 percent of the glass melting market.

Data Quality

The proposer's glass conglomerate documentation emphasizes the tentative nature of the analysis for this technology. Since the glass conglomerate process has not been demonstrated beyond the bench test level, EEA assumed a "C" data quality code was appropriate.

5.19 FLAT GLASS ENERGY REDUCTION TECHNOLOGY I.D.: 2.515

The goal of this technology is reducing energy consumption in the flat glass industry. The proposer claimed this could be accomplished by installing optical sensors and microprocessor controls to monitor and control glass output.

Service Demand Displacement

The energy savings potential of this technology has not been technically demonstrated, but may include reducing the cullet percentage in glass melting and optimizing the quantity of glass for a given sheet thickness. If a $.4 \times 10^6$ Btu/ton energy savings can be achieved with this technology, the service demand displacement will be:

energy savings	x	combustion	x	furnace	=	service demand
		efficiency		capacity		displacement

$.4 \times 10^6$	x	.3	x	16.25	=	1.95 MMBtu/hr
Btu/ton				ton/hr		

Equipment Cost

The proposer indicated that an ideal application of this technology would cost about \$70,000. EEA assumed that unique circumstances in some glass plants could result in a total installed cost of \$140,000. The ISTUM capital cost distribution for this technology (Block A2.515) was based upon this range.

Annual operating and maintenance charges were anticipated to be 10 percent of capital costs. The 1.95 MMBtu/hr glass sensing equipment was linearly scaled to both ISTUM glass melting size categories.

Maximum Market Fraction

The proposer indicated a market for this technology in 38 glass plants. The maximum service demand displacement for a plant with this control technology might be calculated as follows:

$$\begin{array}{ccccccc} \text{energy} & \times & \text{technically} & \times & \text{annual} & \times & \text{combustion} = \text{maximum service} \\ \text{savings} & & \text{applicable} & & \text{capacity} & \text{efficiency} & \text{demand} \\ & & & & & & \text{displacement} \end{array}$$

$$0.4 \times 10^6 \text{ Btu/ton} \times .75 \times 136,500 \text{ ton/yr.} \times .3 = 12 \times 10^9 \text{ Btu/yr}$$

Based upon the proposer's estimate of 38 applications in the United States, the maximum market fraction is:

$$\frac{\text{Service Demand Displacement for Total Market Penetration}}{\text{ISTUM Glass Melting Service Demand}} = \frac{\text{Maximum market fraction}}{\text{Maximum market fraction}}$$

$$\frac{38 \times (12 \times 10^9)}{79.4 \times 10^{12}} = .006$$

Data Quality

The DOE project manager indicated that the flat glass energy reduction proposal is still in its early stages of development. The technology data has not been verified by outside review or engineering calculations. Because of the lack of corroborating data and the poor definition of the source for energy savings, EEA considered very low data quality codes appropriate.

5.20 CEMENT BLOCK DRYING TECHNOLOGY I.D.: 2.516

The curing of cement block at 150°F currently consumes 3300 to 6000 Btu/block, although ideally the process should consume only 1000 to 1400 Btu/block. This DOE sponsored technology is directed at minimizing energy consumption of this process by adding pozzolanic material to the cement mix, insulating the curing unit, and using the exothermic reaction in the block to drive the curing process. For the ISTUM specification, the modified curing technology was placed in the brick making service sector as a process change.

Service Demand Displacement

Proposal data indicated that cement block kilns using this process could save 1.3×10^9 Btu/year. The ISTUM service demand displacement for this curing modification is therefore:

$$\frac{\text{Annual Energy Savings}}{\text{Hours of operation}} \times \text{fuel efficiency} = \text{service demand displacement}$$

$$\frac{1.3 \times 10^9 \text{ Btu/year}}{2000 \text{ hours/year}} \times .3 = .195 \text{ MMBtu/hr.}$$

For most conservation technologies, the hours of operation used in the service demand displacement calculation is identical to the ISTUM service sector specification. However, in this case EEA determined that the cement block plants typically operate at 2,000 hours/year and not the 7,000 hours/year assumed by ISTUM for the brick firing service sector. Using a load factor of 2000 hour/year therefore increases the accuracy of the service demand displacement calculation.

Equipment Costs

The equipment modifications required for this process change are relatively modest. The cement block curing chambers would be insulated to retain the exothermic heat of the curing reaction. EEA assumed that 90 percent of all cement kilns could adopt this technology at a cost (block A 2.516) of \$1750 to \$3000. Operating and maintenance costs would be approximately 5 percent of capital cost. The cost of the modified cement block curing process was scaled up linearly to the 13.1 MMBtu/hr brick firing service demand size.

Maximum Market Fraction

EEA estimated that the market for this process change includes approximately 7000 kilns for cement block curing. The maximum service demand displacement for a 100 percent market penetration is:

Existing Market	x	Energy Savings	x	Fuel Efficiency	=	Maximum Service Demand Displacement
7000 units	x	1.3×10^9	x	.3	=	2.73×10^{12}
		Btu/unit/year				Btu/year

The ISTUM maximum market fraction for cement block curing in the brick firing service sector is:

$$\frac{\text{maximum service demand displacement}}{\text{industry service demand}} = \text{maximum market fraction}$$

$$\frac{2.73 \times 10^{12} \text{ Btu/year}}{80.3 \times 10^{12} \text{ Btu/year}} = .034$$

Data Quality

Because this technology is not technically complex, using conventional insulation practices and proven techniques for modifying the block mix composition, "B" quality codes were appropriate, and modification in the block mix composition indicated that a "B" quality codes were appropriate.

5.21 CUPOLA FURNACE MODIFICATION TECHNOLOGY I.D.: 2.417

The off-gases of conventional cupola furnaces contains large quantities of carbon monoxide which is typically incinerated by a natural gas after-burner. The cupola modifications proposed in this DOE sponsored project would allow a furnace to operate without the natural gas incineration. For the ISTUM model, this technology was placed in the ironmaking service sector.

Service Demand Displacement

The proposer of this technology indicated that a typical cupola furnace modification could save 35×10^9 Btu/year of natural gas. Based upon this data, the annual service demand relief is:

$$\frac{\text{energy savings} \times \text{combustion efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{35 \times 10^9 \times .4}{5000} = 2.8 \text{ MMBtu/hr}$$

Equipment Cost

The proposer indicated a capital cost range of \$60,000 to \$90,000 for this technology. EEA assumed that 20 percent of all applications would cost between \$60,000 and \$75,000. Extenuating circumstances in 60 percent of the applications would increase the price to \$75,000 to \$90,000.

No incremental operating or maintenance costs are anticipated. The 2.8 MMBtu/hr service demand displacement required that the cupola modification capital costs be linearly scaled to ISTUM size categories in ironmaking.

Maximum Market Fraction

The market for this technology includes about 1,000 existing cupolas in the United States. However, the future market for this technology depends upon the economic viability of the cupola iron casting process. EEA calculated a conservative maximum market fraction by assuming only half of existing cupolas would be technically suitable. The maximum market fraction is therefore:

$$\frac{\text{technical limitation} \times \text{total market units} \times \text{energy savings} \times \text{combustion efficiency}}{\text{ISTUM ironmaking service demand}} = \text{maximum market fraction}$$

$$\frac{.5 \times 1000 \times 35 \times 10^9 \times .4}{46.3 \times 10^{12}} = .15$$

Data Quality

This technology specification was not supported by component cost breakdowns, detailed engineering analysis, or review by outside sources. For these reasons the energy savings and cost data quality were coded as "C". Due to the special difficulties in identifying the potential market for this technology, EEA assumed a "D" quality code for maximum market fraction was appropriate.

5.22 BLAST FURNACE GASIFIER TECHNOLOGY I.D.: 2.219, 2.41

This technology involves the use of existing blast furnaces not currently in operation to produce medium Btu gas (MBG) for industrial applications. There are currently 40 such retired units in the U.S. capable of being retrofitted to consume coal, coke breeze, BOF slag and scrap materials and produce fuel gas, molten iron and slag. In addition to refitting the existing blast furnace to accommodate different proportions of input materials at new charging and residence rates, there is a requirement to add an oxygen plant and the associated piping to support combustion in the furnace.

The specification of this technology is hindered by the following factors:

- The technology is intended as a retrofit application to utilize existing retired blast furnaces. Because the ISTUM methodology does not currently capture the market dynamics of retrofit technologies, the Blast Furnace Gasifier project must be specified as a new technology.
- The original specifications for the capital cost of this technology were erroneously assumed not to have included the cost of the oxygen plant and other contingencies. The inclusion of these costs, which were based on the specifications for a similar facility to generate MBG gas, caused the Blast Furnace Gasifier capital cost to nearly double.
- Little information is available about the MBG gas distribution system required or the cost of such a system. The large volume of gas expected to be produced by the Blast Furnace Gasifier may create a requirement for an extensive pipeline system for its distribution.

The uncertainties associated with the above factors and with the corresponding results of the ISTUM model runs for this technology require that the results not be relied upon as representative of the expected market acceptance of this technology.

Service Demand Displacement

Based on an original estimate for a 20 foot furnace using 630 tons/day of molten metal and 1575 tons/day of coal, the average blast furnace gasifier unit will produce 10 trillion Btu per year of medium Btu gas. Assuming that the Blast Furnace Gasifier is operated for 6000 hours per year (330 days/year) the service demand displacement per unit can be calculated:

$$\frac{\text{annual energy savings}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{10 \times 10^{12} \text{ Btu/yr}}{6000 \text{ hours/yr}} = 1.67 \times 10^9 \text{ Btu/year}$$

The gasifier operating under these conditions will produce 1.67×10^9 Btu/year of MBG gas. The unit will consume roughly 20 percent more energy in the coal input than is produced by the process, for an overall efficiency of approximately 75 percent.

Equipment Cost

As previously indicated, the installed capital costs, including contingencies, for this technology were estimated to be nearly twice the cost indicated by the project manager. The original specifications were assumed to exclude the cost of the oxygen plant and distribution system. The cost of the components erroneously added to account for these factors more than doubles the annualized capital cost of the technology. For more information concerning the specification of these additional components (boiler equipment, site preparation, gas distribution system, etc.), refer to the description of the Medium Btu Gasifier technology.

