VALIDATION OF THE CUMBERLAND ENERGYPLEX CONCEPT

Volume 3: Appendixes

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INTRODUCTION

This volume contains brief appendixes of three types: (1) Some topics, although their analyses were not directly requested in the contract work statement, are examined because they are central to determining the validity of the energyplex concept (e.g., socioeconomic effects and anaerobic digestion of animal wastes to recover energy). (2) Methane from Illinois coal beds is discussed as a potential energy resource; however detailed analysis has been prevented by the paucity of necessary geological data. (3) We note those energyplex elements whose brief examination revealed some barrier. For example, recovering energy from the relatively small amount of municipal waste generated by Charleston and Mattoon shows no economic promise, and cement production in the southeast quadrant of Illinois appears to be limited by inadequate quantities of limestone of the proper quality.

Appendix A

LOCAL SOCIOECONOMIC EFFECTS OF THE CUMBERLAND ENERGYPLEX

The socioeconomic consequences of energy development have become increasingly more important to the public and thus to energy system developers. Socioeconomics should be seriously considered during project planning for three primary reasons:

- (1) Adverse socioeconomic impacts can be the lever for initiating litigation and thereby impede project development.
- (2) If deleterious socioeconomic effects are associated with a project, whether rightly or wrongly, development of future projects in other areas can be adversely affected.
- (3) Adverse socioeconomic conditions can reduce worker productivity and cause delays that can affect a project's economic viability.

The potential liability of socioeconomic issues is vividly illustrated by the following passage from the North Dakota Public Service Commission for the American Natural Gas (ANG) 1978 coal gasification plant permit.

Should the adverse socioeconomic impacts arising as a result of the construction, operation or maintenance of the facility not be at an acceptable minimum: the Commission, on its own motion or upon complaint of any aggrieved person, agency or entity, may require ANG and its co-owners to show cause why it should not thereafter be required to manage the adverse impact at its own expense ... the Commission may require that ANG manage the impact at its own expense, and in a proper case may specify, generally or specifically, the manner in which the adverse impact is to be managed.

The following pages describe the socioeconomic characteristics of the energyplex (e.g., number of workers), the present socioeconomic environment in Coles County, Illinois,* the magnitude of change that may

* Although the energyplex would most likely be located in Cumberland County, Illinois, because of the paucity of data concerning that county, we have chosen neighboring Coles County to analyze as an example of socioeconomic impact.

occur if the energyplex is built, the probable impacts resulting from that change, and several concluding thoughts.

Socioeconomic Description of the Action

Table A-1 shows the estimated construction and operation work forces associated with the energyplex. The peak construction force would number about 6,000 workers and the operational work force approximately 5,000. The construction of all the components is assumed to occur during the 6-year period, 1984 to 1990.

Table A-1

PEAK ENERGYPLEX EMPLOYMENT

<u>Component</u>	<u>Operation</u>	<u>Construction^a</u>
Electrical generation plant (1500 MW)	200 ^b	1,500
Coal gasification plant (250 × 10 ⁶ CFD)	120 ^b	1,125
Oil production (80,000-150,000 b/d)	50 ^b	300
Coal mining (14.8 × 10 ⁶ t/y)	5,106 ^a	2,042
CO ₂ production (250-500 × 10 ⁶ CFD)	20 ^b	500
Ammonia plant (3500 t/d)	150 ^b	1,000
Agriculture and fish culture	100 ^b	300
Other industry	<u>100^b</u>	<u>300</u>
Grand total	5,846	7,067 [*]

*We assume that not all construction work forces peak simultaneously; therefore, the peak work force = 7067 × 0.75 = 5300.

^aReference 3.

^bSRI estimates.

Description of Area Before the Action

Population

The population of Coles County was 50,134 in July 1975. Approximately 74 percent of the county's residents lived in Charleston (18,032) and Mattoon (18,881).¹ The population in the county's other four population centers totaled less than 2,700. County population grew at an average annual rate of 1 percent per year between 1970 and 1975. During that same period, the average annual rates of change in Charleston and Mattoon were 2 and -0.8 percent, respectively.

Economy

The economy of Coles County is well diversified. Personal income in 1974 for the major sectors of the economy was: manufacturing--30.1 percent, including a wide range of products; government--16.7 percent; farm--13.7 percent; wholesale and retail trade--13.4 percent; transportation, communication, and public utilities--9.5 percent; and services--8.1 percent.² Most of the nonfarm economic activity occurs in the county trade centers of Charleston and Mattoon.

Coles County is classified as part of the Champaign-Urbana Economic Area, which also contains Ford, Champaign, Vermillion, Pratt, Douglas, Edgar, and Cumberland Counties.⁴ The economic center, Champaign-Urbana (1975 population, 92,816), lies approximately 45 miles north of Charleston and Mattoon. Terre Haute, Indiana, the center of another regional trade area, is located about the same distance to the east of Charleston.

Personel Income

In 1976, the per capita income in Coles County was \$5,568 or 77 percent of the state figure (\$7,259).⁵ Between 1969 and 1976, per capita income grew at an average annual rate of 11.5 percent in Coles County and 10.3 percent in Illinois. The total personal income in the county in 1976 was \$281 million.

Employment

The Mattoon Labor Market Area, which consists of Coles and Cumberland Counties, had an annual average unemployment rate of 5.1 percent in 1978, down from 5.3 percent in 1977. The Mattoon area rate is typically less than the state rate because of the industrial diversification of the counties. Unemployment is highest in January through March when Mattoon area construction firms are often idle. The average size of the Mattoon area labor force was 31,650 in 1978, up over 3 percent from the previous years' count.

Description of Impacts

Population in Coles County would increase by about 34,500 during the construction phase, and by about 48,200 during the operational phase. Compared to the 1975 population of 50,134 for the county, the construction phase would represent an increase of 69 percent, and the operational phase an increase of 96 percent.

Personal income would increase in the county because of the increased number of workers. If we assume that jobs in the energyplex itself result in an average wage of \$9 per hour* and that indirect employment jobs result in wages of about \$4.50 per hour, personal income would increase by about 61 percent during construction and by about 68 percent during the operational phase. We have calculated these increases by using the 1976 personal income of \$281 million for the county. Moreover, the personal income figures are understated; in reality, personal income will be higher in the county because of local expenditures made by the company and nonlabor income.

These population and personal income percentage increases are calculated by employing worst case assumptions. It is likely that some of the incoming population will settle in counties other than Coles, such as Champaign County to the north, and possibly even as far as the city of Terre Haute in the state of Indiana to the east.

*Values in constant first-quarter 1979 dollars.

Table A-2 shows the facilities that will be affected because of the construction and operations phase, the additional facilities that will be required, and how many new employees will be required because of the energyplex.

Analysis of Impacts

It is premature at this juncture of project planning, when even the site of the energyplex has yet to be established, to attempt to identify the specific significance of changes that could occur. However, it is appropriate to suggest the types of impacts that could occur and their likely importance.

