CASE STUDY APPLICATION OF THE
GUIDEBOOK ON INTEGRATED COMMUNITY ENERGY SYSTEMS:
INDIRECT ECONOMIC AND ENERGY IMPACTS

ARGONNE NATIONAL LABORATORY

**ENERGY AND ENVIRONMENTAL SYSTEMS
DIVISION**

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PREFACE

In any development project, and particularly one that involves community cooperation, there are likely to be various expectations of the results. An integrated community energy system (ICES) is an example of such a project, requiring participation not only of the owner and operator but also that of major customers, and at least the approval of local municipal officials. Each party has an interest in furthering his benefits and reducing his costs. However, since a favorable arrangement for one may not be favorable for another, the distribution as well as the size of impacts should be understood (and adjusted, if necessary). Thus, information on which to make decisions about ICES includes, in addition to a bottom-line assurance to the owner that the project is economically viable, expected effects on the broader community.

This case study is an examination of indirect economic and energy impacts for one proposed ICES development. These indirect impacts are indicators of how the local government should respond to the ICES proposal, based on its revenue, employment, and energy characteristics. The developer has been asked about his expectations, the city's procedures for approving, servicing, and taxing the ICES have been reviewed, and conceptual design of the system has been consulted for cost and energy estimates. It is clear from these experiences that there are a variety of ways in which the worth of ICES is measured, ranging from an investment opportunity to a taxable capital item, and that the resolution of interests is dependent on the division of benefits and the importance attached to each. The case study addresses whether what is good for the ICES is also good for the community.

INTRODUCTION

The following is an application of the Guidebook on Integrated Community Energy Systems: Indirect Economic and Energy Impacts. A case study has been selected to illustrate some of the factors involved in evaluating the benefits and costs of introducing an integrated system to replace conventional alternatives. This case study follows the methodological sequence of the Guidebook and demonstrates its procedures for estimating employment, fiscal effects on the community, and energy impacts resulting from a comparison of an integrated community energy system (ICES) with conventional energy supply systems.

An ICES is being considered for a community located in a small New England city. The city is part of a metropolitan area and has grown nearly to the limits of its available land area. It currently has a population of 24,000 people on approximately 12 square miles. Most of the city is residential, with a small downtown area and some newer commercial development on the outskirts. Many of the residents work elsewhere in the metropolitan area, to which there is easy access by expressway.

The community under consideration is part of the city's newer development. It is a commercial park of offices, shopping center, bank, hospital, and hotel. The oldest buildings in the park were constructed ten years ago. The hospital is now under construction, and the hotel is contemplated but not yet designed. The community, like the city, is reaching maturity, and few extensive additions beyond the hotel are likely.

Buildings that will be connected to the ICES total 3.4 million square feet. The largest areas are the shopping mall (1.8 million square feet) and the hospital (600 thousand square feet). Ten office buildings and the

bank comprise the remaining one million square feet. The community is situated on approximately 140 acres, with the largest number of buildings, the offices, concentrated in the center of its acreage. The offices are leased from their developer and a joint venture partner to more than 75 corporate tenants. Hospital, bank, and the retail outlets in the shopping center are under separate ownership and management.

The integrated community energy system for this community is designed to meet all heating, cooling, steam, and hot water needs. Electricity from the cogeneration unit is to be sold to the local utility, and electricity for the community will be purchased as at present. However, future electrical demand will be reduced, since absorption chillers, which will be powered by heat recovered from the central ICES unit, will partially replace electric air conditioners. In addition, hot water heating from ICES will in some cases lower electrical use. Thus, the ICES involves substitution of energy forms as well as modification of fuel requirements.

Examination of the integrated system, in comparison with existing energy systems, includes both indirect economic impacts (employment and fiscal effects on the city) and indirect energy impacts. The indirect economic analysis proceeds from an initial description of conditions that determine employment and fiscal results through specific estimates of employment and then revenues and costs to municipal government and finally to an evaluation of ICES's worth to the city. The indirect energy analysis compares energy resource requirements of the ICES with those for gas, oil, and electric systems now serving the community.

