LOCAL ENERGY ALTERNATIVES

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ABSTRACT

This paper focuses on such energy alternatives as fossil fuels, municipal and agricultural wastes, solar energy, and nuclear energy. It also describes recent choices of alternative energy resources selected by Southwestern for close examination.

INTRODUCTION

The realization that cheap energy is gone forever is beginning to hit the American public. This reality has been evident to Southwestern Public Service Company since the late 1960's. In a 1970 study the planning department of our company attempted to forecast the type of "raw" energy sources Southwestern would need to meet the future energy requirements of its service area. Even in 1970 energy studies and publications on alternate energy sources and systems were available. For Southwestern Public Service there was not an energy shortage, but rather energy *cost* and *distribution* problems. These problems were complicated by uncertainties and complex issues such as technical feasibility, reliability, natural resource availability, environmental and social impact, and, of course, U.S. national policy. One example of this policy is the Energy Supply and Environmental Coordination Act (June 1974 to December 1984) which, in effect, no longer permits construction of natural gas boilers. Another regulatory action, Docket No. 600 of the Texas Railroad Commission, ruled an eventual decrease of natural gas as a boiler fuel. New sources of energy were the company's only alternative.

BACKGROUND

From its incorporation in 1942 until 1976, Southwestern Public Service was a 100% natural gas steam electric generating system. During the early years of oil exploration on the High Plains and South Plains of Texas, natural gas was plentiful, available, and most economical. It was the right boiler fuel to use. Natural gas is clean and environmentally acceptable. Southwestern's plant design department designed and supervised construction of very economical plants which were operated with excellent reliability. In 1946, 700 million kW supplied the needs of the company's service area. By 1954 it took 2,500 million kW to provide electrical power in the service area. Since 1954 the increase in electric energy use has been about 7% per year. The service area utilized 12,323 million kW in 1977. The economic growth of the company's service area is expected to continue on a level comparable to this forecast.

Careful computer studies form the basis for planning the company's system load capacity (Figure No. 1). This projection is designed to meet long-range forecast requirements. The system capacity must allow for peaks and the ability to maintain the reliability of the system at an unscheduled shutdown of the largest generating unit. The effect of rising prices of natural gas and the requirement to use expensive standby No. 2 fuel oil during natural gas curtailments can be seen in the change in the cost of generating power (Figure No. 2). In 1970 the cost was about \$2.70/Mwhr and jumped to close to \$5.60/Mwhr in 1974. This problem of increasing fuel cost was predicted by company management as early as 1972, and plans for converting to coal as a boiler fuel were begun. These plans resulted in the decision to convert to coal as a fuel base as quickly as economically and

