A CASE-STUDY APPLICATION OF VENTURE ANALYSIS:

THE INTEGRATED ENERGY UTILITY

Volume 3: Appendices

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A.1

Appendix A
UTILITY INTERVIEWS

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INTERVIEW PROTOCOL FOR
REGULATORY COMMISSIONS

Part I

Enclosed are descriptions of proposed systems for integrated power generation and district heating. As you will note, these descriptions contain information on the system economics and the cost of delivered heat. Heat storage can be a determining factor in achieving the utilization of all of the usable output from central power stations, and the cost of aquifers for hot water storage is presented for the appropriate systems.

We would like to learn whether you may perceive these systems as desirable options for utilities and to find out what regulatory problems may exist in the implementation of these systems. We would like to have your comments on the following questions, and on any further points you feel are relevant.

- Are existing electric or gas utility charters broad enough to cover heat sales? If not, how difficult would it be to expand the charter's scope? Is the situation different for municipally owned utilities?
- How would regulations regarding rights of way (both for transmission and distribution) be different for heat than they are for electricity or gas?
- What approaches might be taken to the possible allocation of costs between electricity and steam? Would the regulatory commission be willing to render decisions on a total energy delivered concept?
- What regulatory difficulties are perceived with regard to water rights for heat storage? Would existing riparian doctrines need to be altered?
- Would the commission favor control of district heating by: (a) municipalities (b) electric utilities (c) gas utilities (d) separate heating utilities? Would it be possible from a regulatory point of view if some of these parties undertook developing integrated power as a joint venture?
- Would it become easier to site fossil fueled district heating plants in populated areas if it can be shown that overall air quality for the area is improved?

Part II. Implementation Scenarios

Successful development of the sale of heat will depend on choosing a profitable course for expansion. How would you see integrated power generation developing? Please discuss the possible scenarios listed below.

- (a) Installation of boilers (10-20 Mw capacity), serving the needs of existing or newly built areas until such time as demand builds up to a level where connection to transmission from central plant is feasible.
- (b) Developing service only in newly built areas (where the distribution system may be installed as the area is built up), and proceeding as in (a).
- (c) Waiting until there is a sufficient number of customers to make transmission from central station feasible, and then supplying customers only when major portions of the distribution system are installed.
- (d) Providing service from substations close to load using waste heat from gas turbines. (The utilization of waste heat permits the units to be used economically to generate bare electric power.)
- (e) Providing service to industrial heat loads first to begin the network development with high volume users. Is there an industrial sector in your area that could become the first customer?
- (f) What other approaches might be used?

HIGH-TEMPERATURE WATER SYSTEM DESCRIPTION

The concept of an integrated energy utility concerns the production of both electricity and high-temperature water (HTW) by electric utilities. The HTW is generated essentially as a by-product of electrical generation, although some penalty on electrical generation may be involved. The combined production of HTW and electricity allows efficiencies of up to 80 percent to be achieved. The HTW is delivered by underground pipeline for use in space heating and water heating in residential and commercial establishments and industrial applications for process heat under 350°F. In some configurations underground storage of HTW may be used in order to balance supply with consumptions.

The systems being considered are

Gas Turbine. The gas-turbine system simply places a heat exchanger in the stack and uses the hot exhaust gases to heat water which is then delivered to the customer. This mode of operation delivers waste heat for useful purposes without any degradation in electrical generation.

Combined Cycle. The same gas-turbine and heat-recovery system are modified by addition of a steam turbogenerator to total up to 100 MW_e at high efficiency. At some loss of electricity, useful heat may be provided as process steam or HTW by steam extraction or noncondensing operation of the steam turbine. Both gas turbines and combined cycle can be economic as base-load supply when maximum heat is needed.

Coal Extraction. In this system, steam can be extracted at one or several points in a multistage turbine, according to desired steam pressure-temperature conditions. This system is flexible in that large amounts of heat can be extracted when needed at a cost of reduced electrical generation, or extraction can cease when full electric output is needed. Cooling water or towers would still be required when full electric power is being generated.

Coal Backpressure. Less capital-intensive but less flexible than steam extraction is the backpressure mode. The usual low-pressure turbine, condenser, and cooling tower are replaced by a high-pressure condenser which returns condensate to the boiler and heats water to be piped away to heat loads. The major advantage here is the elimination of the cooling tower but there must be adequate continual demand for heat or heat storage wells to realize this advantage.

LWR Extraction. Current generation LWR turbines are modified to increase the steam extraction at multiple points so that up to 1200 MW_t of useful heat can be provided as HTW with a reduction of 200 MW_e.

Heat Storage Well. A heat storage well is a device for efficiently storing large amounts of heat at low cost for long periods of time by injecting high-temperature water (200-400°F) into aquifers (porous water-bearing layers) and recovering it as needed. While still under development, the heat storage well shows promise as an important component in energy systems. The well provides an obvious advantage in that heat generated during the summer months can be stored for use during the winter months. Daily storage for load balancing can also be accomplished with this system. This may eliminate the need for cooling devices and facilitates the maximum use of waste heat.

Potential Market

Preliminary calculations have been done in order to define the potential market for HTW, that is, the market for which HTW will compete. The market actually captured will depend on how well customers view HTW vis a vis alternative systems. We have defined the potential market as follows:

- ° Residential - All new residential construction taking place after 1975 within SMSA's (Standard Metropolitan Statistical Areas).
- ° Commercial - All new commercial construction taking place after 1975.
- ° Industrial - All industrial demand for indirect heat at a temperature below 350°F minus that portion of demand that could be supplied by utilizing waste heat generated within the plant.

Following these definitions and using Census Bureau projections of households and Department of Energy projections of energy demand in industry, the potential market for HTW can be calculated. This market is shown in the following table.

Potential Market for HTW
(X10¹² Btu)

	1985	2000	2020
Northeast			
Residential	400	940	1600
Commercial	90	240	500
Industrial	190	260	390
Total	680	1440	2490
Northcentral			
Residential	500	1200	2025
Commercial	170	460	950
Industrial	320	460	720
Total	990	2120	3695
South			
Residential	330	790	1330
Commercial	200	520	1080
Industrial	445	670	1090
Total	975	1780	3500
West			
Residential	225	530	900
Commercial	120	320	660
Industrial	150	260	460
Total	495	1110	2020

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INTERVIEW PROTOCOL FOR
ELECTRIC AND GAS UTILITIES

Part I. Historical Perspective

While the systems we will be proposing are hot water systems, we would first like to discuss briefly your company's experience in selling steam. Does your company presently, or has your company ever, sold steam? In your view, does the steam business have a potential for growth?

The steam business in this country currently contributes less than 0.1 percent of the total energy consumed. We would like to have your comments on why the sale of steam may not be viewed as an attractive adjunct to the electric or gas business. (The following list of reasons is not meant to be exhaustive. Please feel free to add to it or modify any statement.)

- (a) Maintenance and installation costs of distribution system are too high.
- (b) Utility is not allowed to price steam at a profitable level.
- (c) Heat load is not sufficiently diverse, resulting in poor load factors.
- (d) Heat load densities are too low in presently accessible areas.
- (e) In the present regulatory environment, cogeneration of steam works against the production of electricity at the lowest cost.*
- (f) The old steam systems are not compatible with new turbo-generation equipment.*
- (g) It is difficult to find plant sites from which to serve new areas.
- (h) Competition from individually packaged heating/cooling plants is too great.

*Electric utilities only.

Part II. HTW Systems Characteristics

Enclosed are descriptions of several proposed systems for integrating power generation and district heating. These descriptions contain information on the system economics and the cost of delivered heat. Heat storage may be included in achieving the utilization of all of the usable output from central power stations, and the cost of aquifers for hot water storage is presented for the appropriate systems.

We would like to learn how you perceive these proposed systems as possible options for your company. Please rate the following attributes of the proposed systems as they relate to a decision you might make to adopt any of them for your system (add to the list, if desired). Please rate these attributes using a "college scale", with "A" as the most important to your decision and "F" as the least.

- Lower cost of delivered energy (that is, both electricity and heat may be produced by cogeneration at lower costs than separately)
- Increased efficiency of energy usage
- Reduction in thermal pollution effects*
- Ability to expand space heating market
- Enhanced public image and greater public acceptance of the utility
- Increased rate base
- Could free natural gas from existing space heating applications for sale at higher prices for industrial uses**
- Opportunity to provide total heating sales and service (heating system, including heat exchanger; building insulation)
- Need for cooling towers may be eliminated for turbines operated in back pressure mode*
- Storage of waste heat may be profitably coupled with other energy storage systems*
- Development of profitable district heating on a large scale will provide a desirable investment diversification

*Electric utilities only

**Gas utilities only

Please rate the following negative attributes which might make you decide against adopting one of the proposed integrated power systems (add to list, if desired).

- Difficulty of allocating costs between electricity and heat*
- Difficulty of raising capital for new venture
- Difficulty of staffing up for such an undertaking
- Need to get necessary regulatory changes for transmission and sale of hot water
- Potential conflicts with competing interests (oil companies, oil dealers, gas** (electric*) companies, etc.)
- Need to change laws regarding riparian rights for underground storage of water
- Need to set up arrangement with electric utility to buy generated electricity or need to set up arrangement to purchase hot water from electric utility**
- The storage well is a necessary part of the system, and its feasibility needs to be demonstrated in the utility's area
- Difficulty of installing distribution system in settled areas
- System implementation would detract from other energy programs currently being developed (name them in order of preference)

Part III. Implementation Decision

- Do you think that a HTW district heating system is feasible for your area?
- What would be required in order to induce you to go into the venture?
- What rate of return on investment would you require?
- It has been suggested that present regulatory postures of the Federal Power Commission and the State Public Utility Commissions, and existing rate structures based on a fair and just return on the valuation of utility property and distributed costs, are not conducive to utility investment in district heating. Do you agree? Do you have specific recommendations for changes in the regulatory environment?

*Electric utilities only

**Gas utilities only

- Several incentives have been suggested to induce utilities to invest in district heating or to seek rule changes which would make investment profitable. Among these incentives are
 - ° an increase in investment tax credit
 - ° federally guaranteed loans up to 10% of investment requirements
 - ° federally funded grants to state PUCs to aid in updating their regulations
 - ° accelerated depreciation for properties and equipment dedicated to waste heat conservation and recovery uses.

Please discuss the above.

Part IV. Implementation Scenarios

Successful development of the sale of heat will depend on choosing a profitable course for expansion. How would you see integrated power generation developing? Please discuss the possible scenarios listed below.

- (a) Installation of boilers (10-20 Mw capacity), serving the needs of existing or newly built areas until such time as demand builds up to a level where connection to transmission from central plant is feasible.
- (b) Developing service only in newly built areas (where the distribution system may be installed as the area is built up), and proceeding as in (a).
- (c) Waiting until there is a sufficient number of customers to make transmission from central station feasible, and then supplying customers only when major portions of the distribution system are installed.
- (d) Providing service from substations close to load using waste heat from gas turbines. (The utilization of waste heat permits the units to be used economically to generate bare electric power.)
- (e) Providing service to industrial heat loads first to begin the network development with high volume users. Is there an industrial sector in your area that could become the first customer?
- (f) What other approaches might be used?

SELECTED HIGH-TEMPERATURE WATER SYSTEMS AND ASSOCIATED COSTS
NORTHEAST REGION

	Gas Turbine No Storage 100 Mw Electric 2.09 x 10 ⁶ MBtu/year Thermal		Coal Extraction Plant Storage 600 Mw Electric 15.6 x 10 ⁶ MBtu/year Thermal		Nuclear Extraction Plant Storage 1200 Mw Electric 60 x 10 ⁶ MBtu/year Thermal	
Data Summary \$1985 in 1985	Industrial	Residential- Commercial	Industrial	Residential- Commercial	Industrial	Residential- Commercial
Total Capital Costs* (millions)	10.70	56.40	389.00	674.00	708.00	1739.00
O&M Costs/Year	1.10	1.10	5.00	5.00	17.00	17.00
Fuel Costs/Year	7.60	7.60	36.00	36.00	27.40	27.40
Delivered Heat Costs (\$/MBtu)	4.91	6.58	5.33	6.81	2.21	3.53
		Alternative Heating Methods Fuel Only (\$/MBtu)				A.13
Home Heating Oil		10.45		10.45		10.45
Natural Gas		6.40		6.40		6.40
Electric Resistive		27.40		27.40		27.40
Middle Distillates	8.00		8.00		8.00	
Residual Fuel Oil	7.59		7.59		7.59	

*Capital costs are comprised of incremental costs for in-plant equipment to deliver heat, a portion of the capital costs for the complete plant based on the assumption that the electric customer pays normal prices for his electricity, and transmission, distribution, and storage costs to sell all available heat.

SELECTED HIGH-TEMPERATURE WATER SYSTEMS AND ASSOCIATED COSTS
NORTH CENTRAL REGION

	Gas Turbine No Storage 100 Mw Electric 2.09 x 10 ⁶ MBtu/year Thermal		Coal Extraction Plant Storage 600 Mw Electric 15.6 x 10 ⁶ MBtu/year Thermal		Nuclear Extraction Plant Storage 1200 Mw Electric 60 x 10 ⁶ MBtu/year Thermal	
Data Summary \$1985 in 1985	Industrial	Residential- Commercial	Industrial	Residential- Commercial.	Industrial	Residential- Commercial
Total Capital Costs* (millions)	10.70	56.40	389.00	674.00	708.00	1739.00
O&M Costs/Year	1.10	1.10	5.00	5.00	17.00	17.00
Fuel Costs/Year	7.60	7.60	18.00	18.00	27.40	27.40
Delivered Heat Costs (\$/MBtu)	4.91	6.58	4.17	5.65	2.21	3.53
Home Heating Oil Natural Gas Electric Resistive Middle Distillates Residual Fuel Oil		Alternative Heating Methods Fuel Only (\$/MBtu)				A.14
		10.45				
		6.40				
		27.40				
	8.00		8.00		8.00	
	7.59		7.59		7.59	

*Capital costs are comprised of incremental costs for in-plant equipment to deliver heat, a portion of the capital costs for the complete plant based on the assumption that the electric customer pays normal prices for his electricity, and transmission, distribution, and storage costs to sell all available heat.

SELECTED HIGH-TEMPERATURE WATER SYSTEMS AND ASSOCIATED COSTS
SOUTHERN REGION

	Gas Turbine No Storage 100 Mw Electric 2.09 x 10 ⁶ MBtu/year Thermal		Coal Extraction Plant Storage 600 Mw Electric 15.6 x 10 ⁶ MBtu/year Thermal		Nuclear Extraction Plant Storage 1200 Mw Electric 60 x 10 ⁶ MBtu/year Thermal	
Data Summary \$1985 in 1985	Industrial	Residential- Commercial	Industrial	Residential- Commercial	Industrial	Residential- Commercial
Total Capital Costs* (millions)	10.70	102.20	389.00	958.00	708.00	2770.00
O&M Costs/Year	1.10	1.10	5.00	5.00	17.00	17.00
Fuel Costs/Year	7.60	7.60	24.50	24.50	27.40	27.40
Delivered Heat Costs (\$/MBtu)	4.91	8.26	4.59	7.67	2.21	4.84
Home Heating Oil Natural Gas Electric Resistive Middle Distillates Residual Fuel Oil		Alternative Heating Methods Fuel Only (\$/MBtu)				A.15
		10.45				
		6.40				
		27.40				
		8.00	8.00			
		7.59	7.59		7.59	

*Capital costs are comprised of incremental costs for in-plant equipment to deliver heat, a portion of the capital costs for the complete plant based on the assumption that the electric customer pays normal prices for his electricity, and transmission, distribution, and storage costs to sell all available heat.

SELECTED HIGH-TEMPERATURE WATER SYSTEMS AND ASSOCIATED COSTS
WESTERN REGION

	Gas Turbine No Storage 2.09×10^6 MBtu/year Thermal		Coal Extraction Plant Storage 15.6×10^6 MBtu/year Thermal		Nuclear Extraction Plant Storage 60×10^6 MBtu/year Thermal	
Data Summary \$1985 in 1985	Industrial	Residential- Commercial	Industrial	Residential- Commercial	Industrial	Residential Commercial
Total Capital Costs* (millions)	10.70	102.20	389.00	958.00	708.00	2770.00
O&M Costs/Year	1.10	1.10	5.00	5.00	17.00	17.00
Fuel Costs/Year	7.60	7.60	18.00	18.00	27.40	27.40
Delivered Heat Costs (\$/MBtu)	4.91	8.26	4.17	7.25	2.21	4.84
		Alternative Heating Methods Fuel Only (\$/MBtu)				A.16
Home Heating Oil		10.45		10.45		10.45
Natural Gas		6.40		6.40		6.40
Electric Resistive		27.40		27.40		27.40
Middle Distillates	8.00		8.00		8.00	
Residual Fuel Oil	7.59		7.59		7.59	

*Capital costs are comprised of incremental costs for in-plant equipment to deliver heat, a portion of the capital costs for the complete plant based on the assumption that the electric customer pays normal prices for his electricity, and transmission, distribution, and storage costs to sell all available heat.

INTERVIEW RESULTS

Part I. Historical Perspective. This section of the interview was designed to learn how the sale of heat is viewed by utilities currently in that business. As shown in the interview protocol, Part I listed a number of factors that may affect the sale of steam, and the utilities were asked to comment on each of them.

Of the 13 utilities with district heating systems, only six agreed that there was some potential for growth within their areas. This potential for growth did not include any significant addition to the existing distribution system. Rather it implied that opportunities existed in the conversion of old buildings or more likely the gaining of new construction as customers in cases where these buildings were proximate to existing distribution lines. A utility with one of the larger district heating systems in the country estimated that future growth for its area would be approximately 2 percent a year. Two utilities, one gas utility and the other a wholly-owned heating subsidiary of an electric utility, hoped to realize increases in the heat sales by serving large commercial or industrial loads from steam plants located close to these loads. For the remaining seven utilities with district heating systems, very little potential was seen for expansion, and one of these utilities is currently studying the possibility of going out of the steam business.

As may be seen from Table A.1, ten of the utilities with the district heating systems indicated that distribution installation costs have become prohibitively high. Cost estimates were said to be relatively insensitive to pipe size. One estimate divided the costs as being 80 percent labor and

Table A.1

INTERVIEW RESULTS ON HISTORICAL PERSPECTIVE OF DISTRICT HEATING

Code Number	Utilities With District Heating System												
	2	3	5	6	14	20	7	9	10	13	18	21	17
Over 1 Million Customers		X	X			X			X				
Municipal Utility								X					
<u>Potential for Growth</u>	*			✓	✓	✓			✓	✓			✓
<u>Historical Perspective</u>													
Maintenance costs too high	✓	✓	✓					✓					
Installation costs too high	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		
Regulated steam prices too low			✓	✓	°			-		°	°		-
Poor heat load factor	✓		✓	✓	✓		✓	✓	✓	✓	✓		✓
Poor heat load densities	✓		✓		✓								
Regulatory problems limit cogeneration			✓								-	✓	-
Incompatibility of old steam systems			✓					✓					
Difficult to find new steam plant sites	✓	✓	✓				✓	✓	✓	✓			
Competition from packaged units		✓							✓	✓			

*Utility considering going out of steam business

°Steam sales are unregulated

(Checkmark indicates agreement; dash indicates no response)

20 percent materials. For installation of 12 in. to 16 in. diameter pipe in one city, estimated costs were \$250 to \$500 per foot; estimates for another city were \$1000 per foot for 24 in. pipeline and \$1200 a foot for 30 in. pipeline. In nondense urban environments estimated costs declined to approximately \$200 to \$300 per foot.

Costs were not the only difficulty, however, associated with installing distribution in existing urban areas. The congestion of existing utility lines under urban streets made the new installations increasingly problematic. Questions were raised regarding the heating effects of underground piping on neighboring electric cables. Public annoyance at utility street excavations were also cited by several utilities as a factor that would have to be contended with.

Ten of the utilities with district heating systems cited poor heat load factors as the second reason limiting the profitability of the steam-heating business. The highest quoted annual heat load factor was 40 percent, the lowest 20 percent, and the average was about 32 percent. Limited use of steam for absorption chilling during the summer months was cited as the primary reason for poor load factors. However, one utility observed that the conservation efforts among their steam heating customers has resulted in a 30-percent loss of load (energy) without any significant reduction in the peak demand.

Though seven of the utilities with district heating systems cited the difficulty in finding new plant sites as limiting district heating growth, none pointed to a current situation where demand could not be served because of limited capacity.

As may be seen from Table A.1, there was no consensus on the other factors suggested in the interview protocol as significant reasons limiting

the growth of steam sales. While installation of distribution piping was generally found to be very high in cost, maintenance of existing distribution systems was a much smaller cost factor, and only four utilities indicated that the maintenance costs presented a problem.

Among the investor-owned utilities interviewed, an electric utility with a district heating system, and the heating subsidiaries of a gas and an electric utility,* are currently allowed to sell steam on an unregulated basis. Of the other eight investor-owned utilities, two indicated that the regulation was a factor in obtaining an adequate return from the steam sales. Several utilities indicated that it was primarily competition that kept the steam sales low, and three of the utilities with district heating systems indicated that competition from individually packaged steam units was threatening.

It was generally agreed that the heat load factors were too low. Only three utilities indicated that poor heat load density was a problem; most of the district heating systems are installed in dense urban areas where high heat load densities can be achieved.

For the electric utilities with district heating systems, no singular regulatory problems were cited as limiting cogeneration. For many district heating systems, the steam is supplied from separate boilers; cogeneration, where it does exist, tends to supply not more than 50 percent of the steam load. As for modern turbo-generating equipment being incompatible with the old steam systems, this was cited as a factor by only two utilities.

*This electric utility also has a separate district heating system where steam sales are regulated.

It was pointed out, however, that the old low-pressure systems could be made compatible through the use of suitable heat exchangers.

Part II. HTW Systems Characteristics. The second section of the interview protocol was devoted to learning what attributes of the proposed HTW systems were important to utility consideration for investment in these systems. A description of the HTW systems was given to the interviewee, and he was then asked to rate both the listed positive and negative attributes of the systems as to their importance in any decision he might make.

Positive Attributes: Table A.2 shows the utility scoring for each of the positive and negative attributes listed for the HTW systems in the interview protocol. Letter scores given by the interviewee were converted into numerical scores and averaged, a five indicating an attribute of greatest significance and a zero indicating an attribute of virtually no significance.

Almost all of the utilities scored the potential for lower total energy costs very high (average rating 4.4) in any considerations for undertaking a HTW system. However, there was some skepticism about how economical cogeneration is, and several utilities said they were in the process of studying limited applications. Increased energy efficiency was also given a high rating by most utilities (average rating 3.9); however, in general, it was felt that achieving increased energy efficiency would be reflected in lower total energy costs and was, therefore, not a completely separable factor. Nonetheless a couple of utilities did indicate that increased energy efficiency meant better fuel utilization and as such was a desirable policy. In California, it was pointed out that increased efficiency of energy usage is currently an important issue in the state's regulatory climate.

The potential for lowering thermal discharges through cogeneration was given an average rating of 2.9. While regulations regarding thermal discharges

Table A.2

INTERVIEW RESULTS ON THE ATTRIBUTES OF HTW SYSTEMS

TYPE OF UTILITY Code Number	Utilities Providing Gas and Electric Service										Average Rating	Utilities Providing Electric Service										Average Rating	Utilities Providing Gas Services			Average Rating	Average Rating for all Utilities
	1	2	3	4	5	6	14	20	7	8		9	10	11	12*	13	15	16	21	17	18		19				
Over 1 Million Customers	✓		✓	✓	✓			✓		✓		✓	✓				✓				✓						
With D.H. System		✓	✓		✓	✓	✓	✓		✓		✓	✓		✓			✓		✓	✓						
Municipal Utility										✓	✓			✓			✓		✓								
Positive Attributes																											
Lower total energy costs	5	5	5	5	4	4	4	5	4.6	5	5	5	5	5	5	5	0	2	4.2	4	5	4	4.3			4.4	
Increased energy efficiency	5	4	5	3	4	5	3	3	4.0	5	5	4	3	5	-	3	5	0	2	3.6	5	4	4	4.3		3.9	
Less thermal pollution	1	3	3	3	4	3	0	4	2.6	4	4	3	2	4	-	5	3	0	2	3.0	-	-	-	-		2.9	
Expand heat market	0	0	2	3	2	4	3	2	2.0	4	3	-	4	2	-	5	2	0	2	2.8	1	4	3	2.7		2.5	
Enhanced public image	3	4	4	3	4	4	3	0	3.1	5	0	4	2	4	-	3	0	0	2	2.2	3	3	3	3.0		2.7	
Added rate base	2	1	2	1	0	3	2	0	1.4	0	0	-	-	0	-	3	0	0	0	.4	-	2	2	1.3		1.1	
Frees natural gas	0	0	4	2	4	3	4	0	2.1	-	-	-	-	-	-	-	-	-	-	-	2	4	0	2.0		2.1	
Opportunity for added services	3	2	2	2	2	0	2	0	1.6	3	0	-	0	0	-	1	1	0	0	.6	2	2	2	2.0		1.3	
Eliminates cooling towers	2	2	2	3	3	2	-	4	2.6	4	3	5	3	4	-	4	0	3	1	3.0	-	-	-	-		2.8	
Additional energy storage	1	-	2	3	4	3	-	1	2.3	2	2	3	5	-	-	5	0	0	0	2.7	-	-	-	-		2.3	
Investment diversification	3	2	2	4	3	4	2	0	2.5	5	2	-	-	0	-	4	0	0	0	1.6	1	4	5	3.3		2.3	
Negative Attributes																											
Cost Allocation	5	2	0	2	3	4	2	0	2.2	2	3	0	0	2	-	5	3	2	3	2.2	-	-	-	-		2.2	
Raising capital	5	2	5	5	4	5	2	5	4.1	5	3	0	1	5	-	5	5	1	5	3.3	0	4	4	2.7		3.6	
Staffing	-	2	0	2	4	3	0	1	1.7	2	1	0	0	3	-	0	3	1	2	1.3	0	0	4	1.3		1.5	
Regulation of hot water	-	2	2	3	2	4	4	1	2.9	-	5	0	1	3	-	0	3	2	3	2.1	0	3	5	2.7		2.5	
Conflict with other interests	-	2	5	2	0	3	3	0	2.1	2	5	0	1	3	-	0	0	5	0	1.8	5	0	3	2.7		2.2	
Riparian rights	5	-	-	4	-	-	-	2	3.7	3	5	5	-	3	-	0	0	5	4	3.1	0	-	5	2.5		3.2	
Interface with electric utility	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	3	2.3		2.3	
Demonstration of storage	-	-	4	4	5	2	-	5	4.0	5	5	4	5	5	-	5	0	5	4	4.2	-	-	-	-		4.1	
Distribution in settled areas	4	5	5	2	5	5	5	5	4.5	5	5	0	3	5	-	3	5	4	5	3.9	1	3	4	2.7		3.8	
Impact on other programs	-	-	0	3	4	2	0	0	1.5	5	3	3	5	2	-	2	0	1	4	2.8	-	4	3	2.3		2.4	

Scale

Ratings are on a six point scale: 5 indicates an attribute of greatest significance
 0 indicates an attribute of virtually no consequence
 - indicates no response, and not included in the averages

*With the exception of the one indicated attribute, interviewee did not give a rating to any other attribute.

were now being met, it was felt the use of district heating for disposal of waste heat could result in greater flexibility in plant siting. In this connection, the possible elimination of cooling towers was seen as beneficial (average score 2.8) though doubts were raised as to whether they could be totally eliminated. There was some feeling that one could not trust in heat storage completely in order to assure that electricity could always be generated when turbines were operated in the backpressure mode. It was pointed out that the presence of cooling towers, reduced in size, may still be desired from the point of view of system reliability and flexibility in operation.

Some utilities saw the possibility of developing HTW systems as enhancing their public image (average rating 2.7) though there was some skepticism expressed as to whether the public is really concerned with issues beyond the cost of power. One utility with a district heating system suggested that a HTW system would provide an opportunity to serve heating customers with an alternative to steam, and the availability of this choice would enhance their public image.

The possibility of expanding the heat market through the development of HTW systems met not very great enthusiasm (average rating 2.5). As may be seen from Table A.2, utilities providing both gas and electric service tended to rate possibility of the expansion of the heat market somewhat lower than utilities providing only electric service (average score 2.0 and 2.8 respectively). Part of this difference is accountable for by the fact that combined utilities are already serving the heating market and in some cases see expansion of district heating as competing with gas sales. As for seeking an opportunity to provide total heating sales and service, the utilities felt that they would not wish to provide these services, and this attribute received an average rating of only 1.3.

The opportunity to free natural gas from commercial and residential heating for sale to industry at higher prices found little favor among the utilities providing gas service (average rating 2.1). Several utilities suggested that if any substantial quantity of natural gas was freed, it might not be allowed to be sold to industry, but would rather be reallocated to other geographic areas. There was relatively little anxiety expressed over being able to meet the residential and commercial gas demand. Interruptible gas-demand agreements with industry, it was felt, made it possible to continue to meet industrial needs in many cases at lower rates than those offered commercial and residential customers.