INDIRECT ECONOMIC IMPACTS

Phase One: Conditions Affecting Impact Estimates

The conditions for the case study are:

- **Ownership.** The ICES will be privately owned by the developer of the office park. The rest of the community (shopping center, bank, and hospital) will be supplied energy under contract. Present plans are for the owner to bear all costs of retrofitting distribution and heating units in buildings, as well as all central facility costs. Customers will be charged on the basis of their hot water, chilled water, and steam consumption.
- **Taxing Policy and Revenue Structure.** Three types of local taxes are relevant in this case. The town levies real estate and personal property taxes and also obtains revenue from income on commercial property. For the case study these result in additional revenue from taxes on the integrated system and no corresponding decrease in commercial revenue (since the income from leased property is not expected to decrease).
- **Regulatory Policy.** At present there is not a settled policy on the regulation of cogeneration in general and of ICES in particular. The future owner is proceeding under the assumption that he will not be regulated by the state. There has not yet been a court case to settle this point, however. According to sources at the state's regulatory agency, current plans for the ICES do not subject it to regulation as a utility under present definition.

At the local level, it appears that the ICES will be treated as any other commercial energy system. Thus, beyond the ordinary compliance with city ordinances, the owner does not face significant local demands for regulation.

- **Public Planning Process.** The city has established procedures for dealing with new development projects, and the ICES will fall under them. A site plan of the projected change must be submitted to city officials, who then have 30 days to respond. A public meeting is required at the end of the review period, and additional meetings can be called by the townspeople. Revisions and modifications can be required, and there is an additional 20-day period for review after any changes are made. Along with the plan submitted to municipal departments - planning board, police, fire, board of health, and building inspector - the conservation commission must be given a separate plan, and the commission also can call for public hearings to evaluate the project.

Environmental regulations are expected to cause the lengthiest involvement in gaining approval for the ICES. Such state and federal regulations will necessitate an early beginning to assure timely completion of the planning process.

To date these conditions, which affect the indirect economics and energy impacts, appear to be well defined and understood by the ICES owner.

Phase Two: Employment

Employment impacts have been derived from previously estimated project costs and from employment expected for operation and maintenance of the ICES central facility. The procedure is illustrated in Figure 1, beginning with descriptions of the system's equipment (Step 1) and of attracted users (Step 2) and then continuing through primary employment (Step 3) and the generation and magnitude of secondary employment (Steps 4 and 5) to an estimate of total employment (Step 6). Both the planned ICES and the existing systems will be examined.

Step One - Identify Characteristics of the Energy Facility that Affect Employment

This step includes identifying the equipment and energy supplies that cause employment impacts and the location (i.e. local or region) and development stage (i.e. planning, construction, or operation) of such employment. The tables below list results for the case study.

FIGURE 1

DIAGRAM OF EMPLOYMENT IMPACTS FROM ENERGY FACILITY

ICES EMPLOYMENT CHARACTERISTICS

<u>Item*</u>	<u>Stage of Development</u>		
	<u>Planning</u>	<u>Construction</u>	<u>Operation</u>
Equipment			
1. Building	1-5. System design; plan approval	1. Building construction	1-5. Operation of central, distri- bution, and end- use equipment; maintenance of structures and mechanical units
2. Central cogeneration unit		2. Purchase and installa- tion of equipment	
3. Distribution		3. Ditching, laying of pipe and wire	
4. End-use heating and cooling units		4. Removal of old heating equipment; purchase and installation of hot- and chill-water systems in commercial buildings	
5. Metering and control		5. Purchase, installation, and testing of com- puter and mechanical metering and control equipment	
Energy			
6. Oil	6. Truck access; supply capacity	6. None	6. Oil delivery
7. Electricity	7. Negotiated sales of ICES elec- tricity to electric utility; grid connection	7. Tie-in to utility grid	7. Maintenance and repair (see under Equipment, above); con- tinued supply from utility

*Some items suggested in the Guidebook are not applicable to this case.