The severity of the impacts cited previously will depend on the ability of the governmental, economic, social, and other systems to accommodate change. Of critical concern of course, is how much change is likely to occur. This will be a function of several factors, including:

- The ultimate geographical configuration of the energyplex; whether dispersed or concentrated
- The proximity of the energyplex to urban areas
- The rate of work force (construction and operation) buildup and decrease
- The magnitude of employment peaks
- The residential location of workers
- The magnitude of local urban resources (e.g., public finance, infrastructure, administration, private capital, and building industry).

For example, if the energyplex is concentrated in a rural area that is not in reasonable commuting distance to major cities, the socioeconomic impacts could be much greater than if the development were closer to urban support systems. Similarly, if the construction work forces for the various energyplex elements peak simultaneously, urban impacts may be greater than if peaks were staggered or reduced.

Table A-2

PEAK URBAN SUPPORT SYSTEM REQUIREMENTS FOR THE ENERGYPLEX

	<u>Construction Phase</u>		<u>Operation Phase</u>	
	<u>Facilities Required</u>	<u>Employees Required</u>	<u>Facilities Required</u>	<u>Employees Required</u>
Elementary and secondary school classrooms	396	999	554	1,397
Water supply, acre-ft/yr	6,900	24	9,600	33
Sewage treatment capacity, million gal	3.4	42	4.8	58
Housing units				
Permanent	6,200	--	6,800	--
Temporary	3,400	--	2,900	--
Transient	700	--	200	--
Police station, sq. ft	7,000	78	9,600	109
Vehicles	14		19	
Fire fighters	--	44	--	62
Medical				
Hospital beds	140		190	
Doctors		65		91
General government offices, sq. ft	7,000	64	9,800	90
Solid waste disposal, landfill acre-ft/yr	60	31	80	43
Parks/recreation	--	22	--	31
Libraries, sq. ft	19,000	10	27,000	13
Total estimated urban acres required, including streets and right-of-way	3,800	--	6,000	--
Total service workers required				
Public sector employees		1,300		1,800
Private sector employees		<u>2,900</u>		<u>7,000</u>
Total		4,200		8,800

Despite the uncertainties in the amount of change that may occur, potential trouble areas can be identified and certain conclusions can be made. The rapid urbanization due to energy development in the western United States has shown that large influxes of population--a doubling or quadrupling over a few years--can strain the social and economic fabrics of small communities to the point of their breaking down. Specifically, the demand for public and private goods and services exceeds supply, prices are driven up, critical commodities such as housing and sewerage are unavailable, living conditions decline, social disruption takes place, and the rate of crime and divorce and other social problems increases. When supply does catch up with demand, it may be found that some short-run ills have spawned longer-term problems, such as a city acquiring a reputation as a poor place to live or poorly planned residential developments.

The change in population and demand for services identified above are great enough to cause such problems. The following paragraphs describe these potential difficulties further, and the following section offers several approaches to avoiding socioeconomic and resultant problems.

Public Finance

A fundamental problem of rapid urbanization is financing public facilities and services. In the long run, after the project has been in operation for a few years, it is likely that public revenues will exceed expenditures; however, because many public capital expenditures should be made before tax revenues will start flowing, front-end financing problems can begin.

Although some sales tax and property tax revenues will begin to accrue as construction workers enter the project area, the bulk of the property tax increase and corporate income taxes will not be collected until the facility is under operation. However, for facilities and services to be in place when the demand occurs, planning and construction must start several years before the revenues from the project become available.

Other impediments to financing the necessary public infrastructure are bonding capacities and the unwillingness of some predevelopment residents to vote higher tax burdens for a development that they are uncertain will benefit them personally. In addition, difficulties may take place if the taxes are generated in one geopolitical jurisdiction and the urban impact occurs in another.

The growth policies of the communities affected by the energyplex will also affect their fiscal situation. For example, it may be difficult to serve urban development that is allowed to occur in scattered patterns. By the same token, if mobile homes (which typically do not pay their own way) proliferate, a long-term fiscal deficit may take place.

Local Business

Because of the uncertainties of energy development projects, private capital for increasing private services (e.g., stores, hotels, restaurants) is not likely to be available until the project is under way. Thus, local businessmen already in the community are likely to have increased trade, at least initially. If they can deal with the stress of managing more employees, dealing with a different clientele, greater demands on their time, and so forth, they may profit.

As chain stores and other professional organizations become established, the predevelopment businesses will have to make further adjustments to remain in operation. In addition to the personal costs cited above, businesses will face greater operating costs as local goods and services become more expensive and as the cost of labor increases because of competition with energyplex wages. In many western boom towns, businesses anticipating a windfall because of energy development eventually closed or were sold because of the operators' inability to adjust from a small town to a more urban situation.

Housing Market

Housing is a primary requirement that cannot be compromised. The energyplex workers, the secondary work force, and their families must

have places to reside. Unfortunately, several serious impediments to the efficient provision of housing exist. Like acquiring capital for new businesses, the financing required for housing construction will not be forthcoming until investors can be sure the project will become a reality. Although land speculation will occur throughout the predevelopment period, housing in sufficient quantities may not be constructed until the project is well along.

Another difficulty is that housing depends on public facilities (e.g., roads and sewers). Therefore, until some of the public finance issues above are resolved, housing development cannot commence. These delays must be considered in the context of the time lags required for normal land acquisition, design, permit approval, financing, and construction.

The experience in the West has also shown that it is difficult for developers in energy development areas to build housing that is appropriately priced for the target market. Inflated land values, imported labor, transportation costs for materials, competition with energy development project construction wages, and so forth, inflate housing costs.

Quality of Life

During rapid growth a shortage of fundamental goods and services (e.g., housing and schools) may occur. Increased truck traffic, noise, airborne dust from construction, crowding, and other factors may disrupt a locale, reducing the quality of life for many persons. In addition, large influxes of construction, and eventually of operation, workers who have different life styles than the predevelopment residents commonly result in the "newcomers" versus "old timers" syndrome that has been well documented in recent energy boom towns.⁶

The project would improve the financial conditions of most residents; however, the poor, those on fixed incomes, and others not participating in the project are likely to fare worse than before because the cost of living will increase. When the supply for public and private goods and

service catches up with demand, schools, shopping conditions, and quality of housing are likely to be better than before the development.

When the population of an area increases rapidly, the social and economic structures are strained. In Gillette, Wyoming, during the development of power generation and mining facilities, the rate of divorces, arrests, school dropouts, public drunkenness, and drunk driving increased substantially (approximately 40 to 80 percent).⁷ Some of these problems can be attributed to dissatisfaction with living conditions, and some undoubtedly reflect the character of the incoming population.

Energy Developer

The anticipation of adverse socioeconomic impacts, as well as their actuality, can be detrimental to the energy developer. A heightened sensitivity to environmental and socioeconomic conditions and strong regulatory requirements have given interested citizens and advocacy groups the ability to stop, delay, relocate, and otherwise impede energy projects.