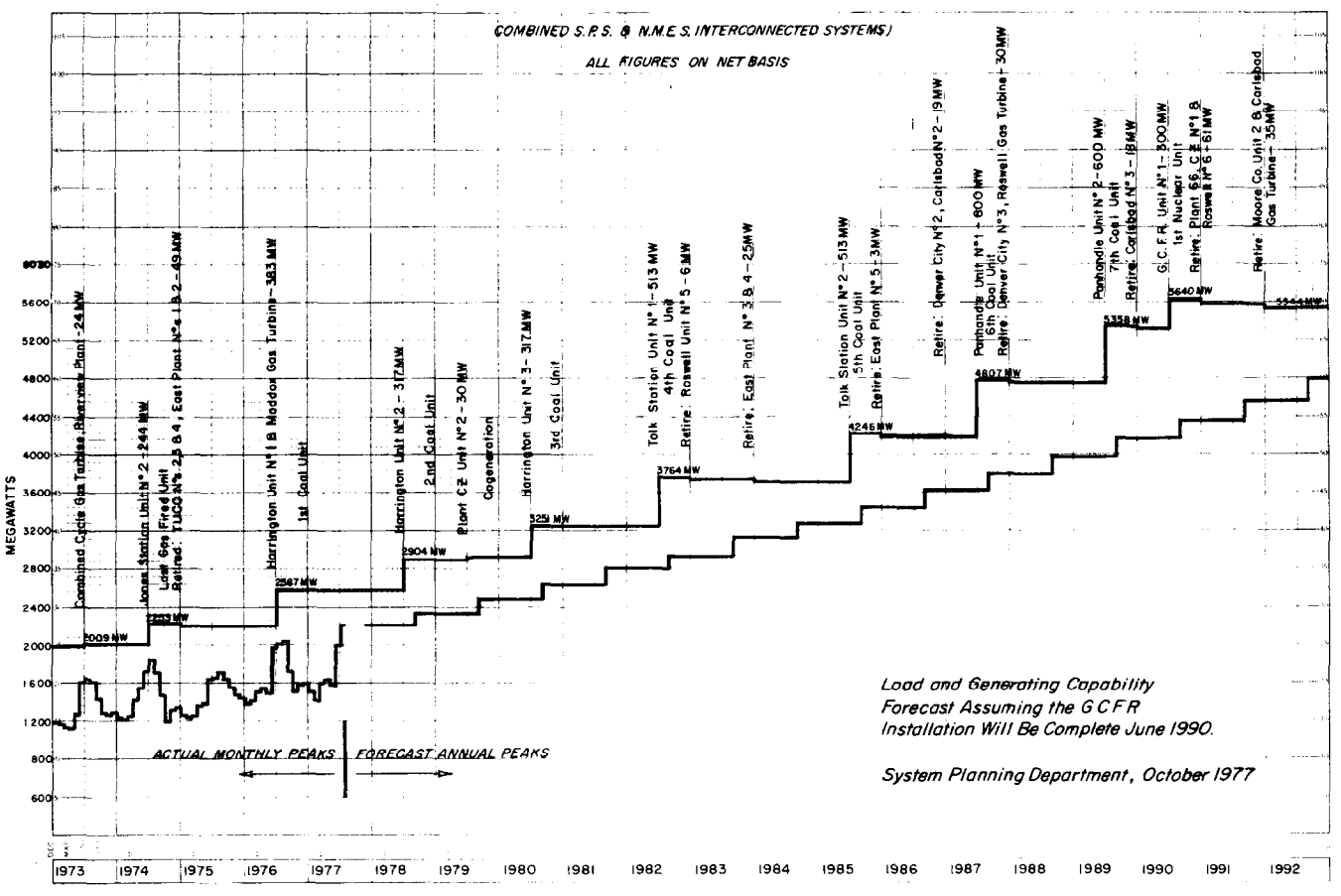

FIGURE 1 PRESENT AND PROJECTED SYSTEM LOAD CAPABILITY

technically feasible. The existing natural-gas-fueled units still represented a useful capital investment, but were not designed for conversion to coal as a fuel. Lead time for selection and evaluation of available systems, the design of the selected system, procurement of a site, coal, and many other 40-year-life-of-plant decisions take about four years before the first kilowatt is produced and delivered.

The reason for coal as a fuel alternative is obvious. As Table 1 indicates, almost 80% of the United States' energy reserves are coal. There are some serious problems with transportation and environmental control and regulation, but not enough to disqualify coal as an excellent source of "raw" energy for the generation of electricity.

Recent examination of Southwestern's long-term forecast in the light of a reasonable reduction in natural gas as a boiler fuel and an increase in coal resulted in the "Fuel Use Forecast—1977 to 1988 Plot" (Figure No. 3). Southwestern Public Service will move from a 100% natural-gas-fired capacity to