CONVENTIONAL SYSTEM EMPLOYMENT CHARACTERISTICS

<u>Item*</u>	<u>Stage of Development</u>		
	<u>Planning</u>	<u>Construction</u>	<u>Operation</u>
Equipment			
1. End-use HVAC	1. Design for replacement when needed	1. Installation of replacement units, when needed	1. HVAC employees and contract maintenance
Energy Supply			
2. Gas	--	--	2. Gas utility
3. Oil	--	--	3. Oil Distribution
4. Electricity	--	--	4. Electric utility

*Some items suggested in the Guidebook are not applicable in this case.

Because the conventional systems are currently in use, most employment for them is concentrated in the operation stage, with need for planning and construction only when old systems are replaced as they wear out. On the other hand, ICES is a new alternative with relatively heavy requirements for employment in the planning and construction stages.

In the case study, good transportation access spreads employment throughout the metropolitan region. All employment therefore falls in the regional category. However, as an illustration, employment is divided into twenty percent local and eighty percent regional categories.

Step Two - Estimate Uses Attracted by the Energy System and Their Employment Characteristics

For the case study, a few users in addition to those now relying on conventional systems are expected to form part of the ICES market. These new users are expected to be influenced by the availability of the integrated system, if it results in lower energy costs. However, it is believed by the developer that new users will join his community whether the ICES is built or not, and so in this case ICES is not credited quantitatively with additional users. The integrated system is not a decisive reason by which customers will be added to the community.

Step Three - Estimate Primary Employment

The magnitude of employment from items in the foregoing tables was estimated as follows:

ICES

- Planning items

- 1-5. System design. From a cost analysis of the ICES, design is estimated as six percent of total costs of \$28 million, or \$1.6 million. At an economic equivalent of \$50 thousand per manyear, design cost implies employment of 32 manyears.

Plan approval. This item is part of a system design for the owner. Also, city staff are not expected to devote more than a few days to plan approval.

6. Truck access; supply capacity. To date these planning items have been included in system design, and employment estimates are consequently part of the total above.

3. Oil distribution. The community annually consumes 17 billion Btu, 120 thousand gallons, of fuel oil. A national average estimate of 1.8 trillion Btu per employee for oil distribution results in annual employment of 0.1, or a total of three manyears.
4. Electric utility. The community purchases at present 120 million kwh of electricity per year. This converts, at 14 million kwh per employee per year, to nine employees (for 30 years, or 270 manyears).

Summing primary employment for the conventional systems yields the following results:

<u>Planning</u>	<u>Construction</u>	<u>Operation</u>
0 manyears	99 manyears	810 manyears

The primary employment table for Step Three is therefore:

<u>Alternative</u>	<u>Primary Employment (Manyears)</u>			
	<u>Planning</u>	<u>Construction</u>	<u>Operation</u>	<u>Total</u>
ICES	33	130	720	880
Conventional	0	99	810	910

Step Four - Employees' Spending and Demands for Services

Since the case study community is part of a large metropolitan area and access to that area is very easy, secondary employment will probably be spread throughout the region, including the city. It has been assumed that average data for the area area applicable to all such employment. As a consequence, a regional base will be used to calculate secondary employment caused by the energy systems.

Step Five - Calculate Secondary Employment

Secondary employment associated with sales and service is estimated from the ratio of areawide employment in sales and service to personal income for

6. Oil delivery. The ICES will consume 1.8 trillion Btu, or 12 million gallons, of oil per year. The equivalent of one full-time driver will be needed for truck delivery. Over the expected life of the ICES, employment is thus 30 manyears.
7. Electricity supply. With the ICES in operation the community will purchase 102 kwh of electricity annually. At an average 14 million kwh per employee, this implies annual utility employment of 7 people, or 210 manyears for the life of the system.

Summing primary employment for the ICES alternative yields the following results:

<u>Planning</u>	<u>Construction</u>	<u>Operation</u>
33 manyears	130 manyears	720 manyears

A similar analysis for the present conventional means of providing energy has also been conducted.

Conventional System

● Planning and construction items

1. Design and installation of replacement equipment (when needed). HVAC equipment in some buildings is likely to be replaced in the next several years. A one-time replacement cost of eight million dollars has been estimated. One-half, or four million dollars, is for installation; and at 50 thousand dollars per man-year of employment, that indicates 80 manyears. The other four million dollars, for equipment, represents (at 210 thousand dollars per manyear) 19 manyears. The total is 99 manyears.
- 2-4. Gas, oil, and electric systems. Because the systems are already in place, their planning and construction are treated as "sunk costs" and no employment is assigned to any development stage other than operation.