In addition, substandard living conditions have been shown to increase worker turnover and absenteeism, and reduce productivity. For example, the turnover in the Gillette, Wyoming, trona mines ranged from 35 to 100 percent more than anticipated. As a result, mine production dropped 25 to 40 percent below the preboom town levels.⁸

When absenteeism and turnover rise, the operator must increase overtime and/or bring in new workers. The latter may require financial incentives, recruiting, and training, all of which can be expensive and will also affect productivity. If more hiring is necessary to stay on schedule, the poor living conditions that precipitated the problem may actually worsen with the coming of more persons into an area that cannot accommodate the population it already has. Thus, a vicious circle may be initiated.

Conclusions

The energyplex would be a large-scale development in a basically rural and small community environment. The influx of population would be great enough to cause a number of severe socioeconomic conditions that would jeopardize the approval of the project and its cost-effective operation.

However, various means can help avoid and mitigate such impacts: The key is planning ahead. The project developers must take the lead role to assure that the job is done and done well. The primary planning and implementation steps should be to:

- (1) Define the potential problems:
 - Identify project needs, variables, schedules, and so forth
 - Assess demands for services and facilities
 - Identify potential socioeconomic problems
- (2) Identify potential methods of avoiding or mitigating impacts
- (3) Establish mechanisms to implement solutions and initiate mitigation action
- (4) Monitor this program and revise it as required.

In practice, the utilities should complement governmental activities that are mounted to ameliorate impacts. The utility's role may range from active to watchful. For instance, the utility itself may find it most effective to plan new urban development, even a new town. This could include developing housing and infrastructure. Other active measures might include coordinating construction schedules to reduce construction peaks or maximizing off-site construction to reduce the worker population during initial development. Less active roles might entail preparing and lobbying for new legislation to give financial relief to affected communities, making performance guarantees to facilitate private investment, prepaying taxes, or giving technical assistance to local governments.

In many western states energy development has recently increased dramatically. As a result, these states have created methods to provide

aid to energy communities. Historically, Illinois has witnessed extensive coal extraction and related activities; however, these have been on the decline since the 1920s. Thus, Illinois does not now have the community support mechanisms (e.g., severance tax and direct aid) that other states have recently acquired. Over the next few years, therefore, regulations and legislation pertaining to energy development are likely to be in transition, and energy developers thus assume active roles in mitigating impacts.

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Appendix B

ENVIRONMENTAL POLICIES

The Clean Air Act Amendments of August 1977, may significantly affect the siting of future industrial plants throughout the nation. The Prevention of Significant Deterioration (PSD) and the nonattainment provisions of the amendments constitute a form of land use legislation in that regulatory agencies will establish limits for controlling regional growth. The full impact of the legislation is not yet known. Draft regulations have already been submitted for a lengthy period of public comment and are now being formalized by the Environmental Protection Agency (EPA). During the public hearings, EPA revised the proposed rules to give industries greater flexibility in meeting overall air pollution standards.

At this time, state air quality control boards have set rigid limits on pollution sources within an industrial complex; utilities, among others, must conform to those limits. EPA's revised proposals would allow firms to suggest trade-offs among sources in a given area to allow reasonable progress toward attaining national ambient air quality standards (NAAQS), while still permitting a new source to be located within that area.

Current regulations allow state enforcement officials either to adopt or reject a policy in their states. Consequently, many states are submitting new regulations that will include increments of pollution within limits to allow for growth. Heretofore, Illinois has adhered closely to federal standards, but the new Illinois standards are unavailable at this time. The Illinois Air Quality Standards, adopted in 1973 and published with amendments through 1977, which were designed for use in the development and implementation plans by state and local agencies within Illinois, may change significantly. However these standards remain in force at present; they are tabulated in Table B-1.

Table B-1

AMBIENT AIR QUALITY STANDARDS IN ILLINOIS*
(Micrograms per Cubic Meter)

Pollutant	Annual	Averaging Time			
		24-Hour	8-Hour	3-Hour	1-Hour
Particulate matter, annual geometric mean					
Primary standard	75	260	--	--	--
Secondary standard	60	150	--	--	--
SO ₂ , annual arithmetic mean					
Primary standard	80 (0.03 ppm)	365 (0.14 ppm)	--	--	--
Secondary standard	--	--	--	1,300 (0.5 ppm)	--
Nonmethane hydrocarbons	--	--	--	160 (0.24 ppm)	--
CO	--	--	10 mg (9 ppm)	--	40 mg (35 ppm)
NO ₂ , annual arithmetic mean	100 (0.05 ppm)	--	--	--	--
Photochemical oxidants	--	--	--	--	160 (0.08 ppm)

Note: These standards can only be exceeded once a year.

* As of 31 December 1977.

Source: Environment Reporter, Vol. 366, p. 0582

Attainment Status Designations

The Clean Air Act Amendments of 1977 directed each state to submit to EPA for approval the NAAQS attainment status for all areas within the state. The designations were based on the results of monitoring air quality levels for the most recent 12-month period before March 1978. Under the provisions of the Clean Air Act, a state may periodically revise and resubmit its list of designations to EPA for concurrence. Table B-2 indicates the published attainment levels for Illinois as of 3 March 1978. The list includes air quality control regions (AQCRs) and the counties in those regions.

From these data, we have developed an AQCR map for Illinois (see Figure B-1). The map locates power plants throughout the state and in the counties surrounding Cumberland County--the area under study. (Generation units within the counties are not pinpointed.)

The pollutants listed in Table B-2 include total suspended particulates (TSP); sulfur dioxide (SO_2); and nitrogen dioxide (NO_2). Cumberland County is rated "better than national standards" in all three categories.

Note that several townships in AQCR 66 have been designated "unclassifiable" in the particulate category. EPA defines "unclassifiable" to indicate that a major source in each township is employing a possibly unauthorized dispersion technique (e.g., a tall stack). EPA's stack height rules, which were not signed until 20 December 1978, would limit stack height to "a good engineering practice." They would also generally prohibit dispersion that varies with atmospheric conditions as a substitute for constant control techniques. As a result these areas are now considered to be "nonattainment" areas. Stacks constructed before 31 December 1970, are exempt from constant control requirements. Their existence in nonattainment areas presents some interesting possibilities, in that their pollutant status may be marketable. This point is discussed later in this appendix.

The designation of an area as "nonattainment" or "attainment" does not in itself determine the future of new construction. Whether a source

Table B-2

POLLUTION CONTROL ATTAINMENT STATUS FOR AIR QUALITY
CONTROL REGION 66, ILLINOIS*

County	Does not Meet Secondary Standards			Cannot be Classified			Better Than National Standards		
	TSP	SO ₂	NO ₂	TSP	SO ₂	NO ₂	TSP	SO ₂	NO ₂
Champaign								x	x
Champaign City				x			x		
Cunningham Township				x			x		
Ludlow				x			x		
Rantoul				x			x		
All other townships							x		
Coles								x	x
Charleston Township				x			x		
Lafayette				x			x		
Mattoon				x			x		
All other townships							x		
McLean								x	x
Bloomington Township	x								
Normal				x			x		
All other townships							x		
Vermillion								x	x
Blount Township				x			x		
Danville				x			x		
Newell				x			x		
All other townships							x		
Clark							x	x	x
Cumberland							x	x	x
DeWitt							x	x	x
Douglas							x	x	x
Edgar							x	x	x
Ford							x	x	x
Iroquois							x	x	x
Livingston							x	x	x
Moultrie							x	x	x
Platt							x	x	x
Shelby							x	x	x

* Primary standards are health based; secondary standards are welfare based. All counties in AQCR 66 meet primary standards.