Credits

The Blast Furnace Gasifier technology receives a credit for producing hot metal in addition to MBG. Assuming that one and one half ton of ore is required to produce 1 ton of hot metal in this process, the net credit for the iron produced is:

VALUE OF IRON PRODUCED (@ \$100/TON)
 - COST OF ORE REQUIRED (@ \$50/TON)

NET CREDIT FOR IRON PRODUCED

$$\begin{aligned} & \$100/\text{ton iron} \times 630 \text{ tons/day iron} \times 330 \text{ days/yr} = \$20.79 \times 10^6 \\ & -\$50/\text{ton ore} \times 630 \text{ tons/day iron} \times \frac{1.5 \text{ tons ore}}{\text{ton iron}} \times 330 \text{ days/yr} = -\$15.59 \times 10^6 \end{aligned}$$

NET CREDIT FOR IRON $\$4.2 \times 10^6$

Maximum Market Fraction

The maximum market fraction is determined as the service demand displaced for all units potentially able to use the technology. The service demand for the Blast Furnace Gasifier is determined as the service demand relief provided to the end users of the MBG produced. Hence, the service demand calculation subsumes the efficiency of the end use process into the calculation:

$$40 \text{ plants} \times 10 \times 10^{12} \frac{\text{Btu}}{\text{plant}} \times \frac{.75 \text{ end use conversion efficiency}}{1} = .3 \times 10^{15} \frac{\text{Btu}}{\text{service demand}}$$

Competing in the steam and steel reheat service sectors, this technology is expected to provide only a fraction of the end use energy requirement. It is estimated that from 20 to 25 percent of the energy in these and other sectors can use low or medium Btu gas. Therefore assuming 240 Btu is available for use in steam production and 60 Btu for steel reheating the maximum market fraction can be estimated for these service sectors:

$$\frac{\text{fraction of low Btu applications} \times \text{steam service demand relief}}{\text{steam service demand requirement}} = \text{steam market fraction}$$

steam service demand requirement

$$\frac{.25 \times 240 \times 10^{12} \text{ Btu}}{192 \times 10^{12} \text{ Btu}} = .31$$

$$\frac{\text{Fraction of low Btu Applications} \times \text{Steel Reheat service demand relief}}{\text{Steel Reheat Service Demand Requirements}} = \text{steel reheat market fraction}$$

$$\frac{.25 \times 60 \times 10^{12} \text{ Btu}}{66 \times 10^{12} \text{ Btu}} = .22$$

Data Quality

The uncertainty associated with the capital costs of this technology has already been acknowledged. Even after the charges for site preparation, feed water, boiler, and gas distribution systems are resolved, the range of capital costs is expected to be very high. Because of these difficulties, the energy savings data was given a "C" quality code.

The extremely large size of the blast furnace gasifier requires a cluster of MBG users. Very little data is available on the potential for linking major industrial energy consumers. Since these concerns are based upon retrofit applications which are not accommodated by the current ISTUM model logic and involve the service demand in multiple service sectors EEA rated the maximum market fraction as "D" quality data in recognition of the modeling difficulties.

The supporting documentation for the fuel switching potential for this technology was relatively good and could be partially confirmed by engineering calculations. EEA rated the energy savings component of the blast furnace gasifier as "B" quality data.

5.23 TECHNOLOGY I.D.: 2.21 - HEAT PUMP - STEAM

The objective of the DOE sponsored research is the development of efficient and economical heat pumps for generating steam from low temperature waste heat sources. The ISTUM specification of this technology competes for steam service demand in the following industries:

<u>SIC Code</u>	<u>Industry</u>
20	Food
22	Textiles
24	Lumber and Wood
26	Paper and Pulp
28	Chemicals
30	Rubber
34	Fabricated Metals
35	Non-electrical Machinery
36	Electrical Equipment
37	Transportation Equipment

Service Demand Displacement

The proposer indicated that this heat pump would produce 8000 lbs/hr of steam. Assuming 1,200 Btu/lb for steam and 7,000 hours/year of operation, the heat pump would displace 67.2×10^9 Btu/year of steam service demand. The hourly ISTUM service demand is therefore:

$$\frac{\text{Annual service demand}}{\text{Hours of operation}} = \text{Service demand displacement}$$

$$\frac{.67.2 \times 10^9}{7000} = 9.6 \text{ MMBtu/hr}$$

Equipment Cost

The capital cost frequency (Block A2.21) was based upon the point estimate of the proposer. EEA estimated that 50 percent of all costs would fall between

\$350,000 and \$450,000, and an additional 40 percent of all costs would fall between \$450,000 and \$600,000. These costs were linearly scaled to the ISTUM steam service sector size categories.

Operating and maintenance costs were estimated at 10 percent of installed capital costs.

Fuel Use and Fuel Share

This heat pump consumes waste heat and electricity. The "fuel share" component shows the relationship between these two fuels according to the following formula:

$$\text{Fuel Share} = 1 - \frac{\text{fuel 2}}{\text{fuel 1}}$$

This technology consumes 57.25×10^9 Btu/year of waste heat and 21.4×10^9 Btu/year of electricity. The appropriate value for "fuel share" is therefore:

$$\text{Fuel Share} = 1 - \frac{57.25 \times 10^9}{21.4 \times 10^9}$$

$$\text{Fuel Share} = -1.67$$

Maximum Market Fraction

Very little data is available on the potential market for this technology. The availability of suitable waste heat sources and the appropriate steam temperature/pressure range would certainly reduce the potential number of applications. Although EEA was unable to precisely determine the maximum market fraction for this technology, the staff consensus supported a maximum market fraction of 10 percent.

Data Quality

The lack of market information indicated that a "D" data quality code was appropriate for maximum market fraction. EEA judged the cost and energy savings to be better documented and rated these as "B" quality data.

5.24 TECHNOLOGY I.D.: 2.11, 2.113, 2.12, AND 2.13 - BOILER AIR/FUEL CONTROL, HEATER AIR/FUEL CONTROL

The boiler air/fuel control and heater air/fuel control technologies represent the DOE research effort into instrument systems to maximize fuel combustion efficiency. The current program is based upon micro-processor controls supported by a stack gas analyzer and possible spectral flame analyzers at each burner. By minimizing excess air and operating major combustion equipment at near stoichiometric levels, fuel savings of 1 to 2 percent are possible.

Based upon data from the DOE project manager, EEA placed the air/fuel control technologies into the steam, clean/intermediate direct heat, dirty direct heat, and non-coal indirect heat service sectors in all industries. The technology specifications for these monitoring devices were based upon a 4 burner 200,000 lb./hr. boiler. EEA accepted the DOE project manager's judgment that the cost of non-boiler applications could be reasonably represented by this single specification because of the "bolt-on" nature of stack monitors and spectral analyzers. The actual energy savings potential in non-boiler applications would probably vary greatly and be more uncertain.

Service Demand Displacement

Based upon a 2 percent energy savings the service demand relief for a 200,000 lb/hr. boiler is:

Percent Energy Savings	x	Fuel Efficiency	x	Boiler Size	=	service demand displacement
.02	x	.82	x	200 x 10 ⁶ Btu/hr	=	3.28 MMBtu/hr

Equipment Cost

The air/fuel control equipment includes a microprocessor, stack gas analyzer, and possibly additional spectral analyzers for individual burners. Differences in installation cost will probably be the single largest factor contributing to total cost variations. EEA assumed the proposer's cost of \$115,000 for a 200,000 lb/hr. air/fuel control system was based upon an ideal boiler application. Total installed cost in 90 percent of all applications (Blocks A2.11, A2.12) was expected to fall between \$115,000 to \$180,000.

Operating and maintenance costs for air/fuel controls was expected to be about 4 percent of total installed cost.

The air/fuel control technology was placed in four service sectors and could compete for service demand in all industrial categories. The equipment costs were linear scaled to ISTUM size categories. No technical restrictions for size or load appeared to be applicable.

Maximum Market Calculation

For most conservation technologies, the maximum market calculation incorporates information on a specific industry structure, estimated energy savings, and technical limitations. EEA has specified the air/fuel control technologies for 4 service sectors and all industries, and does not find any applicable technical limitations to this specification. Therefore, the maximum market fraction is based on just the potential energy savings, estimated to be two percent for air/fuel control.

Data Quality

The capital costs, energy savings, and market potential for boiler air/fuel controls could be verified by engineering calculations and numerous published reports of microprocessor based combustion control equipment. The potential energy savings for non-boiler applications was not documented and included considerable uncertainty in technical areas. The technology data was generally

considered at the "B" quality code, with the energy savings potential of non-boiler applications as a "C" code.

5.25² TECHNOLOGY I.D.: 2.92 HEAT PUMP - DRY MILK

Dry milk processing plants currently consume 400 million Btu/hr in the drying stage. The focus of this project is the design of a high temperature industrial heat pump to utilize low level waste heat and deliver process heat for milk drying. With the DOE sponsored technology, energy consumption in milk drying may be cut in half. For the ISTUM model, EEA placed this technology in the clean direct heat service sector, competing for the service demand in SIC 20, the food industry. The proposed heat pump system would utilize two heat exchangers, the first from a 140°F waste water source and the second from 192° air flow off of a bag house. With this system, ambient air will be elevated to 300 to 350°F for use in the milk drying process.

Service Demand Displacement

The proposer indicated a potential fuel savings of 88×10^9 Btu/year with this heat pump. Based upon this data, the ISTUM service demand displacement is:

$$\frac{\text{fuel savings} \times \text{fuel efficiency}}{\text{hours of operation}} = \text{service demand displacement}$$

$$\frac{88 \times 10^9 \text{ Btu/yr} \times .3}{2000 \text{ hr/yr}} = 13.2 \text{ MMBtu/hr}$$

Equipment Cost

The proposer indicated a total installed equipment cost of \$225,000 for this heat pump. EEA assumed that this cost represented an ideal application and that unique circumstances in some plants would almost double total cost. One half of all applications were estimated to fall between \$225,000 and \$300,000. An additional 40 percent of all applications were expected to cost from \$300,000 to \$500,000.

Operating and maintenance charges were estimated to annually cost about five percent of total capital cost. The 13.2 MMBtu/hr unit was linearly scaled to the ISTUM clean direct heat service sector size categories.

Maximum Market Fraction

The potential market for this technology is limited by the availability of waste heat sources and potential applications in dry milk manufacturing. The proposer estimated that 300 milk drying plants currently operated in the United States. EEA anticipated that about half of these plants were not suitably scaled for this technology or lacked easily accessed waste heat streams. Based upon the proposers annual fuel savings estimate, the maximum market fraction is as follows:

$$\frac{\text{fuel savings} \times \text{fuel efficiency} \times \text{number of plants} \times \text{technical limitation}}{\text{ISTUM Clean Direct Heat Service Demand}} = \text{maximum market fraction}$$

$$\frac{88 \times 10^9 \times .3 \times 300 \times .5}{67.8 \times 10^{12}} = .0548$$

Data Quality Code

Since very little data is currently available on the characteristics of waste heat sources, and the market limits for the milk drying heat pump could not be accurately defined, EEA considered maximum market fraction to be a "D" data quality code. The energy savings of this technology, while based upon engineering calculations, were not verified by outside reviewers and was classed as "C" quality data. Since the cost data was supported by the proposers analysis of off-the-shelf components, EEA judged the cost data to be code "B".

5.26 MOVING BEAM FURNACE TECHNOLOGY I.D.: 2.419

The Moving Beam technology involves an improved transportation mechanism in a steel reheating furnace. The new unit reduces the vibration in the furnace, thereby maintaining the integrity of the insulation, a major problem with conventional walking beam or pusher furnaces. The ISTUM specification is based upon data from the American Iron and Steel Institute report Energy Conservation in the Iron and Steel Industry (page 121) for new applications in steel reheating.