● Operation items

1. HVAC employees and contract maintenance. The conventional heating and cooling systems are operated by personnel hired for each building. In-house employees total 20, and approximately 70 percent of their time is used for the heating systems. Thus the equivalent of 14 full-time employees, or 420 manyears over the next 30 years, are attributable to this item.
2. Gas utility. The community consumes 350 billion Btu (350 million cubic feet) of gas per year. At an estimated 90 billion Btu per employee of the gas utilities, this translates to four employees, or 120 manyears for the 30-year lifetime.

7. Negotiations with the electric utility concerning sales from the ICES have been continuing and are expected to last some time yet. Altogether, however, no more than the equivalent of one manyear will be required.

- Construction items

1. Building construction. The building is projected to cost \$2.6 million, complete with storage and handling capacity. At \$40 thousand per manyear, employment will be 65 manyears.
2. Purchase and installation of equipment. Equipment for the central unit is expected to cost \$12 million, including labor costs for installation. These latter are estimated as 10 percent of total costs, or \$1.2 million. At \$25 thousand per employee, 48 manyears of employment result for this item.
3. Ditching, laying of pipe and wire. This is a \$2.0 million item, which translates, with the same factors used above, to eight manyears.
4. Removal of old heating equipment and retrofit of new units. Retrofit will cost \$1.0 million, which will (under the above estimates) create four manyears of employment.
5. Purchase, installation, and testing of computer and mechanical metering and control equipment. Such equipment will cost \$900 thousand dollars, indicating employment of approximately four manyears.
6. No employment is associated with oil supply during the construction phase of ICES development.
7. Tie-in to utility grid. This item will be the responsibility of the utility. Since it represents a minor addition to normal utility construction efforts, it is assigned no employment equivalent.

- Operation items

- 1-5. Central, distribution, and end-use equipment. The ICES central plant will employ 16 people for the duration of the system (estimated at 30 years), for a total of 480 manyears. Distribution and end-use equipment will be serviced by these employees and by special labor on a contract basis. Because special maintenance requirements are uncertain and are expected to involve relatively small expenditures, no additional employment is estimated for contract labor.

the area. This ratio is then multiplied by personal income for employment of the energy systems. For the metropolitan region in which employment impacts will be felt, the ratio is one sales and service job for every \$30,000 of personal income generated and reduces to the following approximation:

$$\text{Secondary Employment} = \text{Primary Employment} \times 0.7$$

No differentiation was made between multipliers for the three development phases, since the New England area sustains relatively constant income and spending distribution. As for primary employment, secondary employment is assigned 20 percent to the local and 80 percent to the regional category. Secondary employment thus becomes:

<u>Alternative</u>	<u>Secondary Employment (Manyyears)</u>		
	<u>Planning</u>	<u>Construction</u>	<u>Operation</u>
ICES	23	91	504
Conventional	0	69	570

Step Six - Determine Total Employment

Total employment data are the sums of results for Steps Three and Five.

For the earlier findings they are:

<u>Alternatives</u>	<u>Total Employment (Manyyears)</u>			
	<u>Planning</u>	<u>Construction</u>	<u>Operation</u>	<u>Total</u>
ICES	56	220	1200	1500
Conventional Systems	0	170	1400	1600

According to the division made earlier, 20 percent of such employment is local and 80 percent is spread elsewhere in the region. The total employment figures are correspondingly separated: 300 local manyyears and 1200 regional manyyears for the ICES, and 320 local manyyears and 1280 regional manyyears for the conventional.

This completes the employment analysis for the case study community.

Phase Three: Fiscal Impacts

The estimates of fiscal impacts follow the diagram of Figure 2. The energy facility was characterized (Step One), new uses were considered (Step Two), primary fiscal impacts were determined (Step Seven), as were secondary impacts (Step Eight), and they were summed to final figures (Step Nine).