Source: Federal Register (3 March 1978)

FIGURE B-1 POWER PLANTS INSTALLED OR UNDER CONSTRUCTION IN AIR QUALITY CONTROL REGIONS SURROUNDING CUMBERLAND COUNTY

will violate the NAAQS will continue to be determined on a case-by-case basis, independent of any general determination of nonattainment. There are several reasons for this: First, an area's designation may be changed by the time a source begins operation. Second, within each AQCR certain areas will be found where the air quality does not correspond to the designation of the area. Third, the nonattainment status may be based on a localized violation of standards in a small portion of the county or AQCR. These differences are addressed in preconstruction reviews of development under the PSD plan.

Under the preconstruction permit requirements, states have two basic options for dealing with proposed new sources in nonattainment areas:

- The state implementation plan may contain an allowance for new growth, while moving toward attainment of NAAQS, and the state will license sources within the limits of the allowance.
- If the allowance is used up, sources will be licensed only if case-by-case offsets (i.e., reductions of emissions from other sources) are obtained that will ensure reasonable progress toward attainment of the applicable NAAQS.

If the state implementation plan is not being carried out, however, no permits may be issued within the area. Note that federally ordered fuel switches and temporary emissions do not consume the available PSD increment.

Prevention of Significant Deterioration

The regulations for PSD, first published in 1974, were greatly strengthened by the signing of the Clean Air Act Amendments of 1977. PSD regulations are intended to preserve the quality of air in areas now cleaner than required by NAAQS. These requirements include:

- The designation of different categories of land to which the increments are applied
- The designation of maximum allowable increments of air quality deterioration within each category
- The application of a requirement for best available control technology (BACT)
- The implementation of a formal permit program to ensure that the requirements are satisfied.

Land Categories

Under the terms of the regulations, areas are categorized in three classes. Class I areas include international parks, national wilderness areas, primitive areas, wildlife refuges, national lakeshore or seashore, memorial parks, and similar protected areas. Class II almost always will include all other areas. However, Class II areas may be redesignated to Class I or in rare instances to Class III (a special exemption area) by states and other governing bodies, but only after extensive reviews and public hearings. The approval of the governor of the state after consultation with the appropriate committees of the legislature is also required to obtain the designation of a Class III area. The EPA administrator approves the redesignation only if it does not violate the allowable increase in another area.

Allowable Increments

To take area growth into account, the new regulations have set ambient air increments for particulate matter and SO₂ in each of the Class I, Class II, and Class III areas. Table B-3 indicates the proposed increments. PSD increments must be protected not only through the individual preconstruction reviews mentioned earlier, but through the state implementation plan process. States must use "economic" approaches to allocate the increments.

Each class would be permitted increments of pollution up to a level considered significant for that area. In Class I areas, small increases of SO₂ and particulates are considered "significant." Significance levels for Class I appear in Table B-4.

Class II areas permit deterioration up to the levels of secondary NAAQS. If it is demonstrated that a proposed source or modification would adversely affect the air quality in Class I areas (e.g., park or bird sanctuaries), the issuance of a PSD permit is denied. However, the owner of the proposed source may obtain a variance from the federal land manager and the governor after demonstrating that such standards, although they may be violated, may not be "adversely affected," and in such cases EPA would allow the permit.

Table B-3

MAXIMUM ALLOWABLE INCREASE IN POLLUTANT EMISSIONS
(Micrograms per Cubic Meter)

	<u>Class I</u>	<u>Class II</u>	<u>Class III</u>
Particulate matter			
Annual geometric mean	5	19	37
24-hour maximum	10	37	75
SO ₂			
Annual arithmetic mean	2	20	40
24-hour maximum	5	91	182
3-hour maximum	25	512	700

Source: Federal Register (June 1978)

Table B-4

AMBIENT IMPACT SIGNIFICANCE LEVEL
(Micrograms per Cubic Meter, Annual Arithmetic Mean)

<u>Pollutant</u>	<u>Annual</u>	<u>Averaging Time</u>			
		<u>24-Hour</u>	<u>8-Hour</u>	<u>3-Hour</u>	<u>1-Hour</u>
SO ₂	1	5	--	25	--
Particulate matter	1	5	--	--	--
NO ₂	1	--	--	--	--
CO	--	--	0.5	--	2

Source: Federal Register (19 June 1978)

The PSD regulation requires each new "major stationary source" to meet PSD requirements. A "major stationary source" is any one of the 28 classes of sources for which new source performance standards (NSPS) have been established and that has the "potential" to emit 100 tons per year or more of any pollutant. Included within the category of potential

(uncontrolled) sources are fossil-fuel fired steam electric plants of more than 250 million Btu heat input; sulfur recovery plants; and fuel conversion plants among others. The "potential to emit" is the "maximum capacity to emit a pollutant, absent [without] air pollution control equipment [in place]."

At this time, EPA's policy allocates increments on a first-come, first-serve basis; however, EPA is also encouraging state and local governments to consider apportioning increments in the future through marketable permits, emission fees, and emissions density zoning. A marketable permit program would allow a source to sell the unused portion of his maximum allowed emissions to another source to the degree that the source can reduce emissions below the specified level. An alternative would be to charge emission fees according to the quantity of pollutants emitted. The emission density zoning alternative would allow a fixed quantity of emissions per acre, and sources would thus purchase the "air rights" to enough land to cover their emissions.

Best Available Control Technology

Sources locating near PSD areas will be required to use the best available control technology (BACT) to preserve PSD increments. The requirement for the use of BACT is more stringent under the Clean Air Act Amendments. Previously, BACT was interpreted to be equivalent to NSPS; however, the amendments now stipulate NSPS as minimum BACT. BACT will be required for each pollutant for which the potential uncontrolled emissions exceed 250 tons. Until the states assume control of the PSD program, EPA must determine BACT on a case-by-case basis by taking into account several factors that include the environmental impact, cost, the energy required, and technical feasibility.

Special attention is given to phased construction projects (e.g., a three-boiler power plant project). BACT will be reviewed before the construction of each phase to preserve PSD increments by not allowing a phased construction to reserve an increment well into the future. The time limits imposed on phased construction require that construction of

the first unit must begin within 18 months of the date approved in the permit. The period between the start of construction of each unit must not exceed 18 months, and EPA may demand a shorter period.