Energy Savings

The AISI data claims the moving beam furnace uses 2.25×10^6 Btu/ton compared to a conventional walking beam or pusher furnace which consumes 2.4×10^6 Btu/ton. The ISTUM service demand rating of a 300 ton/hour moving beam furnace is:

$$\begin{array}{rclclcl} \text{capacity} & \times & \text{incremental} & \times & \text{fuel} & = & \text{ISTUM service} \\ & & \text{energy savings} & & \text{efficiency} & & \text{demand displace-} \\ & & & & & & \text{ment} \\ 300 & & & & & & \\ \text{ton/hr} & \times & .15 \times 10^6 & \times & .33 & = & 15 \text{ MMBtu/hr.} \\ & & \text{Btu/ton} & & & & \end{array}$$

Equipment Cost

The capital cost of this technology (block A2.419) was drawn from the AISI data. About 20 percent of the applications were expected to cost between 2.0 and 2.6 million dollars. An additional 60 percent of the units were expected to cost between 2.6 and 3.5 million dollars. EEA estimated that operating and maintenance charges for the moving beam technology would be equal to those in the conventional system, so the ISTUM specification includes no incremental O&M costs. Because the moving beam furnace is rated at 15 MMBtu/hr, EEA used linear scaling factors to set capital costs at the ISTUM steel reheating service sector sizes of 3 and 60 MMBtu/hr.

Maximum Market Fraction

Only 50 percent of all reheating involves steel slabs. The ISTUM maximum market fraction for this technology is as follows:

technical market limit	x	percent energy savings	=	maximum market fraction
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$$.5 \times \frac{.15 \times 10^6 \text{ Btu/ton}}{2.4 \times 10^6 \text{ Btu/ton}} = .03125$$

Data Quality

Due to the discrepancies between the AISI and DOE project manager data for the moving beam furnace, EEA rated the technology specification as a "C" data quality code. An additional reason for the low data quality code was the potential difficulties of modeling the possible differences in throughput capacity between the monobeam and conventional steel reheating technologies. The transport mechanism in the moving beam may significantly increase the capacity of reheat furnaces, thereby reducing the total number of furnaces required.

APPENDIX

PRINTOUTS OF THRESHOLD RESULTS
USING ISTUM MARKET
PENETRATION DATA

PROJECT NUMBER 2
(ORIGINALLY 41)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - BLENDED CEMENT
SECTOR - INDUSTRIAL
BRANCH - ALTERNATIVE MATERIALS UTILIZATION
DESCRIPTION - 30% SUBSTITUTION OF FLY ASH OR SLAG IN A 250,000
TON PER YEAR PORTLAND CEMENT PLANT

ACCELERATION OF MARKET ENTRY: 5. YEARS

NEW
SYSTEM

CAPITAL COST (\$)	1250000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.000000E-38
OIL @ 0.00	.000000E-38
COAL @ 1.36	.37500E+12
ELEC @ 2.48	-.78000E+11
(@10500 BTU/KWH)	
OTHER @ 0.00	.000000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	254060.00
ENERGY COST/SAVINGS	316560.00
NON-FUEL O&M	-62500.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	100.0	0.0
1977	0.0	100.0	0.0
1978	0.0	130.0	0.0
1979	0.0	0.0	0.0
1980	5.0	0.0	0.0
1981	20.0	0.0	0.0
1982	40.0	0.0	0.0
1983	65.0	0.0	0.0
1984	85.0	0.0	0.0
1985	105.0	0.0	0.0
1986	130.0	0.0	0.0
1987	155.0	0.0	0.0
1988	175.0	0.0	0.0
1989	200.0	0.0	0.0
1990	215.0	0.0	0.0
1995	260.0	0.0	0.0
2000	300.0	0.0	0.0

PROJECT NAME - BLENDED CEMENT
 BRANCH - ALTERNATIVE MATERIALS UTILIZATION
 DESCRIPTION - 30% SUBSTITUTION OF FLY ASH OR SLAG IN A 250,000
 TON PER YEAR PORTLAND CEMENT PLANT

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		100.0	0.0
1977	0.0		100.0	0.0
1978	0.0		130.0	0.0
1979	0.0		0.0	0.0
1980	5.0	340.0	0.0	0.0
1981	20.0		0.0	0.0
1982	40.0		0.0	0.0
1983	65.0		0.0	0.0
1984	85.0		0.0	0.0
1985	105.0	340.0	0.0	0.0
1986	130.0		0.0	0.0
1987	155.0		0.0	0.0
1988	175.0		0.0	0.0
1989	200.0		0.0	0.0
1990	215.0	340.0	0.0	0.0
1995	260.0	340.0	0.0	0.0
2000	300.0	340.0	0.0	0.0

INVESTMENT
 (MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	RD&D INVESTMENT PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	0.3300	0.0000	375.0000	375.3300
DISCOUNTED	0.2983	0.0000	130.7838	131.0821

ENERGY SAVINGS
 CUMULATIVE TO 2000 (TRILLION BTU)

	TRILLION BTU
GAS	.00000E-38
OIL	.00000E-38
COAL	1436.1
ELECT	298.71
OTHER	.00000E-38

TOTAL 1137.4

ENERGY SAVINGS
 1985 2000

TRILLION BTU	31.18	89.10
MB/DOE	14.73	42.09

TOTAL ENERGY SAVINGS
 (MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
1903.002	404.805

ENERGY PRICES
 (\$/MMBTU)*

GAS	0.00
OIL	0.00
COAL	1.36
ELECT (10500 BTU/KWH)	2.48
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
4.920	0.1366	0.0000	0.0000
ETI	MEI		
1356.8	653.11		

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985) = 30.9%
 ACCELERATION = 5 YEARS

PROJECT NUMBER 3
(ORIGINALLY 211)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - HEAD BOX FOR PAPER
SECTOR - INDUSTRIAL
BRANCH - HIGH TEMPERATURE PROCESSES
DESCRIPTION - HIGH CONSISTENCY FORMING PROCESS FOR PAPERMAKING
LODDING ENGINEERING CORP

ACCELERATION OF MARKET ENTRY: 5. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	700000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 2.15 (\$/MMBTU)	.10000E+12
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	215000.00
ENERGY COST/SAVINGS	215000.00
NON-FUEL O&M	0.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	0.0	1000.0
1978	0.0	250.0	300.0
1979	0.0	710.0	200.0
1980	0.0	570.0	200.0
1981	0.0	0.0	0.0
1982	1.0	0.0	0.0
1983	5.0	0.0	0.0
1984	8.0	0.0	0.0
1985	12.0	0.0	0.0
1986	16.0	0.0	0.0
1987	22.0	0.0	0.0
1988	30.0	0.0	0.0
1989	40.0	0.0	0.0
1990	50.0	0.0	0.0
1995	150.0	0.0	0.0
2000	250.0	0.0	0.0

PROJECT NAME - HEAD BOX FOR PAPER
 BRANCH - HIGH TEMPERATURE PROCESSES
 DESCRIPTION - HIGH CONSISTENCY FORMING PROCESS FOR PAPERMAKING
 LODDING ENGINEERING CORP

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		0.0	1000.0
1978	0.0		250.0	300.0
1979	0.0		710.0	200.0
1980	0.0	0.0	570.0	200.0
1981	0.0		0.0	0.0
1982	1.0		0.0	0.0
1983	5.0		0.0	0.0
1984	8.0		0.0	0.0
1985	12.0	270.0	0.0	0.0
1986	16.0		0.0	0.0
1987	22.0		0.0	0.0
1988	30.0		0.0	0.0
1989	40.0		0.0	0.0
1990	50.0	0.0	0.0	0.0
1995	150.0	0.0	0.0	0.0
2000	250.0	0.0	0.0	0.0

INVESTMENT
 (MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	RD&D INVESTMENT PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	1.5300	1.7000	175.0000	178.2300
DISCOUNTED	1.1294	1.4439	34.2481	36.8214

ENERGY SAVINGS
 CUMULATIVE TO 2000 (TRILLION BTU)

	TRILLION BTU
GAS	173.26
OIL	.00000E-38
COAL	.00000E-38
ELECT	.00000E-38
OTHER	.00000E-38

TOTAL 173.26

ENERGY SAVINGS
 1985 2000

	1985	2000
TRILLION BTU	1.20	25.00
MB/DOE	0.57	11.81

TOTAL ENERGY SAVINGS
 (MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
751.006	116.764

ENERGY PRICES
 (\$/MMBTU)*

GAS	2.15
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
3.256	0.2011	0.0000	0.0000
ETI	MEI		
45.376	65.053		

PROJECT NUMBER 4
(ORIGINALLY 282)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - CEMENT BLOCK CURING PROCESS - SCI SERV
SECTOR - COMMERCIAL
BRANCH - HIGH TEMPERATURE PROCESSES
DESCRIPTION - ADD POZZOLAN TO CONCRETE TO MINIMIZE CEMENT CON-
TENT AND USE EXOTHERMIC HEAT TO CURE BLOCKS

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	1700.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.71 (\$/MMBTU)	.13000E+10
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	2138.00
ENERGY COST/SAVINGS	2223.00
NON-FUEL O&M	-85.00
USEFUL LIFE (YRS)	10.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	1.0	65.4	5.0
1978	50.0	0.0	0.0
1979	200.0	0.0	0.0
1980	400.0	0.0	0.0
1981	800.0	0.0	0.0
1982	1600.0	0.0	0.0
1983	2200.0	0.0	0.0
1984	2800.0	0.0	0.0
1985	3500.0	0.0	0.0
1986	4100.0	0.0	0.0
1987	5000.0	0.0	0.0
1988	5800.0	0.0	0.0
1989	6200.0	0.0	0.0
1990	7000.0	0.0	0.0
1995	10500.0	0.0	0.0
2000	12300.0	0.0	0.0

PROJECT NAME - CEMENT BLOCK CURING PROCESS - SCI SERV
 BRANCH - HIGH TEMPERATURE PROCESSES
 DESCRIPTION - ADD POZZOLAN TO CONCRETE TO MINIMIZE CEMENT CON-
 TENT AND USE EXOTHERMIC HEAT TO CURE BLOCKS

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	1.0		65.4	5.0
1978	50.0		0.0	0.0
1979	200.0		0.0	0.0
1980	400.0	8000.0	0.0	0.0
1981	800.0		0.0	0.0
1982	1600.0		0.0	0.0
1983	2200.0		0.0	0.0
1984	2800.0		0.0	0.0
1985	3500.0	9200.0	0.0	0.0
1986	4100.0		0.0	0.0
1987	5000.0		0.0	0.0
1988	5800.0		0.0	0.0
1989	6200.0		0.0	0.0
1990	7000.0	10700.0	0.0	0.0
1995	10500.0	12400.0	0.0	0.0
2000	12300.0	14333.0	0.0	0.0

INVESTMENT (MILLIONS OF DOLLARS)				
	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	0.0654	0.0050	20.9100	20.9804
DISCOUNTED	0.0595	0.0045	6.6530	6.7170

ENERGY SAVINGS CUMULATIVE TO 2000 (TRILLION BTU)			ENERGY SAVINGS	
		TRILLION BTU	1985	2000
GAS	185.10		4.55	15.99
OIL	.000000E-38	MB/DOE	2.15	7.55
COAL	.000000E-38			
ELECT	.000000E-38			
OTHER	.000000E-38			