Revenue and costs of municipal services were estimated for the ICES only. According to local sources, there will be no alteration in fiscal impacts from existing units whether or not ICES is installed; for example, the tax on the community's buildings will not fall because they no longer use their in-house boilers and chillers. This is because the conventional alternative in use at present is and will be taxed and serviced as an indistinguishable part of the community. Consequently, fiscal impacts for the integrated system will be additional to existing ones; and it is only necessary to compute fiscal impacts for the ICES option to establish a comparison between the two alternatives. Therefore, fiscal impacts for the conventional alternative were not calculated.

Step One - Identify Characteristics of the Energy Facility that Affect Revenue and Cost of Public Services

For the case community, nearly the entire costs of the ICES fall on its owner. He anticipates that he may even be required to provide fire protection, and certainly all capital costs (water and sewer lines, streets, etc.) will be his responsibility. Other services, such as added police, will be minimal. As a result, there are not expected to be any significant service costs to the city for ICES during either the planning, construction, or operation stage.

The integrated system will be taxed at a rate of 74 dollars per 1000 dollars assessed valuation. Currently, property is assessed at 57 percent of

FIGURE 2

DIAGRAM OF FISCAL IMPACTS FROM ENERGY FACILITY

market value. The effective tax rate is thus 42 dollars per 1000 dollars of market value, or 4.2 percent per annum.

The market value of the ICES, taken from cost estimates, is 28 million dollars.

Step Two - Estimate Taxable Assets and Service Demands of Uses

Attracted by the Energy System

There are no such uses for the case study (see Employment Step Two).

Step Seven - Determine Primary Fiscal Impacts

Local revenue from taxes on the integrated community energy system amounts to 4.2 percent of 28 million dollars per annum, or an initial yearly sum of 1.2 million dollars. This represents a 3.7 percent addition to city revenues of approximately 33 million dollars.

Costs for municipal services to the ICES are expected to be negligible, as discussed earlier. Since the owner anticipates being financially responsible for new streets, water, sewer, and whatever other service facilities are necessary at all stages of development, the city will incur only minor expenses for review and approval of designs during the planning stage and inspection of facilities after construction. These costs are orders of magnitude less than the calculated revenue.

Step Eight - Determine Secondary Fiscal Impacts

Since employment is divided between the city and the region, the secondary fiscal impacts will be similarly spread. The following calculations apply only to city data and not to the metropolitan area generally.

The loss in local employment between ICES and the conventional systems (ICES less conventional) was projected to be (320-300 =) 20 manyears for the

30-year life of the project, or the equivalent of 0.7 fewer permanent employees. At an average three persons per household, and under the assumption that there is one wage earner per household, this loss of employment is associated with a population of two.

The revenue loss to city government was calculated in two ways. The estimated cost of an affordable house, for employees earning an average 20 thousand dollars per year, was multiplied by the city's tax multiplier (4.2 percent) to determine real estate revenue per household. As a check, the total real estate taxes were divided by city population.

The first calculation is for taxes on a 50-thousand-dollar house, two-and-one-half times annual earnings of 20 thousand dollars. Under current conditions (\$74 per \$1000 assessment and 57 percent valuation), the household would supply city revenues of 2100 dollars, or 700 dollars per person in the household.

City revenues from real estate taxes in fiscal year 1977 were 16 million dollars. Apportioned among city population of 24 thousand, this represents 670 dollars per capita. However, real estate revenue includes taxes on commercial property, and so the figure may be too high. This indicates that employees paid 20 thousand dollars per year are likely to contribute above the average revenue to city government.

Costs of services to employees are likewise proportionate to population. Because federal and state grants, agency receipts, and other sources of revenue increase the city budget to about 33 million dollars, the per capita expenditures of city government are twice the per capita real estate revenue, or approximately 1400 dollars per person.

In this case, since revenue is derived mainly from sources proportionate to population (i.e. there are no unusual contributions from industrial or government facilities), per capita revenue and cost appear to be in balance. Also, because most employment is long-term rather than temporary, there is little expected negative impact on the city. And finally, the numbers of employees involved (0.7 full-time equivalent) is very small.* Consequently, secondary fiscal impacts in sum neither add to nor detract from primary impacts.