The BACT requirement does not preclude consideration of technology used in other types of sources but that has not been demonstrated for the specific source being reviewed. However, other factors, including economic costs and energy, must be considered before requiring such technology transfer to comply with the BACT requirement.

EPA's PSD regulations will be superseded when a state PSD plan is approved. Individual states may submit PSD plans that are more stringent than the EPA level, but as noted above, previous Illinois standards have closely followed national standards.

PSD Permit Program

Applicants for PSD permits will be required to demonstrate by air quality modeling that the air quality control system they select represents BACT in regard to energy, environmental, and economic factors. EPA will allow less stringent standards for one pollutant if that results in better control of another.

Many sources subject to PSD must present a full year of air quality monitoring data at the proposed site as part of applications to construct, especially when there is good reason to believe that a new source would cause or increase a violation of a NAAQS.

When the potential uncontrolled emission level would not otherwise be approved, emission offsets (additional control of existing sources) may be used to allow construction of a new source. To be acceptable, such reductions must be expressed in terms of actual emissions. These will be included in the modeling. The baseline will be the air quality and emissions level as of 7 August 1977. (The standards for Illinois are tabulated in Table B-1.) Sources that have been added since 7 August 1977, or that will be added, will consume the new PSD increments. (The proposed increments appear in Table B-3.)

Nonattainment Areas

Areas of the country that failed to achieve the NAAQS for a given pollutant after the attainment date of 1 July 1975, have been designated "nonattainment" areas. EPA's policy for licensing new sources in nonattainment areas under the Emission Offset Interpretative Ruling stipulates that major stationary sources of a given pollutant cannot be sited at locations where they would significantly affect a nonattainment area for that pollutant, unless the following conditions are met:

- All major sources in the nonattainment area owned by the applicant comply with applicable emission standards.
- Proposed new emissions are more than offset by a reduction of emissions from other sources in the nonattainment area.
- The emissions offsets must represent reasonable progress toward the attainment of the NAAQS.
- The proposed source will comply with the lowest achievable emission rate.

Compliance of Existing Equipment

The applicant must certify that all major sources that he owns in the nonattainment area comply with all applicable emission limitations and standards under the act or are on acceptable compliance schedules. The applicant may propose emission offsets from his own existing equipment (internal emission offsets) and/or reductions from neighboring sources (external emission offsets). He may be credited with emission reductions achieved by shutting down an existing source or by permanently curtailing production or operating hours below baseline levels, provided that the work force to be affected has been notified. All emission offset situations must be legally enforceable.

Offsets from Other Sources

Generally, offsets should be obtained from sources as close to the proposed new source site as possible. Thus, offsets will be acceptable if obtained within the same AQCR or from other areas that may be affecting proposed new source locations. Emission offsets are credited in pounds per hour, based on maximum production rate.

If a firm seeking to construct a new plant cannot provide the needed offset from its facilities, it may have to buy emission reductions from other existing sources (e.g., the stack pollutant sources in Coles County mentioned above). Some owners of polluting sources may find it more valuable to sell their emissions than to clean up. (The buyer would then eliminate the source of emissions and be credited with the reduction.)

Reasonable Progress Toward Attainment

Offsets from existing sources in the area of the proposed source (whether or not under the same ownership) are required to ensure reasonable progress toward attainment of the applicable NAAQS, as specified in the Clean Air Act Amendments. If the owner wishes to construct a plant in a clean air area, full emission offsets are not required. However, a source to be located in a nonattainment area must obtain more than equivalent offsetting emission reductions from existing sources.

Lowest Achievable Emission Rate

The review requirements for a new source depend on the type of air that is affected. If the air is cleaner than the NAAQS, the PSD regulations will preserve that air quality by limiting new emissions of SO₂ and particulate matter. If the air is dirtier than the NAAQS, the source will be subject to the provisions of EPA's Emission Offset Interpretative Ruling. This standard, which is much more stringent than the clean air requirement, requires the source to meet the "lowest achievable emission rate." The "lowest achievable emission rate" is defined as the greater of

- The most stringent emission limitation in effect in the country, applicable to the proposed source, or
- The lowest emission rate that can be achieved with current technology. This refers to BACT.

A source may be subject to the provisions of the PSD regulations, as well as to the Interpretative Ruling. For example, a source may affect a clean air area with one pollutant (thereby being subject to PSD

regulations) and may affect another nonattainment area with the same (or another) pollutant, thereby being subject to the Offset Ruling.

The policy developed under the Emission Offset Interpretative Ruling will remain in effect until 1 July 1979. At that time, each state will address the licensing of proposed new sources in nonattainment areas under new source review requirements in the revised state implementation plan.

Permit Procedure in a Nonattainment Area

As the starting point in reviewing a permit application for a nonattainment area, it is assumed that every locality in that area will exceed the NAAQS (as of the new source start-up date) and that any major source locating in the area will significantly contribute to the violation. However, if the applicant presents relevant arguments (including necessary analysis or other demonstration) why that assumption is incorrect, the applicability of the ruling is determined by the specific facts in the case.

Interpretative Ruling after 1 July 1979

After 1 July 1979, the Interpretative Ruling will apply only to cases of interstate air pollution or delayed designation of a nonattainment area. "Delayed designation" refers to any major increment that was added between 1975 and 1979 that placed an area in violation.

Banking of Offsets

EPA has modified the originally proposed requirements relating to "banking" of emission offsets to allow new source growth. Current draft regulations provide that if a state wishes to recognize banking, those offsets must be identified and accounted for in the state implementation plan control strategy. As long as the pollution control requirements under the act are satisfied, the state is left free to govern ownership, use, sale, and commercial transactions in banked emissions. As a result, offsets that exceed the requirements of reasonable progress toward

attainment may be "banked" to provide offsets for a source seeking a permit in the future. Likewise, the owner of an existing source that reduces its emissions may bank any resulting reductions beyond those required by the state implementation plan for use under this ruling. This will be the case even if none of the offsets are applied immediately to a new source permit. Transactions (selling an offset) among pollution sources are allowed only if the emissions are comparable in nature and in their effect on public health; some cancer-causing pollutants cannot be traded at all. EPA has invited further comment on the proposed regulations.

State or Community Initiated Emission Offsets

The necessary emission offsets may be proposed either by the owner of the proposed source, or by the local community or the state. The emission offset commitments must be enforceable by authorized state and/or local agencies under the Clean Air Act, and the offsets accomplished by the start-up date of the new source.

A state or community that desires a source to locate in its area may commit itself to reduce emissions sufficiently from existing sources (including mobile ones) that those reductions outweigh the impact of the new source and thus permit its construction. Like source-initiated emission offsets, the commitment must be something more than one-for-one (i.e., it cannot equal the status quo: it must improve it). The state must submit the commitment as state implementation plan (SIP) revision for EPA approval.