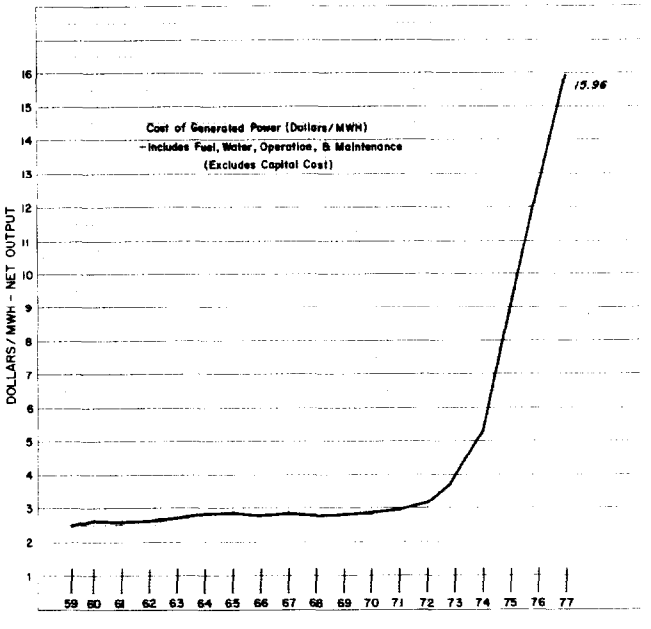

FIGURE 2 COST OF GENERATED POWER (DOLLARS Mwhr) INCLUDES FUEL, WATER, OPERATION, & MAINTENANCE (EXCLUDES CAPITAL COST)

TABLE 1--LOCAL REFUSE FUELS

	UNITS OF MEASURE	QUAD-RILLION Btu	PERCENT ACCORDING TO Btu CONTENT
Coal	217.0 billion tons	4,557	79.5
Petroleum	35.5 billion bbl	197	3.4
Natural Gas	250.0 billion cu ft	258	4.5
Natural Gas Liquid	6.5 billion bbl	26	0.5
Oil in Bituminous Rock	1.3 billion bbl	7	0.1
Shale Oil	80.0 billion bbl	450	7.9
Uranium Oxide	520.0 thousand tons	234	4.1

48% coal-fueled capacity by 1985. Plans beyond 1985 are not firm, as of early 1978, but it looks as if coal will be the predominant boiler fuel through 1990.

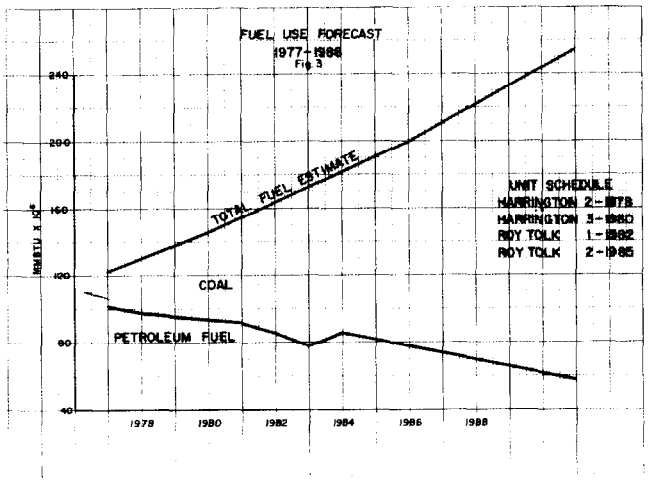

FIGURE 3 FUEL USE FORECAST, 1977-1988

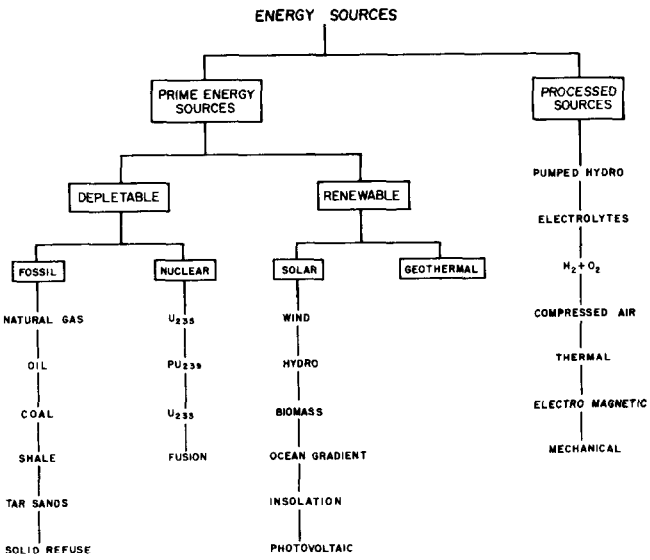

FIGURE 4 POSSIBLE ENERGY SOURCES FOR THE GENERATION OF ELECTRIC POWER

ALTERNATIVES

A schema of possible energy sources for the generation of electric power is shown in Figure No. 4. The most farfetched of the energy sources are not treated in this paper; the rest are evaluated against some criteria for good utility-company practice. I have summarized the evaluation of the alternatives being considered in Table 2.