HTW systems as a venture providing investment diversification was given an average rating of 2.3, the main consideration being whether the system would be sufficiently profitable. The possibility of adding to the rate base through investment in HTW systems was not seen as an advantage by the utilities (average rating 1.1). Increased capital investment was seen as placing an additional burden on profitability requirements and on obtaining fair rates of return from public-service commissions. One utility that has a district heating system prefers to apportion capital investments in cogeneration as much as possible to electrical generation in order to be able to keep steam prices competitive with other heat sources.

The possibility that the storage of waste heat may be profitably coupled with other energy storage systems was given an average rating of only 2.3 principally because there appeared to be difficulty in realizing how storage of waste heat could be harmonized with the other energy storage systems. While the load-leveling possibilities of storage were appreciated for district heating, optimization of a total energy system with various forms of storage was questioned.

Negative attributes: As may be seen from Table A.2, the highest rated negative attributes of the HTW systems were the need to demonstrate the ability to store hot water in order to obtain high-load factors (average rating 4.1) and the difficulty of installing distribution systems in settled areas (average rating 3.8). While the idea of heat storage was generally seen as appealing, some skepticism was expressed as to the feasibility of aquifer storage particularly with respect to environmental and seismic problems that may be associated with such storage. As for the difficulty of installing distribution in settled areas, several utilities pointed out that the space under urban streets is already crowded with utility lines and a new distribution system would create great difficulties.

Raising the capital needed for HTW systems was given an average score of 3.6. The municipal utilities generally scored this the lowest indicating that they had no difficulty in raising bonds for municipal ventures. While the investor-owned utilities agreed that raising capital was not easy, they generally felt that capital could be obtained if the system could be proved to be economically attractive. It was agreed that the economic viability of the HTW systems would be largely dependent on cost allocation between electricity and heat, but few utilities thought allocating costs would be a problem, and this factor received an average rating of only 2.2. There appeared to be no technically intrinsic difficulty in allocating costs between steam and electrical generation, but rather the need to come to some agreement with regulatory bodies regarding how these costs were to be divided.

Most of the utilities saw no problems in obtaining regulatory approval for the transmission and sale of hot water, and this factor was rated at 2.5. Even where the factor was given a somewhat higher rating by some

ities, it was felt that principal difficulties would be with regulatory delay, and that ultimately regulatory approval could be obtained. There was little knowledge of riparian laws among the interviewees; a number of those questioned passed on scoring this item, while some of those who did score it suggested that riparian problems could be avoided if the HTW systems could be shown to be closed and if storage aquifers were sufficiently isolated from other underground reservoirs (average rating for this factor was 3.2).

Acquiring proper staffing for HTW systems was not seen as presenting any difficulty and was given an average rating of 1.5. Neither did the utilities generally see any problem in the sale of hot water conflicting with other heating interests, giving this an average rating of 2.2. It was pointed out that all of the utilities are in the business of selling energy for heating and thus are already in competition with a variety of heating interests. It was admitted, however, that the sale of heat in the form of hot water would make the utility compete with itself for potential heating customers, but that this would be no different from gas and electricity competition in a combination utility.

Some utilities saw the possibility of a commitment to the development of HTW systems as affecting the development of other energy programs (average rating 2.4), but in general it was felt that if the economics of the HTW systems were favorable this would not be a drawback.

Neither of the three gas companies suggested that an interface with an electric utility (for the sale back of electricity should the gas utility own the generating equipment for supplying the heat to their own district heating system) was an insurmountable difficulty, though none had any specific idea as to what problems might be associated with such an arrangement.

Nor did the gas companies suggest any difficulty in buying hot water from the electric utility for distribution through their own district heating system. One of the gas companies did, however, comment that it was rather unlikely they would set up a cogeneration scheme themselves; this utility indicated that buying hot water from the electric utility was a more possible arrangement, though the gas company would prefer to be in complete control of heat production.

Part III: Implementation Decision. Part III of the interview protocol presented a number of questions regarding regulation and government incentives that could bear on the implementation of HTW systems, and the utilities were asked for their replies.

Five of the utilities agreed that HTW systems might find suitable applications in their area (see Table A.3). For these utilities, this possibility was qualified by questions regarding the economics of the HTW systems. Many of the utilities expressed concern that hot-water systems could not be installed in older, high-density urban areas. While a number of utilities granted that HTW systems might find application in new areas, doubt was still expressed as to whether the system could prove itself economically. Some utilities indicated that regulatory problems could affect the installation of HTW systems, but there was general agreement that these difficulties would not be insurmountable. Principal concern was the effect of regulatory delay, during which approved cost relationships can change dramatically.

Several utilities felt that a primary inducement for persuading them to invest in HTW systems would be a large enough scale demonstration to show that hot-water system is more economical than competing heating alternatives. Other than a demonstration, however, no specific incentives were suggested, the general sentiment being that proof of economic attractiveness would

Table A.3

INTERVIEW RESULTS ON THE IMPLEMENTATION OF HTW SYSTEMS

TYPE OF UTILITY Code Number	With District Heating													No District Heating								Total Agreeing
	18	17	2	3	6	5	14	20	7	9	10*	13	21	1	4	8	11	12+	15	16	19	
Over 1 Million Customers				X		X		X			X			X	X	X	X		X		X	
Municipal Utility		X								X						X		X		X		
<u>Implementation Decision</u>																						
Feasibility of HTW		✓					✓				✓				✓	✓		-				5
Regulatory problems foreseen			✓		✓	✓		✓	✓		-							-	✓		✓	7
Helpful incentives:																						
Increased investment tax credit			✓	✓	✓		✓	✓			-	✓			✓	✓		-			✓	10
Federally guaranteed loans				✓							-	✓										2
Aid to PUC's			✓																			1
Expanded accelerated depreciation		-					✓	✓		-	-	✓	✓		✓	-		-		-	✓	6
Required return on investment:																						
Return on equity (percent)	15-17	-	-	12	14	15	15-18	11-14	-	-	-	15	30-40	14	13	-	12	-	-	-	-	
Total return on equity and debt (percent)		10	9.1		9.5	9.2			7		-	10							9.2	10		
<u>Implementation Scenarios</u>																						
Start with small boilers in new and old areas					✓						-	✓								✓	✓	4
Start with small boilers only in new areas		✓		✓		✓			✓		-	✓			✓	✓		-			✓	8
Wait until available market can be served by central station											-					✓		-		✓		2
Begin with service from gas turbines in sub-stations				✓					✓		-			✓				-				3
Begin with service to large industrial loads	✓	✓		✓	✓	✓		✓			-	✓				✓		-			✓	9

✓ indicates agreement

- indicates no response

* interviewee had to leave before all the issues were addressed

+ interviewee did not respond directly to the question

provide necessary and sufficient motivation. One utility with a district heating heating system, though admitting little enthusiasm for the idea of the HTW system for large-scale district heating, said that it might consider doing the demonstration itself if it were supported by an outside grant, provided that the demonstration could be made with a generating plant already scheduled to be built.

The utilities were not overly enthusiastic about any of the suggested incentives that might lead them to make a decision favorable to HTW systems. Increased investment tax credit was generally agreed to provide a positive incentive, but only about half of the utilities indicated that it could have a significant effect (see Table A.3). Accelerated depreciation was seen as a positive step by the investor-owned utilities, which pay a federal income tax, but a far from determining factor.

The idea of federally guaranteed loans was seen as a positive incentive by only two utilities; the general feeling was that the venture should be able to stand on its own feet economically and there should be no need for such government intervention. Only one utility thought that there was any virtue in giving grants to a public utilities commission; it was generally felt that the regulations themselves presented no insurmountable problems.

Part IV: Implementation Scenarios. In the last part of the interview protocol five scenarios showing how HTW systems could develop were described. The utilities were asked to comment on the likelihood of each of these scenarios.

Nearly half of the utilities believed putting small boilers in newly built areas until such time as demand builds up to a level where connection to transmission from a central plant is feasible (Scenario B) or providing

heating to large industrial loads (Scenario E) represented possible applications for the growth of HTW systems (See Table A.3). While supplying large industrial loads with heating was seen as a possibility, many of the utilities did not see this as a strategy leading to HTW district heating systems; that is, many utilities were receptive to the idea of cogeneration or the sale of heat to large industrial plants, especially if these plants were located in the vicinity of the electric generating station. Utilities agreeing that HTW district heating might start with small boilers placed in new areas were also in agreement, as were most of the other utilities, that this strategy in older areas would be extremely difficult. Only four utilities saw the possibilities of installing small boilers in existing areas as well as in new areas. Most of the utilities felt there were severe problems associated with the installation of distribution systems in older urban areas.

The use of waste heat from gas turbines in substations located close to load centers (Scenario D) was generally not seen as a possibility primarily because of environmental problems regarding air and noise pollution. One utility commented that the use of waste heat from fuel cells or batteries rather than from gas turbines in substations might be a more feasible arrangement.

The idea of waiting until a sufficient number of customers was available to make transmissions from a central station feasible (Scenario C) appealed to only two of the utilities. It was generally felt that it would be extremely difficult to make a match between customers' ongoing heating requirements and the ability to deliver the heat at some future date. Customers' heating requirements would have to be met during the waiting period by some alternative means, which would have to be discarded at an economic penalty when the utility was ready to supply him with heat.

Regulatory Interviews

Telephone interviews were conducted with representatives of four state regulatory commissions and the Federal Energy Regulatory Commission. While utility regulations will vary from state to state, the interviews with four representative states (New York, Michigan, California, and Florida) do not suggest any serious regulatory problems that would inhibit development of HTW systems. Although there was general support given for cogeneration in applications where the economics could be shown to be favorable, none of the commissions had given serious thought to expansion of district heating systems using electric-utility waste heat.

The interview protocol that was sent to each of the commissions is shown in Appendix A. The interview consisted of two parts. In the first part a set of questions was posed to learn whether HTW systems were perceived as desirable options for utilities and to find out what regulatory problems might exist in the implementation of these systems. Part 2 of the protocol suggested several scenarios by which HTW systems might develop. Comments were sought on the desirability of these scenarios from the point of view of the public regulators.

Responses to the interview protocol are summarized below.

Part 1. Regulatory Policy Questions.

Are existing electric or gas utility charters broad enough to cover sales? The sale of heat cogenerated with electricity can be expected to fall under the jurisdiction of public-utility commissions, except when this is done by municipally owned utilities, which are controlled by their own city councils. Where existing charters for utilities may have to be broadened to include the sale of heat via a district heating network, it would be the

local authorities who would give city and county franchises to permit installation of the distribution system.

In general no intrinsic difficulties were seen with established utility regulations concerning heat sales, though one interviewee emphasized that it would be necessary for a utility that wished to get into the business of selling heat to show that there was a profit potential. This interviewee expressed doubts about the economic viability of district heating because of installation and maintenance costs. He expressed, as did the other interviewees, his Commission's interest in cogeneration, saying that this Commission encourages utilities and private heat consumers to work together and come up with an arrangement involving the sale of heat or cogeneration that the Commission would examine for approval. The California Public Utilities Commission has recently produced a policy statement directing electric utilities to augment cogeneration projects, and is working with the utilities to develop appropriate tariffs.

How would regulations regarding rights of way (both for transmission and distribution) be different for heat than they are for electricity or gas?

The Gas Division of the Public Service Commission of the State of Michigan issues a Certificate of Convenience and Necessity which regulates the right of way for high-pressured gas transmission lines. Presumably, this requirement would apply to long-distance hot-water pipelines, though it is expected that the utility would use its usual procedures in obtaining needed rights of way (the taking out of an easement, buying the land outright, acquisition through eminent domain). Distribution would be primarily a matter for local authority approval.

In California the Public Utilities Commission must approve new transmission, and it is felt that regulation of hot-water pipelines would fall

into its jurisdiction; the Commission is primarily concerned with the financed and systems aspect of proposed transmission additions.

In Florida, the Division of State Planning must approve large transmission lines (above 240 KV), while the Public Service Commission examines environmental problems associated with this transmission. However, underground pipe transmission does not appear to fall under the Public Service Commission's jurisdiction at this time.

The New York Public Service Commission regulates transmission and rights of way under Public Service Law, Article 7. Currently, the hearing processes take two years, but it is expected that underground pipelines, because of their lower possible environmental impact, may have an easier time gaining regulatory approval than overhead electrical transmission.

If the hot-water transmission lines cross state boundaries, the Federal Energy Regulatory Commission could be involved as they are in the regulation of interstate gas transmission. This would be particularly probable if the hot-water pipelines were to make use of existing electrical or gas rights of way.

What approaches might be taken to the possible allocation of costs between electricity and steam? No intrinsic difficulties were perceived in the allocation of costs, though the dangers of cross-subsidization were perceived. One interviewee expressed the feeling that it was possible that electric revenues might subsidize steam presumably on the basis of the overall benefits to be derived from cogeneration. Another felt that the steam system should be supported by an adequate rate of return using long-range incremental costs from which to derive needed revenues. It was pointed out by one of the interviewees that determination of the cost of

service for steam would involve not only an allocation of plant expenses and investments, but also a factor reflecting the extent to which electrical generation may be degraded. While the commissions have been reflecting upon tariff policy with respect to cogeneration, none had proceeded to a point where they could see regulating steam and electricity on a total energy-delivered basis.

What regulatory difficulties are perceived with regard to water rights for heat storage? Several interviewees felt that precedence with respect to underground gas storage in aquifers may be relevant to the underground storage of hot water. Where such gas storage exists the commissions recognized the relevant capital investments for rate-making purposes and permit the utilities to recover their costs.

One interviewee felt that riparian rights could present a problem in his state. He suggested that laws may be needed to determine the ownership rights of the land with respect to underground storage and for the protection of the fluid stored.

As for federal involvement, that would appear to come about if environmental impact statements were required, and this would true in cases where federal funds were involved. Under such conditions it was felt that the Federal Energy Regulatory Commission could be involved.

Would the commission favor control of district heating by a) municipalities, b) electric utilities, c) gas utilities, d) separate heating utilities? None of the interviewees from the state commissions expressed any particular preference for ownership of district heating systems. With respect to the federal government, its espoused position on cogeneration could be encouraging to electric utilities to establish district heating systems. Proposed

legislation (HR 8444) includes the use of expanded investment tax credits as an incentive for cogeneration.

It was suggested that one of the problems that might limit a nonelectric utility from going into cogeneration is the fact that its electric sales (presumably to the electrical grid) would bring it under federal regulations. (An individual gas company or a private heating company generating steam for sale in boilers is not subject to federal regulation, there being no federal responsibility for local sales of steam or hot water.) The government is considering exempting some industries from FERC jurisdiction as an encouragement to cogeneration. There is also a possibility of the Federal Energy Regulatory Commission intervening in state cases to encourage higher rates of return for cases where cogeneration can be shown to have an overall social benefit.

There is felt to be a need to improve communication between the various state regulatory commissions and FERC, and some effort is now being directed toward increasing coordination among the state agencies and FERC.

Would it become easier to site fossil-fueled district heating plants in populated areas if it can be shown that overall air quality for the area is improved? The problem of siting plants was seen to be primarily one of their impact on air quality. Current regulations require that new plants in urban areas be allowed only if they do not degrade air quality. While in general the Public Utility Commissions do not enter directly into the approval of plant siting, the Commissions would be interested in encouraging improvement in overall air quality through cogeneration, especially if this resulted in increased efficiency of energy generation.

It was felt that it might be easier to replace old plants with new ones using the same urban site. It was pointed out, however, that in areas where space heating uses nonpolluting fuel (natural gas, or electricity) rather

than oil, the environmental benefits that could be obtained by supplying heating from a central plant fired by fossil fuel rather than by individual heating units would be achieved only if there were severe curtailments in supplies of gas which threatened conversion to oil (assuming that restrictions were also placed on the expansion of electric heating).

Part 2. Implementation Scenarios. There were few comments given with respect to the Implementation Scenarios of Part 2 of the protocol. Though interest exists in cogeneration, little enthusiasm was expressed for a large growth of district heating. One of the interviewees did see the possibility of supplying steam from local plants burning municipal solid waste. He felt that such a project should be supported by the federal government and the resulting low-cost heat could provide a needed attraction to help revitalize problem urban areas in his state. Such a project, he felt, would be under municipal control, and the electricity produced by this plant would be sold back to the local private utility.

One respondent did feel that providing service to industrial heat loads first was the preferred implementation scenario. Another interviewee commented, without singling out any particular scenario, that the major problems that would have to be overcome are siting, fuel transportation, environmental issues, and the ability to raise the initial investment for the distribution system.

Federal policy regarding the use of waste heat from gas turbines fueled by natural gas (which could make them easier to locate in urban areas) is currently being reviewed. Gas is not allowed as a fuel for new electric generation, and conversion of existing gas-fueled generation is being required. Under present policy, cases where there has been waste-heat recovery from natural gas-fueled turbines have resulted not only in the prohibition of elec

electrical generation, but also in the closing down of the associated steam generator on the fear that gas might be diverted to make electricity (e.g. Lake Superior District Power Company and Stoffer Chemical Company in Flambo, Wisconsin (RP 72-6)). Future government policy may introduce greater flexibility into such situations, though the needed assurance that cogeneration is carried on in good faith and at an acceptable level of efficiency could present difficult regulatory problems.

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UTILITY INTERVIEW COMMENTS

On the following pages are summaries of comments made during the interviews. The comments are grouped together under each item in the interview protocol, which may be found on page A.2.

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Part I--Historical Perspective

A. Maintenance and installation costs of distribution system are too high.

- A utility that is admittedly unhappy with its steam business finds that the costs of repairs in downtown area are difficult, and the costs of new installations are almost prohibitive.
- For a utility with an extensive district heating system, it is not so much maintenance but installation. Installation costs are extremely high reaching as high as \$1200 per foot. The biggest part of this expense is in terms of excavation and labor, with piping costs adding only incremental differences. For example a 24-inch pipe size can be laid for about \$1,000 per foot, while a 30-inch pipe size will cost approximately \$1200 per foot for distribution in the most densely populated parts of the city.
- A utility currently examining the potential for district heating growth sees maintenance costs as no problem. However installation costs are very high, and have prevented the system from expanding. A customer who desires heat must pay to have the system extended to his facility, and because of these costs the system has been fairly static.
- One utility feels that maintenance and installation costs are not too high when the load is located near the existing distribution system. However, if new pipes are needed to service the load, the costs tend to be very high.
- The costs of distribution are not too high in high-density areas. The costs of distribution are too high in low-density areas.
- Maintenance is not a major factor. Installation costs are the important problem. In this city there are a lot of narrow streets under which run many other utility lines, which makes it difficult to locate distribution piping.
- Maintenance is not a problem but installation costs are an extreme problem. In this city the cost of installing the main is approximately \$200 per foot. There is often a conflict with other utilities locating distribution pipe in the vicinity of their underground lines.

- A utility that has only two very large customers for steam finds that maintenance problems exist, but that they are not severe (the systems being only five years old, with the loads located approximately 2,000 feet away from the steam generators).
- For a utility whose steam service started with urban redevelopment, the cost of distribution now seems to be very high primarily due to escalating installation costs. Furthermore, with increased system age, the cost of maintenance also is going up (this district heating system is now 15 years old).
- While maintenance costs are not a severe problem, installation costs for a utility in a dense urban area run between \$300 and \$1200 per foot.
- Maintenance and installation costs of the distribution system are not too high. Extensions have been made with contributions from customers, and they are happy to do so to obtain satisfactory steam service.

B. The utility is not allowed to price steam at a profitable level.

- For a utility with a large district heating system, the problem is not that the utility is not allowed to price steam at a profitable level because of regulatory constraint. The reason that they cannot make an adequate return on steam for sales is that the pricing must be set to meet competition. This utility foresees losing an additional 25 percent of its customers in the near future unless they are able to make the steam service more attractive. If the trends of customers going into their own equipment continues, the utility may seek to try to burn a higher sulfur content of coal, taking advantage of the possibility of reduced low level emissions through the use of tall stacks.
- Steam sales for one investor-owned utility are regulated by the city council while electric sales are regulated by the public service commission. This utility believes it has not received a fair rate of return from the steam sales. Steam sales have been hurt particularly through the loss of customers during the 1960s to gas.
- A utility that has very little steam sales observes that the pricing of steam at a profitable level would not be a problem because steam sales are not regulated.
- For a utility whose steam sales are not regulated, it is possible to price the steam at a profitable level and meet the competition of alternative heating sources.

- The heating subsidiary of one utility is not regulated; however, in order to price steam at a profitable level, cogenerated electricity must be sold to the grid at an appropriate base rate.
- A municipal utility prices steam on a break-even basis. Steam sales are not regulated by the Public Utilities Commission but by the City Council.
- Steam sales generated by the subsidiary of one gas company are unregulated. The legislature has examined the problem of regulation of these steam sales, however, and the prospect exists in the future that regulation will be imposed.
- A gas utility that does not have a franchise to sell steam at present expresses interest in installing steam systems at large sites and refurbishing steam systems within buildings. If they go into the business, they would hope to supply steam through a subsidiary that would be unregulated.
- One utility comments it has been able to price steam at a profitable level largely because of the nature of the loads served (their customers are primarily commercial, with a few industrial customers, but very few residential customers). They feel that rate increases have been granted because there has been no arousing of public opposition.
- One utility feels that it is able to price steam at the same profit level as electric sales.

C. Heat load is not sufficiently diverse, resulting in poor load factors.

- For a utility large steam system, the heat load was felt to be fairly diverse, yielding a load factor of about 35 percent. For this steam system the summer load was aided by a large amount of air conditioning.
- A utility cited the lack of air-conditioning load as the primary reason for having a load factor in the neighborhood of 20-30 percent.
- Lack of air conditioning demand in a utility's district heating system causes the load factor to drop dramatically in the summer. In 1976 the load factor was 23.3 percent, and the difference in steam sales at peak sales winter to summer is a factor of about 10:1.

- Thirty percent of the steam sales for one utility are allocated to a large cannery, which helps provide for a summer balance. However, the cannery's operation sometimes extends to the winter months, which causes problems.
- The annual load served by a utility with an annual load factor of about 40 percent is concentrated mostly in the four-month period December to March. Minimum steam service in the months of May and September amount to approximately 20 percent of the peak winter demand. Poor load factor is considered a major difficulty.
- A utility with an average annual load factor of 35 percent (which it considers poor) observes that there is not a sufficient industrial base. This utility has summer loads requiring chilled water, but there are separate distribution systems for the steam and the chilled water. This utility complains of problems with daily load factor. Conservation efforts have resulted in a 30-percent loss of load to commercial buildings as heat is turned off when not needed. This has resulted in a reduction in total demand but in little reduction in peak demand.
- Annual load factor for one utility is about 39 percent. There is a proximate 10:1 ratio between winter peak and summer peak steam demands.

H. Heat load densities are too low in presently accessible areas.

- One utility admits that it has tried to expand to obtain higher heat load densities and has failed in the effort, finding retrofit almost impossible. Growth was possible only in the downtown area accompanying rehabilitation projects.
- While one utility finds that it has a good load density, concern is expressed that there have been losses as older buildings have been torn down.
- For a utility serving a large city, load densities are adequate in presently served two-by-three-mile downtown area. They are still reasonably high in adjoining areas, where there are medical and university complexes and other business areas. No expansion is being sought actively in these areas at present. An apartment complex of over 50 units would be considered as a feasible addition to the existing system if it were reasonably close

to an area that is presently served. Single-family residences are not considered candidates for expansion. At present this utility is looking into and evaluating possibilities for future expansion.

- One utility maintains a dense heat load by serving high-rise buildings.
 - The downtown area served by one gas and electric utility does not have sufficient density, and it is felt that the customers could be served better by gas rather than steam.
 - A utility that considers density to be optimum in the areas currently being served, feels that beyond these areas densities are too low for expansion.
- E. In the present regulatory environment, cogeneration of steam works against the production of electricity at the lowest cost.
- A utility that produces all of its steam from boilers burning gas or oil observes that current regulations require that new plants burn coal. Cogeneration therefore would not be possible in plants located close to the central downtown area of the city.
 - A large utility that generates about 50 percent of its steam by cogeneration, believes there is no penalty to electric customers.
 - A utility that has no cogeneration and generates all of its steam in boilers believes that cogeneration does work against the production of electricity at the lowest cost.
 - Although one utility has no cogeneration in its system and all of the steam is produced through coal-burning boilers, it feels there would have to be a better regulatory environment in order to make cogeneration economically feasible.
 - For a northwest utility, severe air quality problems prevent the use of coal-fired steam plants (current plants burn hogged fuel--a mixture 80 percent bark and 20 percent wood fiber, which comes from mills in the area and is an environmentally benign fuel), and hence limit possibilities for cogeneration. Steam for district heating is generated in boilers that also may be used to supply turbines for peaking. Interruptable steam loads give flexibility to this arrangement.

- A utility that uses backpressure turbines in a topping cycle has no serious regulatory problems regarding cogeneration.
- In a fairly large steam district heating system, 50 percent of the steam is produced by backpressure turbines in a topping cycle. The cogeneration units are said to be very efficient, and for these units steam sales have preference over electrical generation. While steam sales are unregulated for this utility, FPC allocation rules are followed in allocating costs, and no problems are encountered.
- Cogeneration of steam does not necessarily work against the production of electricity at the lowest cost. However, electricity produced from cogeneration must be sold to the grid at a fair rate to avoid penalizing electric customers.
- In a moderately large steam system, steam from topping turbines is supplemented by low-pressure boilers. Cost allocation is complex but the utility is able to do it in a satisfactory manner and has no problems with regulatory commissions.
- Most of the steam sales for one utility are generated in steam boilers, and it is asserted that cogeneration of steam definitely works against the production of electricity at the lowest cost. Cogeneration is a highly inefficient system--actually "an expensive giant steam reduction valve." It is further asserted that there would be regulatory problems associated with cogeneration.

F. The old steam systems are not compatible with new turbo-generation equipment.

- For a large utility steam system, new steam system capacity will make use of topping units; there appears to be no serious difficulty of compatibility. (This utility currently generates about 50 percent of its steam demands from topping and extraction turbines that are oil fired.)
- For a utility that generates all of its steam in boilers, there is felt to be a degree of incompatibility with respect to old steam systems and new turbo-generation equipment.
- For a utility where there is no cogeneration at present, new turbo-generation equipment is not perceived as being incompatible with old steam systems. The low pressure of old systems can be made compatible through the use of suitable heat exchangers.

- A utility that uses only boilers to produce steam believes old steam systems to be compatible with new turbo-generation equipment.
- A utility with no cogeneration at present nonetheless perceives old steam systems to be compatible with new turbo-generating equipment.
- For one moderately large utility that generates about 50 percent of its steam in topping turbines, old steam systems are generally seen as compatible with new generators. (It is pointed out that this may depend on the construction standards: for this utility's steam distribution system, steam is carried at 300 lbs. per square inch in the new mains and at 250 lbs. per square inch in older mains.)

G. It is difficult to find plant sites from which to serve new areas.

- Sites for new plants would have to be located more than 10 miles from the downtown areas served by one utility, and therefore cannot contribute to expanding downtown sales of steam. For this utility there are no good candidate new areas where a plant is feasible and where the heat load densities are sufficiently high. Even gas turbines may not be located downtown because of noise and air pollution.
- While it is difficult to find plant sites from which to serve new areas, a utility serving a large metropolitan city has been able to rebuild on sites where existing plants have become obsolete.
- One utility admits it would be difficult to find plant sites in their urban areas served. However, they have not been looking to expand. All of the heat for their steam system is generated in one plant, and at present they have excess capacity.
- One utility has sought to increase its capacity by expanding plants at older sites; approximately 50 percent of the steam load is supplied from cogeneration turbines at these plants, many of them now burning coal.
- A utility that has a moderately large steam load agrees that plant sites are difficult to find if it is required that the plants must be close to the load served.

- One of the problems in siting is the noise level of the plant, but noise levels may be reduced at some economic penalty. One utility now is evaluating possibilities for noise reduction in their study of serving downtown redevelopment from proximate plant sites.
- The last plant built to serve the moderately large steam load of one utility was built 20 years ago, and there was no problem in siting. While their steam load growth has been fairly flat over recent years, increases in capacity could be built at their existing sites.
- A gas utility that serves a small heat load owns several sites that are felt to be adequate to serve any area in the city.