TOTAL ENERGY SAVINGS (MILLIONS OF DOLLARS)	
ACTUAL	DISCOUNTED
737.732	142.491

ENERGY PRICES
(\$/MMBTU)*

GAS	1.71
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
0.795	0.7463	0.0000	0.0000
ETI	MEI		
2226.4	705.22		

* ENERGY PRICES BASED ON
EIA 0178F

MARKET PENETRATION (1985)= 38.0%
ACCELERATION = 3 YEARS

PROJECT NUMBER 5
(ORIGINALLY 137)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - FOAM FIBER TECHNOLOGY
SECTOR - COMMERCIAL
BRANCH - HIGH TEMPERATURE PROCESSES
DESCRIPTION - CONTINUOUS APPLICATION OF DYESTUFFS AND CHEMICALS
TO TEXTILES BY NOVEL PROCESS, REPLACES PAD BATH

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	65000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.79 (\$/MMBTU)	.25000E+11
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 2.31	.10000E+10
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	47060.00
ENERGY COST/SAVINGS	47060.00
NON-FUEL O&M	0.00
USEFUL LIFE (YRS)	15.0
SCRAPPAGE VALUE (FRACTION)	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	123.0	77.0
1978	1.0	123.0	164.0
1979	1.0	124.0	0.0
1980	50.0	0.0	0.0
1981	100.0	0.0	0.0
1982	180.0	0.0	0.0
1983	240.0	0.0	0.0
1984	300.0	0.0	0.0
1985	400.0	0.0	0.0
1986	530.0	0.0	0.0
1987	660.0	0.0	0.0
1988	780.0	0.0	0.0
1989	890.0	0.0	0.0
1990	1000.0	0.0	0.0
1995	1500.0	0.0	0.0
2000	2000.0	0.0	0.0

PROJECT NAME - FOAM FIBER TECHNOLOGY

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - CONTINUOUS APPLICATION OF DYESTUFFS AND CHEMICALS
TO TEXTILES BY NOVEL PROCESS, REPLACES PAD BATH

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		123.0	77.0
1978	1.0		123.0	164.0
1979	1.0		124.0	0.0
1980	50.0	0.0	0.0	0.0
1981	100.0		0.0	0.0
1982	180.0		0.0	0.0
1983	240.0		0.0	0.0
1984	300.0		0.0	0.0
1985	400.0	800.0	0.0	0.0
1986	530.0		0.0	0.0
1987	660.0		0.0	0.0
1988	780.0		0.0	0.0
1989	890.0		0.0	0.0
1990	1000.0	0.0	0.0	0.0
1995	1500.0	0.0	0.0	0.0
2000	2000.0	0.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	0.3700	0.2410	130.0000	130.6110
DISCOUNTED	0.3066	0.2055	36.8028	37.3150

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	512.61
OIL	.00000E-38
COAL	.00000E-38
ELECT	20.504
OTHER	.00000E-38

TOTAL 533.12

ENERGY SAVINGS	1985	2000
TRILLION BTU	10.40	52.00
MB/DOE	4.91	24.56

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
2157.449	401.867

ENERGY PRICES
(\$/MMBTU)*

GAS	1.79
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	2.31
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
1.381	0.4445	0.0000	0.0000
ETI	MEI		
784.63	414.34		

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 50.0%
ACCELERATION = 3 YEARS

PROJECT NUMBER 6
(ORIGINALLY 40)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - PAPER PULP CHARACTERIZATION
SECTOR - INDUSTRIAL
BRANCH - ALTERNATIVE MATERIALS UTILIZATION
DESCRIPTION - IMAGE ANALYSIS EQUIPMENT TO HELP OPTIMIZE PAPER-
MAKING PROCESS AND INCREASE RECYCLING NBS

ACCELERATION OF MARKET ENTRY: 10. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	110000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.00000E-38
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 1.42	.72000E+11
TOTAL OPERATING COST/SAVING (\$/YR)	96983.36
ENERGY COST/SAVINGS	101983.36
NON-FUEL O&M	-5000.00
USEFUL LIFE (YRS)	10.0
SCRAPPAGE VALUE (FRACTION)	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	135.0	0.0
1977	0.0	150.0	0.0
1978	0.0	175.0	0.0
1979	0.0	100.0	50.0
1980	0.0	90.0	100.0
1981	1.0	90.0	100.0
1982	1.0	0.0	50.0
1983	1.0	0.0	30.0
1984	4.0	0.0	20.0
1985	10.0	0.0	10.0
1986	50.0	0.0	0.0
1987	100.0	0.0	0.0
1988	180.0	0.0	0.0
1989	270.0	0.0	0.0
1990	360.0	0.0	0.0
1995	590.0	0.0	0.0
2000	930.0	0.0	0.0

PROJECT NAME - PAPER PULP CHARACTERIZATION

BRANCH - ALTERNATIVEMATERIALS UTILIZATION

DESCRIPTION - IMAGE ANALYSIS EQUIPMENT TO HELP OPTIMIZE PAPER-
MAKING PROCESS AND INCREASE RECYCLING NBS

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		135.0	0.0
1977	0.0		150.0	0.0
1978	0.0		175.0	0.0
1979	0.0		100.0	50.0
1980	0.0	560.0	90.0	100.0
1981	1.0		90.0	100.0
1982	1.0		0.0	50.0
1983	1.0		0.0	30.0
1984	4.0		0.0	20.0
1985	10.0	650.0	0.0	10.0
1986	50.0		0.0	0.0
1987	100.0		0.0	0.0
1988	180.0		0.0	0.0
1989	270.0		0.0	0.0
1990	360.0	750.0	0.0	0.0
1995	590.0	875.0	0.0	0.0
2000	930.0	1100.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	0.7400	0.3600	102.3000	103.4000
DISCOUNTED	0.6085	0.2251	21.9363	22.7699

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	.00000E-38
OIL	.00000E-38
COAL	.00000E-38
ELECT	.00000E-38
OTHER	528.56

TOTAL 528.56

ENERGY SAVINGS
1985 2000

TRILLION BTU	0.72	66.96
MB/DOE	0.34	31.63

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
1073.848	176.618

ENERGY PRICES
(\$/MMBTU)*

GAS	0.00
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	1.42

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
1.134	0.5433	0.5433	0.5433
ETI	MEI		
211.87	260.93		

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 1.5%
ACCELERATION = 10 YEARS

PROJECT NUMBER 7
(ORIGINALLY 108)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - HYPERFILTRATION - CLEMSON UNIVERSITY
SECTOR - INDUSTRIAL
BRANCH - HIGH TEMPERATURE PROCESSES
DESCRIPTION - 30 GPM CLOSED CYCLE FILTER TO REDUCE WATER CON-
SUMPTION, RECYCLE MATERIALS, AND SAVE ENERGY

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	133000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.96 (\$/MMBTU)	.13000E+11
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 2.48	-.50000E+09
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	40200.00
ENERGY COST/SAVINGS	24240.00
NON-FUEL O&M	15960.00
USEFUL LIFE (YRS)	8.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	50.0	32.0
1978	0.0	255.0	302.0
1979	0.0	234.0	96.0
1980	10.0	96.0	55.0
1981	200.0	0.0	0.0
1982	450.0	0.0	0.0
1983	700.0	0.0	0.0
1984	940.0	0.0	0.0
1985	1160.0	0.0	0.0
1986	1390.0	0.0	0.0
1987	1620.0	0.0	0.0
1988	1850.0	0.0	0.0
1989	2080.0	0.0	0.0
1990	2300.0	0.0	0.0
1995	2860.0	0.0	0.0
2000	3600.0	0.0	0.0

PROJECT NAME - HYPERFILTRATION - CLEMSON UNIVERSITY
 BRANCH - HIGH TEMPERATURE PROCESSES
 DESCRIPTION - 30 GPM CLOSED CYCLE FILTER TO REDUCE WATER CON-
 SUMPTION, RECYCLE MATERIALS, AND SAVE ENERGY

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		50.0	32.0
1978	0.0		255.0	302.0
1979	0.0		234.0	96.0
1980	10.0	10000.0	96.0	55.0
1981	200.0		0.0	0.0
1982	450.0		0.0	0.0
1983	700.0		0.0	0.0
1984	940.0		0.0	0.0
1985	1160.0	3314.3	0.0	0.0
1986	1390.0		0.0	0.0
1987	1620.0		0.0	0.0
1988	1850.0		0.0	0.0
1989	2080.0		0.0	0.0
1990	2300.0	10000.0	0.0	0.0
1995	2860.0	10000.0	0.0	0.0
2000	3600.0	10000.0	0.0	0.0

INVESTMENT (MILLIONS OF DOLLARS)				
	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	FEDERAL	PRIVATE		
	0.6350	0.4850	478.8000	479.9200
DISCOUNTED	0.4976	0.3884	161.2629	162.1489

ENERGY SAVINGS CUMULATIVE TO 2000 (TRILLION BTU)			ENERGY SAVINGS	
			1985	2000
GAS	549.82	TRILLION BTU	14.50	45.00
OIL	.00000E-38	MB/DOE	6.85	21.26
COAL	.00000E-38			
ELECT	-21.147			
OTHER	.00000E-38			
TOTAL			TOTAL ENERGY SAVINGS (MILLIONS OF DOLLARS)	
			ACTUAL	DISCOUNTED
	528.67		2094.756	410.618

ENERGY PRICES (\$/MMBTU)*		SCREENING CRITERIA			
		PAYBACK PERIOD	RATE OF RETURN		
GAS	1.96		NOM	BASE	POST
OIL	0.00	3.308	0.1811	0.0000	0.0000
COAL	0.00				
ELECT (10500 BTU/KWH)	2.48				
OTHER	0.00				
		ETI	MEI		
		463.48	235.97		

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985) = 35.0%
 ACCELERATION = 3 YEARS

PROJECT NUMBER 8
(ORIGINALLY 38)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - BOILER AIR/FUEL CONTROLS
SECTOR - INDUSTRIAL
BRANCH - WASTE ENERGY RECOVERY & UTILIZATION
DESCRIPTION - MICROPROCESSOR ANALYSIS OF AIR-FUEL RATIO TO
MAXIMIZE COMBUSTION EFFICIENCY - 2% FUEL SAVINGS

ACCELERATION OF MARKET ENTRY: 4. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	115000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.96 (\$/MMBTU)	.10000E+11
OIL @ 2.61	.10000E+11
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	40700.00
ENERGY COST/SAVINGS	45700.00
NON-FUEL O&M	-5000.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	158.5	25.0
1977	0.0	154.5	10.0
1978	0.0	168.0	0.0
1979	0.0	300.0	0.0
1980	10.0	900.0	0.0
1981	200.0	0.0	0.0
1982	1200.0	0.0	0.0
1983	2400.0	0.0	0.0
1984	3600.0	0.0	0.0
1985	4800.0	0.0	0.0
1986	6000.0	0.0	0.0
1987	7000.0	0.0	0.0
1988	7900.0	0.0	0.0
1989	8900.0	0.0	0.0
1990	9800.0	0.0	0.0
1995	13500.0	0.0	0.0
2000	17000.0	0.0	0.0