Step Nine - Estimate Total Fiscal Impacts

The total fiscal impacts seem plain. The ICES, when compared to the present conventional systems, might add more than one million dollars to city revenues and cause no significant negative effects. These revenues are applicable to the operation stage, when the ICES has been constructed, and accrue to the local level of government.

*Even if total employment in the region is considered, the difference between ICES and current systems in the number of manyears is equivalent to only three full-time people.

Phase Four: Evaluation

The evaluation phase is to apply the employment and fiscal impacts results to consideration of the following issues:

- Should the municipality encourage or participate in the integrated community energy system.
- What are the expected distributions of costs and benefits.
- How does ownership affect various interests in the community.

In this case, there appear to be obvious benefits to the encouragement of the ICES effort. The city stands to gain substantial revenues at little cost and almost no employment loss to the region. City encouragement of the ICES is in order, and on the basis of the fiscal impacts* the public good strongly coincides with the furthering of the project.

Therefore responses to the issues are:

- The municipality should encourage (but not participate directly in) the ICES.
- With the developer bearing nearly all costs, the local public generally benefits.
- Private ownership in this case is good for all parties. Other ownership options (public, semi-public, and mixed) have not been considered for the ICES.

At this point in the planning and design of the ICES, it seems that ownership, taxing policy, revenue structure, regulatory policy, and public planning process are positive, presenting no indication of need to change conditions affecting indirect economic impacts of the system. Fiscal impacts of the ICES, compared to current conventional systems, are favorable.

*There are, of course, other variables to be included in a full decision process.

INDIRECT ENERGY IMPACTS

Indirect energy impacts for the ICES and for current systems were calculated using values typical of energy supply systems in the New England region. These supply systems are as follows.

- ICES. The central cogeneration unit will be supplied by No. 6 fuel oil, which is typically refined in New Jersey and brought by barge or tanker north to New England and distributed from bulk storage by truck. Crude petroleum to the refinery is obtained both from domestic and from foreign (Caribbean, Middle East, African) sources.

Electricity from the ICES will be sold to the local utility, and in turn, community needs will be met by the utility. At present, the utility generates electricity using nuclear and oil power plants supplying 24 and 76 percent of the total, respectively. By early in the next decade, when the ICES is complete, these fractions will change to 30 percent nuclear and 70 percent oil. No. 6 fuel oil is used for oil-fired power plants and is the result of essentially the same supply system as for the ICES, except that deliveries are made in bulk rather than by truck. Nuclear fuel for lightwater reactors is produced from domestic uranium ore through milling, production and enrichment of uranium flouride, fuel fabrication, and delivery.

- Conventional Systems. Heating is currently fueled by natural gas and oil. The gas supply system is almost completely dependent on domestic resources, though some supplemental liquefied natural gas (LNG) is used by New England utilities. Domestic gas is processed in a gas liquids plant to remove liquid products and then transmitted by pipeline to distribution, again by pipeline. Oil for heating, No. 2 fuel oil, is supplied by truck from bulk storage as will be oil to the ICES, and the supply system corresponds to that described for the ICES fuel.

Electricity is used for cooling, lighting, the operation of motors and appliances, and other miscellaneous applications. It is used for heating several buildings, as well. Electricity is supplied by the utility and results from the supply series described above.

The energy characteristics of these supply systems have been determined in earlier work*, and such findings will be used in this case study.

Direct Energy Demands

Annual community consumption of fuels are shown in the following table, constructed from an analysis of direct costs and energy consumption for

*Using Net Energy Methodology for Energy Planning: Tradeoffs of Supply vs. End-Use Technologies, Volume II, prepared for Energy Research and Development Administration, Washington, DC, April 15, 1977.

the ICES and conventional alternatives.*

Annual Energy Consumption

<u>System</u>	<u>Energy Form</u>	<u>Amount</u>	<u>Heating Value</u>	<u>Heating Equivalent¹ (10⁹ Btu)</u>
ICES	Oil: Residual	11.9·10 ⁶ gal.	150·10 ³ Btu/gal.	1800
	Electricity:			
	Net ²	(25·10 ⁶ kwh) ³	3413 Btu/kwh	(85) ³
Conventional	Gas	349·10 ⁶ scf	1032 Btu/scf	360
	Oil: Distillate	120·10 ³ gal.	139·10 ³ Btu/gal.	17
	Electricity	118·10 ⁶ kwh	3413 Btu/kwh	400

¹Heat value as fuel enters the community.