H. Competition from individually packaged heating/cooling plants is too great.

- For a utility with a large steam system, competition from individually packaged units is great. The price of steam is increasing faster than the price of private systems. (For this utility capital costs range between \$30 and \$40 per pound of steam boiler capacity, while for private customers these costs range in the vicinity of \$10 to \$15). Equipment for the steam system is deteriorating at a faster rate than the utility can replace it economically. Where the customers' load factor is sufficiently high, customers will find it profitable to generate steam for themselves. For example, apartment houses find it economically advantageous to install private systems. If the customer's heat load factor is greater than 30 percent he can probably generate steam at about one dollar less per thousand pounds than the utility can sell it to him for. (Steam is priced by this utility at about \$7 per thousand pounds.) The tax situation in this city also is prejudicial in favor of private heating plants; utility steam charges must reflect a gross revenue tax, a city sales tax, and a fuel usage tax, while a customer who generates steam in his own plant faces only a fuel usage tax.
- For one utility, competition is not so much from individually packaged steam boilers but rather from sales of electric heat or from gas heat sales. For this municipal utility in the Northwest, electric prices are so low that electric heating provides the main competition.
- One utility sees packaged boilers as providing serious competition because they use available natural gas. This situation is seen to be changing in the near future as natural gas prices rise.

- A northeastern utility finds that there is heavy competition from individually packaged boilers. The primary fuel in this area is oil, and private customers can use domestic oil which, even though purchased in small lots, is only slightly more expensive than the low-sulfur imported oil that the utility is required to burn. Operation and maintenance costs are lower for individual boilers because there are no transmission and distribution heat losses. Furthermore, high pressure utility steam systems in this state are required to be operated by licensed operators, while low-pressure systems of individually packaged heating plants are not, and this adds an additional expense to utility operations. In the city in which this utility operates, there are municipal taxes on the plant and distribution system of the utilities steam system, but such taxes are not levied against individually packaged boilers. (The utility is investigating this apparent inequity.)
- A utility with a moderately large steam system has not found competition from individually packaged units great, and in fact the utility steam system has taken over customers from some of these units. However, it is pointed out that customers are constantly studying the economics of supplying their own steam, but in the past three years the utility has lost only one customer due to individually packaged steam units.
- A utility that has not suffered from competition with individually packaged plants feels that individual plants will be less attractive because of the oil crunch. (Many individual units are oil fired, while the utility steam system is fueled by coal.)
- A gas utility does not find serious competition from individual boilers largely because the PUC has restricted the amount of gas to new customers. For environmental reasons customers cannot burn coal and must use oil, and against oil, this utility with a small steam systems feels it can be competitive.
- One gas company comments that though it does not produce steam as a by-product (that is, by cogeneration) and therefore does not have the advantages of shared fuel costs, they are nonetheless able to meet the competition in heating. A strong customer attraction to their system is supplied by offering chilled water for air conditioning.

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Part II--HTW Systems Characteristics

Positive Attributes

A. Lower cost of delivered energy (i.e., both electricity and heat may be produced by cogeneration at lower costs than separately).

- A primarily hydroelectric-based utility finds that it cannot make economic sense out of cogeneration. For this utility, thermal generation is used primarily for peaking. During nonpeak periods it would not be economical to use thermal generation in order to meet heat demands.
- A utility with low winter heat demand expresses skepticism that cogeneration could be done economically, except after peak hours when reduced electric demand might allow the bleeding of excess steam for sale.
- Concern by one utility is raised with regard to legal problems associated with cogeneration; union problems; questions of whether the equipment for cogeneration can be economically manufactured; proof of the reliability of the system; and finally, will it make money for the utility over the long term? It is felt that a long-term commitment would be required of thermal customers in order to justify utility investment.
- The lowered cost of delivered energy is rated very high by this utility, but it is believed that the best source is the utilization of waste heat from fuel cells rather than cogeneration.
- While the lowered cost of delivered energy is rated high, more important is a commitment to broader energy issues on a national level, e.g., conservation.
- Lowered costs of delivered energy are of prime consideration: "This is the bottom line."
- A comment is made by one utility that extraction and back-pressure turbines are very complex devices and complicated to operate; skepticism is expressed as to the overall energy efficiency of cogeneration and over whether lower energy costs could be achieved. This essentially coal-burning utility feels that the best utilization of fuel is not obtained through cogeneration, and that separate boilers are preferred to generate heat for the district heating system.

B. Increased efficiency of energy usage.

- Efficiency by itself is not important; economics are the major criterion.
- For a California utility, increased efficiency of energy usage is a very important issue in the state's regulatory climate.
- Skepticism is expressed by one utility as to the potential of increased efficiency for energy usage with a turbo-generator. It is doubted that the sale of steam or hot water could bring a high enough price to offset the loss in electric revenues from the degraded generator.
- A utility giving increased efficiency of energy usage the highest rating, says this goes hand-in-hand with producing energy at lowest cost.
- One utility comments that they are vitally interested in increasing energy efficiency, e.g., in bringing the total energy efficiencies of turbo-generators from 33 percent to 80 percent. However, such possibilities must be shown to be economical from a total corporate point of view.
- One can always improve efficiency by increased investments. The question is, are they economical?
- One utility agrees that increased efficiency is a valuable attribute, but discovers this has little to do with the market unless there are suitable economies. For this eastern utility, concern about fuel availability makes the efficiency of energy usage (both for electricity and for district heating) an important item. However, it is pointed out that the issue ultimately will be reflected in fuel costs.
- A California utility points out that conservation is very big in California and increased energy efficiency thus is very important.

C. Reduction in thermal pollution effects.

- For one large eastern utility, thermal pollution problems now are reduced by supplying its district heating system with cogenerated steam.
- While cogeneration can help meet the thermal pollution problems, one utility points out that it is able to meet its regulations requiring that the discharge be no greater than 5° above ambient river temperature.

- A northwestern utility expresses the feeling that there will be no thermal pollution problems in their climate.
- Comment is made that thermal pollution is a "political football" and that we should not be as concerned about it as we are. However, it is agreed that a reduction in thermal pollution effects might give a greater flexibility in plant siting.
- One utility feels that there will be little reduction in thermal pollution effects because it will not be possible to store all of the heat generated during the summer.
- For a California utility, reduction in thermal effects is considered very important in relation to present regulatory concerns.

D. Ability to expand the space-heating market.

- A utility with a district heating system sees too many problems in the expanding of the space-heating market by district heating. It is felt that this will duplicate this company's existing gas distribution system.
- A western municipal utility is thinking of using geothermal source for expanding the space-heating market. However, low electric rates compete very severely for the space-heating market.
- For one utility with a moderately large district heating system, the ability to expand the space-heating market is seen as a definite attribute.
- An eastern utility with a moderately large district heating system would take advantage of the possibility of expanding its space-heating market by being aggressive in attracting customers in their downtown area.
- A comment is made that restrictions on natural gas in the areas served by a midwest electric utility are forcing people to consider heat pumps for space heating; industry converting from natural gas is beginning to consider the use of electrode boilers.
- A gas company without a district heating system now supplies space-heating market with gas. It is felt that district heating would duplicate their own energy distribution system.

- One utility, with a low demand for residential space-heating because of climate, comments that it might be interested in expanding the space-heating market in industrial development areas. There is no interest, however, in going into the residential/commercial absorption air conditioning market because the technical skills for operating and maintaining such a network are not available in their area.
- For a northwestern utility that is largely hydroelectric-based, the space-heating market will be primarily served by cheap electricity.

E. Enhanced public image and greater public acceptance of the utility.

- A utility with a district heating system suggests that a HTW system would provide an opportunity to serve heating customers with an alternative to steam and that the availability of this choice would enhance their public image.
- For one utility with a district heating system, attempts to point out that district heating results in a better air quality have not been successful: people do not seem to appreciate efforts along this line by the utility.
- One municipal utility does not see public image as an issue. Since the city council responds directly to the desire on the part of the voters, utilities serve the public's wishes.

F. Increased rate-base.

- The observation is made that any benefits from an increased rate-base would depend upon the attitudes of the Public Service Commission. The important thing is that the utilities should be allowed to maintain the same level of return on investment.
- One comment points to the fallacy in the assumption: utilities do not build just to increase their rate-base; they build to serve customers to earn an adequate return.
- One utility points out that increased rate-base is not advantageous for hot water sales but is an advantage for electric sales. This is because hot water sales face competition from other heat sources while electric sales

do not. The degree of capitalization (rate-base) is important in the regulation of electric revenues; hot water prices, however, must be kept competitive by minimizing capital investment. For these reasons, this utility, which has a moderately large district-heating system, likes to apportion the capital investment for cogeneration as much to electrical generation as possible.

- One utility observes that increases in the rate-base often result in regulatory delays before adequate rates-of-return adjustments are made.

G. Could free natural gas from existing space-heating applications for sale at higher prices for industrial uses.

- A combined gas and electric utility comments that any residential/commercial surplus of natural gas would be reallocated to other geographical areas rather than be allowed to be sold to local industry at higher prices.
- A combined electric and gas utility observes that this would especially help those industrial or large customers who are on an interruptable basis.
- A combined electric and gas company feels that freeing natural gas to sell to industrial users at higher prices would work only for a short time, that regulatory action would follow to make adjustments so that the benefits would not accrue to the company.
- Freeing natural gas for industrial use is seen by one utility as going against the policy of conservation of natural resources.
- A combined electric and gas utility feels that since most industrial customers are on interruptable service, a large portion of any natural gas freed would be reallocated to other geographic areas.
- An eastern combined electric and gas utility points out that the residential customers pay higher prices for natural gas than do industrial customers.
- A western gas company observes that while they do get higher prices for gas sales to industrial customers, there is enough gas available for the industrial market.

H. Opportunity to provide total heating sales and service (heating system, including heat exchanger; building insulation).

- A utility with a district heating system observes that they have this opportunity now.
- One utility without a district heating system comments that providing such services would involve them with different regulatory groups and this would not be attractive. This utility does allow customers to finance insulation through utility billing, but the utility contracts this service and does not own the insulating company.
- A municipal utility observes that is not consistent with their charter to provide total sales and service.
- A utility with a district heating system believes that most utilities are not allowed by their regulatory commissions to provide total heating sales and service.
- One utility, a holding company, pointed out that there are SEC limitations on diversifications that can be made.

I. Need for cooling towers may be eliminated for turbines operating in backpressure mode.

- One utility suggests that there would be difficulty in getting a properly matched load even with the use of storage, and that cooling towers still would be needed. However, it may be possible to reduce the size of the cooling towers.
- One utility sees the elimination of the cooling towers as an asset in plant siting.
- The comment is made that it is not possible to eliminate cooling towers (though it may be possible to reduce their size) because tying generation of heat and electricity together would limit need for electric production.
- Certain types of systems may use dry cooling towers rather than wet cooling towers but all systems must use some form of cooling tower. However, the attribute may give greater flexibility in plant siting.

- Elimination of cooling towers will require storage. If the storage is to be in underground aquifers, it is felt that there would be great environmental problems in the southeastern areas served by this utility.
- For one utility the idea of the elimination of cooling towers is simply pretty far-fetched.

J. Storage of waste heat may be profitably coupled with other energy storage systems.

- A utility with a very large district heating system comments that if the state-of-the-art would allow this to be exploited economically storage could become a very important factor.
- One utility expresses difficulty in realizing how storage of waste heat would relate to other forms of energy storage.
- One utility, while interested in different ways of load-leveling believes getting a district heating system started would not be inhibited by any lack of ability to store heat.
- One utility sees the advantage of storage as helping the load factor but points out that storage will not help the load factor for the distribution system, which represents the major factor in investment in district heating.
- A California utility suggests that the underground problems with seismic balance may make the implementation of aquifer storage difficult.

K. Development of profitable district heating on a large scale will provide desirable investment diversification.

- A utility with a district heating system observes that diversification is important if profitability can be demonstrated, but feels that HTW systems would not be profitable.
- One utility comments that they already have diversification through their present steam district heating and does not see much diversification benefit from HTW systems. For

this utility, with a moderately large district heating system, electric sales still represent 95 percent of their overall revenues, and steam sales do not get much corporate attention or resources.

- The attractiveness of HTW systems as investment diversification would be dependent on the profitability of the system; critical would be how the costs were allocated between electricity and heat production. This utility with a district heating system feels that no policy has yet been articulated by their PUC, which is particularly encouraging to the development of the district heating.

Negative Attributes

A. Difficulty of allocating costs between electricity and heat.

- One utility with a district heating system points out that this is an important item for them because electric sales now are regulated by the public utilities commission while the steam sales are regulated by the local city council in the city they serve.
- For a utility without a district heating system, the difficulty of allocating costs between electricity and heat is seen as a serious problem, and it is observed that the utility would not go into the venture unless the cost allocation allowed by the regulatory body was favorable.
- A utility without a district heating system sees problems of allocating cost between electricity and heat as tractable technical problems only.

B. Difficulty of raising capital for new venture.

- One utility pointed out that lease-back type arrangements (in which a bank or insurance company purchases the equipment and leases it to the utility) of private plants are starting to occur. This may become a pattern for acquiring capital property in situations where there may be problems in raising capital.
- A utility with a small district heating system believes there would have to be some kind of government subsidies in order to expand district heating on a large scale.

- A utility with a moderately sized district heating system says it would be very difficult to raise capital for HTW system.
- A municipal utility with a triple A bond rating has no problem in raising capital.
- It is pointed out that the raising capital presents problems because of the time delay of regulatory response to rate increase requests.
- For one utility the raising of capital is very difficult largely because regulatory commissions do not allow a sufficient rate of return.

C. Difficulty of staffing-up for such an undertaking.

- A utility with a district heating system points out that staffing will be no problem if the venture can be shown to be profitable.

D. Need to get regulatory changes for transmission and sale of hot water.

- A utility with a district heating system points out that they have a charter for HTW systems and see no difficulty in getting necessary regulatory changes to implement such systems. The problem, however, is the time delay for regulatory approval, as it is with all regulatory actions.
- A utility with a moderately large heating system observes that obtaining the necessary regulatory changes for the transmission of hot water may be time consuming but otherwise should present no problems, provided it can be shown that the system will result in lower costs to the customer and is in accord with desired energy policies.
- One municipal utility points out that there would have to be a change in the city charter in order to implement district heating.
- A utility without a district heating system comments that it is not known what regulatory problems might arise, but observes that coal slurry pipelines have had regulatory problems.

E. Potential conflicts with the heating interests (oil companies, oil dealers, gas or electric companies, etc.).

- An electric utility with a district heating system says that competition "is what its all about," and HTW district heating would present no additional problems.
- A gas utility with a small district heating system foresees that there would be problems resolving conflicts with competing interests.
- A company with a moderately large district heating system suggests that potential conflict with competing interests will be no problem if the system is developed on a small scale and does not grow too rapidly.
- A utility with a moderately sized district heating system comments that potential conflicts with competing interests might be a problem if the gas and oil situation starts to improve.
- A municipal electric company says that the development of district heating may result in conflict with the local private gas company.
- A municipal electric company suggests that it is politically vulnerable to private competing interests.
- A gas company without a district heating system foresees fierce competition from oil and electric companies.
- A utility with a large district heating system suggests that the development of HTW system will raise potential conflicts with their own existing steam systems as well as with competing oil dealers.

F. Need to change laws regarding riparian rights for underground storage of water.

- A comment from a western utility suggests that HTW storage probably will not come under the riparian laws if the system is a closed system.
- It is pointed out that the situation may be analogous to underground storage of gas, which is done without difficulty now. However, water may seep into other reservoirs, and this may present problems.

- A utility in the Midwest suggests that there may be many legal problems associated with such water storage.
 - A utility in an eastern coastal state observes that much of their state is governed by riparian laws, which extend to areas once washed by the sea (such as drained marshes and spill-overs from estuaries).
- G. Need to set up an arrangement with an electrical utility to buy generated electricity or the need to set up an arrangement to purchase hot water from an electric utility.
- One gas utility would rather make their own electricity and hot water and sell the electricity back to a utility; however, it is pointed out that it is unlikely that they would set up a cogeneration scheme. A possible arrangement would be the purchase of hot water from an electric utility, though this gas company would prefer to be in complete control of the production of heat.
- H. The storage well is a necessary part of the system and its feasibility needs to be demonstrated in the utility's area.
- Though the storage well is seen as an integral part of the system, it is observed that it still will be necessary to be able to decouple the electric generating from the district heating load unless the district heating load is very small.
 - An eastern utility points out with respect to the storage well that people get very concerned about environmental problems and one cannot predict what may happen in terms of acceptance of such storage.
 - One utility comments that storage is unnecessary for their present district heating system nor would it be necessary for the proposed HTW systems.
 - A California utility says that if the storage well is necessary, security against earthquakes would have to be demonstrated.

I. Difficulty of installing distribution in settled areas.

- While settled areas present a major problem, service to new towns (such as Columbia, Maryland) would be considered a possibility by one utility if the district heating system could be designed and built as the town developed and if there were feasible plant sites nearby that could be used to provide the heat.
- The difficulty of installing distribution systems in settled areas is seen as a major problem. However, urban redevelopment may continue to provide opportunities where such installations will be easier.
- A utility with a district heating system sees no technical problems in installing distribution in urban areas, but feels that the cost is a very large problem. Public reaction to the inconvenience of tearing up streets also will have to be dealt with.
- For a western utility with a small district heating system, installation of an HTW system is seen as having fewer difficulties than a steam system. (Expansion of steam lines tend to cause problems.) For this utility the existing network of other underground lines (in particular oil-carrying pipelines) may make installation of district heating system difficult.
- A utility that has developed a steam service primarily to serve redeveloped areas in an urban center comments that while costs are very high, there are no technical difficulties in installing distribution in settled areas.
- A utility with a district heating system observes that installation of the distribution system in settled areas is difficult because there is already a lot of underground equipment in the streets. This combination electric and gas utility (that does not have a district heating system) observes that people complain about streets whenever distribution systems are installed, but their resistance can be dealt with.
- An all-electric utility without a district heating system feels that installing distribution systems in settled areas would be very difficult because of the public reaction to digging up of streets.
- A gas company observes that installation of district heating distribution is difficult primarily because there is already crowding of equipment under the streets and because of the difficulties in rerouting high-density traffic in urban areas.

- One electric utility observes that it is difficult to find routes in their urban area for underground cables that are much smaller than distribution piping. It also is suggested that there could be severe problems caused by thermal losses from the distribution pipes heating electric and communication cabling.

J. System implementation would detract from other energy programs currently being developed.

- For a California utility, district heating as an alternative to other programs could bring its own blessings. There is a feeling among the regulatory bodies that decentralization is the desirable goal--that "small is beautiful." There is tremendous competition to get enough electrical energy and gas supplies in California. The attractiveness of district heating might aid the utility in securing its needed share of fuel supplies and could be helpful in influencing plant siting decisions.
- For a midwestern utility, the potential associated with district heating is of primary interest.
- A utility with a district heating system perceives a HTW system as detracting from their existing steam system.
- A utility with a district heating system comments that top management is less knowledgeable about district heating than about other energy programs (the fuel cell for example), but that if district heating can be expanded profitably, it could move to the top of the priority list.
- A utility with a district heating system agrees that choices must be made. This utility now is looking into the possibility of solar and fuel cell developments.
- While one utility does not see district heating as seriously affecting other R&D programs, there is a feeling that the antinuclear people might use district heating as an argument against nuclear power.
- A western utility determined to burn less fossil fuel close to urban areas comments that implementation of district heating could detract from development of solar water heating and solar space conditioning.

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Part III--Implementation Decision

A. Do you think that a HTW District Heating System is feasible for your area?

- For a utility that is considering going out of the district heating business, an HTW system is seen as virtually impossible because of the problems of retrofitting. It is felt that expansion of the electrical distribution system in urban areas will be easier because the existing ducts can carry more cables. This utility is inclined to favor expansion of the use of heat pumps.
- A utility with a large district heating system considers it too difficult to convert from steam to hot water, though hot water systems may be possible in areas that are not currently served by steam.
- One utility without a district heating system observes that the HTW system would be very expensive in developed areas but might be possible in new areas.
- A utility with an existing district heating system currently is studying the possibility of either expanding its district heating with steam or converting to HTW, or possibly retaining the existing steam distribution and adding hot water system components.
- A northwestern utility believes HTW system would appear to be feasible only if supplied from a geothermal source.
- A utility with a district heating system feels that the current congestion on urban streets would prevent the installation of HTW systems.
- A gas company with a district heating system comments that if cogeneration can supply hot water at a sufficiently low cost, the conversion from steam may be feasible.
- One utility with a district heating system points to the difficulties of conversion from steam to hot water and to the difficulty of laying pipes in the streets, particularly with a hot water system that would require return pipe.
- A utility without a district heating system sees hot water district heating as marginally feasible on a small scale, and presently is studying the potential for limited areas in its territory.

- One utility without district heating comments that there may be a merit in district heating system in the downtown industrial and the new areas, but not in existing residential areas.
- A utility without a district heating system observes that HTW will not be feasible for their area. Most of the buildings in their area all have steam heating and there is not much new construction.
- A utility with a district heating system sees possibilities for HTW systems delivering heat to lower density markets at greater distances than can be served by steam, and comments that it would seek these markets if the economics allowed it.

B. What would be required in order to induce you to go into the venture?

- One utility can envision no inducement unless there were a severe energy shortage in competing heating fuels.
- For a utility with a district heating system, the required inducement would be a demonstration of the HTW system on a large enough scale to exhibit all of its problems and costs. This utility might consider doing the demonstration itself if it were supported. While they are not enthusiastic about the idea of a HTW system for large-scale district heating, they would look at a proposal if it were tied to a plant they were already planning to build.
- For a utility that is currently studying expansion of its present steam district heating system or conversion to a HTW system, the inducement to go into the venture would be profitability. However, if it should prove to be not economically viable by itself and some incentives in the form of subsidization were granted, the venture would still be considered.
- For one utility with a district heating system, a hot water system would have to be shown to be more economical than competing alternatives. Regulation problems would have to be ironed out and a permit or franchise obtained to distribute and sell the hot water. It is felt that a long time may be needed to obtain regulatory approval and that precedent with existing steam systems may not be sufficient.
- A gas company says it could enter into a joint venture with an electric utility for an HTW system. This company says it would be willing to consider such a venture, though no arrangements have been explored.

- A utility with a district heating system comments that inducements to go into the HTW system venture would be a demonstration of the feasibility of the storage well, assurance of a good load factor and load diversity, and the ability to be very competitive with other sources of heating.
- A utility with a district heating system would want to be assured that the HTW system would be commercially available with all of the bugs worked out and that there would be adequate metering for the sale of hot water available. A favorable demonstration of the system is emphasized as required in order to convince investors.
- Inducements to go into district heating for one utility would be a decisive economic advantage and the assurance of a strong market. Licensing problems for the district heating plant would have to be worked out, though there do not appear to be licensing problems with regard to a distribution system.
- Very favorable economics would be the only inducement to go into such a venture.
- For a municipal utility, demonstration of the economic feasibility and the potential for conservation of energy would be required inducements.
- For a northwestern utility, served largely by the hydro-electric power, district heating would be of interest only when their system requires a significant amount of thermal generation. This will only come about as a result of a dramatic increase in electrical demand.

C. It has been suggested that the present regulatory postures of the Federal Power Commission and state public utility commissions and existing rate structures based upon a fair and just return on evaluation of utility property and distributed costs are not conducive to utility investment in district heating. Do you agree? Do you have specific recommendations for changes in the regulatory environment?

- While one utility agrees that regulatory environment would not be a problem in the state, it is conceded that considerable time would be required to gain approval of HTW district heating scheme but that in the end satisfactory regulations could be achieved.
- Conceding that current regulatory environment is a problem, one utility feels that if district heating is made sufficiently attractive, the regulatory commission would be receptive to necessary changes in order to implement the scheme.

- A utility with district heating agrees that the present regulatory environment in the country may not be conducive to promotion of district heating, though the attributes of energy conservation associated with district heating may help change this. This utility feels that commissions must recognize replacement costs in the rate base as a step to obtaining an adequate rate of return on investments.
 - One utility points out that the regulatory posture often is detrimental because of regulatory delay. By the time a system is approved, cost relationships may have changed dramatically.
 - A utility that is considering district heating applications does not anticipate regulatory problems.
 - Regulatory delay has a greater impact on restraining investment than disagreements with regulatory commissions on adequate rate of return. This is pointed out by a utility that has found that its regulatory commission tends to ignore inflation and other relevant factors in this time delay, thus reducing the effective rate of return considerably.
 - A municipal utility, controlled by its own city council and not the state regulatory body, feels that publicly owned utilities may have an easier time implementing district heating.
 - A municipal utility feels that its city council would make a decision favorable to district heating based upon economic, environmental and energy efficiency considerations. In this state, the energy siting agency is sensitive to local concerns, and this could present some problems in the siting of district heating plans.
 - Regulatory lag needs to be shortened.
 - One utility sees some progress in regulatory attitudes. This utility now is allowed to use a projected cost for rate hearings rather than historical costs, but a problem still remains in that commissions do not allow adequate charges for cost of service.
- D. Several incentives have been suggested to induce utilities to invest in district heating or to seek rule changes that would make investment profitable. Among these incentives are a) an increase in investment tax credit, b) federally guaranteed loans up to 10 percent of investment requirements, c) federally funded grants to state public utility

commissions to aid in updating their regulations, d) accelerated depreciation for properties and equipment dedicated to waste heat conservation in recovery uses. Please discuss the above.

- The investment tax credit is an attractive strategy, particularly if subsidiary organizations are allowed to take advantage of it. Accelerated depreciation would also help.
- Both investment tax credit and accelerated depreciation are said to be helpful. No interest is expressed in federal loans. While observing that the regulatory commission presents no problem, the comment is made that the grants may facilitate their studies and thus provide some benefit.
- An increase in the investment tax credit will be helpful. Guaranteed loans seem like a good idea, but this utility with a district heating system suggests that 10 percent might not be an adequate amount.
- One utility points out that they are a flow-through company and therefore an increase in investment tax credits and accelerated depreciation do not provide much of an incentive. Even fully guaranteed loans would not be a strong incentive. Primary consideration is the economic attractiveness of the system itself.
- While an increase in investment tax credit would be good, even further steps might have to be taken such as tax-free bonding.
- One utility would not appreciate having federally guaranteed loans, commenting that it should not be necessary to do this if the system is economically sound. Increase in investment tax credit and accelerated depreciation would help, but neither one would be very significant. More significant incentives would be lower property, state, and federal taxes.
- An increase in investment tax credit and accelerated depreciation would help bring the capital costs down. However, federally guaranteed loans and grants to state regulatory commissions would be of no help.
- A utility with a double A bond rating is unenthusiastic about federally guaranteed loans. It is felt that this could unbalance their debt structure. An increase in the investment tax credit would help--how much would depend on their corporate tax situation at the time. Accelerated depreciation would be a positive step. They see no problems in their present regulatory environment and therefore see no need to make federal grants to state public utilities commission.

- A municipal utility comments that an increase in investment tax credit would help. Capital is raised with the backing of the city government and there is no need for the federal government to guarantee loans. Since they are not regulated, they have no problems with regulatory commissions. As a municipal utility, they pay no federal income tax, so accelerated depreciation is of no consequence to them.
- One municipal utility suggests that the Internal Revenue Service rules as they relate to tax-free bonds present a stumbling block to innovation in the energy field. It is felt that existing IRS rules constrain a municipal utility in raising capital through tax-free bonds for a multipurpose plant where the product may be sold to a private company for marketing (for example, sale of gas produced from a solid waste disposal plant that has been purchased by tax-free bonds to a private gas utility).

Part IV--Implementation Scenarios

Successful development of the sale of heat will depend on choosing a profitable course for expansion. How would you see integrated power generation developing? Please discuss the possible scenarios listed below.

- A. Installation of boilers (10-20 megawatt capacity) serving the needs of existing or newly built areas until such time as demand builds up to a level where connection to transmission from central plant is feasible.
- B. Developing service only in newly built areas (where distribution system may be installed as the area is built up) and proceeding as in (A).
- C. Waiting until there is sufficient number of customers to make transmission from central station feasible and then supplying customers only when major portions of the distribution system are installed.
- D. Providing service from substations close to load using waste heat from gas turbines (the utilization of waste heat permits the units to be used economically to generate base electric power).
- E. Providing service to industrial heat loads first to begin the network development with high volume users. Is there an industrial sector in your area that could become the first customer?

- For a utility with an already existing district heating system, none of the scenarios seem feasible. Scenarios A and B are ruled out since new boilers would have to be coal-fired, and the siting of such plants will be impossible. While industrial cogeneration presents a possibility, there is no large industry in this utility's area to make Scenario E implementable.
- A utility with a district heating system feels that Scenario D has potential, as they do have gas turbines in many areas and there is the possibility of utilizing waste heat at these locations.
- Scenario E seemed the most attractive and likely to this utility, which already has a district heating system. As for starting with small boilers, installation in new areas (Scenario B) rather than duplicating existing energy systems would be more desirable. While Scenario C seems quite difficult to accomplish, if it could be done it might help bring about favorable economics.