PROJECT NAME - BOILER AIR/FUEL CONTROLS
 BRANCH - WASTE ENERGY RECOVERY AND UTILIZATION
 DESCRIPTION - MICROPROCESSOR ANALYSIS OF AIR-FUEL RATIO TO
 MAXIMIZE COMBUSTION EFFICIENCY - 2% FUEL SAVINGS

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		158.5	25.0
1977	0.0		154.5	10.0
1978	0.0		168.0	0.0
1979	0.0		300.0	0.0
1980	10.0	0.0	900.0	0.0
1981	200.0		0.0	0.0
1982	1200.0		0.0	0.0
1983	2400.0		0.0	0.0
1984	3600.0		0.0	0.0
1985	4800.0	20000.0	0.0	0.0
1986	6000.0		0.0	0.0
1987	7000.0		0.0	0.0
1988	7900.0		0.0	0.0
1989	8900.0		0.0	0.0
1990	9800.0	0.0	0.0	0.0
1995	13500.0	0.0	0.0	0.0
2000	17000.0	0.0	0.0	0.0

INVESTMENT
 (MILLIONS OF DOLLARS)

	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	1.6810	0.0350	1955.0000	1956.7160
DISCOUNTED	1.2779	0.0341	593.4409	594.7529

ENERGY SAVINGS
 CUMULATIVE TO 2000 (TRILLION BTU)

GAS	1891.2
OIL	1891.2
COAL	.00000E-38
ELECT	.00000E-38
OTHER	.00000E-38

TOTAL 3782.5

ENERGY SAVINGS	1985	2000
TRILLION BTU	96.00	340.00
MB/DOE	45.35	160.60

TOTAL ENERGY SAVINGS
 (MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
17140.777	3274.426

ENERGY PRICES
 (\$/MMBTU)*

GAS	1.96
OIL	2.61
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
2.826	0.2295	0.2295	0.2295
ETI	MEI		
2495.8	993.14		

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985)= 24.0%
 ACCELERATION = 4 YEARS

PROJECT NUMBER 9
(ORIGINALLY 267)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - POLYPROPYLENE TO FUEL - PROCEDYNE CORP
SECTOR - INDUSTRIAL
BRANCH - ALTERNATIVE MATERIALS UTILIZATION
DESCRIPTION - REFINING OF WASTE ATALYTIC POLYPROPYLENE INTO
NO. 6 FUEL OIL

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	2000000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	2.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.000000E-38
OIL @ 2.61	.34600E+13
COAL @ 0.00	.000000E-38
ELEC @ 2.48	-.25200E+11
(@10500 BTU/KWH)	
OTHER @ 0.00	.000000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	5768104.00
ENERGY COST/SAVINGS	8768104.00
NON-FUEL O&M	-3200000.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	50.0
1977	0.0	0.0	25.0
1978	0.0	115.0	0.0
1979	0.0	0.0	0.0
1980	1.0	0.0	0.0
1981	1.0	0.0	0.0
1982	1.0	0.0	0.0
1983	1.0	0.0	0.0
1984	1.0	0.0	0.0
1985	1.0	0.0	0.0
1986	2.0	0.0	0.0
1987	2.0	0.0	0.0
1988	2.0	0.0	0.0
1989	2.0	0.0	0.0
1990	2.0	0.0	0.0
1995	4.0	0.0	0.0
2000	6.0	0.0	0.0

PROJECT NUMBER 10
(ORIGINALLY 23)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - RECUPERATORS
SECTOR - INDUSTRIAL
BRANCH - WASTE ENERGY RECOVERY & UTILIZATION
DESCRIPTION - GENERIC RECUPERATOR BASED ON AISI SPECS FOR AN
18 MMBTU/HR UNIT AT 1800F W/10% EXCESS AIR

ACCELERATION OF MARKET ENTRY: 1. YEARS

NEW
SYSTEM

CAPITAL COST (\$)	62200.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.96 (\$/MMBTU)	.24000E+11
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	43040.00
ENERGY COST/SAVINGS	47040.00
NON-FUEL O&M	-4000.00
USEFUL LIFE (YRS)	15.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	1300.0	400.0
1978	0.0	1100.0	400.0
1979	0.0	1500.0	500.0
1980	1000.0	3000.0	1000.0
1981	2500.0	0.0	0.0
1982	3900.0	0.0	0.0
1983	5000.0	0.0	0.0
1984	6500.0	0.0	0.0
1985	7600.0	0.0	0.0
1986	8600.0	0.0	0.0
1987	9500.0	0.0	0.0
1988	10500.0	0.0	0.0
1989	11400.0	0.0	0.0
1990	12400.0	0.0	0.0
1995	16300.0	0.0	0.0
2000	20400.0	0.0	0.0

PROJECT NAME - RECUPERATORS

BRANCH - WASTE ENERGY RECOVERY AND UTILIZATION

DESCRIPTION - GENERIC RECUPERATOR BASED ON AISI SPECS FOR AN
18 MMBTU/HR UNIT AT 1800F W/10% EXCESS AIR

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		1300.0	400.0
1978	0.0		1100.0	400.0
1979	0.0		1500.0	500.0
1980	1000.0	0.0	3000.0	1000.0
1981	2500.0		0.0	0.0
1982	3900.0		0.0	0.0
1983	5000.0		0.0	0.0
1984	6500.0		0.0	0.0
1985	7600.0	7575.0	0.0	0.0
1986	8600.0		0.0	0.0
1987	9500.0		0.0	0.0
1988	10500.0		0.0	0.0
1989	11400.0		0.0	0.0
1990	12400.0	12384.0	0.0	0.0
1995	16300.0	16280.0	0.0	0.0
2000	20400.0	20384.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	6.9000	2.3000	1268.8800	1278.0800
DISCOUNTED	5.2669	1.7529	432.5201	439.5399

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	5894.8
OIL	.00000E-38
COAL	.00000E-38
ELECT	.00000E-38
OTHER	.00000E-38

TOTAL 5894.8

ENERGY SAVINGS

	1985	2000
TRILLION BTU	182.40	489.60
MB/DOE	86.16	231.27

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
23031.749	4650.704

ENERGY PRICES
(\$/MMBTU)*

GAS	1.96
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
1.445	NOM	BASE	POST
	0.4260	0.4260	0.4260
	ETI	MEI	
	662.51	87.839	

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 100.3%
ACCELERATION = 1 YEARS

PROJECT NUMBER 11
(ORIGINALLY 112)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - POULTRY PROCESS - GEORGIA TECH
SECTOR - COMMERCIAL
BRANCH - AGRICULTURE AND FOOD PROCESSES
DESCRIPTION - WASTE HEAT RECOVERY ON REFRIG. UNITS, GEN. ENERGY
HOUSEKPG IN A DBL-SHFT POULTRY PROCESSING PLANT

ACCELERATION OF MARKET ENTRY: 5. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	80000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.96 (\$/MMBTU)	.39200E+11
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	71832.00
ENERGY COST/SAVINGS	76832.00
NON-FUEL O&M	-5000.00
USEFUL LIFE (YRS)	10.0
SCRAPPAGE VALUE (FRACTION)	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	75.0	0.0
1978	0.0	150.0	40.0
1979	0.0	50.0	10.0
1980	1.0	0.0	0.0
1981	10.0	0.0	0.0
1982	25.0	0.0	0.0
1983	60.0	0.0	0.0
1984	100.0	0.0	0.0
1985	150.0	0.0	0.0
1986	195.0	0.0	0.0
1987	225.0	0.0	0.0
1988	255.0	0.0	0.0
1989	285.0	0.0	0.0
1990	310.0	0.0	0.0
1995	400.0	0.0	0.0
2000	500.0	0.0	0.0

PROJECT NAME - POULTRY PROCESS - GEORGIA TECH
 BRANCH - AGRICULTURE AND FOOD PROCESSES
 DESCRIPTION - WASTE HEAT RECOVERY ON REFRIG. UNITS, GEN. ENERGY
 HOUSEKPG IN A DBL-SHFT POULTRY PROCESSING PLANT

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		75.0	0.0
1978	0.0		150.0	40.0
1979	0.0		50.0	10.0
1980	1.0	250.0	0.0	0.0
1981	10.0		0.0	0.0
1982	25.0		0.0	0.0
1983	60.0		0.0	0.0
1984	100.0		0.0	0.0
1985	150.0	325.0	0.0	0.0
1986	195.0		0.0	0.0
1987	225.0		0.0	0.0
1988	255.0		0.0	0.0
1989	285.0		0.0	0.0
1990	310.0	410.0	0.0	0.0
1995	400.0	510.0	0.0	0.0
2000	500.0	510.0	0.0	0.0

INVESTMENT
 (MILLIONS OF DOLLARS)

	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	FEDERAL	PRIVATE		
	0.2750	0.0500	40.0000	40.3250
DISCOUNTED	0.2297	0.0406	12.4400	12.7103

ENERGY SAVINGS
 CUMULATIVE TO 2000 (TRILLION BTU)

GAS	224.55
OIL	.00000E-38
COAL	.00000E-38
ELECT	.00000E-38
OTHER	.00000E-38

TRILLION BTU
 MB/DOE

ENERGY SAVINGS	1985	2000
	5.88	19.60
	2.78	9.26

TOTAL ENERGY SAVINGS
 (MILLIONS OF DOLLARS)

TOTAL 224.55

ACTUAL	DISCOUNTED
898.579	172.312

ENERGY PRICES
 (\$/MMBTU)*

GAS	1.96
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
1.114	0.5539	0.0000	0.0000
ETI	MEI		
637.51	345.67		

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985) = 46.2%
 ACCELERATION = 5 YEARS

PROJECT NUMBER 12
(ORIGINALLY 74)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - CEMENT KILN WASTE AS FUEL
SECTOR - INDUSTRIAL
BRANCH - ALTERNATIVE MATERIALS UTILIZATION
DESCRIPTION - 30% SUBSTITUTION OF REFUSE-DERIVED FUEL FOR COAL
IN A 305000 TON/YEAR CEMENT KILN

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	2000000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.000000E-38
OIL @ 0.00	.000000E-38
COAL @ 0.00	.000000E-38
ELEC @ 0.00	.000000E-38
(@10500 BTU/KWH)	
OTHER @ 1.11	.550000E+12
TOTAL OPERATING COST/SAVING (\$/YR)	507844.01
ENERGY COST/SAVINGS	607844.01
NON-FUEL O&M	-100000.00
USEFUL LIFE (YRS)	30.0
SCRAPPAGE VALUE (FRACTION)	0.05

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	282.0	0.0
1977	0.0	50.0	0.0
1978	0.0	339.0	0.0
1979	0.0	0.0	0.0
1980	1.0	0.0	0.0
1981	1.0	0.0	0.0
1982	1.0	0.0	0.0
1983	1.0	0.0	0.0
1984	1.0	0.0	0.0
1985	2.0	0.0	0.0
1986	2.0	0.0	0.0
1987	2.0	0.0	0.0
1988	2.0	0.0	0.0
1989	2.0	0.0	0.0
1990	3.0	0.0	0.0
1995	6.0	0.0	0.0
2000	9.0	0.0	0.0