Gas and Oil

As indicated above, the criteria that disqualify natural gas and oil as an alternative are economics and availability. Also, natural gas and oil are heavily regulated businesses, and the U. S. national policy shuts the door to any further consideration.

Coal

Next, the examination of coal comes into focus. Glance at Table 1 again. Coal represents about 80% of the available energy in the U. S. and that is a persuasive consideration. Fifty-four percent of the coal in the U. S. is west of the Mississippi River, and 71% of the Western coal is low sulfur. For Southwestern Public Service, the Western low sulfur coal is, of course, closer than the Eastern coal, but not that close; the coal for our Harrington Station facility, in Amarillo, travels 950 rail miles.

Another consideration of coal as an alternative is that the large national move to coal will produce some new circumstances. By 1985 coal usage in the U.S. should double to about 1.3 billion tons per year. This will require approximately 3,700 new locomotive units, 75,000 new hopper cars, and possibly new and replacement railways.[1] In round numbers, the coal demand will require the opening of a new mine every month between now and 1985.[2] This expansion could represent as much as 20 billion dollars in new capital. Coal has many positive points, but there are some additional uncertainties besides transportation. Some of these uncertainties are:

deposit characteristics
mining conditions
coal character
labor relations
equipment performance
financial security
governmental regulations

TABLE 2 SUMMARY

S.P.S. Co. Local Energy Alternative	Criteria	Reliability	Economic Justification	Available Reserves	National Policy	Environmental & Social Impact	Technical Feasibility
Natural Gas and Oil	Only When You Don't Need It.	Out Of Reach	Lots Locally	A "No! No!"	Clean	Existing	
Coal (Transported)	Some Transportation Problems	Nothing Is Cheap Anymore	Lots But It's A Long Haul	One Answer	Problems! Problems!	You Bet! It Depends	
Coal - Mine Mouth	Difficult	Needs Study	Yes H_2O - ?	Not Defined	No Big Problems	Yes	
Coal (Gasification)	Not Really	We Can't Afford It	No Plants	Pushed	Marginal	Some 1st Gen. No 2nd Gen.	
Coal (Cogeneration)	Depends On Partner	Some Can Be Justified	Fuel Dependent	Pushing	Same As Coal	Yes... With Conditions	
Conservation	No	Some	No	Biggest Shove	Real Social Impact... No Growth	Not Really	
Municipal Waste	Limited	Not Here	Not Enough	No Problem	Probable Not	Yes - With Limits	
Agricultural Waste	Transportation And Collection	Could Be--- More Study	Worth More Study	No Problem	More Study	Yes - With Limits	
Wind	No	No	Yes	Big Push	Land Use, Visibility, T.V.	Definition Please!?!	
Solar	Fair Weather Friend	If You Don't Care What It Cost!	Yes	Unreasonable Suggestion	You Can Bet On It	No!	
Shale Oil	Yes	Still Too High Priced	Lot's Of Resource, But No Reserve	Some	Problems Problems	Close, Needs Study And Time	
Geothermal	———	No Local	Source	———	———	———	
Biomass	None	Unknown	Maybe	Favorable	About The Same As Others	Needs Work	
Nuclear	Yes	Within Range, Regulated Out Of Sight.	S.P.S. Opinion No!	Bad News	The Most Sensible	Breeder Needed	
Fusion	Looks Promising - Long Wait Ahead				OK To Unknown	Maybe 50 Years To Go	

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Furthermore, there will be a base increase in electricity rates, because it costs three times as much to build coal-fired generating plants as it does natural-gas-fired generating plants. Additionally, environmental issues are often irrational and expensive to resolve, and environmental controls will undoubtedly increase.

Southwestern Public Service has also investigated the alternative of first-generation coal gasification technology. This alternate energy system was disqualified because of economics and energy loss.[3] Water requirements are another drawback to coal gasification. The process, therefore, is not adaptable as fuel for existing gas-fired boilers. It is not the answer for Southwestern at this time because direct use of coal is less expensive.