- For a utility with a district heating system, Scenario A seems a reasonable way to expand the system. As for Scenario E, there are industrial loads within one mile of this utility's current district heating system, and it is felt that these loads would have to be brought in to be an essential part of the system.
- A utility that has a district heating system and that is primarily a coal-fired utility does not believe it would use gas turbines in substations to sell heat or hot water. This utility does not see great advantages to cogeneration except in individual cases where an industry may be built sufficiently close to an existing plant to purchase the steam.
- None of the scenarios particularly appeal to this municipal utility with a district heating system. This utility sees itself providing heat service on a case-by-case basis to industry, but not as a prelude to developing a HTW distribution system.
- For a utility with a district heating system, Scenario A appears reasonable and no need is seen to restrict developments to new areas. Problems with noise pollution would prevent the use of turbines proximate to load centers (Scenario D). While Scenario E seems a reasonable way to begin such development, it is observed that there are no large industrial loads in this utility's area.
- For a utility examining the possibilities of going into district heating, the installation of boilers newly built areas seems eminently logical. It is pointed out that in Copenhagen there are both gas and hot water mains in the street and that when a person's gas heat system wears out, it is hoped that he will connect to hot water. A similar development could be foreseen in U.S. cities. However, while this utility has provided heat to some industrial loads, it is felt that cogeneration schemes will not expand rapidly, nor will district heating develop soon on a wide scale.
- One electric utility sees its future as building very large plants in remote areas to supply electric power to urban areas. The only possibilities foreseen for selling hot water is to large industrial customers located close to the generating plant and where the plant has been designed in advance to serve these customers.
- A municipal utility suggests that it may be feasible to install boilers to serve a new or existing area if gas is used as the fuel in order to meet air quality and noise standards. However, Scenario C is preferred if it can be shown to be feasible. Rather than using waste heat from gas turbines as

suggested in Scenario D, waste heat might be used from fuel cells or from batteries. As for Scenario E, serving industrial loads with heat does not yet appear to be economical in this utility's area.

- For a midwestern utility currently studying the industrial demand in their area in order to appraise the possibilities for cogeneration, Scenario E appears to be the most meaningful.
- To a utility now serving a district heating load in a re-developed urban area, Scenario B seems the most attractive, particularly if one can bring HTW systems into a new town, such as Columbia, Maryland.
- For a utility with a district heating system, Scenario E is the most plausible, though industrial process heat needs to be approximately 400° and up and a HTW system, therefore, may not be suitable. However, for this utility the scenario is discounted as there are no large industrial customers in their immediate service area. As for Scenarios A and B, installation of boilers would be costly, impractical, and risky. Scenario C is felt to be impractical because of the economic penalty of having to discard existing heating systems when connection to a central district heating is made.
- One municipal utility now is surveying its area to identify major industrial users of heat that are proximate to their generating plants and determine if sales of steam to them may be feasible. One of the motivating factors that may make the cogeneration attractive is the possibility of having lower emissions by utility generation of heat than are produced by the industries burning polluting fuels. Scenario B seems feasible, but concern is expressed about penetrating residential areas. Scenario D may be a possibility provided there are no emission problems.

B.1

Appendix B

NET SOCIAL BENEFITS - QUANTITATIVE CALCULATIONS

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NET SOCIAL BENEFITS - QUANTITATIVE CALCULATIONS

Industrial Sector

The IEU social benefits model was constructed on a regional basis for four regions--the Northeast, North Central, South and West. Although the input data varies regionally, the methodology and ordering of the equations do not. The model is described without mention of the regional segmentation; however, the process does take place for each of the regions.

For each of the alternate industrial generation technologies in each time frame, the change in industrial demand is equal to the product of the potential demand and the difference of the penetration levels with and without high temperature water (HTW). That is,

$$C_{s,t} = (P_{s,t} - Q_{s,t}) (M_t - M_{t-1})$$

where

C = change in industrial demand
 P = system penetration without HTW
 Q = system penetration with HTW
 M = potential industrial market
 t = time period
 s = system type

The cumulative industrial HTW market for a time period is equal to the cumulative HTW market from the previous time period plus the product of the potential industrial market and the industrial HTW penetration. That is,

$$I_t = I_{t-1} + S_t (M_t - M_{t-1})$$

where

I = Industrial HTW market
 S = industrial HTW penetration
 M = potential industrial market
 t = time period

Because the different industrial systems will be built in different years, it becomes important to define the cost of delivered energy in a given year for a plant built in another year, since a plant built at one time will have cost escalations different from those of a plant built at a different time. The earlier plant will have different capital costs than the later plant, even if the efficiencies do not differ. For each system, the dollar cost in year t of the delivered heat from a plant built in year y is equal to the initial cost plus an escalation factor. That is,

$$\$_{s,y,t} = D_{s,y} (1 + E_s)^{t-y}$$

where

$\$$ = cost of delivered heat from system s , built in year y ,
in time t
 D = cost of industrial system s , built in year y
 E = escalation rate for system s
 s = system
 y = year system built
 t = time

Having developed these costs, it is possible to develop the consumer surplus for industrial systems. That is

$$B_t = \sum_s B_{s,t}$$

$$B_{s,t} = \sum_y C_{s,y} (\$_{s,y,t} - H_t)$$

where

B = Consumer Surplus for industrial systems (i.e., change
in total cost)
 C = change in industrial demand
 $\$$ = cost of delivered heat from system s , built in year y ,
in time t
 H = HTW cost of delivered heat
 s = system
 y = year system built
 t = time

However, the consumer surplus is only a part of the net social benefits. It is necessary to add the profits that would be accrued by the innovation, less the profits that would have been accrued by the competitors. The

competitors' profit is defined by the cost of the fuel delivered by each system times the profit to sales percentage for the fuel. Therefore,

$$A_t = \sum_s A_{s,t}$$

$$A_{s,t} = \sum_y (C_{s,y}) (\$_{s,y,t}) (F_s)$$

where

A = industrial competitors' profits
 C = change in industrial demand
 \$ = cost of delivered heat from system s
 F = profit to sales percentage associated with the fuel
 for each system
 t = time
 s = system
 y = year system built

The profit accrued from the HTW system is equal to the product of the HTW market, the HTW delivered energy cost, and the profit to sales percentage.

That is,

$$G_t = I_t (H_t) (F_s)$$

where

G = HTW profits
 I = industrial HTW market
 H = HTW cost of delivered heat
 F = profit to sales percentage
 t = time
 s = system

While these functions are aggregated later in the model, the information is now available to derive the net social benefits accrued by industrial use of the innovation. That is, the net social benefits are equal to the consumer surplus plus the resource savings (HTW profits minus competitor profits lost).

Residential & Commercial Sector (R&C)

As was the case with the industrial sector, the R&C sector was developed on a regional basis. Again, the modeling process is described as if there • were no regional segmentation.

Because the different R&C systems use various fuels at different efficiencies, with different capital-equipment-fuel ratios, it is necessary to adjust the data so that the fuel costs are on a common basis. This common basis is the input cost of fuel need to produce the required heat output. Therefore,

$$O_{s,t} = (Z_{s,t}/J_s) (T_s)(1.06)^t$$

where

- O = adjusted cost of system
- Z = input cost of fuel
- J = system efficiency
- T = multiplier to include capital costs of system
- 1.06 = 6 percent inflation rate
- s = system
- t = time

For each residential and commercial system the cumulative change in demand is equal to the cumulative total for the previous time period plus the product of the change in market penetration for each system with and without HTW, and the change in R&C market demand. That is,

$$C_{s,t} = C_{s,t-1} + (K_{s,t} - L_{s,t}) (N_t - N_{t-1})$$

where

- C = cumulative change in R&C demand
- K = R&C market penetration without HTW
- L = R&C market penetration with HTW
- N = potential R&C market demand
- s = R&C system type
- t = time

As was the case in the industrial sector, the consumer surplus is equal to the change in demand multiplied by the system cost differentials with and without HTW. For matters of modeling convenience, the consumer surplus for the R&C sector was cumulative. Thus,

$$B_t = \sum_s C_{s,t} (O_{s,t} - H_t)$$

where

B = consumer surplus
 C = cumulative change in R&C demand
 O = cost of fuel (input cost)
 H = HTW cost of delivered heat
 t = time
 s = system

When other system benefits (fuel availability, safety, cleanliness) are included in the benefit calculations they are subtracted from the costs ($O_{s,t}$ and H_t). If the difference in costs is still negative the value of $C_{s,t} (O_{s,t} - H_t)$ is set to zero under the assumption that the net benefits to the consumer must at least remain the same, they cannot decline.

Similarly, for each system the profit for the competitors is equal to the product of the change in demand, the cost of the fuel, and the profit percent. That is,

$$A = \sum_s C_{s,t} (O_{s,t}) (F_s)$$

where

A = profit for competitive systems
 C = cumulative change in R&C demand
 O = cost of fuel
 F = R&C profit percentages, for each system
 t = time
 s = system

The cumulative R&C HTW market is equal to the HTW market in the previous time period plus the product of the HTW penetration and the change in R&C market. That is,

$$R_t = R_{t-1} + S_t (N_t - N_{t-1})$$

where

R = R&C HTW market
 S = R&C HTW penetration
 N = potential R&C market
 t = time

The profit for the HTW systems is expressed by

$$G_t = R_t (H_t) (F_s)$$

where

G = HTW profit
 R = R&C HTW market
 H = HTW cost of delivered heat
 F = profit to sales percentage
 t = time
 s = system (in this case, HTW)

The residential and commercial resource savings associated with the innovation is defined by the HTW profits minus the competitor profits which are lost, or

$$R_t = G_t - A_t$$

where

R = resource savings
 G = HTW profit
 A = profit for competitive systems
 t = time

Net social benefits are the sum of consumer surplus and resource savings for both industrial and residential and commercial.

C.1

Appendix C

THE FINANCIAL ANALYSIS MODEL

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THE FINANCIAL ANALYSIS MODEL

The computer model used for the financial and risk analysis in this report was written within a software package called PAUS (Planning and Analysis in Uncertain Situations), which is a proprietary product of Bonner & Moore Associates, Inc. and available through the National CSS, Inc. time-sharing network.

The complete model is displayed in Figure C.1. The initial 39 statements with their associated descriptions define all the input and output variables. Included here are all the variables that have distribution functions associated with them as well as fixed data constants. The remaining statements included between the "DEFINE MODEL" statement and the "ENDJOB" statement are the instructions (written by The Futures Group staff) that carry out the intended financial analysis.

The control file contains the modifications to the main program needed to execute a particular case. A sample set of numbers is shown in the figure. Any of the data variable constants or distribution function-parameters may be modified at this time and data variables can be changed to distribution functions and vice-versa.

The statement "Run 100" causes the model to be executed 100 times, with values picked randomly from all distributions on each single run, and automatically generates output histograms.

The requests file provides instructions for printing the output histograms. In this case the instructions call for the printing of the histograms of costs per million Btu for every fifth year. An example of such a histogram is displayed in Figure C.2.

MODEL FILE

```

TITLE 'UTILITY PROB VENTURE ANALYSIS'
DEFINE LABELS
BTUP      DATA 1      'MIL BTUS PER PLANT PER YEAR'
REDU      DATA .25    'ELECT REDUCT FOR HEAT'
STFA      DATA 1      'STOP/NO STOP FACTOR'
RAOM      DATA 1.06    'ESCALATION RATE FOR O+M'
FICR      DATA .15    'FIXED CHARGE RATE'
ESRA      DATA 1      'ESCALATION RATE FOR CAP COSTS'
TRAN      DATA 0      'TRANS COST MEAN'
DIST      DATA 0      'DIST COST MEAN'
TRDT      BETA1 .67 2.0 1.0 'TRANS/DIST COST FACTOR'
EQUP      BETA1 1 3 2    'HEAT EQUIP CAP COSTS'
PLCS      BETA1 1 3 2    'PLANT CAP COSTS'
AQCA      BETA1 1 3 2    'AQUIFER CAP COSTS'
HTDQ      BETA1 1 3 2    'HEAT EQUIP+TRANS/DIST O+M'
AQOP      BETA1 1 3 2    'AQUIFER O+M COSTS'
QPMR      BETA1 1 3 2    'FIXED/VAR PLNT O+M COSTS'
FUEL      BETA1 1 3 2    'PLANT FUEL COSTS'
RECO      BETA1 .50 .80 .65 'RECOV/CONFIG FACTOR'
FESR      DATA 1.07    'FUEL ESCALATION RATE'
CDLT      DATA 1      'ESCAL RATE FOR GAS TURB COSTS'
BTUR      DEPEND        'AVAILABLE BTUS'
PLNT      DEPEND        'YEARLY PLANT COSTS'
TRAD      DEPEND        'YEARLY TRANS/DIST COSTS'
EQCS      DEPEND        'YEARLY EQUIP COSTS'
STCS      DEPEND        'YEARLY AQUIFER CAP COSTS'
CAPC      DEPEND        'TOTAL HEAT CUST CAP COSTS'
DELT(1/30) DEPEND        'HEAT CUST PLANT PER CENT CHARGE'
HCAP(1/30) DEPEND        'YEARLY HEAT CUST PLNT CHARGES'
YPLT(1/30) DEPEND        'YEARLY ESC/NOT ESC PLNT CAP COST'
YOPM(1/30) DEPEND        'YEARLY HEAT EQ+TR/DIS O+M'
YPLM(1/30) DEPEND        'YEARLY PLANT O+M'
YROM(1/30) DEPEND        'YEARLY AQUIFER O+M'
YOPM(1/30) DEPEND        'YEARLY HEAT CUST O+M FOR PLANT'
HFUL(1/30) DEPEND        'YEARLY HEAT CUST FUEL CHARGE'
YFUC(1/30) DEPEND        'YEARLY PLANT FUEL COSTS'
CUCS(1/30) DEPEND        'YEARLY TOTAL HEAT COSTS'
CUCB(1/30) DEPEND        'YEARLY CUST COST PER MIL BTU'
YCAC(1/30) DEPEND        'YEARLY ESC/NOT ESC CAP COSTS'
DEFINE MODEL
BTUR=BTUP*RECO
DELT(1)=REDU*STFA
DELT(2/30)=DELT(1/29)*CDLT
PLNT=PLCS*FICR
TRAD=TRDT*FICR*(DIST*RECO+TRAN)
EQCS=EQUP*FICR
STCS=AQCA*FICR

```

Figure C.1. The Financial Risk Analysis Model

CONTROL FILE (CONT.)

```

/PLM(1)=OPMH
/PLM(2/30)=YPLM(1/29)*RAOM
YFUC(1)=FUEL
YFUC(2/30)=YFUC(1/29)*FESR
YAOM(1)=AOPP
YAOM(2/30)=YAOM(1/29)*RAOM
YPLT(1)=PLNT
YPLT(2/30)=YPLT(1/29)*ESRA
HOPM(1/30)=DELT(1/30)*YPLM(1/30)
HFUL(1/30)=DELT(1/30)*YFUC(1/30)
HCAP(1/30)=DELT(1/30)*YPLT(1/30)
CAPC=TRAD+ECCS+STCS
YCAC(1)=CAPC
YCAC(2/30)=YCAC(1/29)*ESRA
CUCS(1/30)=YCAC(1/30)+YOPM(1/30)+YAOM(1/30)+HOPM(1/30)+HFUL(1/30)
+HCAP(1/30)
CUCB(1/30)=CUCS(1/30)/BTUA
ENDJOB

```

CONTROL FILE

```

MODIFY
BTUP P1=15600000
ESRA P1=1.06
TRDT P1=282000000 P2=844000000 P3=422000000
EQUP P1=27900000 P2=37200000 P3=31000000
PLCS P1=682400000 P2=812600000 P3=744800000
AOPR P1=38000000 P2=104900000 P3=76000000
FUEL DATA P1=0
HTDO DATA P1=4880000
AOPP DATA P1=350000
OPMA DATA P1=6080000
ENDATA
RUN 100
ENDJOB

```

REQUESTS FILE

```

DEFINE OUTPUT
FASTPLTFR CUCB(1)
FASTPLTFR CUCB(6)
FASTPLTFR CUCB(11)
FASTPLTFR CUCB(16)
FASTPLTFR CUCB(21)
FASTPLTFR CUCB(26)
FASTPLTFR CUCB(30)
ENDJOB

```

Figure C.1. The Financial Risk Analysis Model (Cont.)

UTILITY PROB VENTURE ANALYSIS
 RUN NO. 1

FASTPLOT FOR VARIABLE CUCE(21)
 YEARLY CUST COST PER MIL BTU

MEAN = 18.6581 CONF LIMIT ON MEAN (0.95) = .391905
 STD DEV = 1.99952 CONF LIMIT ON STD DEV (0.95) = 1.76141

COEF OF SKEWNESS = .559359 COEF OF KURTOSIS = 5.06035

SMALLEST VALUE = 14.5566 UNDERFLOW = 0 (0.0 PCT)
 LARGEST VALUE = 24.7258 OVERFLOW = 1 (1.00 PCT)

Figure C.2. Histogram From Nuclear Plant, Industrial Case,
 Year 2000. Values Include Capital and Operating
 Costs Only.

The form of distribution function compiled in the main program (designated BETAL) is a modified beta distribution and was chosen for two reasons. The distribution is a very flexible one in that by appropriate choice of parameters virtually any shape function may be obtained. In addition, rather than inputting a mean and standard deviation, the inputs consist of an upper limit, lower limit, and most likely value. The program then calculates internally the required parameters to produce a distribution that is compatible with the inputs. This process is convenient since judgments concerning the distribution associated with a particular variable naturally arise in terms of upper, lower, and most likely values. However, if a different distributional form is desired in a particular run, this can be accomplished through an appropriate modification statement in the control file.

Several additional observations should be made here about the control file. In Figure 3.1 the variables TRDT, EQUIP, PLCS, and AQCA have parameter modifications associated with their lower, upper and most likely values. The variables FUEL, HTDO, AQOP, and OPMA have been changed from distributional variables to data variables. This modification process is the basic method for inputting data for the various cases of interest.

The FUEL variable has been set at zero. This reflects the manner in which the market penetration model (described in Appendix D) was used. Since the financial model and the market penetration model are two separate entities, it was necessary to pass results from the financial model to the market penetration model. This required careful consideration of the probabilistic processes involved so that the simulations in the market penetration model were correct.

One important consideration was the fact that in the market penetration model all the alternative energy systems and fuels are considered simultaneously.

A natural assumption here is that the future prices of various fuels will have a high positive correlation. Therefore it was necessary to sample the fuel distributions within the market penetration model rather than in the financial analysis model. A further complication existed because the final calculation in the financial analysis model consisted of a ratio of two random variables. Therefore the fuel component of this ratio was simulated separately so that its representation in the market penetration model reflected the ratio calculation in the financial model.

The general approach was to run the financial model without the fuel costs, then pass to the market penetration model the capital and operating cost distributions from the financial model and the fuel cost distributions calculated from the ratio simulation and theoretical arguments.

The output distribution from the financial model is derived from the sum of several independent variables within the financial model. Since sums of independent random variables tend to be normally distributed, it was expected that this phenomenon would occur in this analysis. An examination of the output distributions confirmed this expected result. Therefore the normal distributional form was used in the market penetration model with parameters obtained from the results of the financial model.

D.1

Appendix D

MARKET PENETRATION DECISION MODEL

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MARKET PENETRATION DECISION MODEL

The market penetration decision model uses information developed during the study that describes the market in which HTW will be competing and calculates the share of that market that is likely to be captured by HTW systems.

The inputs to the model include the following:

- Potential market size for the industrial and residential and commercial sectors (discussed in Chapter 4).
- The present and future technologies that will be available and competing for the above market and the operating characteristics of those technologies (taken largely from the MOPPS study, presented in Chapter 4).
- Fuel prices (taken from MOPPS study).
- Cost for HTW generated by different types of plants (developed in Chapter 4).
- Decision weights and system attributes for residential systems (presented in Chapter 4).

Given these inputs, the model calculates penetration rates from 1975 to 2025 for each of four regions, Northeast, North Central, South and West.

The costs of energy delivered from each of the industrial systems are determined by calculating the capital cost, the O&M cost, and the fuel charge. The capital cost is the initial cost of the equipment multiplied by a capital charge factor of .15. This is converted to dollars per million Btu by dividing by the product of the output capacity (in 10^6 Btu/hr) and the capacity factor (in hours/year).

$$CC_s = (IC_s \times CCF) / (OC_s \times CF_s)$$

where

CC = capital charge (1975\$/10⁶Btu)
 IC = initial cost (1975\$)
 CCF = capital charge factor (15%/year)
 OC = output capacity (10⁶Btu/hr)
 s = system

The fuel charge is the fuel cost divided by the fuel efficiency of the system.

$$FC_{s,t} = F_{f,t} / E_s$$

where

FC = fuel charge (1975\$/10⁶Btu)
 F = fuel cost (1975\$/10⁶Btu-input)
 E = fuel efficiency
 s = system
 t = time
 f = fuel

The total cost is the sum of the capital charge, the fuel charge and the O&M charge inflated to current prices.

$$EC_{s,t} = (CC_s + FC_{s,t} + OM_s) \times (1+IR)^{t-1975}$$

where

EC = energy cost (\$/10⁶Btu)
 CC = capital charge (1975\$/10⁶Btu)
 FC = fuel charge (1975\$/10⁶Btu)
 OM = operation and maintenance costs (1975\$/10⁶Btu)
 IR = inflation rate (6%)
 s = system
 t = time

These calculations are only performed if the system is available to the market by time t.

D.5

For those systems that also cogenerate electricity a credit is taken for the value of the electricity.

The HTW costs are found by determining the weighted average of HTW costs from the different types of plants built in different years.

$$AHTWC_t = \left(\sum_h \sum_{y=1975}^t HC_{h,y,t} \times HM_{h,y} \right) / \left(\sum_h \sum_y HM_{h,y} \right)$$

where

AHTWC = average HTW cost (\$/10⁶Btu)
 HC = HTW cost (\$/10⁶Btu)
 HM = market captured by HTW (Btu)
 h = type of HTW generating plant
 y = year plant was built
 t = time

The perceived value of each system is the sum of the decision weight for cost times the relative cost and the decision weight for other benefits times the other benefits rating. The relative cost is the cost for that system divided into the cost of the least expensive of all systems. The total perceived value is adjusted for learning in the first few years after introduction by multiplying it by a learning curve multiplier that increases from 0 to 1 in the ten years after introduction.

$$ISPV_{s,t} = (2x(LEIS_t/EC_{s,t}) + 1xOB_{s,t}) LCM_{s,t}$$

where

ISPV = industrial system perceived value
 LEIS = least expensive industrial system (\$/10⁶ Btu)
 EC = energy cost (\$/10⁶ Btu)
 OB = other benefits
 LCM = learning curve multiplier
 s = system
 t = time

The other benefits of industrial systems describe all the elements taken into account in the decision that are not covered by the cost calculations. This includes mainly measures of convenience of use and some other economic considerations such as requirements for land for stockpiling fuel (coal, for example). Our estimates of these other benefits on a scale of 0 (worst) to 10 (best) are as follows:

Atmospheric fluidized bed	.2
Pressurized fluidized bed	.2
Conventional coal with FOD	.2
Low Btu gas from coal	.2
Solar planar collector	.6
Advanced internal combustion engine	.8
Advanced external combustion engine	.8
Open cycle Brayton engine	.8
Electrical Industrial heat pump	1.0
Backpressure steam turbine	.7
Conventional oil	.8
Conventional gas	.9
High temperature water	1.0

The perceived system value is converted to a relative perceived value by dividing by the average value of all systems.

$$RPV_{s,t} = ISPV_{s,t} / (\sum_s ISPV_{s,t} / NS_t)$$

where

RPV = relative perceived value of system
 ISPV = industrial system perceived value
 NS = number of system, available at time t
 s = system
 t = time

The penetrations are then determined by using the relative perceived values in the conversion curve which is approximated by the following equation:

$$PEN_{s,t} = 10^{-1.65 + 3.126 \times RPV_{s,t}}$$

where:

PEN = penetration into new market
 RPV = relative perceived value
 s = system
 t = time

D.7

These penetrations are then normalized to sum to 1.0.

The procedure for residential and commercial is similar. First the perceived value of each system is calculated by summing the products of system ratings and decision weights for each of the five decision criteria, adjusted for the learning process as before.

$$PV_{s,t} = (\sum_c DW_{c,t} \times R_{c,t}) LC_s$$

where:

PV = perceived value of system
 DW = decision weight
 R = criteria rating
 LC = learning curve
 C = decision criteria
 s = system
 t = time

The relative perceived value is the perceived value divided by the average perceived value for all systems.

$$RPV_{s,t} = PV_{s,t} / (\sum_s PV_{s,t} / NA_t)$$

where

RPV = relative perceived value
 PV = perceived value
 NA = number of alternatives
 s = system
 t = time

The penetration is then calculated through the use of the conversion curve.

$$PEN_{s,t} = \frac{10^{(-4.98 + 9.964 RPV_{s,t})}}{(1 + 10^{(-4.98 + 9.964 RPV_{s,t})})}$$

where

PEN = penetration into market
 RPV = relative perceived value
 s = system
 t = time

These penetrations are then normalized to sum to one. Actually the calculations are done twice for each region, once for the area that has natural gas available and once for the area that does not. The two figures then are combined to determine total penetration.

Once the penetration for HTW for both sector is determined, the size of the new HTW market is calculated as the product of the penetration rate and the growth in the market.

$$HTWM_t = IPEN_t \times (IM_t - IM_{t-1}) + RPEN_t \times (RM_t - RM_{t-1})$$

where:

HTWM = high temperature water market (10^6 Btu/year)

IPEN = industrial penetration

IM = potential industrial market (10^6 Btu/year)

RPEN = residential penetration

RM = potential residential market (10^6 Btu/year)

This market is then allocated to the different types of HTW generating plants based on the conditions defined for the development path being considered.

E.1

Appendix E

INTERNATIONAL DISTRICT HEATING SYSTEMS

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INTERNATIONAL DISTRICT HEATING SYSTEMS

There are currently at least twenty-three countries using district heating. They are

Austria	W. Germany	Rumania
Bulgaria	Holland	Sweden
Canada	Hungary	Switzerland
Czechoslovakia	Iceland	United Kingdom
Denmark	Italy	USA
Finland	Japan	USSR
France	Norway	Yugoslavia
E. Germany	Poland	

These systems vary in size, fuel, and configuration. There are high and low temperature steam systems and high temperature water systems. Total connected thermal capacity ranges from under 100 megawatts for Switzerland to over 494,000 megawatts for the USSR. Appendix E discusses the history of district heating, configurations and types of systems, and the forces that promoted or constrained district heating. This is done on a country-by-country basis as the data allow.

The International District Heating Association (IDHA) is probably the best informed source of data on international district heating. Although the IDHA puts substantial effort into the collection of these data, its accuracy and completeness is only as good as the data reported to it. Unfortunately, these data are not always complete and therefore are often vague.

Sweden

With the exception of process uses within industrial plants, district heating in Sweden uses high temperature water (HTW) as the transmission medium for the heat. District heating started on a large scale in about 1953 and currently there are systems operating in about 50 areas. These systems supply 15-20 percent of Sweden's space and water heating demand and are expanding at a rate of about 1000 MW per year. Most of the district heating systems

serve only city centers and the more densely populated suburbs. There are district heating systems in 70 percent of Sweden's urban areas and in some urban areas, such as Västerås, the system has grown to a point where it now supplies 98 percent of its heating demand.

Until about 10 years ago, hydro-resources had been adequate for meeting the electricity requirements. Combined heat and power (CHP) plants then began to become common as the hydro-resources were no longer able to fulfill the electricity requirements. These CHP systems now produce about one-sixth of the heat for the district heating systems or about 3 percent of Sweden's total space and water heating demand.

There are many factors that have fostered the growth of district heating in Sweden. These include

- maximum fee agreements which guarantee that the cost for district heating will not exceed the cost for other forms of central heating.
- long-term, low-interest guaranteed loans made at interest rates of 5-6 percent for time periods of up to 30 years.
- district heating being classified as an energy-saving procedure, thereby qualifying the system subscribers for grants of up to 35 percent.
- high-density-load apartment blocks, built on green-field sites, belonging to municipalities that required the installation of a district heating system as a condition of development.
- the absence of natural gas and discouragement of oil-fired central heating on environmental grounds. The only real alternative to district heating is electrical space heating, and district heating is more economical at housing densities above 14 dwellings per hectare (5-1/2 dwellings per acre).
- historical patterns of evolution where collaboration of municipal works and major power producers has been well developed.
- the design and insulation of buildings and heating systems within the buildings that are compatible with district heating.

- long-term contractual agreements of up to 30 years, which protect both the consumers and suppliers of heat.
- the perception that district heating assures the continuity of supply of energy and helps fulfill national goals of fuel independence through increased efficiency.
- R&D into standardization and prefabrication of distribution and transmission equipment.
- a political and legal atmosphere in Sweden that promotes proactive planning.
- a structure where all district heating systems are owned and operated by the local town councils. In Sweden, it is legal for local authorities to generate, distribute, and sell both heat and electricity; however, local authorities are prohibited from engaging in the purpose of making any significant profit. Therefore, they resell the heat for a price that represents their actual cost and tends to minimize rates.
- industrial cooperation with local government. For example, the Swedish Wine and Spirit Monopoly sells waste heat to the Stockholm Energy Authority for space heating. This results in costs savings for both the Swedish Wine and Spirit Monopoly and district heat consumers because the otherwise waste heat can be used.