PROJECT NAME - CEMENT KILN WASTE AS FUEL
 BRANCH - ALTERNATIVEMATERIALS UTILIZATION
 DESCRIPTION - 30% SUBSTITUTION OF REFUSE-DERIVED FUEL FOR COAL
 IN A 305000 TON/YEAR CEMENT KILN

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		282.0	0.0
1977	0.0		50.0	0.0
1978	0.0		339.0	0.0
1979	0.0		0.0	0.0
1980	1.0	140.0	0.0	0.0
1981	1.0		0.0	0.0
1982	1.0		0.0	0.0
1983	1.0		0.0	0.0
1984	1.0		0.0	0.0
1985	2.0	140.0	0.0	0.0
1986	2.0		0.0	0.0
1987	2.0		0.0	0.0
1988	2.0		0.0	0.0
1989	2.0		0.0	0.0
1990	3.0	140.0	0.0	0.0
1995	6.0	140.0	0.0	0.0
2000	9.0	140.0	0.0	0.0

INVESTMENT (MILLIONS OF DOLLARS)				
	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	FEDERAL	PRIVATE		
	0.6710	0.0000	18.0000	18.6710
DISCOUNTED	0.6076	0.0000	4.9698	5.5774

ENERGY SAVINGS CUMULATIVE TO 2000 (TRILLION BTU)			ENERGY SAVINGS	
		TRILLION BTU	1985	2000
GAS	.00000E-38		1.10	4.95
OIL	.00000E-38	MB/DOE	0.52	2.34
COAL	.00000E-38			
ELECT	.00000E-38			
OTHER	50.012			
TOTAL	50.012		79.398	14.862

TOTAL ENERGY SAVINGS (MILLIONS OF DOLLARS)	
ACTUAL	DISCOUNTED
79.398	14.862

ENERGY PRICES
(\$/MMBTU)*

GAS	0.00
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	1.11

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
3.938	0.1645	0.0000	0.0000
ETI	MEI		
24.460	8.8582		

* ENERGY PRICES BASED ON
EIA 0178F

MARKET PENETRATION (1985)= 1.4%
ACCELERATION = 3 YEARS

PROJECT NUMBER 13

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - DIRECT REDUCTION OF ALUMINUM

SECTOR - INDUSTRIAL

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - DIRECT REDUCTION OF ALUMINUM BY AN 80% EFFICIENT
300000 TON/YEAR BLAST FURNACE

ACCELERATION OF MARKET ENTRY: 10. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	150000000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	3.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.000000E-38
OIL @ 0.00	.000000E-38
COAL @ 0.00	.000000E-38
ELEC @ 2.97	.380000E+14
(@10500 BTU/KWH)	
OTHER @ 0.00	.000000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	94860000.00
ENERGY COST/SAVINGS	112860000.00
NON-FUEL O&M	-18000000.00
USEFUL LIFE (YRS)	30.0
SCRAPPAGE VALUE (FRACTION)	0.05

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	300.0	300.0
1978	0.0	1000.0	700.0
1979	0.0	4000.0	2000.0
1980	0.0	4000.0	2000.0
1981	0.0	8000.0	4000.0
1982	0.0	0.0	0.0
1983	0.0	0.0	0.0
1984	0.0	0.0	0.0
1985	1.0	0.0	0.0
1986	1.0	0.0	0.0
1987	1.0	0.0	0.0
1988	1.0	0.0	0.0
1989	1.0	0.0	0.0
1990	1.0	0.0	0.0
1995	2.0	0.0	0.0
2000	2.0	0.0	0.0

PROJECT NAME - DIRECT REDUCTION OF ALUMINUM

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - DIRECT REDUCTION OF ALUMINUM BY AN 80% EFFICIENT
300000 TON/YEAR BLAST FURNACE

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		300.0	300.0
1978	0.0		1000.0	700.0
1979	0.0		4000.0	2000.0
1980	0.0	140.0	4000.0	2000.0
1981	0.0		8000.0	4000.0
1982	0.0		0.0	0.0
1983	0.0		0.0	0.0
1984	0.0		0.0	0.0
1985	1.0	30.0	0.0	0.0
1986	1.0		0.0	0.0
1987	1.0		0.0	0.0
1988	1.0		0.0	0.0
1989	1.0		0.0	0.0
1990	1.0	140.0	0.0	0.0
1995	2.0	140.0	0.0	0.0
2000	2.0	140.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	17.3000	9.0000	300.0000	326.3000
DISCOUNTED	11.8039	6.2036	116.8089	134.8163

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	.00000E-38
OIL	.00000E-38
COAL	.00000E-38
ELECT	1312.0
OTHER	.00000E-38

TOTAL 1312.0

ENERGY SAVINGS	1985	2000
TRILLION BTU	38.00	76.00
MB/DOE	17.95	35.90

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
5222.816	959.658

ENERGY PRICES
(\$/MMBTU)*

GAS	0.00
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	2.97
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
1.581	0.2812	0.0000	0.0000
ETI	MEI		
53.292	70.880		

* ENERGY PRICES BASED ON
EIA 0178F

MARKET PENETRATION (1985)= 3.3%
ACCELERATION = 10 YEARS

PROJECT NUMBER 14
(ORIGINALLY 27)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - ALUMINUM SMELTER MOD - KAISER AND ALCOA
SECTOR - INDUSTRIAL
BRANCH - HIGH TEMPERATURE PROCESSES
DESCRIPTION - DEVELOPMENT OF AN IMPROVED CATHODE RETROFIT FOR
HALL CELLS

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	165000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.000000E-38
OIL @ 0.00	.000000E-38
COAL @ 0.00	.000000E-38
ELEC @ 2.48	.210000E+11
(@10500 BTU/KWH)	
OTHER @ 0.00	.000000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	52080.00
ENERGY COST/SAVINGS	52080.00
NON-FUEL O&M	0.00
USEFUL LIFE (YRS)	8.0
SCRAPPAGE VALUE (FRACTION)	0.01

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	65.0	60.0
1977	0.0	147.0	180.0
1978	0.0	500.0	250.0
1979	0.0	1000.0	500.0
1980	5.0	600.0	300.0
1981	10.0	500.0	250.0
1982	20.0	0.0	0.0
1983	50.0	0.0	0.0
1984	100.0	0.0	0.0
1985	175.0	0.0	0.0
1986	300.0	0.0	0.0
1987	450.0	0.0	0.0
1988	650.0	0.0	0.0
1989	900.0	0.0	0.0
1990	1225.0	0.0	0.0
1995	3150.0	0.0	0.0
2000	6000.0	0.0	0.0

PROJECT NAME - ALUMINUM SMELTER MOD - KAISER AND ALCOA
 BRANCH - HIGH TEMPERATURE PROCESSES
 DESCRIPTION - DEVELOPMENT OF AN IMPROVED CATHODE RETROFIT FOR
 HALL CELLS

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		65.0	60.0
1977	0.0		147.0	180.0
1978	0.0		500.0	250.0
1979	0.0		1000.0	500.0
1980	5.0	22500.0	600.0	300.0
1981	10.0		500.0	250.0
1982	20.0		0.0	0.0
1983	50.0		0.0	0.0
1984	100.0		0.0	0.0
1985	175.0	26000.0	0.0	0.0
1986	300.0		0.0	0.0
1987	450.0		0.0	0.0
1988	650.0		0.0	0.0
1989	900.0		0.0	0.0
1990	1225.0	30000.0	0.0	0.0
1995	3150.0	35000.0	0.0	0.0
2000	6000.0	40000.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	2.8120	1.5400	990.0000	994.3520
DISCOUNTED	2.0834	1.1660	184.9551	188.2045

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	.00000E-38
OIL	.00000E-38
COAL	.00000E-38
ELECT	811.68
OTHER	.00000E-38

TOTAL 811.68

ENERGY SAVINGS
1985 2000

TRILLION BTU	3.67	126.00
MB/DOE	1.74	59.52

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
3296.029	522.246

ENERGY PRICES
(\$/MMBTU)*

GAS	0.00
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	2.48
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
3.168	0.1903	0.1903	0.1903
ETI	MEI		
160.72	113.16		

* ENERGY PRICES BASED ON
EIA 0178F

MARKET PENETRATION (1985)= 0.7%
ACCELERATION = 3 YEARS

PROJECT NUMBER 15
(ORIGINALLY 21)

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - MOVING BEAM FURNACE
SECTOR - INDUSTRIAL
BRANCH - HIGH TEMPERATURE PROCESSES
DESCRIPTION - IMPROVED TRANSPORT MECHANISM TO REDUCE VIBRATION
IN A STEEL REHEATING UNIT

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	2000000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 2.26 (\$/MMBTU)	.22500E+12
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	508500.00
ENERGY COST/SAVINGS	508500.00
NON-FUEL O&M	0.00
USEFUL LIFE (YRS)	30.0
SCRAPPAGE VALUE (FRACTION)	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	300.0	90.0
1977	0.0	600.0	150.0
1978	0.0	600.0	60.0
1979	0.0	0.0	0.0
1980	0.0	0.0	0.0
1981	0.0	0.0	0.0
1982	0.0	0.0	0.0
1983	1.0	0.0	0.0
1984	2.0	0.0	0.0
1985	4.0	0.0	0.0
1986	5.0	0.0	0.0
1987	6.0	0.0	0.0
1988	8.0	0.0	0.0
1989	10.0	0.0	0.0
1990	12.0	0.0	0.0
1995	24.0	0.0	0.0
2000	36.0	0.0	0.0

PROJECT NAME - MOVING BEAM FURNACE

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - IMPROVED TRANSPORT MECHANISM TO REDUCE VIBRATION
IN A STEEL REHEATING UNIT

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		300.0	90.0
1977	0.0		600.0	150.0
1978	0.0		600.0	60.0
1979	0.0		0.0	0.0
1980	0.0	0.0	0.0	0.0
1981	0.0		0.0	0.0
1982	0.0		0.0	0.0
1983	1.0		0.0	0.0
1984	2.0		0.0	0.0
1985	4.0	200.0	0.0	0.0
1986	5.0		0.0	0.0
1987	6.0		0.0	0.0
1988	8.0		0.0	0.0
1989	10.0		0.0	0.0
1990	12.0	0.0	0.0	0.0
1995	24.0	0.0	0.0	0.0
2000	36.0	0.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	RD&D INVESTMENT PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	1.5000	0.3000	72.0000	73.8000
DISCOUNTED	1.3413	0.2760	16.5406	18.1579

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	68.850
OIL	.00000E-38
COAL	.00000E-38
ELECT	.00000E-38
OTHER	.00000E-38

TOTAL 68.850

ENERGY SAVINGS
1985 2000

TRILLION BTU	0.90	8.10
MB/DOE	0.43	3.83

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
291.203	48.567

ENERGY PRICES
(\$/MMBTU)*

GAS	2.26
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
3.933	0.1646	0.1646	0.1646
ETI	MEI		
30.030	13.550		