Southwestern Public Service is performing studies to determine the feasibility of operating a mine-mouth coal-fired generating station utilizing high-voltage transmission lines to the source of use. This may be the answer to transportation uncertainties, but other problems with land use, electrical-transmission technology, water, and economics are not yet resolved.

Co-generation with other utility companies with coal as a fuel is being used by Southwestern in Pampa, Texas. This alternative has a favorable criteria evaluation, but is very dependent on the partner in the project. It must pay its own way and

have long-term financial security for the utility.

Conservation

Conservation is an energy alternative. But it has limited economic justification for the electric energy users in Southwestern Public Service Company's service area. It has always been a company policy to promote the "wise" use of electricity in the home or factory, and Southwestern will continue to encourage the "wise and proper" use of electric energy, but the company recognizes that energy consumption and the GNP march in lockstep. The extreme conservation measures advocated in Amory Lovins' "Soft Energy Path" are not really technically feasible and are death to the social well-being of this area, and the country.

Solid Waste

Fuel for steam-electric generation from municipal solid waste or agriculture waste is not a total alternative. These waste products, by shredding and classifying, can be blended with coal in some boiler designs. The technology for burning this type of material has been utilized. One of the better examples is the City of Ames Iowa Project.[4] The amount of energy available from such fuel is shown in Table 3.

TABLE 3—LOCAL REFUSE FUELS

	Sulfur Percent	Moisture Percent	Ash Percent	Btu/lb
Typical Bovine Waste	0.5	29.1	24.9	6,350 (dry)
Western Coal	0.40	28.0	5.0	8,500
Milo Stalks	0.17	5.0	14.4	6,767
Cotton-Gin Trash	0.25	6.0	7.0	7,225
Typical Municipal Refuse (unclassified)	0.20	20.0	31.4	5,000-7,000

Southwestern Public Service has investigated municipal solid-waste application at Harrington Station and determined that this alternative could not pay its way for the company or the City of Amarillo. The company will continue to re-examine this potential from time to time.

The use of agricultural waste for fuel has the same problems as municipal waste used for fuel. The collection and handling of large enough quantities of agricultural waste is usually the cost item which disqualifies this alternative. Serious studies are being made by Southwestern Public Service for the use of agricultural waste in the form of cotton-gin trash. Evaluation studies for collection, storage, handling, and total cost per million Btu to the boiler are being performed. Consideration is also being given to the characteristic of the ash products. Solid waste for fuel is an alternative worth continued study.

Wind Energy

What about wind turbine generators? Southwestern is involved in several wind energy projects. There is plenty of potential wind energy available in the company's service area. Information collected to date indicates that wind velocities exceed 8 mph over 70% of the time.[5] Southwestern, along with Southwest Research Institute and Texas Tech University, studies the operational cost of wind power integrated with the existing electrical system.[6] The assessment of this study and another study on wind energy and the use of pumped air storage indicate that the costs are too high to be competitive alternatives and that numerous technical problems must be resolved.[7]

Commercial wind-turbine generators large enough to be economically operated and maintained are not available. The company is cooperating under contract with the Department of Energy (DOE) and NASA to collect wind-potential data and to provide a potential site for demonstration of a large horizontal wind-turbine generator.

The largest operating demonstration wind-turbine generator (located at Clayton, N. Mex.) is of 200-kW capacity. It would take 1,780 such machines to replace the newest 356,000-kW coal-fired plant (Harrington Station) in Southwestern's system. There are plans for 2,500-kW commercial wind-turbine generators which would be set of 160-ft towers. Still, capacity to replace existing energy sources would require 142 such machines. Even in Amarillo and other parts of the company's service area, the wind does not blow all of the time; energy storage or back-up power systems would be required for round-the-clock demands.

Southwestern Public Service is participating with the DOE and Stone and Webster Engineering in a *Southwest Project* study on rapid commercialization of various solar-powered and wind-

energy systems. Some application for remote power generation by small vertical-axis turbines has good potential at such time as reliable machines are available. There is possible application for pumping irrigation waters for agriculture with the future development of wind-turbine pumps.