Although the facilitating factors are well documented, there is a lack of information on the factors that hindered the growth of district heating. A major limitation which was mentioned to wider distribution to single-family residences is the cost of distributing heat using current technologies. (References 11, 12, 20, 21)

U.S.S.R.

In terms of space heating, the Soviet Union has the largest connected thermal capacity in the world. In 1976, the total connected thermal capacity was 494,275 megawatts, with a maximum heat output of 353,550 megawatts. The Soviet Union operates over 1000 dual-purpose heat and electric stations that supply heat to 800 cities, industrial locations, and other population centers.

Heat and electricity are cogenerated in Moscow, Leningrad, and other cities with populations greater than 100,000.

A majority of the district heating systems have been using steam as the transmission medium, but high temperature has been gaining ground. Approximately 40 percent of the district heating capacity in the U.S.S.R. is produced using cogeneration. As reported in proceedings published in District Heating from the Third International District Heating Conference in Warsaw, Poland, April 1976:

In 1974, one-third the power of the thermal-electric power stations consisted of the installed capacity of power stations working in the country, and it reached about 60 GW. The volume of energy supplied by these thermal-electric power stations reached 4×10^9 GJ, that is to say, about 40% of the country's total power demand for low and medium temperature demand...So far, steam (53%) has been the leading heat carrying agent, although the share of water continues to increase, and rose from 27% in 1960 to 47% in 1975.

Plans envisage further increase in power of the thermal-electric power stations, where electric power and thermal power in big cities such as Moscow, Leningrad, Kiev, Minsk and Kharkov will reach the level of 1000-1500 Mw and 3500-4500 Mw (i.e., 3000-4000 G cal/h), respectively.*

It is hard to assess the forces that fostered the growth of district heating in the USSR. Since the Soviet Union is a planned society, it is obvious that a government policy decision was responsible for its growth. In fact, there is legislation requiring total energy utilization for sources of 500 or more megawatts. However, the actual system perceptions that caused this policy to be implemented are unknown.

(References 3, 21, 23)

*Stanislaw Andrzejewski, "General Report Therma III--Combined Heat and Power Generation," District Heating (January-February-March 1977), pp. 30-31.

West Germany

The first European district heating installation appeared in Hamburg in 1893. This long tradition of district heating has led West Germany to have the largest public district heating supply system in Western Europe, supplying slightly more than 150 trillion Btu's in 1972, using steam and hot water. As reported in a report by the District Heating Working Party of the Combined Heat and Power for the British Department of Energy:

Although district heating began in Berlin as early as the 1920s and a number of other large towns followed suit during the next decade, significant expansion did not take place until after the war. The proportion of Germany's space and hot water heating requirements provided in this way rose from 1 per cent [sic] in 1960 to 4 per cent in 1970, to around 7-8 per cent today, and is expected to reach 12 per cent by 1980. Some 78 per cent of the total connected district heating load and 68 per cent of the heat supplied comes from combined heat and power plant--much of which is owned and run by the local town utility companies. Until the late 1950s, district heat was in the main supplied from combined heat and power plants, but during the cheap oil era from 1958 to 1973 and with the need to find markets for Ruhr coal, there was a considerable expansion of district heating schemes operating with heat only boilers.*

There have been several market studies that have analyzed the potential for district heating. A study done by H. Wilkens in Energy International has estimated that 32 percent of the total West German home heating demand could be satisfied by district heating (this assumed that district heating would not be feasible for communities of less than 20,000 population). There are other studies which propose dual-purpose nuclear stations providing heat for cities of up to 40 km distance from the plant.

*District Heating Working Party of the Combined Heat and Power Group, District Heating Combined with Electricity Generation in the United Kingdom--Energy Paper Number 20, p. 18.

In addition to the rebuilding that took place after World War II, there are several other factors that have an impact on the development of district heating systems in Germany. According to the British Department of Energy study, these include

- (a) cheap waste heat from combined heat and power plants near high density areas.
- (b) subsidies for new combined heat and power plants and district heating networks to conserve energy, reduce the emission of sulfur and nitrogen oxides, and reduce oil imports. Additional subsidies to encourage the burning of coal are included.
- (c) the planning of town utility companies may help to prevent the superimposition of district heating and gas networks.*

(References 8, 9, 21, 25, 26)

East Germany

The German Democratic Republic (GDR) has had district heating for approximately 30 years and now has a connected thermal capacity of over 6000 megawatts. According to a report by the Argonne National Laboratory, the installed capacity of district heating systems in the GDR increased by 132 percent between 1964 and 1974. The same report states that between 1976 and 1980, 90 percent of the new houses--415,000 houses--will be supplied by these systems. Since the vast majority of the GDR's primary usage is coal (greater than 80 percent), the district heating systems are also powered by coal.

(References 4, 25)

*Ibid.

Austria

District heating has been used in Austria for almost 40 years. There are currently two municipal incineration plants utilizing the waste heat and transmitting it as steam for heating and district heating. The total steam capacity is 1320 tons/day.

(References 4, 25)

Bulgaria

There is little data about district heating in Bulgaria. Sophia, the capital city, is supplied with heat from a district heating system. Both the total connected thermal capacity and maximum heat output for Bulgaria are about 10,000 megawatts on a total basis and 500 megawatts per million inhabitants.

(Reference 4)

Canada

There are district heating systems in several Canadian cities, including Vancouver, Toronto, Winnipeg, Ottawa, New Toronto, Ajax, London, Halifax and Grand Mere. In 1976 the three largest systems were

- Toronto, with an annual total delivered steam load of 1542 million pounds and annual steam sales of 1249 million pounds (representing increases of 11 and 14 percents over the 1975 levels).
- Vancouver, with an annual total delivered steam load of 830 million pounds and annual steam sales of 729 million pounds (representing increases of 7 and 9 percent over the 1975 level).
- Winnipeg, with an annual total delivered steam load of 538 million pounds and annual steam sales of 447 million pounds (representing no growth in delivered steam and a decrease in sales from the 1975 level).

In addition to the systems, there are several much smaller group systems. Examples of these systems include hospitals, universities, government building and public facilities, such as a railroad station.

There are several studies that were initiated to determine whether the main system in Toronto should expand in order to service a downtown complex of hospitals and related buildings. Several models were constructed including a model to analyze the heat demand; a heating cost model which related to system selection, a financial sector, rate schedules, and cost comparisons; air pollution models; and an aesthetic and social benefits model. Analysis of these model simulations showed that expansion of the district heating was favorable in some aspects and less favorable in others over competing fuels. On balance, expansion of the system was indicated.

(References 15, 24)

Czechoslovakia

Although Czechoslovakia has had district heating in one form or another for almost 50 years, it is only in the last ten years that its connected thermal capacity expanded rapidly. Between 1965 and 1975 the connected thermal capacity has increased more than tenfold, from around 3000 megawatts to around 35,000 megawatts. According to the Argonne National Laboratories report: "Czechoslovakia develops nuclear heat and power plants based on pressurized-water reactors, with an utilization factor of 0.7-0.8."*

*Energy and Environmental Systems Division, Potential for Scarce-Fuel Savings in the Residential/Commercial Sector Through the Application of District Heating Systems, p. 29.

As for the reasons for this development, the Argonne Report says, "In Eastern Europe, state ownership of all power plants, industries, and houses has had a characteristic influence on the development of district heating." (References 4, 25)

Denmark

District heating is an extremely important element in Denmark's energy posture. District heating has existed in Denmark for 50 years and about one third of all dwellings are supplied with heat transmitted through a district heating network. There are as many as 460 systems, operated by 430 different companies, all using high temperature water as the transmission medium. Ninety-five percent of all of the customers receive their heat directly from the network without an intervening heat exchanger.

The Danish experience is particularly relevant since the large number of viable district heating systems developed without government intervention. Two of the most important factors attributed with facilitating this growth are Denmark's historical experience in World War II, and the government posture towards capital carrying charges. With regard to the historical experience:

During the German occupation of Denmark it was found that, although there was a great shortage of all forms of fuel, those on the public district heating network fared relatively better than those relying on their own heating system. It was not surprising, therefore, that in the immediate postwar period, when there was a great increase in improved forms of heating, many homes chose to join the district heating networks rather than the alternative of central heating at a time when oil was still relatively expensive.*

*District Heating Working Party, p. 17.

With regard to the government posture towards capital carrying charges:

There have been few subsidies. However, it must be recognized that many of the schemes were developed using capital carrying interest rates of around 6 percent. Allowing for modest inflation of a few percent per annum, it is clear that the effective rate in real terms would have been only five percent or even slightly less. Moreover, part of the capital charges were borne by the consumer, who was able to obtain income tax relief on his interest payments...Economics of district heating schemes are greatly favored by low discount rates and this goes some way to explain the commercial success of the Danish schemes.*

(References 8, 21)

Finland

District heating only started developing in Finland after World War II. Although there were some minor local heat distribution networks, the first major system was a steam system implemented in a Helsinki suburb in 1953. Hot water as the transmission medium was first used in 1957. Now when the district heating systems are constructed, two-pipe hot-water lines are generally used to transmit the heat.

Currently, about one eighth of the population (600,000 people) are supplied with district heating. This includes about one half of Helsinki's population. However, the number of people served should increase substantially after a new nuclear combined heat and power plant is built to serve the Helsinki area. To wit, the current system maximum is now 1280 MW and is projected to increase to 3900 MW in 1985.

There are two major forces that have facilitated the growth of district heating. First, since almost all of the fuel required for producing thermal

*Ibid.

energy is imported, there is a substantial amount of pressure to maximize scarce fuel resources. Secondly, there is an efficient approach to either increasing or adding new areas to the systems.

When hot water district heating is to be used in some new locality, the thermal heat generation is usually arranged by a heat supply station; if there is no station, portable plants are used. The portable heating centers have proven to be convenient, especially at the initial building phase where the required quantity of heat is still small. The capacity of the portable heating centers varies from 0.3 to 6.3 gigowatt calories per hour (Gcal/h). When a district heating network has grown large enough to warrant it, a heat-and-power plant or plants are then built to produce the required heat supply.*

(References 10, 21, 25)

France

There is 10,000 MW of district heating in France predominantly using high-temperature steam as the medium of transmissions of this 10,000 Mw; approximately 40 percent is in Paris and its suburbs. The next largest system is only 400 MW and the remaining systems are substantially smaller. There is virtually no combined heat-power generation.

(Reference 8)

Hungary

In 1960, the Budapest Municipal District Heating Works was formed to provide hot water district heating for new housing developments. Between 1965 and 1975 the system has more than quadrupled the number of homes it serves (23,000 to 104,000). In the period between 1960 and 1970 the heat

*U. Halme, "District Heating in Finland," District Heating (October-November 1973), p. 17.

output increased by a factor of more than 30 (40×10^6 cal/h to 1065×10^6 cal/h) and the length of the distribution increased by a factor of almost 13 (16 km to 206 km).

(Reference 18)

Italy

There are virtually no real district heating systems in Italy; however, there are twelve municipal incineration plants that utilize waste heat for power, heating, and industrial uses. The total capacity of these systems is around 4000 tons of steam per day.

(Reference 21)

Holland

Even though there has been an almost 60-year history of district heating in the Netherlands, it has remained a very small part of the total energy picture. There are three district heating systems with a total connected thermal capacity of under 2000 megawatts. The two largest systems are steam--the smallest is high temperature water. In addition, there are a few other municipal incineration plants that utilize the waste heat for sludge drying and power.

(References 21, 25)

Japan

Japan has two large-scale district heating systems, one in Sapporo and one in the Ootenachi area of Tokyo. The Sapparo system uses high temperature hot water to heat a high-density core area of the city. The total rated output of Sapporo's boilers is 1.1 billion Btu/hour.

There were many factors that helped promulgate the development of the Sapporo system, but by far the most important one was the need to reduce air pollution. By implementing district heating it was possible to replace hundreds of stacks with one that could be better controlled. Although not a driving force initially, the conservation elements of district heat have helped continue its growth. Additionally, 70 percent of the required capital investment was made by the federal and local governments. Another factor that aided district heating in Sapporo was the prefabrication of pipes in the distribution systems and standardization of converter room layouts for the heat transfer equipment. Negative or hindering factors to the growth of district heating in Japan include

- current siting practices that prohibit the transport of waste heat from electric generating plants.
- the difficulty in raising funds, coupled with high production costs.
- the lack of administrative support coupled with the fact that district heating is considered a public utility. This means that district-heating energy prices are regulated by the Ministry of International Trade and Industry.
- engineering problems of interference with other utility lines and traffic congestion during construction.

(References 1, 2, 16)

Norway

Norway does not have district heat per se, however, it does utilize waste heat from a municipal incineration plant. The steam system has a 312-tons-per-day capacity for industrial uses.

(Reference 21)

Poland

Poland's district heating systems have a total connected thermal capacity of about 40,000 megawatts. Approximately 30 towns are supplied with heat from power plants and commercial heating plants, and an additional 10 are supplied from heating units in condensing power plants. According to the Argonne report:

The local heating plants work in almost all towns. Over 100 industrial power plants supply heat to adjacent housing estates. The share of commercial and industrial power plants in heat production for heating and hot water grew from 12.8 percent in 1970 to 21 percent in 1975, and further growth is planned up to 40.8 percent by 1980 and 58.4 percent by 1990.*

It was only after World War II that Poland started to develop its district heating. The destruction that occurred during the war made rebuilding a necessity for Poland and systems were begun during that rebuilding. District heating also provides a method of maintaining pollution control. Poland has virtually no indigenous oil supplies and limited natural gas, but is rich in coal. However, the coal has a high sulfur content, which can lead to pollution problems. Use of central processing can help control the sulfur dioxide and other pollutant-emissions problems.

(References 4, 13, 19, 21)

Rumania

Although Rumania has had district heating for only 20 years, it has one of the fastest growth rates for the systems. It now has a connected thermal capacity of about 15,000 MW. About 60 percent of the heat is generated using ordinary boilers, 25 percent in backpressure units, and the other 15 percent is produced through other combined heat and power plants. In the ten years from 1960 to 1970, the installed capacity of combined heat and power rose from

*Argonne, p. 30.

399 MWe to 2167 MWe with an extraction capability of 30 percent of total capacity. This capacity was expected to rise to 5400 MWe by 1980.

(References 4, 21, 25)

Switzerland

Switzerland has a three-pronged energy approach which emphasizes conservation, energy research, and oil substitution. While district heating currently supplies less than 2 percent of the heat required in Switzerland, there are several studies underway to determine how district heating could be expanded to help attain the national energy goals. There are systems in Basle, Berne, Lausanne, Geneva and several smaller cities with a total connected thermal capacity of under 1000 MW.

(References 4, 25)

United Kingdom*

Although there have been district heating systems in the United Kingdom for 75 years, they supply a relatively small portion of the total energy needs. There are a great number of reasons for this lack of development, but the two major ones deal with past experience. First, early system implementation resulted in several failures which gave the industry a bad reputation. Secondly, it is only recently that central heat has become universally acceptable in the United Kingdom.

There are however, several systems operating in the United Kingdom. The important ones include

- the Pimlico system which uses exhaust steam to fill the heating requirements of 11,000 London residents.

*For a much more detailed analysis, see CH&P study.

- the Liverpool system which uses hot water produced through combined heat and power generation.
- the Nottingham system, currently under construction, which will have a connected load of 129 MW by 1980. This system will use waste heat from incinerated municipal refuse and will be supplied to the system through backpressure systems.

(References 4, 8, 22)

Yugoslavia

According to the Argonne report, "In Yugoslavia, in the town of Kikinda, heat pumps with geothermal waters are expected to be used as district heating systems."*

(Reference 4)

*Argonne, p. 30.

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F.1

Appendix F

POLITICAL AND REGULATORY ENVIRONMENT

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Summary

The current regulatory environment affecting integrated energy utility systems is the general group of laws and agencies that affect the production and distribution of heat and electricity in the United States. The overlap of authority within and between agencies on the national, state, and local level is inevitable. The bureaucratic maze is complicated by recent administrative reorganization, new legislation, and the short supply of experts in the legal and regulatory fields associated with energy issues.

In part, this shortage of specialized manpower results from a change in the national energy picture during the last four years. Economic and financial issues are no longer restricted to questions of capital, investment, and utility rates. Measurement of the social impact of energy development, particularly health and environmental costs, has become an important component of regulatory decisionmaking. The trend to put a dollar value on social costs has accentuated political controversies based on the value of conservation and the allocation of costs between consumers and producers of energy. Many social impacts are not yet amenable to economic analysis, and new developments in science and technology have unanticipated consequences for the regulatory environment. This section reviews the existing political and legal environment affecting district heating, and identifies several general policy issues such as the impact of regulation on innovations and the regulatory basis for the measurement of social costs.

Administrative Locus of Authority

The Market Oriented Program Planning Study (MOPPS) conducted by ERDA in 1977 predicted there will be no significant regulatory barriers that will inhibit utility companies, municipalities, or joint ventures from undertaking cost-effective, energy-conserving, and environmentally acceptable community energy systems. This generally optimistic picture applies to district heating, one type of community system.

However, despite the favorable environment for regulation, the MOPPS study indicated that institutional and political constraints will be limiting factors. Historically, political bodies such as public utility commissions have been reluctant to become involved in new regulatory experiences with unknown political consequences. In addition state agencies are wary of the recent reorganization of the energy-related agencies of the federal government into the massive Department of Energy.

On October 1, 1977 the Department of Energy became the 12th Cabinet Agency. The new Department has almost 20,000 employees and a first-year budget of \$10.4 billion. In an effort to bring together the many fragmented energy programs and offices created over the years within the federal government, the following functions and resources have been transferred to the new Department.*

*Department of Energy, Information, Vol. 1, No. 1 (October 14, 1977), p. 9.

F.5

Figure F.1. Department of Energy

Figure F.2. Department of Energy, Federal Energy Regulatory Commission

- Federal Energy Administration (excludes pending FY 78 supplemental): All functions, including oil pricing and allocation, conservation, coal use, strategic petroleum and reserve, energy information, resource development.
- Federal Power Commission: All functions, including natural gas regulation, interstate wholesale electric rate setting, and hydroelectric licensing.
- Energy Research and Development Administration: All functions, including R&D in fossil, nuclear, fusion, solar, geothermal, and conservation; uranium enrichment and production military applications and safeguards; environment and health research.
- From Department of Interior: Authority over the Southeastern, Southwestern, Alaska, and Bonneville Power Administrations, and the power marketing functions of the Bureau of Reclamation and the Falcon Dam and Amistad Dam on the Rio Grande. Also the setting of economic terms for leasing public land for energy development (such as the Outer Continental Shelf), mineral lands containing geothermal resources, and authority of the Bureau of Mines for gathering data on fuel supplies, R&D on mining technology, and coal preparation analysis.
- From Department of Defense (Navy): Administration of and jurisdiction over three Naval oil reserves and three Naval oil shale reserves.
- From Interstate Commerce Commission: Functions related to transportation of oil by pipeline, including pipeline valuation and rate setting.
- From Department of Commerce; Functions related to industrial energy conservation.
- From Department of Housing and Urban Development: Authority to set energy conservation standards for new buildings.

Federal agencies with jurisdiction by law or expertise for environmental impacts that might be encountered in electric power generation appears at the end of this chapter.

Federal Regulation

Conflicting regulatory requirements can have a serious impact on the degree to which district heating or any other experiments with an integrated energy system appear economically desirable. The current legal framework affecting

the use of energy was developed during a time of falling energy costs when the greater use of electricity was encouraged. In the current conservation environment it is necessary to reassess and redesign the public law affecting energy, and to study the requirements of a legal structure attuned to the need for social adjustment to energy problems. Several recent studies on energy suggest that changes in the legal and regulatory environment will require research, litigation, and test cases in order to develop information on the effect of existing laws on public attitudes, and the extent to which there is legal precedent and public support for incentives or disincentives to conservation.*

The following discussion briefly reviews the major legislation and agencies responsible for energy regulation on the federal level, with a particular focus on the political and regulatory environment for district heating. Table F.1 lists federal legislation germane to this study.

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) was established in 1977 under the Federal Reorganization Act which created the Department of Energy. The FERC inherited most of its regulatory responsibilities from the former Federal Power Commission. These responsibilities include setting rates for the wholesale sale and transmission of natural gas and electric power, and licensing nonfederal hydroelectric power projects. In addition, the FERC has taken over from the Interstate Commerce Commission the authority to regulate oil pipeline transmission. Another function of FERC is to review DOE proposed rules affecting FERC functions.

*See e.g., recommendations in James M. Utterback et al., Strategic Alternatives for Energy Conservation (Cambridge, MA: Center for Policy Alternatives, Massachusetts Institute of Technology, February 1977); Thermo Electron Corp., A Study of Inplant Electric Power Generation in the Chemical, Petroleum, Refining and Paper and Pulp Industries, June 1976.

Table F.1

FEDERAL LEGISLATION AFFECTING THE SUPPLY
AND PRODUCTION OF ENERGY IN DISTRICT HEATING

<u>Atomic Energy Act of 1954</u> 68 Stat 919	The Atomic Energy Commission
<u>Clean Air Act with 1970 Amendments</u> 42 U.S.C. 1857 et seq.	Environmental Protection Agency
<u>Federal Coal Mine Health and Safety Act of 1969</u> PL 91-173	Department of the Interior, Bureau of Mines
<u>Federal Power Act</u> 16 U.S.C. 791a-825r	Federal Power Commission
<u>National Environmental Policy Act of 1969</u> 42 U.S.C. 4321-4347	The Council on Environmental Quality issued guidelines for the preparation of environmental statements. Various other government agencies issued rules and regulations to implement this Act as it applied to their activities. Examples are:
	Atomic Energy Commission Corps of Engineers Federal Power Commission
(For legislation dealing with water quality, see pp. 5.40-5.43.)	
Creation of Department of Energy, August 4, 1977	
<u>Emergency Natural Gas Act of 1977</u> PL 95-2	
<u>Clean Air Act Amendments of 1977</u> PL 95-65	

The Federal Power Commission (FPC) was established under the Federal Water Power Act in 1920 and, until the creation of FERC, regulated interstate aspects of electric power and natural gas industries. Like the FPC, the FERC's regulatory authority is limited to wholesale rates and services. Jurisdiction over retail natural gas and electric rates and services resides with the individual states. Recent policy issues inherited by the FERC relate to the structure of the electric utility industry and FPC rate-making policies. A recent study by the Government Accounting Office (GAO) poses the question of whether there is a need to restructure the electric utility industry, and to amend the Federal Power Act.* The Federal Power Act, which governs the operation of the wholesale portion of the electric utility industry, has not changed substantially since 1935, although there have been significant alterations in the factors that affect that industry. In particular, the current market situation of increasing fuel prices, and inflation in operating and construction costs, has had a significant effect on the demand for electric energy, and consequently on the entire utility industry. Industry leaders themselves are unsure as to the best course of action to pursue. The issues that complicate the policy questions are as follows:

1. The lack of federal and state coordination resulting in conflicting requirements, fragmented policies and procedures, and jurisdictional differences.
2. Inadequate and differing demands for forecasting methodologies.

*Energy: Issues Facing the 95th Congress, April 28, 1977; see also E. Berlin, C. J. Cichitti and W. J. Gillen, Perspectives on Power, A Study of the Regulation and Pricing of Electric Power (Cambridge, MA: Ballinger Publishing Company, 1974).

3. Lack of standardized criteria.
4. Inadequate financing for operations and expansion.
5. Possible imposition of load management and pricing alternatives with concomitant socioeconomic implications.
6. Uncertain effects and costs of new technologies.
7. Potential conflict of environmental and conservation requirements with industry objectives. There are 3600 utilities in the United States. The FERC must work effectively with municipal cooperative state, federal, and private utilities.

The FERC is involved in the regulation of transmission of bulk power but is not expected to have direct jurisdiction over the issue of heat transmission by means of hot water or steam. However, the regulatory picture regarding bulk power is unclear and some of the unresolved issues may result in rulings affecting the transmission of heat. For example, the FERC should be the expert agency to handle transmission regulation, but the FPC took the position that it lacked authority to compel power companies to transmit power to municipal and cooperative customers. Transmission rights now must be worked out with the Department of Justice, the Nuclear Regulatory Commission, the Securities Exchange Commission under the Public Utility Holding Company Act, or the Federal District Court in the event of litigation.*

The FPC established curtailment priorities for natural gas that may have a significant effect as shortages of natural gas are experienced or expected.**

* U.S. General Accounting Office, Problems in Planning and Constructing Transmission Lines which Interconnect Utilities. June 9, 1977; Senate Commerce Committee Hearings: Electric Utility Rate Reform and Regulatory Improvement, April 27, 28, 1976, p. 433.

** Another new office within the DOE, the Economic Regulatory Administration, is charged with principal responsibility for enforcement of pricing and allocation regulations. Other offices concerning matters pertaining to enforcement, regulations, and emergency planning, fuels regulation, and utility systems, now administer portions of the Federal Power Act.

The Dow study suggests that industrial and other consumers of natural gas who have low priority may decide it is prudent or necessary to arrange for other sources of heat.*

The National Environment Policy Act reinforces the FERC obligation to undertake environmental assessment of proposals and viable alternatives to building power plants. Under the Act, the Federal Power Commission was to serve as the collector and disseminator of information useful to other federal and state agencies, including state public-utility commissions. This obligated the FPC to investigate the utilization of water resources as it affects the location, capacity, development, costs, and relationship to markets of power sites. The information gathered by the FPC in the course of application procedures for siting of power plants was essential to the agencies involved in land-use planning. These responsibilities will now be assumed by the Environment Office within DOE.

The FERC is also involved in rate base regulation. The influence of the FERC on the rate activities of the Interior Department power marketing agencies has an impact on consumption patterns. This is particularly true in the federal power areas such as Bonneville Power Administration and Tennessee Valley Authority.

The Federal Power Act details congressional concern with consumption patterns, and concern with the protection and promotion of the public interest. Regarding the regulation of natural gas, the FERC's responsibilities extend beyond economic considerations to those involving the environment and conservation.

The Federal Energy Regulatory Commission's mandate includes protection of consumers against exploitation. However, its effects on consumer interests are indirect. In the regulation of wholesale prices in the electricity and gas

*Energy Industrial Center Study, Paul W. McCracken, William G. Rosenberg, Gerald L. Decker. DOW Chemical Company, Special Report, June 1975. The DOW study deals with the technical, environmental, economic, legal and regulatory aspects of two approaches to conserving fuel burned to produce steam: the generation of by-product electric power from the steam generated by industry for use in manufacturing, and the supplying of steam to industry from the utilities' central power stations.

industries the effect on consumers is largely economic. In the licensing of hydroelectric power plants the concern is environmental, since these products involve construction of dams and pumped storage plants.

Based on interviews conducted for this study it is unlikely that either the utilities or the state Public Utility Commissions will encourage the active participation of the FERC in regulation of steam or heat sales. Results of this study indicate that the FERC will not be directly involved in the regulatory picture affecting district heating at this time.

Nuclear Energy Regulation

If district heating achieves broad application in the United States it is likely to involve nuclear powered electric generating equipment.* The Nuclear Regulatory Commission (NRC) is responsible for regulating the construction and operation of commercial nuclear power plants and most activities associated with the nuclear-fuel cycle. To assure that there is no undue risk to public health and safety, NRC carries out such responsibilities as developing standards and regulations, issuing licenses and inspecting and enforcing licensing compliance with regulations. Nuclear power plants currently provide about 8 percent of the country's total electricity.** In some local areas this figure is as high as 42 percent. As of June 30, 1977, there were 65 commercial nuclear power plants licensed to operate in this country and another 77 under construction (Figure 5.3).

*A nuclear plant for district heating and electric generation was built and placed in service in 1963 in Agesta, Sweden. It was shut down in 1974. The Agesta reactor served a new town 6-1/2 miles from Stockholm. Output was 10 MW electric power and 55 MW heat which provides 60 percent of the town's peak heating load. The Canadian study for the city of Toronto concluded (as of 1973) that nuclear energy was not a feasible alternative for district heating at that time, but might become a "desirable choice": Toronto District Heating Study, Vol. 2, p. 51.

**Energy: Issues Facing the 95th Congress, April 28, 1977, Chapter 5.

NUCLEAR POWER REACTORS IN THE UNITED STATES

SOURCE: ERDA News, September 5, 1977, p. 6.

Figure F.3. Nuclear Power Reactors in the United States

Site work is authorized at 12 more; in the planning stage, 54 reactors have been ordered and 22 reactors planned but not yet ordered.

The most serious issues affecting the development of nuclear power in the United States concern the safety aspects of the power plants and the potential damage to the environment. In 1970, when the Environmental Protection Agency (EPA) was established, the authority of the AEC to set "generally applicable environmental standards for the protection of the general environment from radioactive material" was transferred to the EPA by Reorganization Plan No. 3.*

The objective of the Reorganization Plan was to have EPA develop ambient and other offsite requirements for radiation. This has not been realized, and the NRC alone has determined offsite levels and exposures and incorporated them at its discretion in the conditions it imposes on licensees.**

The National Environmental Policy Act of 1969*** provides that EPA and other agencies with jurisdiction or special expertise review detailed environmental impact statements for all significant actions affecting the environment. The NRC prepares such statements before issuing licenses for nuclear facilities including power reactors, testing facilities, fuel reprocessors and isotopic-enrichment plants, as well as when regulations are promulgated.