Appendix C

METHANE FROM ILLINOIS COAL BEDS

Coal beds comprise both the source and reservoir rock for gas formed during coal formation. Although the gas is composed almost entirely of methane, the presence of other heavier hydrocarbons gives it a heating value somewhat higher than methane--in the 1,010 to 1,060 Btu per cubic foot range--that is quite similar to a conventional dry natural gas. Some CO₂ and nitrogen are present, but the amounts are usually insufficient to lower the heating value below 1,000 Btu per cubic foot.

The U.S. coal bed gas resources are a function of the subsurface coal beds defined by the U.S. Geological Society (USGS).^{*} Table C-1 summarizes the distribution of coal gas, about 80 percent of which is located in the West.

Almost all coal beds contain significant concentrations of methane, which historically has posed a hazard to coal mining safety. About 80 billion cubic feet (Bcf) of gas per year is vented from active mines to the atmosphere in a mixture of 1 part gas to 200 parts air. Thus, a vast quantity of methane is wasted during underground mining operation, and so far no serious effort has been made to capture the gas from active mines. Among the difficulties in recovering the gas for delivery to markets are the costly equipment required to prohibit air entry into the gas during collection, and the vast system of vacuum and compression facilities required for that collection.

Gas resources in the thick coal beds of the western United States and deep unmineable coal seams with favorable geological characteristics may significantly add to domestic gas supplies. Degasification of these

^{*} USGS, Bulletin 1417 (1975).

Table C-1

DISTRIBUTION OF COAL BED METHANE IN THE UNITED STATES

	<u>Coal (trillions of short tons)</u>	<u>Estimated (cubic feet of gas per ton)</u>	<u>Estimated Gas-In-Place (trillion of cubic feet)</u>
Eastern United States*			
Above 3,000 ft			
Identified	0.5 }	235	165
Hypothetical	0.2 }		
3,000 to 6,000 ft			
Hypothetical	<u>Negl</u>		
Total	0.7		
Western United States			
Above 3,000 ft			
Identified	1.0 }	190	495
Hypothetical	1.6 }		
3,000 to 6,000 ft			
Hypothetical	<u>0.4</u>	480	<u>190</u>
Total	3.0		
Total U.S. coal bed gas resources			850 [†]

* East of Mississippi River.

[†] Assume 40 percent of gas-in-place is physically recoverable.

beds would involve coal that is not now being mined and that probably will not be mined in the foreseeable future.

The Department of Energy is now engaged in limited testing of Illinois coal beds for their gas content and potential recovery of methane from this gas. Because the test results are not yet available, the energyplex concept does not yet include estimates of this domestic energy resource.

Appendix D

MUNICIPAL WASTE ENERGY RECOVERY

Disposal of municipal solid waste (MSW) has historically taken place by landfill or open burning. However, the combination of site availability, rising land and transport costs, stringent environmental restriction, and interest in recovering and using the energy in MSW has made it desirable to seek alternative waste disposal methods. The concept of recovering energy from MSW is not new. Direct burning of refuse in incinerators and raise steam has been successfully practiced in Europe for more than 20 years, and in the United States numerous waste-to-energy projects are under way.

Figure D-1 shows the major process options for energy recovery from MSW. The most widely used processes for energy recovery from MSW have been direct combustion in a furnace or co-firing of the materials with fossil fuel for steam generation. Recently, MSW has begun to be used as fuel for cement kilns. By 1980, 90 percent of the kilns in the United States will be able to burn coal;^{*} in many of these units, refuse-derived fuel (RDF) and agricultural or forestry residues can be substituted for coal. Figure D-2 shows a typical simplified process flow diagram for production of a refuse-derived solid fuel (RDSF) from MSW. RDSF is the shredded, classified, and chemically processed organic matter of MSW. The fuel is mechanically condensed and routed to the end users.

The more advanced thermal processes of pyrolysis, thermal gasification, and liquefaction may produce liquid, gaseous, or solid char products. In some instances, the gases leaving the reactor are immediately combusted for steam generation. Pyrolysis, thermal gasification, and liquefaction

^{*}"Conversion to Coal Firing Picks Up Steam," Chemical Engineering, 14 February 1977, pp. 84 (4), 40, 42, 44.

NOTE: Cement kilns can use RDF instead of oil, gas, or coal as a source of energy for cement production. Numerous projects are under way in the United Kingdom, Germany, Canada, and the United States.

FIGURE D-1 ENERGY RECOVERY PROCESSES

FIGURE D-2 TYPICAL SIMPLIFIED PROCESS FLOW DIAGRAM FOR PRODUCTION OF A REFUSE-DERIVED SOLID FUEL

processes are advantageous because they produce less environmental pollution than conventional incineration and have a higher thermal efficiency.

Pyrolysis consists of the thermal decomposition of organic matter in the absence of oxygen at near atmospheric pressure and elevated temperature to form hydrocarbon of lower molecular weight. Biochemical conversion processes include methane fermentation (anaerobic digestion) for the production of a fuel gas (composed of as much as 70 percent CH_4 , with the remainder mostly CO_2) and fermentation of sugars to ethyl alcohol. The fermentable sugars may be produced by acid or enzymatic hydrolysis of cellulose.

The original energyplex concept included an estimated 150 tons per day of MSW as a resource element. Currently, the recovery of energy values from such MSW does not appear to be economically attractive for quantities of less than 350 tons per day and some estimate that 1,000 tons per day is the minimum that is economical. The two major urban areas near Cumberland County are the cities of Charleston and Mattoon, and their MSW is estimated to be no more than 100 tons per day. MSW as an energy resource element was therefore not considered in detail in SRI's concept validation study for the Cumberland Energyplex.

Appendix E

ENERGY RECOVERY FROM ANIMAL WASTES

Power plant reject heat may be employed to recover energy and nutrients from the manure of confined livestock. Siting confined livestock operations near power plant sites can be advantageous because it alleviates manure disposal and odor problems, allows the use of warm water to hasten the decomposition process and enhance nutrient assimilation, and produces fuel and feed items.

Numerous research studies have been directed toward digesting and separating animal waste into high protein feed and methane rich gas by using the heat rejected from a power plant as an energy source. The systems that have been researched would use manure waste as a nutrient source for aerobic algal pond culture and bacterial anaerobic digestion.

Animals are confined in facilities with slotted floors above solid floors or in facilities with solid floors and flushing gutter systems. The waste is flushed from both types of facilities and moved to sedimentation tanks. Clarified effluents are pumped to an algal pond, and solids are discharged to a heated anaerobic digester. Liquid from the digester may also be pumped into the algal pond. Sludge may be irrigated onto a soil filter area. Pond effluent from the algal separation process is returned to the flushing facility to complete the cycle.

Dried algae may be fed to various farm animals as a dietary supplement substituted for fishmeal in animal feeds and soybean meal in chicken mash. It may also be used as a fuel for electric power production or as a source for methane production. The heat content of algae is about 400 Btu per pound. Yield ranges from 14 to 45 tons per acre on a dry weight basis, with value at \$154 per ton in 1977 dollars.* Culture temperatures

*M. Olszewski, Oak Ridge National Laboratories, private communication (14 March 1979).

must be above 59°F in winter and below 105°F in summer, but there appears to be no optimum temperature.