²Net electricity is defined as amount purchased less amount sold.

³() indicate negative number.

Process Series

The process series are listed below.

Petroleum to Fuel Oil

Research and exploration
Production
Gathering
Crude pipeline
Tanker loading
Tanker
New Jersey refinery
Barge loading
Tug and barge
Bulk storage
Distribution

Petroleum to Electricity

Research and exploration
Production
Gathering
Crude pipeline
Tanker loading
Tanker
New Jersey refinery
Barge loading
Tug and barge
Power plant
Transmission
Distribution

Natural Gas

Research and exploration
Production
Gathering

Nuclear Electricity

Mining
Milling
Fluorination

*Information provided by Argonne National Laboratory. Electricity is both purchased and sold by the community under the ICES alternative. Purchases amount to 102 million kwh; and sales total 127 million kwh, which results in a net negative consumption of 25 million kwh. This represents, on the other hand, a positive contribution of 25 million kwh to the utility, replacing a similar amount of generation that would be required in the absence of the ICES.

Natural Gas (continued)

Liquids plant
Transmission
Distribution

Nuclear Electricity (continued)

Enrichment
Production of fuel
Delivery
Power plant
Transmission
Distribution

These four series represent energy supply systems for the ICES and conventional alternatives.

Processes and Series Characteristics

Energy characteristics of processes and series are reported concurrently, because the data have been developed previously. Summary results are as follows.

Petroleum to Fuel Oil

<u>Pathway Step</u>	<u>Resource Leaving Step (Btu)</u>	<u>Energy Subsidy (Btu)</u>			<u>Total</u>
		<u>Coal</u>	<u>Crude & Gas</u>	<u>Hydro & Nuclear</u>	
In situ--33% Recovery	3,448				
Research & Exploration	1,138	0.24	1.05	0.08	1.37
Production	1,081	4.44	12.86	1.66	18.96
Gathering	1,081	0.19	0.37	0.03	0.59
Crude Pipeline	1,080	2.10	1.76	1.14	5.00
Tanker Loading	1,080	0.04	0.09	0.01	0.14
Tanker	1,080	0.53	7.29	0.15	7.97
N.J. Refinery	1,010	8.71	63.09	3.85	75.65
Barge Loading	1,010	0.04	0.09	0.01	0.14
Tug & Barge	1,010	0.08	1.53	0.02	1.63
Bulk Storage	1,010	0.23	0.54	0.05	0.82
Distribution	1,000	0.48	3.93	0.10	4.51
Total	1,000	17.08	92.60	7.10	116.78

Petroleum to Electricity

<u>Pathway Step</u>	<u>Resource Leaving Step</u> (Btu)	<u>Energy Subsidy</u> (Btu)			
		<u>Coal</u>	<u>Crude & Gas</u>	<u>Hydro & Nuclear</u>	<u>Total</u>
In Situ--33% Recovery	11,440				
Research & Exploration	3,775	0.79	3.47	0.27	4.53
Production	3,585	14.73	42.63	5.52	62.88
Gathering	3,585	0.64	1.22	0.11	1.97
Crude Pipeline	3,582	6.95	5.84	3.79	16.58
Tanker Loading	3,582	0.13	0.29	0.03	0.45
Tanker	3,582	1.76	24.18	0.50	26.44
N.J. Refinery	3,351	16.28	117.48	7.37	141.13
Barge Loading	3,351	0.13	0.29	0.04	0.46
Tug & Barge	3,351	0.26	5.06	0.07	5.39
Power Plant	1,099	22.52	46.31	4.01	72.84
Transmission	1,055	6.47	9.52	0.95	16.94
Distribution	1,000	6.56	20.10	1.91	28.57
Total	1,000	77.22	276.39	24.57	378.18