*Reorganization Plan No. 3 (1970) Section 2(a) (5USCA Appendix II). Plan transferred to Administrator of AEC all functions of Federal Radiation Council.

**Considerations of Health Benefit-Cost Analysis for Activities Involving Ionizing Radiation Exposure and Alternatives, A Report of Advisory Committee on the Biological Effects of Ionizing Radiations, Assembly of Life Sciences (Washington, D.C.: National Academy of Sciences, 1977), p. 85. (Hereafter referred to as Ionizing Radiation.)

***National Environmental Policy Act of 1969, 42 USC, Section 4321, et seq. (1970).

The Nuclear Regulatory Commission's involvement in the environmental aspects of nuclear plant sitings includes cooling water requirements and effects. The production of hot water piped directly from the nuclear plant, as is being studied in Sweden, France, and Germany, involves questions of the radiological safety of the hot water. Presumably this would also be a matter for NRC attention and regulation. (This matter also comes under the jurisdiction of the Environmental Protection Agency.)

Nuclear-power plants produce significantly greater amounts of waste heat. Discharge of this heat in the form of hot water can have major impacts on marine life in the receiving waters. Sudden changes or significant increases in temperature have lethal effects on marine life, and less rapid or smaller increases in water temperature affect rate of growth, the ultimate size and reproductive and other behavioral responses of marine life.

There are a number of ways to moderate the impact of thermal discharges on receiving waters. One alternative is regulation of the rate of flow and volume of water going through the system, depending upon the characteristics of the receiving water. In other situations closed cooling systems, such as cooling ponds or cooling towers, may be required. These systems are more expensive than once-through cooling; in addition evaporation from towers can cause localized fog. If salt water is cooled in towers the result can be a salt spray that is harmful to vegetation in the immediate area of the tower.

The use of waste heat in the form of hot water by industry, agriculture, aquaculture and possibly even in desalinization plans would obviate adverse marine and terrestrial effects as well as make productive use of the so-called waste heat. The Environmental Protection Agency recently has issued

regulations permitting the use of thermal effluents and other waste water under controlled conditions in aquaculture. A number of aquaculture projects in Massachusetts and Maine will be producing oysters, lobsters, and mussels using the heated or nutritionally rich waste water.*

Of particular interest in this discussion of integrated energy systems is the direction to the NRC (in the Energy Reorganization Act of 1974) to consider the feasibility and practicability of nuclear energy centers. A separate group of regulatory problems is posed by co-locating facilities in nuclear parks. These would eliminate many of the risks involved in transportation of nuclear materials. However another group of problems arise such as protecting the energy center against terrorists and saboteurs.

According to an April 1977 statement on the President's Energy Program, the Administrator of the Energy Research and Development Administration in FY1978 will initiate a new demonstration program to make use of waste heat generated by uranium enrichment plants at Oakridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. The recovered waste heat would be used onsite and by nearby households, industries, and farms.

The nuclear program faces a wide spectrum of constraints ranging from the availability of uranium, its processing, utilization, and reprocessing of spent fuel, disposal of waste products, and old plant equipment. The program is also threatened in many states by proposals to impose moratoria on construction and operation of nuclear plants. Among the constraints on

*John A. S. McGlennon, "Thermal Pollution: The Challenge of the Future," Environment News (July 1977).

nuclear generation are many of a regulatory nature. Environmental and health constraints include those affecting siting, licensing, leasing of federal land, state and federal restraints on surface mining, disposal of nuclear wastes, and governmental safety and health regulations.

In addition to the problems associated with these aspects of regulation, the electric utility industry has problems related to the utilization of nuclear fuel. Principal among the utilization problems is the complex set of standards developed for the licensing of spent-fuel reprocessing. A further concern is the growing need to store spent fuel. Delays and controls in licensing reprocessing facilities are necessitating the installation of expanded onsite storage for spent-fuel assemblies. Regulatory problems with the reprocessing of spent nuclear fuel and the lack of governmental action regarding disposal of nuclear waste is considered a severe constraint. According to the National Electric Reliability Council (NERC), the limited storage capability for high-level waste at current reprocessing sites in conjunction with the time needed to design, build, and demonstrate a chosen disposal technique could result in a shutdown of reprocessors.*

According to the 1977 Annual Report of the NERC, conflicting and overlapping regulations on the length of the approval process are making it difficult and almost impossible to site new coal-fired and nuclear generating plants.** The industry organization consists of nine regional

*National Electric Reliability Council, Fossil and Nuclear Fuel for Electric Utility Regeneration. Requirement and Constraints, 1976-1985.

**National Electric Reliability Council, Seventh Annual Review of Overall Reliability and Adequacy of the North American Bulk Power Systems, a report by the Interregional Review Subcommittee of the Technical Advisory Committee, July 1977, p. 13.

reliability councils and encompasses all of the power systems of the United States and the Canadian systems of Ontario, British Columbia, Manitoba, and New Brunswick. The NERC calls upon the Congress and the states to establish a mechanism for eliminating duplicative hearing procedures, resolving conflicts between agencies, and obtaining final and irreversible decisions on the siting of generating plants. In relation to licensing of nuclear plants the National Electric Reliability Councils recommend separation of site approval and plant licensing.

Constantly changing and increasingly rigid operating constraints for nuclear power plants are an area of deep concern to the electric power industry. A recent (April 1978) Supreme Court decision sharply limited the ability of environmentalists to get help from the Federal Courts in their attempt to block nuclear power plants. This decision could stimulate nuclear energy development.

Environmental Regulation

The federal environmental protection statutes that affect electric power generation include the National Environmental Policy Act of 1969, the Clean Air Act as amended in 1970 and 1977, and the Federal Water Pollution Control Act (FWPCA) as amended in 1970. (For a list of federal agencies with jurisdiction by law or special expertise on various types of environmental impacts that might be encountered in electric power generation see the Addendum.) Perhaps due to industry pressure, the Environmental Protection Agency's (EPA) role in regulation of nuclear power plant design and operation has been limited to setting general environmental standards, based on economic and technical feasibility.* Environmental limitations on other toxic and hazardous pollutants

*Ionizing Radiation. The National Academy of Sciences report on ionizing radiation exposure is highly critical of the EPA and the NRC for failing to force NRC licensees to further limit emissions in the public interest. This EPA policy is an exception to the otherwise all-inclusive scheme for water-pollution control as designed by Congress in the FWPCA that requires EPA to regulate (1) electric generating facilities as "point sources"; (2) radioactive effluents"; and (3) other waste water discharges of a polluting nature from nuclear plants and toxic materials.

are usually established on the basis of environmental and health effects.

The National Environmental Policy Act applies only to federal projects. The Clean Air Act involves federal standards enforced by the Administrator, but enforcement may be delegated to those states whose enforcement procedures are found to be adequate. The provisions of the Federal Clean Air Act do not preclude state or local enforcement of emission standards for pollution abatement so long as such standards or limitations are not less stringent than those set under the Act. Under the Federal Water Pollution Control Act the states have primary responsibility for controlling water pollution.

The cost of pollution controls and their effect on the power industry as well as on the consumer are of increasing concern to the regulatory agencies. A recent study reports that the financial outlook for pollution control is "guardedly optimistic due to favorable trends in earnings and recent regulatory decisions."* The states that regulate power companies have been willing to allow them larger returns of revenue, usually by allowing increases on utility bills. The study indicates that larger power companies will encounter little difficulty with external financing of pollution-control equipment. In the case of smaller companies, states may have to allow them higher returns on their service. The impact on major users of electricity and other business areas such as the sulfur industry will be much smaller.

*Economic and Financial Impacts of Federal Air and Water Pollution Controls on the Electric Utility Industry (Wellesley Hills, MA: Temple, Barker and Sloan, Inc., 1977). According to this report the direct increase in an average residential electric bill as a result of federal pollution control regulations will be approximately \$1.80 per month in 1980 and \$2.80 per month in 1985.

The Clean Air Act of 1970 lists one of its purposes: "To protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population." The courts have interpreted this clause as preventing the deterioration of air in areas that are cleaner than the national ambient air quality standards. The air quality restrictions resulting from the system established under the Federal Clean Air Act affect utility planning in terms of (1) fuel selection, (2) lead times in the overall planning horizon, (3) land availability and site selection, and (4) financing."*

EPA recognized the difficulty in complying with standards that would be encountered by the electric utility industry due to the unavailability of stack-gas scrubbers, other control technologies, and low-sulfur fuels. Before the oil embargo, EPA adopted a clean-fuel policy, which urged the states to voluntarily relax sulfur dioxide regulations that were more stringent than necessary to protect public health. However, when the events of October 1973 raised questions regarding existing energy policy, EPA participated in an effort to amend the Clean Air Act of 1970. In August 1977 President Carter signed into law the Clean Air Act Amendments of 1977 (PL 95-65) ** which amended most sections of the 1970 Clean Air Act (PL-604).

Regarding standards for new sources of pollution, the 1977 Amendments require that boilers fired by fossil fuels use "the best technological system of continuous emission reduction" even if they use untreated low-sulfur coal, as a step toward compliance. Standards for such sources include both

*H. J. Young, Sr., Vice President, Edison Electric Institute, ASME Paper "Energy and Other Environmental Considerations in Preventing Air Quality Degradation: Impact on Electric Utility Planning," 1977. Statement expresses industry concern regarding effect of clean air regulation on utility planning.

**For analysis of 1977 amendments see Congressional Quarterly Weekly Report, V. XXXV, No. 33, pp. 1713-1718.

performance standards for emissions and a percentage reduction in pollution from untreated fuel. There are stiff penalties on companies that do not meet 1982 deadlines.

Preliminary analysis of the impact of the 1977 legislation suggests that it satisfies the long-range goals of environmentalists but that deadlines have been pushed back to soften the impact on industry. Utility spokesmen express concern over the cost of pollution-control equipment and penalties for noncompliance. The Congress continues EPA's existing regulations regarding companies that build new plants in areas that already fail to meet minimum air-quality standards. These companies will have to arrange for some other facility to clean up their emissions so the addition of a new plant will not further degrade air quality. States have latitude to waive this requirement for five to ten years under specific conditions.

The capital expenditure impacts of the 1970 Clean Air Act on the electric utility industry were estimated at \$13.6 billion from 1975-1980, and \$20 billion from 1975-1985.* The new more stringent 1977 regulations can be expected to raise these figures. The pollution-control equipment involved are scrubbers and precipitators (largely used for western low-sulfur coal). These are two of the three most costly control items, the third being cooling towers. Together these three items account for 91 percent of the total impact of the 1970 legislation.** Nitrogen oxide emission regulations on all plants placed in service after 1977 and significant deterioration regulations can be expected to add significantly to the costs of air-pollution control for the utility industry.

*Temple, Barker and Sloane, "Economic and Financial Impacts of Federal Air and Water Pollution Controls on the Electric Utilities Industry" (May 1976), p. III-21.

**Ibid., p. III-26.

Water-quality regulation affects the selection and design of thermal discharge facilities and heat storage in underground water. There are federal, state and local statutes involved. Certain of the laws used to regulate industry's use of water have been broadly interpreted from old laws, to obtain authority to act today. A recent review of water-quality regulation affecting alternate means of power generation suggests that current regulations should be viewed as "somewhat transitory" since they will probably change as information is developed and energy and resource policy unfolds. A less free use of national water assets is expected.* Water-quality legislation is summarized in Table F.2.

Under the Federal Water Pollution Control Act, electric generation facilities are subject to federal regulations but the primary responsibility for control is delegated to the states. There are two forms of water pollution relevant to the electric generation process. One is the introduction of toxic substances into surface and ground water and the other is thermal discharges. Many organics and inorganics, including PCBs, chromates, and nitrosamines, may originate from electric generation facilities, and solvents including benzene and other ring compounds used in various fuel extraction processes are also prominent on the toxic lists. One of the most common toxic sources results from the introduction of chlorine into cooling and processing waters as a biocide. Its use constitutes a threat of unknown proportions since most of the by-products, including chloramines and chloroform and its derivatives, are known to be inimical to human health. The impact of many

*Argonne National Laboratory. Social Costs for Alternate Means of Electrical Power Generation for 1980 and 1990. Chapter VI. Thermal Discharge from Power Plants. Argonne, IL: ANL, 1973 (NTIS:ANL 8093-V4).

Table F.2

FEDERAL LEGISLATION AFFECTING WATER QUALITY

- Refuse Act (Section 13 of the Rivers and Harbors Act of March 3, 1899) prohibited the discharge of any waste matter into navigable waters, excluding discharges from streets and sewers.
- Public Health Service Act of 1912 authorized investigation of water-pollution-control problems affecting public health, and the relationship of public health to disease.
- Oil Pollution Act of 1924 to control discharge of oil into coastal waters.
- Federal Water Pollution Control Act, 1956 strengthened by a series of amendments including the Water Quality Act of 1965 which created the Federal Water Pollution Control Administration, and the Clean Water Restoration Act of 1966 which ordered states to set water quality standards.
- The Water Quality Improvement Act of 1970, which required state certification of federal permits affecting water quality and gave the Environmental Protection Agency responsibility for additional information and comment on water-quality standards.
- Fish and Wildlife Coordination Act as amended which required any federal agency proposing a water project to consult the Interior Department and state officials on the proposal's potential effect on fish and game.
- National Environmental Policy Act of 1969 which established the Council on Environmental Quality and required federal agencies to submit environmental impact statements to CEQ.
- EPA guidelines on effluents and hazardous discharges.
- Safe Drinking Water Act (PL 93-323) and 1977 amendments.
- Toxic Substances Control Act of 1976 and 1977 amendments.

chemicals and the compounds they form when they are introduced to surface waters has yet to be adequately assessed by the regulatory agencies.

Thermal discharge has an environmental impact only if it occurs at close intervals to other discharges where volume is low or where circulation is poor. Unfortunately, we may expect low volume and poor circulation in many areas with a high potential for energy-facility siting. Since discharges frequently transport toxics, plant wastes, and cooling-water blowdowns, and are even more frequently treated with chlorine, they constitute a secondary threat. Heat may also increase the reaction time of toxics and materials already in place causing thermal introduction to act synergistically.

There are two major sources of water pollution in the electric generation process. These are (1) cooling water used to condense the steam that has driven the turbine generator--which water will be at a higher temperature than the body of water into which it may be discharged; and (2) water periodically discharged from the condenser in the boiler system to remove impurities.

Earlier studies of co-generation and the generation of processed steam have reviewed the regulatory implications of water pollution.* In summary, these studies conclude that if the process adds no impurities to the steam, such steam might be condensed and recirculated indefinitely. Otherwise, the steam condensate will be discharged. Therefore, it is possible that there would be no significant water pollution in this process.

A study of heat storage wells (GE-TEMPO, 1976) states that the regulatory impact of heat storage wells "depends a good deal upon how they (EPA and state environmental agencies) make the tradeoff between thermal discharge into surface

*Dow, Energy Industrial Center Study, p. 9; GE-TEMPO, Role of Heat Storage Wells, p. 6-7, 6-8, 6-9.

water as opposed to heat storage in groundwater."* Since the number of heat storage wells that may be needed for district heating (as proposed in this study) is a fraction of the approximately 7 million water-supply wells in the United States, the potential impact of the use of heat storage wells on water-supply well fields will be minimal. For discussion of assumptions regarding use of heat storage wells in this study, see Chapter 4. At the least, however, new facilities will require an environmental impact statement under the NEPA.

The Safe Drinking Water Act (PL 93-523) was amended in 1977 (PL 95-190). That part of the amendments that relate to underground water is a minimal part of the bill. Ten million dollars a year was allocated for underground water source study; rural drinking water supplies was allocated \$1 million a year. As regards its impact on pollution by industry (including, presumably, utilities) the bill extends the deadline by which industries must install best available technology to mid-1984.** The legislation was hailed as a reasonable compromise by the Chamber of Commerce spokesman and environmentalists.

Transmission of Bulk Power

Regulatory responsibility for providing transmission services for bulk power supplies was confused before the creation of the Department of Energy. The FPC took the position that it lacked authority to compel power companies to transmit power for municipal and cooperative customers.*** Transmission rights were worked out with Department of Justice, the Nuclear Regulatory

*Ibid., p. 6-8.

**1977 CQ Almanac, p. 707; Chemical Week (November 23, 1977), p. 15.

***Electric Utility Rate Reform & Regulatory Improvement-Hearings, Senate Commerce Committee, April 27, 28, 1976, p. 433.

Commission, the Securities and Exchange Commission under the Public Utility Holding Company Act or the federal district court in the event of litigation. Currently the FERC handles these matters.

Transmission of heat or hot water is not subject to federal regulation, unless the hot water pipes cross state lines.

Federal Demonstration Projects

A division of the Department of Energy in charge of industrial applications of district heating is studying the development of an energy plan for Mercer County, North Dakota.* In this community, approximately 6500 people reside in six cities covering 700,000 acres. There is already one large utility, and three more plants are planned. There is a potential boom-bust cycle facing the area. The DOE is encouraging planning that would include attracting industries that can utilize the waste heat such as those in agriculture and fishing. Regulation and planning is being done by the local Energy Development Board, which is responsible for developing a city-wide development plan.

The utilities in the county are run by the Rural Electrification Administration. Working with the utility, the Public Service Commission has written into the siting permit a requirement that the Commission cooperate with local authorities on district heating. In North Dakota all siting and rates are covered by the Public Service Commission. This includes all sources of energy such as mines and generating plants.

A demonstration project for developing district heating and cooling systems for communities through power-plant retrofit and a distribution network was recently announced by the DOE. The first phase will include planning

*Telephone conversation with G. Leighton, December 5, 1977. Building and Community Energy Systems, Department of Energy.

"institutional strategies," which presumably means attention to regulatory implications.*

State Regulation

The role of regulator has changed hands several times in the history of this country. After the Civil War the so-called Granger Acts of state legislatures set prices and conditions of service by state statute. As electricity became important to the economy, state commissions were established rapidly, but gradually their actions became subject to court review and interpretation. Between 1898 and 1944 the courts were the regulators, defining both the scope and the results of regulations.

The Hope Natural Gas decision (1944) marked a change as the courts indicated that they would limit their interest in utility pricing and performance to consideration of the end result of regulation. Since the Hope decision the role of regulator has been held by state commissions. The courts review public utility commission actions and state legislatures are responsible for the establishment of the commissions, their jurisdiction, and the enunciation of standards to be applied.

The state public utility commissions operate within this framework to put regulation into effect. Among the functions that commissions perform are the following:

- Determine fair value and find fair rate of return.
- Approve utility rate schedules with respect to permissible degrees of discrimination.
- Allow operating expenses as part of pricing process.
- Specify depreciation schedules to be used.
- Impose various service standards on the supplying utilities.

*Commerce Business Daily (March 3, 1978), p. 1.

- Pass upon issuance of securities.
- Issue certificates of public convenience and necessity.
- Monitor utility intercorporate relations.

Practically all state public-utility commissions have the authority to review utility rates. The review is designed to insure that the public pay no more than is just and reasonable and that the utility receive a fair rate of return. Public utility commissions in many states regulate sales of securities, and are involved in power-plant siting and licensing. The trend has been to give state public-utility commissions authority over siting where no authority previously existed, and to strengthen such authority where it already did exist.

Students of state regulatory commissions have found that these institutions tend to be unwilling to extend their jurisdiction beyond simple rate and service regulations. Some utility commissions have resisted setting rates except on a cost-of-service basis. Although inverted rate structures and peak-load pricing might encourage electric energy conservation, commissions have been reluctant to apply these tools without specific legislative mandate.

Regulating Heat Sales

There is no definitive answer as to whether public utilities can sell heat, whether these sales must be regulated, and if so, according to what rate regulations. In several cities heat is provided to separate complexes (e.g., Hartford's Constitution Plaza and in government sites in Madison and Dade Counties in Wisconsin) and is not subject to a regulated rate. The general consensus of both utility spokesmen and representatives of state public utility commissions is that there has been too little experience with private utilities selling heat. Consequently the regulatory issues have not yet been raised. There was no opinion expressed regarding the

question of whether unregulated heat sales would provide an incentive to the investor-owned utilities.

In general, the attitude expressed was that sales of heat or hot water would eventually be regulated if the volume of business increased significantly.

In Michigan, water companies have the option of marketing heat in towns of 25,000 or less. This would not constitute a viable district heating market; however, it has been suggested that the district heating company could function as the water utility in which case both water and heat would be regulated.*

Other studies and our own review of regulatory practices in the United States, Canada, and Europe show that there is no clear pattern regarding regulation. Utility charters vary from jurisdiction to jurisdiction and a national study such as this could not provide a conclusive answer on regulatory attitudes toward the sale of hot water or heat.** It would be necessary to approach this question on a district-by-district basis.

Regulatory issues posed in the series of interviews conducted for this study covered electric and gas utility charter provisions, right-of way regulation, rate setting, water rights, apex of control, and environmental-regulation implications. The results of these interviews have been presented in Chapter 4. In brief, the answers cover the following issues:

1. Are heat sales covered in electric and gas utility charters?
 - probably
 - no potential problems expected
 - policy in state of evolution towards conservation orientation.

*GE-TEMPO, p. 6-14.

**Ibid., p. 6-17 confirms the results of this study.

2. Regulations for rights of way for heat.
 - certificates of convenience and necessity issued by state
 - utility charters probably cover obtaining rights of way for hot water pipes
 - transmission lines for electricity or hot water that cross state lines, probably would involve regulation by Federal Energy Regulatory Commission
3. Allocations of cost between heat and electricity
 - no established policy in most states
4. Regulatory issues involved in water rights and underground storage
 - speculation regarding impact on riparian rights, need for new legislation, possible precedent seen in underground gas storage and involvement of federal agencies.
5. Public utility commission attitudes toward source of control for district heating (private, municipal, federal, etc.).
 - no preference indicated.
6. Siting problems near urban areas
 - commission might encourage district heating if positive impact on urban air pollution can be demonstrated.

Rate Setting Attitudes

There are several areas in which state commissions may be involved in the regulation of heat sales as a venture connected with the sale of electricity. Potential areas of regulation include: rate setting, reliability, transmission, underground storage, and sales of equipment to customers (e.g., heat exchangers, meters) as well as the larger issue of power-plant siting which encompasses nuclear power regulation in some instances. However no broad regulatory policy has developed, since few utilities are faced with these ventures on any large scale.

Rate setting was a particular focus on an interview with a public utility commissioner, who has frequently been identified as a representative of

consumer interests in Connecticut.* His comments, summarized below, suggest several issues and approaches that may be of concern when regulatory commissions review their position on district heating.

- Revenues from district heating may be treated by some regulatory commissions as "income from other sources" which would be excluded from the rate base, i.e., unregulated. In this case heat could be sold at whatever price the market would bring. However any degradation in electrical generation must be compensated for by some portion of the heat revenues so that the electric customer is not penalized.
- Conversely some commissions would regulate heat sales. Many schemes between these extremes are possible depending on the philosophical attitudes of commission members at the time the system is proposed. The regulatory authority in most states as well as case law is sufficiently broad to permit a variety of interpretations by the commissioners.
- If the system makes sense economically and can be shown to conserve significant amounts of fuel, some commissions might even allow it to be priced to cover incremental costs alone, with no allocation of plant costs to the heat customer. This would presumably represent a lower bound on the price of delivered heat.
- A utility attempting to do a venture analysis on district heating would not know with any assurance what position the commission would take on the issues of costing, pricing, rate of return, and implementation. Thus several iterations of proposal and counterproposal may be necessary before a decision would be made.
- If the transmission/distribution system has a longer life than the plant, he would be inclined to give little value to the excess life. In the case of nuclear plants, the plants would probably not be rebuilt at the same site so some or all of the transmission line would be useless. The distribution system would be unaffected.
- Utility regulators are required to satisfy three interests in setting rates: the consumer, the investor, and the public-at-large. The trend is to include "public needs: existing and foreseeable." This involves calculations of social overhead and marginal social costs. Connecticut statutes require PUCA to consider conservation, environment and economic development.

*Interview, Member, Public Utility Control Authority, Nov. 17, 1977.

- Since commissioners are not bound by statute as to how they would treat the regulation of a district heating system, it is important to interview a representative sample of both liberal and conservative commissioners.

Additional interviews with regulators conducted for this study in New York, Michigan, California, and Florida,* as well as the results of the Energy Industrial Center Study,** indicate that neither steam nor hot water heat sales are viewed as a troublesome new area for potential regulation. The general view is that existing regulatory policy will probably govern sales of heat by utilities.

The case of cogeneration raises separate issues: Cogeneration is the process by which industrial plants generate electricity as a by-product of industrial steam production and, in some cases, wish to sell the excess electricity back to the utility. The major issue involved in cogeneration is the rates and conditions under which the excess power generated by industry is sold to electric utilities. As a situation involving changes in existing regulatory thinking and the development of incentives for conservation, experience with cogeneration is suggestive of the institutional constraints that may face the introduction of increasing numbers of district heating ventures.

A recent survey of public utility commissions contained a question regarding the commissions' attitude on rates for consumers of wind, solar, or other small generation for supplemental power.*** The responses of each state are reported in Table F.3. Thirty-three state commissions had no policy on such rates.

*See Chapter 4.

**Dow Chemical Co. et al., June 1975.

***Irving Stelzer, "Rate Structure Revision: A Federal or a State Problem?" Table D, National Economic Research Associates, Inc. (1977).

Table F.3

STATE PUBLIC UTILITY COMMISSION POLICY ON RATES FOR CONSUMERS WITH SOLAR, WIND OR SMALL GENERATION

Alabama	none
Alaska	none
Arizona	none
California	The Commission is just getting involved in the study of alternate energy sources; present rates do not discriminate against users of solar powered, wind-powered or small generators of electric power. California is moving toward rates that will encourage utilities to purchase the excess power generated by alternate energy sources.
Colorado	Issue of special rates for alternate energy sources is being investigated. A demand energy rate for solar-energy users was made optional instead of mandatory.
Connecticut	Encouraging
Delaware	None
District of Columbia	Yes
Georgia	None
Hawaii	None
Idaho	None
Illinois	Solar rates, approved for Commonwealth Edison and Central Illinois Light Co.
Indiana	Encourages supplemental generation of power
Iowa	None
Kansas	Encouraging
Kentucky	None
Louisiana	None
Maine	None
Maryland	Nondiscrimination
Massachusetts	Yes
Michigan	Yes. Special rate for auxiliary services to residential customers generating their own power, with sale of excess power by customer to utility at reasonable cost.
Minnesota	None
Mississippi	None
Missouri	None
Montana	The commission is encouraging the development of small supplemental hydro, solar, and wind generation. It opposes standby charges and considers treating these sources of power like gas (in determining eligibility for certain rates) to be discriminatory. The commission encourages the utilities to buy excess power from these sources and is contemplating holding generic hearings on this issue.
Nebraska	Commission does not regulate electric utilities
Nevada	None
New Hampshire	None
New Jersey	Nondiscriminatory
New Mexico	None
New York	Solar, wind rates
North Carolina	Encouraging
North Dakota	None
Ohio	None
Oklahoma	Discouraging. Supplementary or auxiliary power sources cannot be installed without commission approval.
Oregon	None
Pennsylvania	None
Puerto Rico	The Commission does not regulate electric utilities
Rhode Island	None. Investigation begun
South Carolina	Investigating
South Dakota	None
Tennessee	None
Texas	None
Utah	None
Vermont	None
Virginia	None
Washington	None
West Virginia	None
Wisconsin	Yes. One company has an experimental rate that provides lower cost offpeak to provide incentives for development of supplemental heating sources with offpeak electric heat backup. The commission does not discriminate against users of alternate energy sources.
Wyoming	None

SOURCE: Irving Stelzer, Jr., "Rate Structure A Revision: A Federal or State Problem?" A report presented before the Eighty-Ninth Annual Convention, National Association of Regulatory Commissioners, November 17, 1977. Table D, Rate Structure Revision.

Responses of those states with an existing policy or where policy was under consideration are instructive. In California, the commission is studying rates that will encourage utilities to purchase excess power generated by alternate energy sources; in Colorado, the matter is under investigation; Connecticut's policy is definitely encouraging, with a nondiscriminatory rate. In Florida, the Tampa Electric Company rate gas customers with less than 25 kw loads were exempted from standby charges; in Illinois the commission approved solar-assisted heating rates for Commonwealth Edison and Central Illinois Light Company; Indiana and Kansas encourage supplemental generation of power; Maryland is studying the issue; Massachusetts and Michigan have a nondiscriminatory policy in effect; and Michigan has a special rate for auxiliary services to residential customers generating their own power.