Although nutritional quality varies with the algal species, it is impossible to control the species that grow in the ponds. As water temperatures vary seasonally, the predominant species of algae also change. Periods of low sunshine will reduce the algal population, and during the winter months growth ceases entirely because of a combination of low temperature and low solar radiation. The rate of growth is more rapid in shallow, plastic lined ponds that are subjected to continuous agitation with small circulation pumps or paddles. Mechanical centrifuge harvesting of the algae is energy-intensive and requires a significant capital investment. Moreover, the equipment now in use has been described as temperamental. Problems in harvesting result from algal size, cell density, and the large volume of water. Bacteria are cultivated in these ponds to consume organic wastes that would otherwise rob aquatic life of oxygen. The system has not been demonstrated on a commercial scale.

The anaerobic digester interests farmers as a means for manure disposal, and the methane obtained is considered to be an advantage. One digester design is a concrete tank equipped with mixing and provided with a heat source to operate at 95 to 104°F for methane production. An average detention time of 23 days produces 12 cubic feet of methane per pound of volatile suspended solids, indicating that tanks must be constructed in series. Waste heat could significantly reduce the cost of maintaining digester temperatures. The market for the methane would be the power plant or other facilities in the energyplex.

For a study about the anaerobic fermentation of agricultural residue, the Department of Rural Sociology at Cornell* interviewed dairymen, scientists, and others to determine their reaction to the emerging

* Anaerobic Fermentation of Agricultural Residue: Potential for Improvement and Implementation, Department of Energy, HCP/T2981-07 (February 1978).

technology of methane production from anaerobic fermentation. In general, they indicated that when methane generation can be positively demonstrated and is economically proved they will be interested. Currently, however, they believe it is still too far from commercial implementation to be given serious consideration. Therefore, compared with other demands for capital, a methane production system might be viewed as a low priority item. Positive effects of a fermentor include efficiency in residue management, pollution control, conservation of fertilizers, and energy production.

Insofar as integrated systems are concerned, one of the best examples is a waste treatment system designed by Kaplan Industries of Florida. This company feeds as many as 30,000 head of cattle in its feedlots at one time and slaughters about 250,000 head per year. The system is designed to overcome local problems that include heat, heavy rainfall, flies, odor, lack of grain, and waste disposal. Animal wastes from confinement facilities fall through slotted floors onto a concrete floor (which is automatically scraped every 2 hours) and are pumped to an open holding tank. Undigested solids are separated from the wastes by use of vibrating screens. The solids, which are then washed, treated with formalin, and stored in compost piles, are used to replace other sources of roughage and may supply 25 to 35 percent of the feed ration. The feed formula consists of steam-flaked corn, citrus pulp, ground hay, molasses, peanut meal, bone meal, and by-products from the meat packing plant.

The clarified liquid effluent from the waste stream is pumped to a series of holding ponds. The first six ponds (with a surface area of 60 acres) are reclaimed phosphate mine pits and are operated as anaerobic lagoons. Shallow ponds with mechanical aerators are operated as aerobic lagoons that may be stocked with tilapia, a type of fish, which are harvested periodically, processed at plant, and sold as fillets. The fish processing waste is returned to Kaplan's rendering plant for feed processing into fish meal, which is recycled to the cattle ration. Biologically treated wastewater is chlorinated and recycled to the feedlot

for drinking and process water. Excess water is used to irrigate corn and sorghum grown for silage or forage.

Utilization of waste heat has been suggested as a means to speed up the decomposition process, and design and construction of a methane generator that would use waste heat are under consideration. Methane would substitute for the fuel oil currently used by Kaplan Industries. Undigested solids from the methane gas generator will be processed into animal feed. Recovery of investment costs for this expansion is expected within 3.5 years.

Appendix F

GRAIN DRYING

Wheat, corn, and soybeans are grown throughout Illinois, and grain drying presents an important seasonal demand for energy. Throughout the Midwest, farmers are experimenting with double cropping of wheat and soybeans to increase crop yield per acre. Winter wheat must be harvested in early July to make way for planting soybeans. Consequently, wheat drying operations commence in July, and the timing is critical to the farmer who plans double cropping.

Corn is harvested during October and November. Increasingly, the corn is shelled in the field, but some corn is still shelled at local elevators. Grains are artificially dried at harvest to prevent spoilage in storage. Commercial drying facilities associated with elevators are available locally, and if the grain contains large amounts of moisture, it is likely that the farmer will use such facilities. In Illinois, liquid petroleum gas (LPG) is the predominant fuel source for grain drying.

Freshly harvested grain contains from 22 to 25 percent moisture, depending on weather conditions at harvest. To reduce the moisture in 1 bushel of corn from 25 to 15 percent, 11,940 Btu are required.* If the heat is supplied by electricity, the electricity requirement will be 0.35 kilowatt-hour per bushel to remove 1 percent of the moisture. The moisture level in corn should not be reduced below 14 percent, unless an abnormally long storage period is foreseen. A farmer is penalized for selling corn with high moisture content to an elevator but will receive no rebate for selling corn that is too dry.

*Energy Relationships for a 320-Acre Iowa Farm, ERDA/USDA-19464/76/FR-3 (August 1977).

Two approaches to corn drying are recognized: The shelled corn may be spread and exposed for periods as short as a few hours to temperatures between 120 to 225°F. The fuel for rapid drying is most frequently LPG. The second approach requires the grain to be placed in upright cylindrical bins and aerated with air that is raised 5 to 10°F above ambient temperature for about 25 days. Bin drying may take place with or without stirring devices, although equipment that does not use stirring devices may result in overdrying of bottom layers. Electricity is required to power the fans and stirring devices.

The heat source for slow drying may be LPG, electricity, or reject heat. Experiments with wheat drying indicate that in July, with its hot days and low humidity grain moisture can be reduced by 5 percent in just 2 weeks by using conventional bins and solar warmed air. Although solar grain drying equipment is commercially available in this region, farmers are slow to accept change and distributors lack confidence in equipment performance. Drying in ambient air conditions is attempted only if the moisture content of the grain is below 20 percent.

Weather conditions are critical in grain drying operations. Mold may occur if corn takes too long to dry. High- and low-temperature drying methods each have disadvantages: High-temperature drying inhibits growth of mold but kernel damage may limit marketability except for livestock feed. Low-temperature drying produces good grain quality, but can only be used if the corn's moisture content is low. There is a strong trend in this area toward individual on-the-farm drying, which is advantageous because energy consumed in transportation is thus eliminated.

A review of the literature does not indicate any current research projects in the area of waste heat utilization for grain drying. The requirement for low humidity drying and the susceptibility of grain to spoilage may be a pertinent consideration for power plant reject heat use. The seasonal nature of grain drying operations (and availability of local elevators) would probably preclude new investment in grain drying facilities adjacent to the power plant. The low capacity factor for warm water delivery and heat exchange systems would increase unit costs

considerably if facilities were installed only for crop drying. Effective heat exchange systems for grain drying have not yet been demonstrated. It has been suggested that operation could be integrated with another heat user (such as greenhouse heating) that may be idle during the summer. This system would require lower investment but land requirements for storage might pose a problem.