Solar

Solar energy appears to be a free energy alternative until you try to purchase and install an electric generating facility. Solar-power research has been going on for over 40 years, and the same problems continue to exist. The main problem is that it is very expensive to collect low-value Btu's from solar sources and concentrate them into the high-value Btu's necessary to generate electric power.

We have an average of 13,000 Btu/sq yd/day solar input, and maybe 20% of this energy could be collected; this would mean about 2,600 Btu/sq yd/day. There are 8,425 Btu's in a pound of coal used at Harrington Station, Unit No. 1. The average coal consumption at that station is 7.2 million lb/day—so that, for equivalent energy, about 7.5 sq mi of solar collectors would be required. The solar alternative can only be justified for special applications considering environmental and land-use problems coupled with capital cost estimates—limitations which indicate solar generation costs to be four times coal generation costs.

Southwestern has done some very preliminary work to evaluate the use of solar collectors to assist existing gas-fired facilities. Study of such a hybrid plant will continue when more information is available concerning the performance of solar collectors. Southwestern will be monitoring, with interest, the DOE and Southern California Edison's solar demonstration-plant project. At this time solar energy is disqualified because of its lack of technological feasibility. Also, evaluation of conceptual plants are not cost effective. Other factors seldom considered in the evaluation of solar energy are the safety hazards, land use, and associated environmental problems. Southwestern is also following with interest the studies that show potential for solar space heating besides the conversion to electric energy.

Shale Oil

Shale oil has been investigated by Southwestern as a potential source of fuel. The company participated in, and still has interest in, a project of in situ processing of shale oil developed by Garrett Research and Development Company, Inc. It can be noted again in Table 1 the enormous amount of energy locked in the shale oil deposits in the western states. The technique developed by Garrett uses explosives to condition the underground shale oil formation for recovery of the kerogen by igniting a fire at the bottom and feeding a controlled amount of oxygen from the top. The liquified kerogen is recovered from pools in the bottom of the formation and is then available for direct, or indirect, use. This particular source of energy looks very promising, but it will require more development and time before it can be cost effective. Here again, U. S. national policy and environmental concerns could overshadow the potential of using shale oil. The problems of transporting shale oil to Southwestern's facilities is another problem which still requires resolution.

Geothermal

Geothermal alternatives are often mentioned and promoted by the government and the media. There are successful operating geothermal facilities in the U. S., but there are no known acceptable geological formations in the High Plains area of Southwestern's service territory.

Biomass

Biomass alternatives have only been viewed briefly by the company. I do not classify the utilization of agricultural waste as biomass, for the term usually refers to the intent of harvesting a growing plant or utilizing bacteria to generate gases for direct use in a process. In time, as other alternatives become less feasible or technical information indicates further studies are needed, Southwestern will give more serious consideration to this alternative.

Nuclear

Southwestern Public Service performed coal-nuclear comparison studies in 1975 to determine the optimum fuel selection for plants to

be constructed during the next 10 years. One particular study, performed by the planning department of the company, indicates that coal and nuclear are very competitive, but that on Southwestern's system the available nuclear units would be too large and would result in a transmission/generation reliability and stability problem.[8] With growth and time (or joint ownership) this problem could be solved. The evaluation indicated that from an economic standpoint coal and nuclear are "neck and neck" except for nuclear energy's high construction costs due to regulatory delays. Changes caused by environmental regulations concerning coal could make nuclear more competitive and the alternative to be selected. The results of the in-house study were similar to conclusions from other studies reviewed by the company.[9,10,11,12]

But because of the numerous uncertainties about the nuclear fuel cycle and other institutional policies of the present Federal Administration, nuclear power is for now very questionable on Southwestern's system. The company would have to bear a financial burden for 10 years or more of planning, permit acquisition, and construction before any return on the capital investment could be expected. This is a considerable penalty.

An additional factor considered by the company when evaluating this alternative is that the limited amount of nuclear fuel available without recycling and the breeder reactor would tend to force a decision toward coal as a fuel, even over the long term. It is Southwestern's stated position that without the breeder reactor the company, with presently available information, will not pursue nuclear power as a source of energy.