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 2.0%
ACCELERATION = 3 YEARS

PROJECT NUMBER 16

SUBSTITUTE TECHNOLOGY INPUT DATA FORM

PROJECT NAME - PULP PAPER SLUDGE DRYING

SECTOR - INDUSTRIAL

BRANCH - ALTERNATIVE MATERIALS UTILIZATION

DESCRIPTION - NOVEL METHOD OF DRYING PULP SLUDGES, RECOVERY OF
STEAM, ELIMINATION OF FUEL USE

ACCELERATION OF MARKET ENTRY: 3. YEARS

	CONVENTIONAL SYSTEM	SUBSTITUTE SYSTEM
CAPITAL COST (\$)	1850000.00	3000000.00
MANUFACTURING COST (\$)	0.00	0.00
YEARS TO INSTALL	1.0	2.0
ANNUAL ENERGY SAVINGS (BTU/YR)		
GAS @ 0.00 (\$/MMBTU)	.000000E-38	.000000E-38
OIL @ 2.51	.12750E+12	-.20400E+11
COAL @ 0.00	.000000E-38	.000000E-38
ELEC @ 2.39	.11160E+11	.11050E+12
(@10500 BTU/KWH)		
OTHER @ 0.00	.000000E-38	.000000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	346697.40	212891.00
ENERGY COST/SAVINGS	346697.40	212891.00
NON-FUEL O&M	0.00	0.00
USEFUL LIFE (YRS)	16.0	16.0
SCRAPPAGE VALUE (FRACTION)	0.00	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	1400.0
1977	0.0	0.0	350.0
1978	0.0	180.0	350.0
1979	1.0	0.0	0.0
1980	1.0	0.0	0.0
1981	1.0	0.0	0.0
1982	1.0	0.0	0.0
1983	1.0	0.0	0.0
1984	1.0	0.0	0.0
1985	2.0	0.0	0.0
1986	2.0	0.0	0.0
1987	3.0	0.0	0.0
1988	4.0	0.0	0.0
1989	5.0	0.0	0.0
1990	6.0	0.0	0.0
1995	10.0	0.0	0.0
2000	15.0	0.0	0.0

PROJECT NAME - PULP PAPER SLUDGE DRYING
 BRANCH - ALTERNATIVE MATERIALS UTILIZATION
 DESCRIPTION - NOVEL METHOD OF DRYING PULP SLUDGES, RECOVERY OF
 STEAM, ELIMINATION OF FUEL USE

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	1400.0
1977	0.0		0.0	350.0
1978	0.0		180.0	350.0
1979	1.0		0.0	0.0
1980	1.0	45.0	0.0	0.0
1981	1.0		0.0	0.0
1982	1.0		0.0	0.0
1983	1.0		0.0	0.0
1984	1.0		0.0	0.0
1985	2.0	54.0	0.0	0.0
1986	2.0		0.0	0.0
1987	3.0		0.0	0.0
1988	4.0		0.0	0.0
1989	5.0		0.0	0.0
1990	6.0	60.0	0.0	0.0
1995	10.0	67.0	0.0	0.0
2000	15.0	76.0	0.0	0.0

INVESTMENT (MILLIONS OF DOLLARS)				
	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	0.1800	2.1000	17.2500	19.5300
DISCOUNTED	0.1488	2.0074	4.5447	6.7009

ENERGY SAVINGS
 CUMULATIVE TO 2000 (TRILLION BTU)

		TRILLION BTU
GAS	.00000E-38	
OIL	21.355	MB/DOE
COAL	.00000E-38	
ELECT	-14.343	
OTHER	.00000E-38	

TOTAL 7.0114

ENERGY SAVINGS
 1985 2000

0.10	0.73
0.05	0.34

TOTAL ENERGY SAVINGS (MILLIONS OF DOLLARS)	
ACTUAL	DISCOUNTED
54.139	9.255

ENERGY PRICES
 (\$/MMBTU)*

GAS	0.00
OIL	2.51
COAL	0.00
ELECT (10500 BTU/KWH)	2.39
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
8.595	0.0564	0.0000	0.0000
ETI	MEI		
4.2924	21.059		

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985) = 3.7%
 ACCELERATION = 3 YEARS

PROJECT NUMBER 17

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - HEAT PUMP - GARRETT

SECTOR - INDUSTRIAL

BRANCH - WASTE ENERGY RECOVERY & UTILIZATION

DESCRIPTION - HIGH TEMPERATURE HEAT PUMP USING BOTH HOT WATER
AND HOT AIR WASTE HEAT

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	225000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 2.06 (\$/MMBTU)	.88000E+11
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 2.57	-.28000E+11
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	98020.00
ENERGY COST/SAVINGS	109320.00
NON-FUEL O&M	-11300.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	1400.0
1977	0.0	0.0	350.0
1978	0.0	500.0	350.0
1979	0.0	500.0	0.0
1980	0.0	400.0	0.0
1981	1.0	0.0	0.0
1982	1.0	0.0	0.0
1983	5.0	0.0	0.0
1984	9.0	0.0	0.0
1985	13.0	0.0	0.0
1986	15.0	0.0	0.0
1987	18.0	0.0	0.0
1988	21.0	0.0	0.0
1989	24.0	0.0	0.0
1990	26.0	0.0	0.0
1995	39.0	0.0	0.0
2000	65.0	0.0	0.0

PROJECT NAME - HEAT PUMP - GARRETT
 BRANCH - WASTE ENERGY RECOVERY AND UTILIZATION
 DESCRIPTION - HIGH TEMPERATURE HEAT PUMP USING BOTH HOT WATER
 AND HOT AIR WASTE HEAT

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	1400.0
1977	0.0		0.0	350.0
1978	0.0		500.0	350.0
1979	0.0		500.0	0.0
1980	0.0	0.0	400.0	0.0
1981	1.0		0.0	0.0
1982	1.0		0.0	0.0
1983	5.0		0.0	0.0
1984	9.0		0.0	0.0
1985	13.0	100.0	0.0	0.0
1986	15.0		0.0	0.0
1987	18.0		0.0	0.0
1988	21.0		0.0	0.0
1989	24.0		0.0	0.0
1990	26.0	0.0	0.0	0.0
1995	39.0	0.0	0.0	0.0
2000	65.0	0.0	0.0	0.0

INVESTMENT (MILLIONS OF DOLLARS)				
	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	1.4000	2.1000	14.6250	18.1250
DISCOUNTED	1.0621	2.0074	3.6645	6.7341

ENERGY SAVINGS CUMULATIVE TO 2000 (TRILLION BTU)			ENERGY SAVINGS	
			1985	2000
GAS	50.918	TRILLION BTU	0.78	3.90
OIL	.000000E-38	MB/DOE	0.37	1.84
COAL	.000000E-38			
ELECT	-16.201			
OTHER	.000000E-38			
TOTAL	34.717			
			TOTAL ENERGY SAVINGS (MILLIONS OF DOLLARS)	
			ACTUAL	DISCOUNTED
			145.304	25.496

ENERGY PRICES (\$/MMBTU)*		SCREENING CRITERIA			
		PAYBACK PERIOD	RATE OF RETURN		
			NOM	BASE	POST
GAS	2.06	2.295	0.2753	0.0000	0.0000
OIL	0.00				
COAL	0.00				
ELECT (10500 BTU/KWH)	2.57				
OTHER	0.00				
		ETI	MEI		
		8.3062	7.9983		

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985)= 13.0%
 ACCELERATION = 3 YEARS

PROJECT NUMBER 18

SUBSTITUTE TECHNOLOGY INPUT DATA FORM

PROJECT NAME - CUPOLA FURNACE MODIFICATION

SECTOR - INDUSTRIAL

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - DEVELOPMENT OF AN IMPROVED CUPOLA TO ELIMINATE
SECONDARY NATURAL GAS CONSUMPTION

ACCELERATION OF MARKET ENTRY: 8. YEARS

	CONVENTIONAL SYSTEM	SUBSTITUTE SYSTEM
CAPITAL COST (\$)	20000.00	75000.00
MANUFACTURING COST (\$)	0.00	0.00
YEARS TO INSTALL	1.0	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)		
GAS @ 1.96 (\$/MMBTU)	.25000E+11	.00000E-38
OIL @ 0.00	.00000E-38	.00000E-38
COAL @ 0.00	.00000E-38	.00000E-38
ELEC @ 0.00	.00000E-38	.00000E-38
(@10500 BTU/KWH)		
OTHER @ 5.11	.19500E+12	.19500E+12
TOTAL OPERATING COST/SAVING (\$/YR)	1044648.48	995648.48
ENERGY COST/SAVINGS	1044648.48	995648.48
NON-FUEL O&M	0.00	0.00
USEFUL LIFE (YRS)	10.0	10.0
SCRAPPAGE VALUE (FRACTION)	0.10	0.10

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	219.0	0.0
1978	0.0	219.0	0.0
1979	0.0	87.0	0.0
1980	3.0	100.0	50.0
1981	20.0	100.0	50.0
1982	50.0	0.0	0.0
1983	100.0	0.0	0.0
1984	250.0	0.0	0.0
1985	350.0	0.0	0.0
1986	500.0	0.0	0.0
1987	700.0	0.0	0.0
1988	900.0	0.0	0.0
1989	1100.0	0.0	0.0
1990	1400.0	0.0	0.0
1995	1460.0	0.0	0.0
2000	1500.0	0.0	0.0

PROJECT NAME - CUPOLA FURNACE MODIFICATION

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - DEVELOPMENT OF AN IMPROVED CUPOLA TO ELIMINATE
SECONDARY NATURAL GAS CONSUMPTION

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		219.0	0.0
1978	0.0		219.0	0.0
1979	0.0		87.0	0.0
1980	3.0	1325.0	100.0	50.0
1981	20.0		100.0	50.0
1982	50.0		0.0	0.0
1983	100.0		0.0	0.0
1984	250.0		0.0	0.0
1985	350.0	1410.0	0.0	0.0
1986	500.0		0.0	0.0
1987	700.0		0.0	0.0
1988	900.0		0.0	0.0
1989	1100.0		0.0	0.0
1990	1400.0	1430.0	0.0	0.0
1995	1460.0	1460.0	0.0	0.0
2000	1500.0	1500.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	0.7250	0.1000	82.5000	83.3250
DISCOUNTED	0.5758	0.0652	28.2278	28.8688

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	499.54
OIL	.00000E-38
COAL	.00000E-38
ELECT	.00000E-38
OTHER	.00000E-38

TOTAL 499.54

ENERGY SAVINGS

	1985	2000
TRILLION BTU	8.75	37.50
MB/DOE	4.13	17.71

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
2007.667	384.883

ENERGY PRICES
(\$/MMBTU)*

GAS	1.96
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
1.122	0.5509	0.0000	0.0000
ETI	MEI		
600.41	450.16		

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 24.8%
ACCELERATION = 8 YEARS

PROJECT NUMBER 19

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - BLAST FURNACE MBG GASIFIER

SECTOR - INDUSTRIAL

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - CONVERSION OF A 20 FT, 1575 TPD BLAST FURNACE TO
PRODUCE MEDIUM BTU GAS AND 630 TPD IRON