In Montana, the commission is encouraging the development of small supplemental hydro, solar, and wind generation, and encourages the utility to buy excess power from these sources; in New Jersey one utility has a solar tariff on file; New York's commission has a general policy against rate discrimination; North Carolina revised its provision of residential rate schedules so that customers using nonfossil energy sources would not be disqualified. The other states are investigating the matter. Only Oklahoma had a definite policy of discouraging the use of auxiliary power, requiring commission approval for the installation of supplemental or auxiliary power sources.*

Power-Plant Siting

The state and federal interest in regulation of power siting has been the result of problems of environmental destruction and decreasing electric power reliability. The extent of government involvement in power-plant siting is evidenced in Table F.4. Power-plant siting in the past, if:

*Ibid. See Table 5.3.

Table F.4

POWER-PLANT SITING: GOVERNMENT INVOLVEMENT

Federal Legislative Framework

Federal Power Act (1920)
 Atomic Energy Act (1954)
 Administrative Procedure Act (1946)
 The National Environmental Policy Act (1970)
 Clean Air Act (1970) and Amendments (1977)
 Federal Water Pollution Control Act Amendments of 1972
 Coastal Zone Management Act 1972
 Fish and Wildlife Coordination Act

State Agencies

Environmental Protection Agency (water resources commission,
 air quality board, etc.)
 Department of Natural Resources
 Department of Fish and Wildlife
 Highway Commission
 Department of Public Health
 State Police
 Office of Parks and Recreation
 State Planning Commission (wetland agency, etc.)
 Department of Transportation
 Industry Commission

County

Planning Board
 Highway Board
 Pollution Control Agency
 Health Authority

Municipality

Fire Department
 Department of Sanitation
 Pollution Control Agency
 Health Authority
 Departments issuing miscellaneous permits for boiler operation,
 street changes, blasting, oil storage, etc.

regulated at all, was the subject primarily of local zoning laws. State regulation of power was restricted to protecting the consumer by regulating rates. As the concern of the states for the relationship between the environment and the utility has increased, the National Association of Regulatory Utility Commissioners (NARUC) proposed a Model State Utility Environmental Protection Act of 1970. Many states adopted the important features of the Model Act.

Because power plants and transmission lines have a considerable impact on the environment, the NARUC calls for

- long-range plans by the utilities and the state government to insure the time necessary to study possible implications of the proposed sites.
- environmental review and assessment of proposed construction by qualified state agencies.
- public hearings to allow citizen participation in the siting of power plants.

A recent study of energy policy in Texas surveyed siting procedures in all the states and concluded that

1. Environmental review and public hearings appear to be accepted in most states as legitimate controls for power-plant siting.
2. Many states do not provide for long-range planning for electric power or certification of power plants and transmission lines.
3. A few states have established a land-use agency.*

State power-plant siting controls are detailed in Table F.5.

*California, Colorado, Florida, Maine, New York, Vermont, Virginia. Lyndon B. Johnson School of Public Affairs. Policy Research Project Report. Energy in Texas, Volume I: Electric Power Generation. Lyndon B. Johnson School of Public Affairs. The University of Texas at Austin (1976), pp. 104, 105.

Table F.5

STATE POWER PLANT SITING CONTROLS

State	Certification required for construction of		Public hearings required	Environmental review	1-stop siting procedure	Long range plans (by state and/or utilities)	State land-use agency
	Power plants	Transmission line					
Alabama	Y	Y	Y	NA	N	NA	NA
Arizona	Y	Y	Y	Y	Y	Y	NA
Arkansas	Y	Y	Y	Y	N	NA	NA
California	Y	Y ¹	Y	Y	N	Y	Y
Colorado	Y ¹	Y ¹	Y	Y	N	N	Y
Connecticut	Y	Y	Y	Y	Y	Y	N
Delaware	N	N	N	Y	N	NA	NA
Florida	N	N	N	Y	N	NA	Y
Georgia	N	N	N	N	N	NA	NA
Idaho	Y	Y	N	NA	N	NA	NA
Illinois	Y ²	Y ²	Y	Y	Y	N	NA
Indiana	N	N	N	Y	N	NA	NA
Iowa	N	Y ¹	Y ¹	Y	N	NA	NA
Kansas	Y	Y	Y ¹	NA	N	NA	NA
Kentucky	Y	Y	Y	Y	N	NA	NA
Louisiana	N	N	N	Y	N	NA	NA
Maine	Y	Y	Y ¹	Y	N	N	Y
Maryland	Y	Y	Y	Y	Y	Y	N
Massachusetts	Y ¹	Y ¹	Y	Y	N	NA	NA
Michigan	N	N	N	Y	N	NA	NA
Minnesota	Y	N	Y	Y	N	NA	N
Mississippi	Y	Y	Y	Y	N	NA	NA
Missouri	Y	Y	Y	Y	N	NA	NA
Montana	N	N	N	Y	N	NA	NA
Nebraska	N	N	Y	Y	N	NA	NA
Nevada	Y	Y	Y ¹	Y	Y	NA	NA

¹Required under certain circumstances²Nuclear power plants only

SOURCES: Southern Interstate Nuclear Board, 1972.
Electric Power and the Environment, U.S. President, Office of Science and Technology, 1970
 Association of the Bar of the City of New York, Special Committee on Electric Power and the Environment, Electricity and its Environment, West Publishing Co., St. Paul, Minn., 1972.
 Correspondence with state government officials from California, Maryland, New York, and Oregon.

SOURCE: Lyndon B. Johnson School of Public Affairs, Policy Research Project Report, Energy in Texas, Vol. 1: Electric Power Generation, The University of Texas at Austin, 1976.

Table F.5 (Cont.)

STATE POWER PLANT SITING CONTROLS

State	Certification required for construction of		Public hearings required	Environmental review	1-stop siting procedure	Long range plans (by state and/or utilities)	State land-use agency
	Power plants	Transmission line					
New Hampshire	Y	Y	Y	Y	Y	Y	NA
New Jersey	N	Y	Y	Y	N	NA	NA
New Mexico	Y	Y	Y	Y	Y	N	NA
New York	Y	Y	Y	Y	Y	Y	Y
North Carolina	Y	N	Y ¹	Y	N	NA	NA
North Dakota	N	Y	Y	Y	N	NA	NA
Ohio	N	N	N	Y	N	NA	NA
Oklahoma	N	N	N	NA	N	NA	NA
Oregon	Y	N	Y	Y	Y	Y	N
Pennsylvania	Y ¹	Y	Y	Y	N	NA	NA
Rhode Island	Y	Y	Y	Y	N	NA	NA
South Carolina	Y	N	Y	Y	N	NA	NA
South Dakota	N	N	Y	NA	Y	NA	NA
Tennessee	Y	Y	Y ¹	NA	N	Y	NA
Utah	Y	Y	Y	Y	N	NA	NA
Vermont	Y	Y	Y	Y	Y	N	Y
Virginia	Y	Y	Y	Y	N	NA	NA
Washington	Y	Y	Y	Y	Y	N	Y
West Virginia	Y	N	Y	Y	Y	NA	NA
Wisconsin	Y ¹	Y ¹	Y	Y	Y	NA	NA
Wyoming	Y	Y	Y	Y	Y	Y	NA

The delay and added cost to power-plant construction due to the public participation in site selection have led to coordination of all reviews in one agency (one-stop selection) in some states.

Local Regulation

In a district heating system the cost of the distribution network represents a major part of the system cost. Among the major factors that determine the cost of the system are several that are subject to the control of local authorities. Laying conduits is particularly related to the regulation of land use; however, other aspects of the system, such as connections to individual businesses or residences, are governed by zoning and building ordinances. The authorities of several contiguous areas may be involved in the distribution network for one district heating system.

States and localities share responsibilities for federal air- and water-pollution control but they have almost exclusive jurisdiction over land use, zoning, and building standards. Federal agencies frequently require information on compliance with state laws before licensing a power plant. Hence the state and local authorities play an essential role in power-production regulation.

Public utilities must generally abide by local zoning ordinances. The municipality's power to zone derives in most instances from the state's police power through a general enabling act. Zoning is implemented by local zoning boards and boards of adjustment which have appellate jurisdiction. Variances can be granted usually only after public hearings. Zoning laws have not been subject to a general state plan in most states, although a few state public utility commissions can override local zoning laws. In some states certain vulnerable ecological areas are protected from damaging development. However, in most instances local zoning regulations control.

Generally, local building codes also govern construction of power plants. The utility must seek approval from the local building inspector; in a few instances a state agency is responsible for approving compliance with state building codes.

Utilities are particularly encumbered with local regulation in the matter of transmission lines. In addition to satisfying state and local requirement regarding land use and the crossing of state and local roads and other public property, the utility must seek permits from the myriad jurisdictions along the route's line. Efforts to consolidate licensing procedures are making some progress. In New York, for example, all questions relating to the location of major utility transmission facilities, including their environmental impact, are consolidated into one proceeding. Citizens of the affected localities may participate in the proceedings, but local regulation is unreasonably strict.*

Electric Utility Industry in the United States

The provision of utility service in the United States, like that of most other goods and services, is predominantly under private control. Three fourths of the power produced and sold in the United States is from private power companies. The U.S. Electric Utility industry in 1976 is described in Table F.6.

Investor-Owned Utilities

Originally most utility firms in the United States were very small, served a small territory, and lacked capital and technical sophistication. Sometimes two or more firms served the same territory. However, competition

*Association of the Bar of the City of New York. Special Committee on Electric Power and the Environment. Report: The Electricity and the Environment; the reform of legal institutions (St. Paul, MN: West Publishing Company, 1972), pp. 90-91.

Table F.6

U.S. ELECTRIC UTILITY INDUSTRY--1976

		<u>Percent</u>
284	Private power companies	78.2
2245	Local public systems	10.4
2126	Municipal utilities	
119	Public utility districts and other state and county systems	
919	Rural electric cooperatives	6.4
10	Federal agencies	3.3

SOURCE: Public Power, American Public Power Association
(January-February 1976).

sometimes costs dearly in terms of high rates, poor service, and inadequate plants. Economies of scale dictated that firms consolidate or merge to avail themselves of the advantages of larger production units and larger service areas. The need for modern equipment, capital, engineering, and technical services led to the necessity to borrow money. This led to stock and bond ownership by holding companies. By 1929, sixteen holding companies generated over 80 percent of all electric energy in the United States. This integration movement took place during the period of state regulation of utilities. The problems associated with this concentration of economic power culminated in federal controls over public utilities, beginning in 1933.

Federal regulation of the utility industry is found in six separate acts. Three of these regulate holdings companies: The Securities Act of 1933, which created the Securities and Exchange Commission (SEC) and gave it jurisdiction over all securities sold in interstate commerce, including those of public utilities; the Securities and Exchange Act of 1934, which enlarged the commission's powers; and the Public Utility Act of 1935, known as the Wheeler-Rayburn Act. Part I of Wheeler-Rayburn is called the Public Utility Holding Company Act.

Federal holding-company legislation was designed to supplement state regulation, not to replace it. The object of the Public Utility Holding Company Act was to preserve what was in the public interest and prohibit what was adverse to the consumer and the investor.

One significant aspect of this legislation affects the sale of heat by utilities. Holding companies typically owned parts of gas and electric systems, water and telephone systems. After passage of this legislation the holding company was forced to choose one system to retain and dispose of all other holdings so that only a single integrated system remained. Among the legal issues involved in the sale of heat by an electric or gas utility that is a holding company is whether the sale of heat is "incidental or economically necessary or appropriate to the operation of the integrated public utility system."*

The controls and regulations drawn up in the 1930s pose serious problems in the economic and political environment facing the utilities in the 1970s.

*49 Stat 803 (1935), Section 2 as quoted in M. Farres and R. J. Sampson, Public Utilities: Regulation, Management, and Ownership (Boston: Houghton Mifflin Company, 1973).

Efforts to change the regulatory structure have been the focus of extensive congressional hearings. Despite the evidence that some regulatory structures are outdated, there is strong resistance to change stemming from both institutional and political issues.

Originally, electric utilities supplied the bulk of district heating, when the plants were located in core cities and the steam delivered as heat was taken from the topping turbines in the electric generation process. However, the need for larger generating plants and the dispersion of populations to suburbs and rural areas has resulted in a radical change in the source of district heating. As of 1975 only 12 percent of the total district heat delivered in the United States came from topping turbines.*

The general attitude today of many large utilities is that the sale of heat will not be profitable and will involve difficult regulatory issues. Several of these utilities still in the steam business report that they consider continued service an obligation and that repair to steam pipes has seriously drained the companies financially. Presumably the situation would be different if the sale of heat and electricity by the generating plant were planned at the time a new town or development was put on the drawing board. However, previous negative experience may condition utility thinking.

Publicly Owned Utilities

Public ownership of utilities takes several different forms. The federal government controls electric power through government corporations such as the Tennessee Valley Authority. The Bonneville Power Administration is directed

*Role of Heat Storage Wells, pp. 6-29.

by the Department of Energy. States and local municipalities use departments or form semiautonomous organizations. In addition nonprofit cooperatives or service districts provide utility services in designated areas without any particular political subdivision.

Publicly owned utilities operate under different constraints from privately owned utilities. However, the primary difference is that they do not have to make a profit.

There are 2200 municipal and other local publicly owned electric utilities in the 50 states, Guam, the Virgin Islands, Puerto Rico, and American Samoa. Of these, 867 purchase all or part of their wholesale power requirements from private power companies subject to the jurisdiction of the Federal Energy Regulatory Commission. Municipal production amounts to about 5 percent of the countries' total electric generation. The number of municipal electric utilities has declined since the 1920s when low-priced federal power and "preference" clauses favoring public purchasers greatly stimulated municipal ownership. At that time, government loans to cooperative associations and the strong public reaction against the abuses of the electric utilities brought the number of municipal utilities to a peak of 3,000.

The Federal Power Act was designed, in part, to protect the wholesale purchasers of electricity in their transactions with supplying privately owned utilities. Although there are some large local publicly owned electric utilities, such as those serving the cities of Los Angeles, Seattle, Memphis, and Jacksonville, the average local public power system is small, serving an estimated 5,000 meters. In contrast the average privately owned electric utility services more than 281,000 meters.

Another point of sharp contrast relates to the relative importance of wholesale sales to the seller and purchaser of wholesale power. Revenues

from wholesale sales to the average privately owned power company account for about 8.2 percent of total electric operating revenues. Only 1.5 percent of the revenues of the average private power company are derived from wholesale sales to publicly owned electric utilities. The purchase power costs of the local public power systems served by privately owned utilities represent an estimated 70 percent or more of the total electric operating and maintenance expenses of the average publicly owned electric utility.

A few states have become involved in utility ownership in the electric field. The New York State Power Authority primarily handles power produced from the St. Lawrence River Project and the Niagara River. South Carolina, Texas, and Oklahoma have a state power authority and in Nebraska, all electric power distribution has been under public ownership since 1946.

The federal government has been in the electric power business since the early 1890s. The largest federal project is the Tennessee Valley Authority (TVA), organized as a government corporation in 1933. Other federal power projects include the Bonneville Power Administration and power harnessed from the federal hydroelectric project on the Columbia River. A district heating demonstration project might be conducted with a federally owned power facility to avoid the complications of rate of return calculations while testing the heat storage well concept.

A recent study of the heat storage well concept concluded that municipally owned utilities are likely to be the first to implement central heat generation and franchised distribution.* Municipals can impose taxes and issue bonds that provide capital at low interest rates. The fact that municipals tend to be smaller and closer to their electric and heat loads than private plants would also contribute to the possibility that they might

*Heat Storage Wells, p. 6-28.

become active in district heating. Many of the district heating systems in this country are run by municipalities--although this thought must be tempered by a restatement that municipal utilities only generate 5 percent of the electricity in the United States.

European experience with municipals has been more extensive. In Sweden the nuclear electric generating station, which will supply both Lund and Malmo with electricity and heat by 1984, is owned by a consortium of six local municipal utilities. As of 1974 these utilities supplied electricity to 20 percent of Sweden's population.*

The Canadian study of district heating for Toronto was conducted by the municipality and is an excellent example of an integrated analysis which included incentives to encourage the success of the project with the public, including individuals and businesses.**

Consumer Protection

According to lawyers at the Federal Trade Commission (FTC) there is a need for a new legislation and also a need for an increase in the jurisdiction of existing legislation to provide for more extensive testing, and standard setting and adequate regulation of energy technologies. The FTC's proposed new labeling requirements would affect some of the technologies connected with the integrated energy utility system such as the heat exchanger and water heaters. Proposed labels would indicate such general specifications as the size relative to the consumer's particular hot water needs and the particularized operating costs based on local utility rates and local use habits. The FTC would like to see mandatory minimum standards for efficiency that would go into effect 18 months after these labeling

*Ibid., pp. 6-35.

**Toronto, District Heating Study .

standards to give the forces of the marketplace a chance to improve aggregate efficiency without the need for minimum efficiency standards. The FTC also suggests that state regulations should be preempted by these consumer regulations so that the consumers do not have to refamiliarize themselves with different labeling information from one part of the country to another.

Regarding the implications of the President's Energy Program for the utilities, Michael Pertshuk, the new chairman of the FTC, expressed concern that energy legislation should not become a vehicle to undercut the effectiveness of the antitrust laws.* The President's program gives the utilities three new functions: (1) inspecting homes to recommend residential retrofitting, (2) selling and installing conservation measures, and (3) financing conservation measures. The Chairman of the FTC feels that each of these jobs should be done by private parties, and not regulated industries. Another FTC concern is that consumers may lose control over the purchase of equipment. If utilities sell this equipment, this might make consumers subject to coercive debt-collection techniques from the utilities. The FTC warned that the utilities may overcharge for the equipment since regulatory agencies have not been designated in the legislation. The positive benefit of involving the regulatory agencies, according to the FTC chairman, will be an increase in energy efficiency and an increase in information provided to the consumer.

The implications for district heating are that the FTC would be a force pressuring for regulation. If the meters and other equipment located in the home or business receiving the hot water heat are to be regulated, then it is likely that the sale of the heat also would be subject to regulation.

*Testimony before the Senate Sub-Committee on Antitrust Monopoly, June 23, 1977.

Innovation in Regulated Industries

Earlier studies of district heating have concluded that economic and institutional obstacles stand in the way of broad implementation of district heating systems in the United States.* One of the implications of this observation is that advances in district heating technology will be limited by the difficulty of mobilizing capital. Studies of district heating suggest that there is a need for the development of new construction techniques and equipment, improved pipeline design, and development of plastics with increased pressure capacity. Development of such innovations is capital intensive.

To what extent does regulation provide a spur or a brake on the utility industry's inclination to adopt innovative technologies? An answer to this question would set the scene for the discussion in Chapter 6 on Government Incentives. It has been suggested by Averch and Johnson that rate-of-return regulation tends to increase the capital intensity of public utilities production methodology.** This is to say that the public utility that is inclined to innovate chooses a more capital-intensive technology rather than an equally good, perhaps even more efficient method where the capital output ratio would be lower. However critics of this thesis contend that it is based on a condition of limited competition in a riskless industry, but that in fact competition, uncertainty, and regulatory lag in the electric utility industry provide sharp spurs for optimizing the social costs in a regulated firm.***

*Karheck et al., "Prospects for District Heating in the United States," Science, Vol. 195 (March 11, 1977), pp. 948-955.

**Harvey Averch and Leland L. Johnson, "Behavior of the Firm under Regulatory Constraint," American Economic Review, Vol. 52 (December 1962), pp. 1059-1069.

***R. H. Males, "Investment Behavior of the Utility under Regulatory Constraint," Public Utilities Fortnightly (September 11, 1969), p. 21.

Males claims that regulated firms do not operate according to the Averch-Johnson hypothesis. The literature is not conclusive. The question remains whether regulations have a positive or negative influence on technological innovation. The literature concerning energy utilities often discusses the ERTI relationship and regulation in general in terms of broad considerations rather than specific regulatory parameters. Technology is also discussed in general terms rather than specific technological innovations.*

In general, it has been assumed that to innovate successfully management must be willing to take a high degree of risk in anticipation of a rather large payoff. Because of the structure and regulation of the energy utility industry, management will tend not to innovate since the payoff for any particular innovation is restricted primarily by rate-of-return regulation. This postulate is in addition to the Averch-Johnson theory that those innovations that are advanced by the energy utilities tend to be more capital intensive than those innovations that might have been adopted in the competitive marketplace. The reasoning behind this theory is that rate-of-return regulation limits the return on investment based on the size of the capital investment base. The higher the capital intensiveness of new technology, the more of a buildup will occur on the rate base and, in effect, the higher net earnings will become.

Another argument centers around regulatory lag--that period during which an innovation and the existing rate structure coexist before and during regulatory review by the appropriate regulatory agency. During this period, the

*A thorough review of these areas is contained in Economic Regulation and Technological Innovation: A cross national literature survey and analysis, Vol. 1 Analysis. Gilman Research Associates, Inc. (January 1974), and in Almarin Phillips, ed., Promoting Competition in Regulated Markets (Washington DC: The Brookings Institution, 1975).

public utility enjoys higher-than-normal return on its investment since the rate structure remains the same even while the cost-savings innovation is employed. Some argue that regulatory lag is the biggest incentive for public utilities to innovate: due to capital intensiveness of new technology in the energy utility field, the payoff time for any new innovation would be substantial. Therefore, the monopoly profits that the energy utilities would be able to maintain during the period of regulatory lag would fall short of the profit incentive required during the full term of the investment. In the current market of rising fuel prices, the lag works against the utility.

Although the economic regulation of the capital-intensive technology is concentrated in patent problems and antitrust considerations, the state public utility system has jurisdiction over electric power-rate structures. Consequently, in the regulation of nuclear power as well as conventional sources the state utility commission governs competition and market penetration by setting the rate at which the heat or electricity is sold.

A recent study of the role of storage wells in future U.S. energy systems concludes that publicly owned utilities are more likely to implement that innovation.* This judgment is based on the form of ownership, regulatory and financing considerations, experience in selling steam, proximity to concentrated loads, and community incentives for environmental protection and energy conservation. The heat storage well study suggests that the concept of net-energy savings is new to regulatory laws and institutions and that the least regulated of the regulated industries would therefore be most likely to innovate.

*C. F. Meyer, W. Hausz, "Role of the Heat Storage Well in Future U.S. Energy Systems," GE-TEMPO Center for Advanced Studies, Santa Barbara, California and Washington, DC (1976).

There is not sufficient experience with implementation of energy conservation innovations to support this conclusion. However, it suggests an interesting hypothesis for further research.

Conclusion

Conflicting regulatory requirements and lengthy and involved proceedings in overlapping jurisdictions of federal, state, county, and local government bodies represent the political and regulatory environment for energy policy in the United States at this time. Experience with and studies pertaining to cogeneration suggest that even where technical and economic obstacles can be overcome, political and institutional barriers may be insurmountable without government assistance. The general consensus, confirmed by this review of the regulatory environment, suggests that federally provided incentives and disincentives will be necessary to stimulate both private-sector and public-sector investment in district heating.

A recent study of strategic alternatives for energy conservation poses the key question: What are the requirements of a legal structure attuned to the need for social adjustment to energy problems?*

The regulatory environment in which energy policy is currently operating was designed on the basis of past experience with falling energy costs. There is a movement toward reassessing and redesigning public law affecting energy. District heating systems, currently not the subject of much specific regulation, may become of more interest to public utility commissions if there is greater interest in the use of this approach for the conservation of energy. Federal regulation could be a positive force to stimulate private- and public-section applications, research, and development of supporting technology. There is insufficient basis for judging whether there are any benefits from regulating the sale of heat on the local level.

*J. Utterback, Center for Policy Alternative, Massachusetts Institute of Technology, CPA-77-1, February 1977.

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Appendix G
INSTITUTIONAL IMPACTS

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INSTITUTIONAL IMPACTS

Among the most critical barriers to implementation of district heating are those stemming from the institutions affected by innovations in the energy industry.

Institutional barriers to the implementation of district heating have been noted in reports on European efforts to stimulate wider adoption of these systems.* A recent study concerned with technological innovation in the public sector in the United States comments that "institutional barriers...reflect the interactions, influences, and motivations of those interests that play a role in supporting the adoption and diffusion of new programs."**

District heating involves a variety of interests whose purposes may conflict. In Sweden, for example, introducing oil-fired plants for combined generation of heat and electricity changed the competitive situation between the established producers of electricity and the local authorities who are primarily responsible for district heating. Oil-fired plants posed a threat to the rate of expansion of the nuclear industry and were vigorously opposed. The Secretariat for Future Studies in Sweden concluded that the development of a favorable atmosphere for energy conservation technologies would require an in-depth analysis of the institutional obstacles such as regulation and the economic structure of the energy industry.

Some of the conclusions of the Swedish studies suggest areas of investigation for analysis of the situation of district heating in the United States. The relationship between distributors and producers of

*See in particular articles from the Secretariat for Future Studies in Sweden reprinted in Hearing. Part 8. Middle and Long-Term Energy Policies and Alternatives, House, Committee on Interstate and Foreign Commerce. Subcommittee on Energy and Power. 94th Cong. 2nd S. 1976, pp. 215ff.

**Peter W. House and David W. Jones, Getting it Off the Shelf, A Methodology for Implementing Federal Research (Boulder, CO: Westview Press, 1977), p. 150.

electricity, for example, has a significant impact on attitudes towards changing the source of heating. If the investor-owned utilities that produce electricity also sell heat, their political and market position in the community becomes stronger. However, if municipal utilities also sell heat, they are entering a market previously dominated by private firms. The resulting conflict is generated both by a shift in economic benefits from private business to public utilities and by the resulting shift in political power. If local authorities produce a large part of the electricity and heat they distribute, the electricity producers and the fuel distributors will have a different market situation.

Another area of impact is the regulatory system that affects the power industry. Rules and laws were made in a period of declining cost and stable or increasing supply: the system of rules governing rates, depreciation and accessibility to the capital market reflect a built-in force for expansion. Quality-of-service rules were written in the 1930s and quality offered may exceed the quality needed. Current activity at the Federal Trade Commission and other federal agencies suggests that this area is being reevaluated. In particular, attention is being directed to the question of who should stabilize voltage: the appliance manufacturer, the individual, the landlord, or the electricity producer. The answer to this issue has significant implications for the cost as well as the role of alternative energy options.

Technologies themselves create a social system consisting of the technologists, the industries dependent on the technology, and the industry that manufactures the technology. The regulatory system reflects the social system surrounding the technology. When technical components bridge technologies belonging to different organizations and different

professional schools, they may be subject to intense struggles and may be rejected. The Swedish study concludes, "There are some very steep stumbling blocks in the way of different alternative energy sources... These blocks do not depend on the complexity or the novelty of the technology involved but on the social systems built around existing technologies."* Utilities, for example, have had little problem accepting nuclear power because it represents a promise. They are much more negative about systems based on cogeneration because these are perceived as a threat.

Although bureaucratic red tape may be the visible institutional barrier, it frequently represents a stronger force, the resistance of agencies and the interest groups that lobby them. The political basis for institutional resistance is a frequently concealed but nonetheless direct cause of a failed policy or a faulty implementation process.

In short, all of the political and regulatory, technological, environmental and economic issues discussed in the previous sections provide the basis for the institutional barriers to implementation of district heating.

Public-Sector Barriers

Institutional barriers in the public sector differ somewhat from those in the private sector. The fragmentation of agencies and organizations (such as those responsible for environmental protection and listed in the Addendum) acts to hinder the implementation of programs that have broad-ranging impacts. Hierarchical and jurisdictional relationships are difficult to arrange and the process of coordination and resolution of conflicts among organizations and individuals often leads to delays and impasses.

*See Swedish study cited above.

Two institutional barriers at the agency level have been noted in studies by Anderson.* The agency's ability to implement a policy is affected by its relationship with its constituency. Some agencies have more political influence and are treated with more deference than others. In addition, the power and influence an agency can exert varies over time depending upon public priorities and the status of its mission. Specifically, environmental goals frequently conflict with industry and labor's goals. Public policy on energy has reflected the changing political fortunes of these interests.

Evidence in Europe suggests that district heating implementation requires strong political support and government intervention in order to overcome institutional barriers. These barriers tend to be more significant in situations such as those facing electric utilities today. The immediate satisfaction of economic objectives (satisfactory rate of return) must be deferred in the interest of long-term social gain (pollution control and energy conservation). The politician operates in a short-term setting. It is difficult to gain his support for long-term benefits accruing from public policy that will not be apparent by the next election.

Private-Sector Barriers

Institutional barriers to implementation of innovations in the private sector are primarily reflected in organizational considerations. Major innovations will affect

- company goals and objectives
- company reputation
- organization structure
- morale
- power distribution

*Public Policy Making (New York: Praeger Publishers, 1975). See also P. House and D.W. Jones, Getting it Off the Shelf (Boulder, CO: Westview Press, 1977).

Firms set priorities and allocate resources according to a well agreed-upon set of goals and objectives. If the proposed project is viewed as inconsistent with company directions it is likely that it will be screened out early. In conversations with utility executives for this project (Section 4 Interviews) many said they had not considered seriously the possibility of implementing district heating. It is likely that an early screening process resulted in the rejection of the integrated energy system before it was adequately considered.