Natural Gas

<u>Pathway Step</u>	<u>Resource Leaving Step</u> (Btu)	<u>Energy Subsidy</u> (Btu)			
		<u>Coal</u>	<u>Crude & Gas</u>	<u>Hydro & Nuclear</u>	<u>Total</u>
In Situ--70% Recovery	1,656				
Research & Exploration	1,159	0.24	1.07	0.08	1.39
Production	1,101	4.52	13.09	1.70	19.31
Gathering	1,101	0.20	0.37	0.03	0.61
Liquids Plant	1,059	0.70	1.07	0.28	2.05
Transmission	1,013	1.22	2.26	0.23	3.71
Distribution	1,000	0.86	2.27	0.20	3.33
Total	1,000	7.74	20.13	2.52	30.40

Nuclear Electricity

<u>Pathway Step</u>	<u>Resource Leaving Step (Btu)</u>	<u>Energy Subsidy (Btu)</u>			
		<u>Coal</u>	<u>Crude & Gas</u>	<u>Hydro & Nuclear</u>	<u>Total</u>
In situ	6,356				
Mined Ore, 5% loss	6,038				
Milling Ore, 5% loss	5,736				
Fluorination, 0.2% loss	5,725				
UF ₆ Enrichment, 32% loss	4,816*				
Production UO ₂ , 1% loss	4,767	150.67	149.24	70.67	370.58
Heat From Reactor	3,433				
Electricity Generation (33.17% efficient)	1,139				
Electricity Sendout	1,099				
Transmission	1,055	6.47	9.52	0.95	16.94
Distribution	1,000	6.56	20.10	1.91	28.57
Total	1,000	163.70	178.86	73.53	416.09

* Includes 81% virgin material (3893 Btu) and 19% recycled material (923 Btu)

These characteristics are standardized for the production of 1000 Btu of energy at the point of end use.

Resource Requirements for ICES and Conventional Systems

From the energy characteristics of the supply systems and the fuel demands for ICES and for the present systems, the following resource requirements result.

System	Fuel	Annual Consumption (10 ⁹ Btu)	Energy Resource Required (10 ⁹ Btu): Primary and Subsidy				
			Oil	Gas	Coal	Uranium	Hydro
ICES	Oil	1800 (85) ²	2000 ¹ 83 (320) ¹ (12) ²	83	31	13	13
	Electricity		(12) ²	(12) ²	(7) ²	(1) ²	(1) ²
Conventional	Total		1800	71	24	12	12
	Oil	17	19 ¹ 1	1	-	-	-
	Gas	360	4	417 ¹ 4	3	-	-
	Electricity	280	1100 ¹ 39	39	22	3	3
	Nuclear	120	11	11	20	720 ¹ 4	4
	Total		1200	470	45	730	7

1 Primary resource requirements.

2 () indicate negative number.

Negative numbers (in parentheses) indicate sales of electricity from the ICES in excess of purchases by the community. This net negative consumption has been represented as a credit equivalent to the resources required to generate that electricity at an oil-fired power plant. For the conventional alternative, electricity is generated 70 percent by oil and 30 percent by nuclear power plants. All numbers are rounded to two places, and resources are reported for both primary and subsidy requirements.

Energy resource requirements listed in the table are shown graphically in Figure 3. It can be seen that the ICES consumes less total heat equivalent

FIGURE 3
ENERGY RESOURCE REQUIREMENTS

than does the conventional alternative, while using slightly more oil than the oil and gas used by the conventional alternative. Conventional systems are dependent on uranium in addition to the scarce fuels.

For this case the ICES conserves energy (though it does not reduce reliance on scarce resources). It therefore appears to be beneficial to the national goal of energy conservation.

CASE STUDY CONCLUSION

The indirect impacts analysis yields the following comparison of ICES with the present conventional systems.

- ICES reduces local employment by 20 manyears, or the equivalent of 0.7 people for the 30 years of the system. Total regional loss of employment is 100 manyears, or the equivalent of three fulltime people for 30 years. These are modest negative impacts.
- ICES results in additional local revenue of more than one million dollars with almost no additional demands on city services. This is a large positive impact.
- ICES reduces total (heat-equivalent) energy resource requirements, but slightly increases the use of scarce fuels. Consequently, this result is mixed.

In sum, because of large potential revenue to local government, the ICES project appears to have generally favorable indirect impacts on the city in which it will be located.