How would the breeder reactor and the closed fuel cycle change the nuclear outlook? As can be noted in Table 1, the percentage of recoverable U. S. energy from uranium oxide is only 4% of the U. S. energy capability. No light-water reactor installations could be installed after the year 2,000 with the open fuel cycle because there would be *no* nuclear fuel by 2,040. Therefore, the potential for additional energy using the plutonium/uranium fuel cycle or other combinations of breeder fuel cycles make the breeder reactor inevitable. For example, 80% of this country's available energy in the form of coal represents 4,557 quads (10^{15} Btu); the breeder uranium-233 fuel cycle with the GCFR (Gas-Cooled Fast-Breeder Reactor) and HTGR (High-Temperature Gas-Cooled Reactor) would supply 360,000 quads.[13] This is 80 times the energy available from coal. Similar estimates of the energy production capabilities of nuclear power using plutonium/uranium fuel cycle are available and indicate the same order of magnitude.[14]

The breeder fuel cycle would be an enormous energy resource which would resolve America's dependence upon foreign energy sources. With the nuclear breeder reactor there would be enough electrical energy available for 35 centuries. The breeder, however, is heavily burdened with political rhetoric and misunderstood social issues, such as the debate over proliferation.[15] The technology for the breeder reactor in this country is over 10 years behind schedule. Breeders are in operation in France, Great Britain, and Russia, indicating that the systems can be safely constructed and efficiently operated. In this country it appears that resolution of the proliferation issue and failure to inform the public about the capabilities and technology of handling radioactive waste will continue to delay the use of this viable energy alternative. The breeder cycle is in reality a *consumer* of conventional radioactive waste.

Southwestern is indicating its commitment to the GCFR program by offering $100 million during the construction phase of a demonstration plant, plus a site on Southwestern's system. The company is a member of the Helium Breeder Associates (HBA), which was recently formed by 35 investor utilities, 7 research corporations, 12 nuclear groups (electric utilities with nuclear units), 3 foreign countries, 8 municipal and/or government entities, along with 75 rural electric cooperatives.

The company has been working with General Atomic Company, initiator of the GCFR concept, and DOE representatives in the reactor research field. The company has given its vote of confidence numerous times to the GCFR program and believes it should be implemented as soon as reasonable technology and economics allow. The GCFR Demonstration Plant proposed by HBA would be a 300-MW(e) unit where testing of conceptual design could be performed. After the testing period, the

unit would take its place as an operating steam electric generating facility on Southwestern's system.

Fusion

One additional alternative should be mentioned, i.e., the use of fusion for the generation of electric power. The dream of fusion power has existed for some time and to date about $2 billion has been spent in research for fusion power. Some estimates for the perfection and commercialization of fusion are as high as $20 billion; yet potentially fusion is a virtually inexhaustible energy alternative. For example, the amount of deuterium available in a one-gallon pitcher of tap water could fuel a fusion process to produce enough energy for a typical American home for a year.

For the last 17 years Southwestern Public Service has been a utility participant to the Texas Atomic Energy Research Foundation (TAERF) which, through 1979, will have funded more than 16 million dollars worth of advanced fusion research at the University of Texas' Fusion Research Center. The major drawback to this energy alternative is the lack of technical feasibility. The design of a "magnetic bottle," which will contain the plasma of the fusion reaction at the tremendous temperatures of the sun, is out of reach at this time.

Southwestern also follows, with interest, information and reports from other fusion studies being directed by the Fusion Power Reactor Senior Research Committee, Division of Magnetic Fusion Energy, DOE. One of the projects under the direction of this group is General Atomic Company's Doublet III. Preliminary testing on Doublet III is scheduled for 1979.

CONCLUSION

It is inevitable that energy will be an expense and that the expense will increase. To re-state the second law of thermodynamics: "there is no such thing as a free lunch." Southwestern's immediate energy needs will be supplied by Western-coal-fired generating plants, but, as you can see from this presentation, the company continues to investigate a wide range of energy alternatives. In accordance with our responsibility to the public, we will implement any energy alternative that will commercially supply to the rate payers a kilowatt of power for a reasonable price.

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