Any public effort to encourage investor-owned utilities to implement district heating will involve bringing about a private-sector review of both economic and social issues involved in the system. To accomplish this review will necessitate overcoming the institutional barriers in the private sector. They are no less formidable than those in the public sector, although they are frequently concealed within financial considerations.

Analysis of innovation in the private sector has led some researchers to the conclusion that a public agency must show a profit potential for an innovation, before a firm will cooperate and support the venture.*

Such analysis assumes that private-sector decisionmakers are locked into a decision process that requires that a venture be profitable by conventional standards. To satisfy these standards it has been suggested that the public sector encourage private-sector implementation of a socially beneficial project in one of these ways: (a) by designing a favorable profit potential into these projects; (b) by providing financial assistance to alter a project's financial implications, directly supporting some aspect

*For a review of the research in this area, see House & Jones, Getting it Off the Shelf.

of this proposed project (e.g., funding development, absorbing risk by guaranteeing return of development costs); or (c) encouraging legislation to force use of the proposed product (e.g., mandatory requirements regarding the use of gas and coal for industry).*

However, it is possible that the private sector will make socially beneficial decisions that involve differed financial gains. In Chapter 6 we will explore the types of incentives that might stimulate private-sector development of district heating. Overcoming institutional barriers is a critical part of that policy analysis. It may involve changing consumer attitudes, the development of new managerial and organizational skills, and involvement of the public sector in market analyses activities that are traditionally the domain of the private sector.

Regarding district heating, some of the institutional interests that are affected include: utilities unwilling to enter a new area of commercial activity or threatened by competing publicly owned utilities; utility commissioners unfamiliar with the technical and financial problems implicit in changing the function of the utility; building and zoning agencies required to develop new codes and techniques for adequate inspection of safety and maintenance requirements; financial institutions required to invest in a venture in which the economic benefits may be long term and a function of social benefits; and the list could be longer.

The electric utility industry has engendered substantial criticism, as have its regulators. Sheldon Novick, who has written extensively on the electric power industry, maintains that the industry's existence was

*Getting it Off the Shelf, pp. 100-101.

predicated on rapid growth, on low rate to industrial users and higher rate to small business and homes.* The first axiom of electricity producers, according to Novick, has been "it is manufactured, delivered, used instantly and cannot be stored." Changing patterns such as these is the task of any who promote a conservation approach in electric power.

Similar observations have been registered regarding the British utility industry. One staunch advocate of district heating in Britain calls for a new policy. "It cannot be left to the electric supply industry as it is now constituted."**

Several studies have commented that the utilities are constrained against innovating conservation technologies such as cogeneration and district heating because they are reluctant to compete with industry in supplying heat and want to maintain their place in the industrial market for electrical power.*** However, more is at stake than economic considerations. Existing distribution of the political power represented by control of industrial sectors would be seriously affected, as has been the case in Sweden. Those involved in the political issues are the utility executives, their suppliers and the regulatory officials involved with the industry.

Commenting on the pressures that affect the regulators, a former member of the Federal Power Commission has observed that "the big problem in the

*The Electric Power Industry," Environment, V. 17, No. 8 (November 1975), p. 6-16.

**Cedric Beatson, "Time for Britain to Take a Fresh Look at District Heating," The Engineer (February 6, 1975), p. 30.

***See e.g., Thermo Electron Co. Study on in-plant generation.

regulatory field is not influence peddling. Abandonment of the public interest can be caused by many things, of which timidity and a desire for personal security are the most insidious. This commission, for example, must make hundreds of decisions each year involving millions of dollars. A commissioner can find it easy to consider whether his vote might arouse any industry campaign against his reconfirmation by the Senate."* On a state level industry pressures can likewise motivate regulatory officials to make "safe" decisions.

Other Studies of Institutional Obstacles to District Heating

Several recent studies of district heating have identified additional institutional barriers to the expansion of district heating in the United States. The Brookhaven study concludes that "government involvement appears mandatory for the promotion of district heating, not only for funding but also because it can include national considerations in the decision process. The fact that the commodity provided by district heating systems has hitherto been supplied by private enterprise means that government operation of district heating systems would put the government in competition with private enterprise."**

Analytical work by The Technical Environments and Management Planning Operation (TEMPO) of the General Electric Company on the heat-storage potential of underground aquifers has assumed that "furnishing energy in the form of heat would be accomplished by the electric utility owning or controlling the nuclear generating station or the gas turbine generating equipment which

*As quoted in John Wadsworth, "The Limits of Organizational Change: Public Utility Regulation in Connecticut," p. 9 (Unpublished paper).

**Karheck et al., Science, Vol. 195 (March 11, 1977), p. 950.

produces high levels of heat output."* This study recommends attention to the barriers that "strew the path" toward implementing the hot-water heating system involved in district heating.

Some of the barriers are at the distribution level: if a combination company providing both gas and electricity were also to provide hot water service, heating service, or air conditioning service in lieu of natural gas or electricity, the user would accept the substitute if it were of equal or better quality and were offered on terms not more onerous than the service it replaced. However, the electric or gas utility would resist the competition. On the regulatory level the question is whether or not to regulate heat sales, and if regulation is required, the jurisdiction and content. Economic studies may be necessary to determine the fair price of the heat and the results of these studies may contradict findings based primarily on the engineering questions involved. Regulation will also introduce the question of the governmental level at which regulation is introduced, conflicts between states, and limitations of other utility regulations.

For example, there are serious transmission problems based on different state regulations. In Texas, member companies of the state system ERCOT are prohibited from interconnecting with systems outside Texas. Members are prevented from buying or selling energy in interstate commerce.** A recent GAO study on transmission lines that interconnect utilities also finds fault with the federal power authorities. In one case cited, the Bonneville Power

*As discussed in John A. Carver, Jr., "Legal and Institutional Planning for MACRO-conservation Measures," Public Utilities Fortnightly (April 24, 1975), Reprint, p. 6.

**U.S. General Accounting Office, Problems in Planning and Constructing Transmission Lines which Interconnect Utilities, Federal Power Commission, June 9, 1977, p. 24.

Administration limits the transfer of surplus energy from the Pacific Northwest and removes the opportunity for new long-term contracts for power with southwestern utilities.

The variety of institutional issues affecting district heating is difficult to summarize because installations under differing environmental, regulatory, and organization circumstances introduce new factors. In short, the institutional barriers result from the answers to the following set of questions:

- Who should own district heating equipment?
- Who should distribute the heat?
- How should such facilities be regulated?
- Will district heating affect the national electrical network?
- How can we insure that district heating will produce net energy and social savings?

Public Attitudes

Public acceptance of energy-conserving innovations is related to the seriousness with which energy problems are perceived. The public distrusts the energy-development industry and the federal government, and confidence in state commissions is even lower.*

In addition, conservation strategies are difficult to convey to consumers because it is necessary to convince them that short-term expenditures of capital will net long-term savings in energy and other socially desirable goals. In Japan, for example, a manager at the leading manufacturer of district heating equipment observes that it is as difficult to convince a homeowner to join a district heating system (based on savings in building space, amortization of

*Heat Storage Well, p. 6-30.

equipment, and advantages that cannot be converted into money savings) as it is to induce a man who uses well water to join the city water system.*

A strategy for introducing district heating performance must overcome consumer resistance as well as that of industry and regulatory agencies. Public education on the advantages of society and energy conservation has been ineffective in the United States. Included in any demonstration project for district heating should be a well-designed public-information program. A Connecticut public utility commissioner has observed that shifts to new patterns of electricity consumption require investments by households, government, and business consumers and that these consumers usually fail to take into account future costs and benefits.**

Impact of District Heating System on Population and Employment

New technology or changes in existing technology can result in serious impacts on employment of particular kinds of labor. An analysis of the employment impacts to be considered if district heating is implemented in communities in the United States requires investigation of the employment issues in each phase of the adoption process--generation, transmission, and installation and operation in a users facility. In addition, it is necessary to calculate the changes in employment due to shifts in demand for raw materials. Changes in labor requirements impact other social factors such as population, housing, and community services. In some cases, innovations in technology may reduce labor requirements, and if the unemployed are not relocated immediately this impact on the community also must be calculated as one of the relevant social impacts.

*Personal communication. S. Akagi, Manager of Environmental System Design Department, Hatachi Zosen, Osaka, Japan. August 1, 1977.

**Tom Standish, Statement in Hearings Electric Utility Rate Reform and Regulatory Improvement. Senate Committee on Commerce 94th Cong., 2nd Sess., 1976, p. 184.

Impacts do not occur at one point but rather at various points and continue for varying lengths of time. These impacts are not perturbations in some steady state but interact with ongoing dynamic processes: population shifts, changing economic conditions, changing lifestyles, and changing attitudes toward consumption.

Phases of impacts:

1. Planning and public discussion
2. Site selection and construction
3. Operation and distribution
4. Aging of facility or growth requiring larger type of generating facility.

Within each of these impact phases are a multiplicity of interacting forces which vary from community to community depending on geographic location, political organization, proximity to energy supply, and a variety of other social, economic, and political factors.

Employment Impacts

Employment analysts conclude that the size of the work force is determined by the number of service jobs created in the community. Initial employment figures would present the basic labor force required for construction of the generating facility and the transmission piping for carrying the hot water. This labor force can be figured in terms of length of time it takes for employment to reach its peak in size. Close surveillance in the planning stages can prevent a situation of "boom and bust," a condition that occurs if there is a rapid increase and decrease in employment.

Total employment is determined by calculating the following:

1. Construction and operating forces for power plant facilities

2. Total employment induced by district heating center
3. Total income induced by district heating center
4. Total population induced by district heating center

Income impacts are based on the type of labor and related wages for the power plants and for the service industries in the community. Population impacts are based on the national average of workers per family and the size of families from which it is possible to calculate the total population induced by the district heating system.

In industries that conserve energy it has been suggested that employment will generally increase since conservation strategies call for energy specialists to monitor and adjust energy usage in plants and buildings. The implementation of long-range conservation plans, which would likely be a part of the process of encouraging district heating, calls for equipment consultants, architects and designers, and other specialists not otherwise required.

However, the short-term effects of changing energy use of energy production patterns may result in temporary unemployment. In the implementation of district heating one group that would likely be affected is the heating fuel suppliers and those providing home heating equipment that would become superfluous if heat were piped to each residence from a central plant. The employment impacts would be greatest on this group if a retrofit development path were selected. A recent analysis of energy conservation strategies suggests that "changing energy use patterns will continue to raise issues, and one must insist that those affected must not be asked to bear a burden that is too heavy. Society can cushion these effects during the transition to a period of more efficient energy utilization."*

*Lee Schipper, "Raising the Productivity of Energy Utilization," Annual Review of Energy, Vol. 1, 1976, p. 492, Reprint.

Other factors that must be considered in evaluative community impacts are changes in the cost-of-living such as the amount, type and quality of housing, land-use patterns, and the development of utilities (power, water, waste and communication), in addition to increased demands on power and transportation. Further impacts will be apparent in the labor-intensive social-service areas: health, education, welfare, law, and public safety.

New facilities may be required when construction workers arrive long before any power facilities are operable and taxable. The community will have a significant front-end-loading problem, i.e., how to finance new capital expenditures before the tax base to pay for them has been built. Since bonding limits may be low or already reached, an individual community may need additional help from private/other public sources. Communities also will need help to finance planning studies.

Remote communities may attempt to avoid major capital expenditures for a short-lived construction boom. The resulting overload of existing public services may invoke social problems or force workers to live further from sites.

Implications for Economic Development

Aside from the economic stimulus of generating plants, will the new district heating system act as a "growth pole?" Since the easiest installations will be in new communities, it is fair to ask what the implications are of encouraging growth in a low-population area. Some of the factors affecting willingness of other industries to co-locate include

- proximity to markets
- raw materials
- transportation

- related businesses
- availability and cost of financial services
- quality, cost and quantity of labor
- local taxes
- local social services

The impact of local taxes is likely to move the taxes upward.

If district heating centers would force planning and require regulation to stimulate financing, better planning and financing of public services might be the result. However, dispersed sites may result in a reduced commitment to pay for temporarily needed public services. This is an important consideration; the site could become unattractive to other industries because of likely shortfalls in public service.

Environmental Impacts

District heating has been held as a preferable system because it promises to reduce air pollution and at the same time increase the efficiency of use of the nation's dwindling fuel supply. District heating combined with a hot water storage system as is proposed in this study provides additional environmental benefits in terms of the reduced requirement for cooling water, but the system also introduces the environmental issues associated with land use, soil erosion, seismicity, and water quality. The following analysis is an effort to identify the issues and to present the information developed in earlier studies. A thorough environmental evaluation depends on a specific implementation of district heating with hot water storage, such as we recommend later in the study.

To aid in identifying potentially major environmental impacts, we have attempted to separate out those impacts associated with electric and heat generation without district heating. However, the extent to which district

heating changes the environmental picture depends on the specific geographic location and the development path selected. Hence this analysis is general and only suggestive.

Water

More than 80 percent of the cooling water used in the United States is for generation of electricity. Nuclear and fossil-fuel steam electric power plants constitute the largest single source of waste heat discharged to water. The chemical energy of fossil fuel and the nuclear energy of uranium and plutonium are converted into electrical energy first by transforming their stored energies into heat, which then raises steam to drive turbine generators that produce electricity. The steam exhausted from the turbine is condensed water; it is then returned to the system to pick up more energy from the burning or fissioning fuel as it again enters the steam cycle. Much waste heat is rejected to the environment in the condensing process. Waste heat is carried from the condenser by a stream of cooling water which usually is discharged into some convenient body of water. The heat rejected is substantially greater than the heat equivalent of the electric energy generated. For a modern, efficient, conventional steam electric plant only about 40 percent is discharged to the environment via the condenser cooling water. Most of the remaining 15 percent goes directly to the air via the hot stack gasses. In a nuclear power plant the waste heat carried away by cooling waters is about 50 percent more than for a modern conventional plant.

Consequently, a system that decreases the amount of water discharged into the atmosphere may result in a significant improvement in the water-related pollution issues affecting power generation.

Regulation of environmental pollution is primarily the responsibility of the states who are themselves responsible to the federal Environmental Protection Administration. State regulation of each environmental

considerations as an adequate water supply, plant location and size, results from an effort to balance the National Environmental Policy Act's requirements and state laws. The Safe Drinking Water Act also provides that the states have primary enforcement responsibility. State regulation must be at least as stringent as the EPA's national primary and secondary water quality standards.

A recent report suggests that the national cost of complying with the Federal Air and Water Acts will be nearly \$450 billion over the decade 1976-1985. According to EPA, the cost of meeting the Water Pollution Control Act amendments of 1977 will be \$183 billion. This, together with the cost of meeting the Clean Air Act amendments (\$264 billion), is equal to about 2 percent of the GNP summed up over the decade.

Aquifer Storage

The heat storage well is a device for storing in aquifers large amounts of useful heat at low cost with low heat loss for long periods of time. According to an earlier study,* geologists and ground water hydrologists agree that hot water can be injected into the ground, stored, and recovered because sand and rock are good thermal insulators and there is sufficient storage space in ground water aquifers which underlie most of the United States. There has yet been no actual operation of a heat storage well. There have been several studies that suggest the technical problems involved in injecting hot water into underground storage aquifers. Interest in development of geothermal resources also has produced computational procedures and models of geothermal reservoirs, but because these have been on a macroscale they are not applicable to individual wells and include only withdrawal and not injection.

*GE TEMPO, "Heat Storage Well in Future U.S. Energy Systems" (Washington and Santa Barbara, 1975).

Because there have been no demonstration projects using the heat storage well in this country, the question of what environmental impacts are to be expected is speculative. Water rights and water rights administration has been a difficult problem in some areas. States handle questions of quality and quantity of water very differently. Riparian doctrines, appropriation doctrines, and mixed doctrines will present different problems in different states. Ground water laws are frequently outmoded. One student of ground water law even suggests that the law of most jurisdictions is based on misunderstanding of the law of the physical universe to which manmade law must adjust.* California has played a major role in establishing law on ground water rights and has set a pattern for other states. The California position is essentially that a public agency has a right to store water in unused natural underground storage space and to prevent others from taking the stored water; that underground basin is subject to a public servitude for water and water conservation purposes; and that storage underground by a public agency is a valid exercise of its police power. This would suggest that water storage should be controlled by a water district which then would be a regulated utility.

The GE-TEMPO study finds that the most important policy direction arising out of the cases that have dealt with water storage is the recognition of the paramount public interest in the use of ground water and the underground storage space.

If the heat storage well is used in conjunction with a generating plant serving a new area of urban development it will be necessary to take into account the impact of the net loss of land that had previously supported

*Charles E. Corker, National Water Commission Report, 1971; Ground Water Law Management and Administration.

farms. When this land is lost to urbanization a significant portion of the area's quality of life is changed. Open lands such as farms maintain local water supplies by absorbing precipitation and transferring it to the ground water system. It would be necessary to protect aquifer recharge areas and provide buffers for water supply and other natural areas. Farms protect critical environmental entities including wetlands and flood plains. An urbanization of previous rural areas can alter the water storage areas.

Temporary alterations of surface water, ground water, and soil quality may occur during the initial drilling and testing in plant construction phases. But these impacts are expected to be minor if kept under control. Impacts such as land subsidence and seismicity may pose problems, but the specific site evaluation would be necessary to identify these problems.

Surface water quality will not be affected if the circulating fluids are well contained in a closed cycle. During construction activities, care must be taken to avoid contaminating streams and other surface water sources. If in this technology fluids are introduced into a subterranean heat exchange chamber and returned to the surface in a closed cycle, the problems inherent in storage or disposal of contaminants will be minimal. If fluids become saturated with minerals in the fractured rock chamber, scaling of equipment and clogging of the fractured zone could result.

Air Pollution Control

Generating stations located remote from the large population centers can burn coal and residual oil, while the total amount of pollutants will be greater than the total amount resulting from fossil fuel heating with gas or low sulfur distillate oil, the ground level concentrations and harmful effects will be less. Heating plants in the city add their pollutants to those produced by transportation and industry. These pollutants

are dispersed at low levels where they are most harmful to people, vegetation, and building materials. Large thermal generating stations can afford the high chimneys needed for effective pollutant dispersal and high efficiency electrostatic precipitators for the removal of particulates when burning coal and residual oil. All of the techniques under development for more effective pollution control, for improved combustion and for the extraction of more useful energy from a given amount of fuel are applicable to these thermal generating stations.

Based on experience in Europe, particularly in Sweden, one of the major arguments for adopting district heating is that it improves air quality. A recent report on combined district heating and electricity production in Sweden states, "In spite of the fact that the major part of the oil fuel burnt was of normal sulfur content (max. 2 1/2 percent), the air quality in district-heated towns is much better than in towns with individual heating. This is due partly to the absolute reduction in the total amount of fuel consumed, partly to better combustion and properly maintained plants, and partly to the discharge from single high chimneys."*

Improvements in air quality imply savings in terms of both human and economic factors. The cost of regulating air quality has been figured in terms of the additional capital costs necessary to acquire the pollution control equipment (an increase of anywhere from \$2-16 billion). Additional energy costs associated with the existing technology, reliability of control technology, regional cost implications, cost impacts of nonattainment areas, and costs of interfuel shift caused by regulations all figure into the cost of

*Neil Muir, "Combined District Heating and Electricity Production in Sweden," a paper presented to Symposium on Energy Conservation (Garston, England, April 7, 1976), p. 4.

air quality control. A large district heating plant that is provided with a tall stack and in which combustion gasses are given a high discharge velocity can assist the country in resolving the problems created by a large number of small heating plants spread over a large area. The large plant also can switch to nonsulfurous fuels in unfavorable weather. In this way the air pollutants would be distributed over much wider areas and better controlled.

Another Swedish study recommends that it is of "the utmost importance to take advantage of the possibilities offered by district heating, since they result in substantial savings in energy and reduce the charges of heated cooling water from the large condensing turbine plants that would otherwise be required."* Since discharges of heated cooling water may in some cases cause damage and cooling towers create environmental problems of their own at increased costs, the advantage of a dual-purpose district heating plant is that it can operate with small volumes of cooling water.

The states and the federal EPA are now conducting extensive analyses to determine the reason for poor air quality in each of the nonattainment areas, and will identify specifically those major and minor sources that are contributing to nonattainment problems. Preliminary analysis indicates that the minor sources making the largest contributions to air quality problems include such stationary sources as small industrial, commercial, and residential boilers.** Coal and oil-fired power plants are one of the major sources of air pollutions. These plants have experienced difficulty in achieving compliance with

*Bertil Kohler, "The Economic and Environmental Aspects of District Heating in Sweden," District Heating (October, November 1973), pp. 22-25.

**U.S. EPA Progress in the Prevention and Control of Air Pollution in 1976, Annual Report of the Administrator to the Congress of the United States in Compliance with Sections 313, 202, and 306 (e) of PL91-604, the Clean Air Act as Amended.

emission standards within the time limits prescribed by the Clean Air Act. EPA has undertaken special efforts to achieve compliance by these sources and continues to bring pressure to bear on the owners and operators of these plants to reduce their pollutant emissions to levels specified in the relevant emission limitations. However, in general this category has the most difficult air compliance problem because of the amount of control required and the associated costs of the control technique needing application. Although the reduction in the quantity of fuel used in district heating plants based on this macro analysis may not be significant, any decrease in the amount of pollution is significant when one looks at the class of power plants as a source of pollution. The 688 large coal- and oil-fired plants in the United States emit nearly 60 percent of the total national emissions of sulfuroxides and are heavy contributors to ambient particulate loadings. District heating can reduce emissions by a significant factor, which will be particularly important in heavily polluted sectors of the country.

In 1973 EPA commented that the power-generating sector of industry was lagging severely in its efforts to meet SO_x emission limitations. At that time more than 70 percent of the coal- and oil-fired capacity in the nation was being operated in violation of applicable SIP emission limitations. Supplies of low-sulfur coal appeared insufficient to assure nationwide compliance with SO_x regulations and utilities were extremely reluctant to use flue gas desulfurization to remove SO_x from stack emissions while burning high-sulfur fuels. Since that time the increase in applications of flue gas desulfurization and the concurrent increase in the use of low-sulfur coal has considerably improved compliance levels for SO_x .*

*Environmental Science & Technology, Vol. 11, No. 10 (October 1977), p. 946 and 947.

EPA has not yet determined the amount of pollution that is placed in the atmosphere by smaller gas- and oil-fired units used in residences and small commercial establishments. However, controlled technology research and environmental assessment efforts are underway for a number of pollutants including trace metals, polycyclic organic matter, and hydrocarbons and fluorides. Several tasks are being funded for the field testing of coal-fired utility and industrial boilers. The objective of this program is to characterize the environmental impact of sources of toxic and potentially hazardous emissions from organic and inorganic materials production combustion and other source categories, and to determine the need for control technology development. Hence, it is not yet possible to state with assurance what the impact of district heating is in terms of the reduction of pollutants from residential heating; however, we have estimated that savings and these are discussed under Socioeconomic Impacts.

There is conflicting evidence, however, on the impact of the use of tall stacks on air pollution. A conclusion of a five-year study by 11 European members of the Organization for Economic Cooperation and Development (OECD) is that tall stacks are not always satisfactory air pollution control measures. The study shows that SO_x pollutants from fossil fuel show up thousands of kilometers from their point of origin even when they were emitted from stacks more than 100 M tall. The belief that such tall stacks would so disperse such pollutants that their concentration would be negligible beyond 100 kilometers was found to have little basis in fact.* Evidence of destructive acid rains and snows, especially in Norway and Sweden and perhaps Scotland, suggest that tall stacks simply complicate the pollution question.

*Environmental Science and Technology, Vol. 11, No. 10 (October 1977), pp. 946, 947.

An EPA study of the effect of SO_2 on conifers and in particular on the growth of winter wheat has found that the northeastern United States consistently receives precipitation that is 10-100 times more acidic than the geological average. Other areas of the country also are impacted. The effects of the increase in the acidic rain on terrestrial ecosystems are being studied. Sulfates in rain appear to be the major contributor to the acidic reaction.*

Levels of sulfur dioxide in the air over the nation's urban areas have decreased on an average of 30 percent from 1970 to 1975. However, levels in the northern regions remain higher than in other areas because of emissions associated with space heating. There was a slight increase in 1975 because of changes in fuel use patterns. In the western states where SO_2 levels are low, there has been an increase because of curtailment in the use of natural gas for industrial purposes. Similar increases can be expected in parts of the Northeast. The year-by-year changes in the SO_2 level measured at all locations within different regional areas of the country are shown in Figure G.1.

In 1976 EPA promulgated regulations to prevent significant air quality deterioration. The administrator required the application of "best available control technology" (BAT) to any new source modification to clean air areas. This requirement may be significant in encouraging the use of district heating in developments in previously rural areas because the significant deterioration program applies in those areas with ambient air cleaner than the national standard. The most stringent technology-based standards apply to sources seeking to construct in areas not meeting national ambient air standards.

*U.S. EPA, Progress in the Prevention and Control of Air Pollution in 1976, p. 26.

SOURCE: EPA, Progress in the Prevention and Control of Air Pollution in 1976, p. 15.

Figure G.1. Sulfur Dioxide Trends--90th Percentile of the Annual Averages for Sulfur Dioxide Monitoring Sites by Geographical Region (1971-1975).

The ruling provides in general that a major new source may locate in an area with air quality worse than the national standard only if stringent conditions can be met. These conditions are designed to insure that the new source of emissions will be controlled to the greatest degree possible, that more than equivalent offsetting emission reductions will be obtained from existing sources, and that there will be progress toward achievement of the standards.*

Under an interagency agreement between the Department of Housing and Urban Development at EPA, it has been decided that any land-use policies and control strategies undertaken for air quality improvement will be developed and implemented within a broader framework of comprehensive planning and management to insure that the policy reflects the constraints of the Clean Air Act in attaining and maintaining standards and in preventing significant impact upon the development of new towns and the encouragement of district heating systems in these new developments.

A recent study of the impact of district heating on air pollution in Toronto, Canada led to some interesting conclusions based on simulations made for the recommended systems. District heating by steam or hot water was found to be second only to district heating by electricity in terms of effectiveness in reducing air pollution levels.** The Canadian study suggests the following: "In order to meet the air quality requirements in the future, it will be necessary to control the emissions from major power stations, from transportation sources, and from industrial sources, as well as from building

*U.S. EPA, Progress in the Prevention and Control of Air Pollution in 1976, pp. 36 and 37.

**Toronto, District Heating Study, Vol. 1, p. 77.

space heating requirements. If any of these sources is allowed to develop immoderately it will matter very little that the others have been considerably controlled or even reduced. As part of an overall scheme it is essential that the emissions from the space heating should be controlled and one of the best means of achieving this is by district heating. If such adequate controls on district heating are in fact imposed together with corresponding controls on the other sources of emissions in the city, then we can expect that the air quality objectives of the future can be attained."*

In sum, district heating in large plants gives more efficient fuel combustion, and sophisticated pollution control hardware is viable and maintainable in these plants. The heating plant also can be located away from the point of heat use. In general, using tall stacks provides a high level release of emissions with more time to dilute and transform the emissions before they reach the ground surface. Individual heating plants in general have less efficient fuel combustion and provide more air pollution because they lack the removal hardware.

Land-Use Impacts

The land-use effects caused by generating plants have been of concern in studies of transmission rights-of-way. As regards district heating there is the additional impact on land use of underground water storage. Some of the land-use effects of concern are the general aesthetic effects such as noise and appearance and the impacts that might interfere with other special uses such as approaches to airports and waterways. A factor in land-use planning is the time involved to plan and construct power plants due to

*Ibid., p. 73.

federal, state, and local environmental requirements. Since transmission lines and power plants must be environmentally acceptable, it is assumed that underground hot water transmission pipes for a district heating system such as that proposed in this study would also involve environmental impact regulation.

An environmental impact statement requires a discussion of the proposed construction, information concerning the project's impact on air/space, air and water quality, scenic and aesthetic features, historical and archeological features, and wildlife. In general it has taken 18 months to 2 years to obtain right-of-way permits for large transmission lines and longer if there are law suits. There is little reason to believe that permits for underground hot water transmission would be obtained without a similar delay. One suggestion that has been made is for the transmission of hot water to become the responsibility of the water utility, in which case the impacts and the process for ameliorating environmental problems would be speeded by the familiarity of the utility with the regulatory environment.

Land-use planning and energy-facility siting have been the subject of many studies by state and federal authorities. Efforts to introduce federal legislation on land-use planning have been unsuccessful. A study by the Association of the Bar, City of New York, suggests that a planning process in which certain areas are set aside where plants could be built without prior clearance, is appealing, but impossible. Many important variables cannot be fitted into the classifications on maps and this particular study suggested an approach which mixed generic standards with ad hoc determination of issues.*

*Special Committee on Electric Power and The Environment, "Electricity and the Environment, the Reform of Legal Institutions" (New York: West Publishing Company, 1972).

The use of underground water storage for district heating will likely increase the complexity and the time required to secure local approval for site, construction, and transmissions.