A major constraint is that the facilities would consume only an insignificant portion of the large amount of the available waste heat. The total energy required for drying is almost the same for low-temperature systems as for high-temperature systems, particularly when high-moisture grain is dried. Energy requirement will range from 12,000 to 15,000 Btu per bushel for a period that may be as short as 1 month.

Appendix G

NITROGEN FOR FOOD FREEZING

Greenhouse gardening, fish and algae aquaculture ponds, and confined livestock could all benefit from the reject heat available from the energyplex. The air separation plant of the SNG facilities produces about 550×10^6 SCFD of nitrogen that could be vented into the atmosphere or used where needed. The possibility of fish freezing by using liquid nitrogen was found to be uneconomical when compared to conventional (blast) freezing method. Although nitrogen is readily available at near atmospheric pressure and in gaseous form, its liquefaction is costly.

Conventional (Blast) Freezing Method

Quick freezing (blast, plate, or immersion freezing) is predominantly used in the fishing industry, although an older method--sharp or slow freezing--is still used to a limited extent. Blast freezers have been used to freeze such fishery products as fish fillets wrapped in moisture-proof, heat-sealable packing films. This method is therefore representative of conventional freezing methods.

Process

Blast freezers are generally small rooms or tunnels served by fans that circulate cold air over a pipe coil evaporator to the product for freezing. A refrigerant (e.g., ammonia, a halocarbon, or brine) is circulated through the evaporator creating a refrigeration effect (Figure G-1). A mechanical chiller extracts the heat. To prevent dehydration and freezer burns, the velocity of air is kept to about 2.5 meters per second, and the period of exposure to air is controlled. Freezing times for various sizes of packaged fish products are shown in Figure G-2.

FIGURE G-1 DEHYDRATION IN CONVENTIONAL BLAST FREEZER

Capital Cost

The capital cost for a conventional freezing and refrigerated storage area to process and store 3,400 pounds of fish fillets per year is estimated to be \$300,000. The assumptions and facilities are as follows:

- 3,400 pounds of fish fillets produced per year
- 1.5 to 2 pounds of fillets, measuring 16 to 19 inches long
- Two 8-hour work days for freezing process time
- A two-stage refrigeration plant with pumped ammonia
- 1-hour freezing time per batch
- 1,540 kilowatt-hours of electrical power consumption for a 16-hour operating day.

Immersion (Liquid Nitrogen) Freezing Method

Immersion freezing in low-temperature brine was one of the first methods for quick freezing fish products. It was used primarily to freeze tuna, shrimp, and crab at sea. Other freezing mediums have been

FIGURE G-2 FREEZING PACKAGED FISH FILLETS AND FISH STICKS IN A TUNNEL-TYPE BLAST FREEZER (AIR VELOCITY 2.5 TO 5 m/s)

used such as R-12 refrigerant and liquid nitrogen (LN) sprayed directly on the product to be frozen. LN spray is coming into wide use for shrimps, scallops, and fish fillets. Generally, the energy cost is high because commercially available LN is expensive. However, with LN spraying virtually no weight loss from dehydration occurs.

Process

In the freezing process, LN is sprayed directly onto fish conveyed through an insulated cabinet (see Figure G-3). Rather than using

FIGURE G-3 FLOW PATTERNS IN TYPICAL LN FREEZER

mechanical refrigeration to regenerate the refrigerant, an immersion system rapidly cools the fish by the evaporation of LN, which occurs at -320°F . Figure G-4 shows a temperature profile of a typical LN process. Production rates of LN freezers generally range from 200 to 5,000 pounds per hour.

Capital Cost

The capital cost for the LN immersion freezing method, refrigerated storage area, and nitrogen liquefaction is estimated to be \$25,100,000, with the cost for the liquefaction facilities estimated at \$25 million. The assumptions and facilities are as follows:

- 3,400 pounds of fish fillets produced per year
- 1.5 to 2 pounds of fish fillets measuring 16 to 19 inches long
- Two 8-hour work days for freezing process time
- 1.15 pounds of LN per 16 pounds of fish
- 28 kilowatt-hour electrical power consumption for a 16-hour operating day
- Nitrogen liquefaction facilities.

FIGURE G-4 IDEALIZED TEMPERATURE PROFILE

Appendix H

CEMENT PRODUCTION

Coal is now being used in the production of some U.S. Portland cement. High-sulfur coals can be used because the sulfur is captured by the limestone in the kiln. Because cement manufacture already requires particulate control, this environmental residual is not increased when coal is used as the cement fuel. The hot gas reject heat from cement plants has been used to raise steam for the cogeneration of electricity in a steam turbine bottoming cycle. This combination of favorable circumstances led to early consideration of cement production as an element of the energyplex.

Further consideration of manufacture of Portland cement as an energyplex element was ended when we learned that the limestone needed in its manufacture is not readily available in the southeast quadrant of Illinois. All of the 2.4 million tons of the quality of limestone required and produced in Illinois is already used in Illinois production, with 45,000 tons imported from other states. The quarry in Illinois closest to Cumberland is Hardin, and the other cement quality limestone quarries are in Cook, LaSalle, and Lee Counties.

Appendix I

SECONDARY ALUMINUM RECOVERY

Recovering aluminum from beverage containers, aluminum foil, and the like required only about 5 percent of the energy originally needed to obtain the metal from its ore. This recovered, or secondary, aluminum, which varies somewhat in its composition from virgin metal, has been principally used in the production of aluminum castings. Coal can be employed as the energy source for recovering, melting, and casting this metal, and the use of coal is expected to increase as oil and gas prices rise. The hot gas reject heat from the production of aluminum castings, can be used to raise steam for the generation of electricity in a bottoming cycle steam turbine. For these reasons, secondary aluminum production was considered a potential candidate as an energypex element.

However, secondary aluminum plants already exist near St. Louis, and primary aluminum plants are found in the nearby western part of Kentucky. Cumberland County, situated about midway between these facilities, would be competing with them for the available supply of scrap aluminum. Moreover the Cumberland location has no apparent advantage and without such an advantage no reason exists for entering a competitive market.

Appendix J

RECOVERY OF MINERALS FROM BRINES

The recovery of minerals (e.g., lithium, strontium, and barium) from disposal brines such as those that result from crude oil production has been a topic of some interest.* Recovery processes frequently include evaporation operations that could use reject heat from the energy-plex coal conversion plants.

However, as the details of tertiary oil recovery using CO₂ became available, we determined that no oil field brine would be available for recovering the minerals. All the brine is to be reinjected into the wells.

* A. G. Collins and M. E. Crocker, Exploitation of Minerals in Disposal Brines, U.S. Bureau of Mines, Paper: SPE 3453, Society of Petroleum Engineers (October 1971).