ACCELERATION OF MARKET ENTRY: 3. YEARS

NEW
SYSTEM

CAPITAL COST (\$)	32000000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	2.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 1.87 (\$/MMBTU)	.10000E+14
OIL @ 0.00	.00000E-38
COAL @ 1.29	-.13000E+14
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	6130000.00
ENERGY COST/SAVINGS	1930000.00
NON-FUEL O&M	4200000.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.01

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	0.0	0.0
1978	0.0	0.0	0.0
1979	0.0	2000.0	500.0
1980	0.0	2000.0	500.0
1981	1.0	2000.0	500.0
1982	1.0	0.0	0.0
1983	1.0	0.0	0.0
1984	1.0	0.0	0.0
1985	1.0	0.0	0.0
1986	1.0	0.0	0.0
1987	1.0	0.0	0.0
1988	1.0	0.0	0.0
1989	1.0	0.0	0.0
1990	1.0	0.0	0.0
1995	2.0	0.0	0.0
2000	2.0	0.0	0.0

PROJECT NAME - BLAST FURNACE MBG GASIFIER

BRANCH - HIGH TEMPERATURE PROCESSES

DESCRIPTION - CONVERSION OF A 20 FT, 1575 TPD BLAST FURNACE TO
PRODUCE MEDIUM BTU GAS AND 630 TPD IRON

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		0.0	0.0
1978	0.0		0.0	0.0
1979	0.0		2000.0	500.0
1980	0.0	40.0	2000.0	500.0
1981	1.0		2000.0	500.0
1982	1.0		0.0	0.0
1983	1.0		0.0	0.0
1984	1.0		0.0	0.0
1985	1.0	40.0	0.0	0.0
1986	1.0		0.0	0.0
1987	1.0		0.0	0.0
1988	1.0		0.0	0.0
1989	1.0		0.0	0.0
1990	1.0	40.0	0.0	0.0
1995	2.0	40.0	0.0	0.0
2000	2.0	40.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	6.0000	1.5000	64.0000	71.5000
DISCOUNTED	4.1105	1.0276	31.2176	36.3557

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

GAS	385.25
OIL	.00000E-38
COAL	-500.83
ELECT	.00000E-38
OTHER	.00000E-38

TOTAL -115.58

ENERGY SAVINGS
1985 2000

TRILLION BTU	-3.00	-6.00
MB/DOE	-1.42	-2.83

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
457.459	76.608

ENERGY PRICES
(\$/MMBTU)*

GAS	1.87
OIL	0.00
COAL	1.29
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
5.220	0.1183	0.0000	0.0000
	ETI	MEI	
	14.910	4.5011	

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 2.5%
ACCELERATION = 3 YEARS

PROJECT NUMBER 20

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - HEAT PUMP - STEAM

SECTOR - INDUSTRIAL

BRANCH - WASTE ENERGY RECOVERY & UTILIZATION

DESCRIPTION - WESTINGHOUSE HEAT PUMP UPGRADES WASTE HEAT TO LOW-TEMPERATURE LOW-PRESSURE STEAM

ACCELERATION OF MARKET ENTRY: 3. YEARS

	NEW SYSTEM
CAPITAL COST (\$)	350000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 0.00 (\$/MMBTU)	.000000E-38
OIL @ 2.61	.840000E+11
COAL @ 0.00	.000000E-38
ELEC @ 2.48	-.214000E+11
(@10500 BTU/KWH)	
OTHER @ 0.00	.000000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	127168.00
ENERGY COST/SAVINGS	166168.00
NON-FUEL O&M	-39000.00
USEFUL LIFE (YRS)	15.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	200.0	0.0
1978	0.0	300.0	0.0
1979	0.0	140.0	0.0
1980	1.0	0.0	0.0
1981	1.0	0.0	0.0
1982	1.0	0.0	0.0
1983	2.0	0.0	0.0
1984	3.0	0.0	0.0
1985	5.0	0.0	0.0
1986	6.0	0.0	0.0
1987	8.0	0.0	0.0
1988	10.0	0.0	0.0
1989	12.0	0.0	0.0
1990	14.0	0.0	0.0
1995	35.0	0.0	0.0
2000	70.0	0.0	0.0

PROJECT NAME - HEAT PUMP - STEAM
 BRANCH - WASTE ENERGY RECOVERY AND UTILIZATION
 DESCRIPTION - WESTINGHOUSE HEAT PUMP UPGRADES WASTE HEAT TO LOW-TEMPERATURE LOW-PRESSURE STEAM

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		200.0	0.0
1978	0.0		300.0	0.0
1979	0.0		140.0	0.0
1980	1.0	0.0	0.0	0.0
1981	1.0		0.0	0.0
1982	1.0		0.0	0.0
1983	2.0		0.0	0.0
1984	3.0		0.0	0.0
1985	5.0	100.0	0.0	0.0
1986	6.0		0.0	0.0
1987	8.0		0.0	0.0
1988	10.0		0.0	0.0
1989	12.0		0.0	0.0
1990	14.0	0.0	0.0	0.0
1995	35.0	0.0	0.0	0.0
2000	70.0	0.0	0.0	0.0

INVESTMENT (MILLIONS OF DOLLARS)				
	RD&D INVESTMENT		CAPITAL INVESTMENT	TOTAL INVESTMENT
	FEDERAL	PRIVATE		
ACTUAL	0.6400	0.0000	24.5000	25.1400
DISCOUNTED	0.5349	0.0000	4.8266	5.3616

ENERGY SAVINGS CUMULATIVE TO 2000 (TRILLION BTU)			ENERGY SAVINGS	
			1985	2000
GAS	.000000E-38	TRILLION BTU	0.31	4.38
OIL	39.539	MB/DOE	0.15	2.07
COAL	.000000E-38			
ELECT	-10.073			
OTHER	.000000E-38			
TOTAL	29.466			
			TOTAL ENERGY SAVINGS (MILLIONS OF DOLLARS)	
			ACTUAL	DISCOUNTED
			171.894	27.369

ENERGY PRICES
 (\$/MMBTU)*

GAS	0.00
OIL	2.61
COAL	0.00
ELECT (10500 BTU/KWH)	2.48
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
	2.752	0.2392	0.0000
	ETI	MEI	
	51.163	21.472	

* ENERGY PRICES BASED ON
 EIA 0178F

MARKET PENETRATION (1985)= 5.0%
 ACCELERATION = 3 YEARS

PROJECT NUMBER 56

NEW TECHNOLOGY INPUT DATA FORM

PROJECT NAME - FLAT GLASS CULLET REDUCTION

SECTOR - INDUSTRIAL

BRANCH - ALTERNATIVE MATERIALS UTILIZATION

DESCRIPTION - REDUCTION OF GLASS CULLET WASTE AND CORRESPONDING
ENERGY SAVINGS IN FLOAT GLASS MANUFACTURE

ACCELERATION OF MARKET ENTRY: 5. YEARS

NEW
SYSTEM

CAPITAL COST (\$)	100000.00
MANUFACTURING COST (\$)	0.00
YEARS TO INSTALL	1.0
ANNUAL ENERGY SAVINGS (BTU/YR)	
GAS @ 2.15 (\$/MMBTU)	.45500E+11
OIL @ 0.00	.00000E-38
COAL @ 0.00	.00000E-38
ELEC @ 0.00	.00000E-38
(@10500 BTU/KWH)	
OTHER @ 0.00	.00000E-38
TOTAL OPERATING COST/SAVING (\$/YR)	87825.00
ENERGY COST/SAVINGS	97825.00
NON-FUEL O&M	-10000.00
USEFUL LIFE (YRS)	20.0
SCRAPPAGE VALUE (FRACTION)	0.00

MARKET PENETRATION DATA - UNITS IN USE

YEAR	UNITS	FEDERAL FUNDING (\$1000)	PRIVATE FUNDING (\$1000)
1976	0.0	0.0	0.0
1977	0.0	0.0	0.0
1978	0.0	30.0	10.0
1979	0.0	200.0	50.0
1980	0.0	50.0	40.0
1981	0.0	0.0	0.0
1982	1.0	0.0	0.0
1983	5.0	0.0	0.0
1984	10.0	0.0	0.0
1985	20.0	0.0	0.0
1986	30.0	0.0	0.0
1987	33.0	0.0	0.0
1988	37.0	0.0	0.0
1989	41.0	0.0	0.0
1990	44.0	0.0	0.0
1995	66.0	0.0	0.0
2000	88.0	0.0	0.0

PROJECT NAME - FLAT GLASS CULLET REDUCTION

BRANCH - ALTERNATIVEMATERIALS UTILIZATION

DESCRIPTION - REDUCTION OF GLASS CULLET WASTE AND CORRESPONDING
ENERGY SAVINGS IN FLOAT GLASS MANUFACTURE

YEAR	MARKET PENETRATION UNITS IN USE	TOTAL MARKET SIZE	FEDERAL RD&D INVESTMENT (\$1000)	PRIVATE RD&D INVESTMENT (\$1000)
1976	0.0		0.0	0.0
1977	0.0		0.0	0.0
1978	0.0		30.0	10.0
1979	0.0		200.0	50.0
1980	0.0	550.0	50.0	40.0
1981	0.0		0.0	0.0
1982	1.0		0.0	0.0
1983	5.0		0.0	0.0
1984	10.0		0.0	0.0
1985	20.0	590.0	0.0	0.0
1986	30.0		0.0	0.0
1987	33.0		0.0	0.0
1988	37.0		0.0	0.0
1989	41.0		0.0	0.0
1990	44.0	640.0	0.0	0.0
1995	66.0	690.0	0.0	0.0
2000	88.0	740.0	0.0	0.0

INVESTMENT
(MILLIONS OF DOLLARS)

	RD&D INVESTMENT FEDERAL	PRIVATE	CAPITAL INVESTMENT	TOTAL INVESTMENT
ACTUAL	0.2800	0.1000	8.8000	9.1800
DISCOUNTED	0.2092	0.0732	2.4500	2.7324

ENERGY SAVINGS
CUMULATIVE TO 2000 (TRILLION BTU)

	TRILLION BTU
GAS	41.299
OIL	.000000E-38
COAL	.000000E-38
ELECT	.000000E-38
OTHER	.000000E-38

TOTAL 41.299

ENERGY SAVINGS
1985 2000

	1985	2000
TRILLION BTU	0.91	4.00
MB/DOE	0.43	1.89

TOTAL ENERGY SAVINGS
(MILLIONS OF DOLLARS)

ACTUAL	DISCOUNTED
168.418	30.830

ENERGY PRICES
(\$/MMBTU)*

GAS	2.15
OIL	0.00
COAL	0.00
ELECT (10500 BTU/KWH)	0.00
OTHER	0.00

SCREENING CRITERIA

PAYBACK PERIOD	RATE OF RETURN		
	NOM	BASE	POST
1.139	0.5141	0.0000	0.0000
ETI		MEI	
109.19		72.584	

* ENERGY PRICES BASED ON
EIA 0178FMARKET PENETRATION (1985)= 3.4%
ACCELERATION = 5 YEARS