WHERE WE ARE IN NUCLEAR POWER DEVELOPMENT

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Nuclear-generated electric power has clearly become of great national importance in the last decade. In mid-1973 it represented 4.6% of the total generating capacity in the U.S. and consisted of 35 operable nuclear power reactors having a generating capacity of about 19,200MW(e). Fifty-six more nuclear units were under construction at that time and an additional 112 had been ordered. By 1985 there will be 275,000MW(e) of nuclear generating capacity, representing some 29% of a total 950,000 MW(e) for the nation.

This substantial commitment to nuclear power is a positive move in an attempt to solve the huge related problems of vastly increasing energy demands, diminishing fossil-fuel supplies, and a deteriorating environment. Nuclear energy provides the most economical means of power generation in many areas of the country, it has a reliable and economic fuel supply, and it is presently the only practical source of electricity that is capable of helping us meet our burgeoning energy needs, while at the same time being environmentally acceptable.

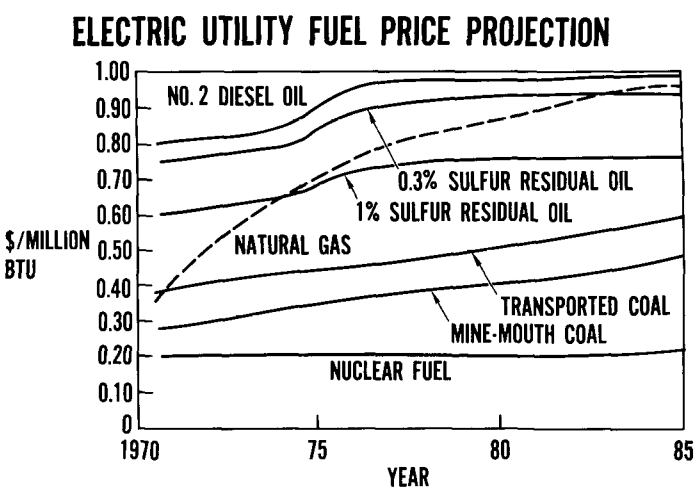

FIGURE 1—Electric utility fuel price projection.

Figure 1 shows a forecast of the relative electric utility fuel prices to 1985. Nuclear fuel starts at a lower base and remains stable in comparison to rising costs of fossil fuels in the near future. Additionally, while capital costs for nuclear plants are currently higher than those for fossil plants, the latter costs will certainly rise. Environmental restrictions requiring clean-up systems to remove sulfur from stack gases of coal-fired generating plants, for example, will raise capital costs considerably.

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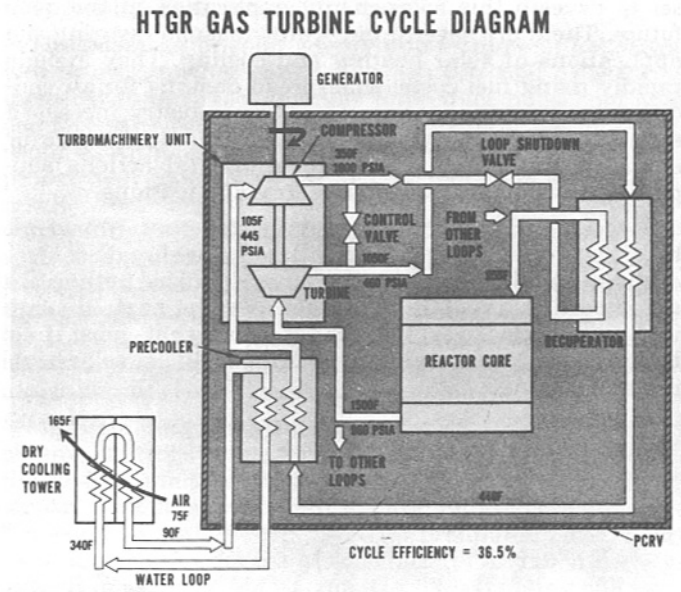

FIGURE 2—HTGR helium gas turbine cycle with dry air cooling.

Water cooled, water moderated reactors known as Light Water Reactors (LWRs) represent most of the nuclear electric generating capability today. These nuclear plants have been quite successful and have operated safely and reliably. The LWR is now being challenged by the High-Temperature Gas-cooled Reactor (HTGR), an advanced nuclear power system that has the advantages of higher thermal efficiency (resulting in less waste heat discharge to the environment), better fuel utilization, and lower amounts of radioactive effluent.

One of the encouraging aspects concerning the HTGR is its unique potential. Among the exciting possibilities in advanced versions of the HTGR are the Direct Cycle HTGR and the Process Heat HTGR. Additionally, follow-on concepts such as the Gas-Cooled Fast Reactor (GCFR) and the thermonuclear fusion reactor will use basic HTGR technology.

In the Direct Cycle HTGR, helium gas, the reactor cooling fluid, also serves as the working fluid by driving closed-cycle gas turbines directly. The entire steam loop and its associated buildings will be eliminated, which should reduce the capital costs of the system considerably. Figure 2 is a schematic of Direct Cycle HTGR system. Of even greater significance is the capability of this system to economically use dry cooling. Total elimination of all re-

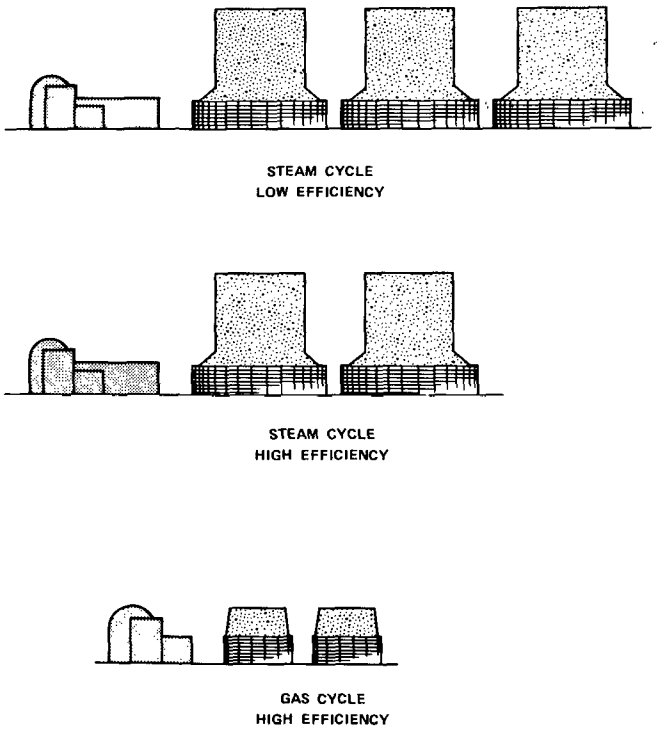

FIGURE 3—Plant size comparison.

quirements for cooling water will increase siting flexibility and may prove to be the only reasonable power plant selection for electric utilities in the arid areas of the world. Figure 3 shows a size comparison of different plants using dry cooling. In the figure, low efficiency and high efficiency in the steam cycle are nominally 33% and 40%, respectively.

The HTGR can be adapted to deliver high-temperature process heat. Some of the more promising HTGR process heat applications requiring temperatures of 1850°F and below include the gasification of coal to produce high-BTU pipeline gas, the direct reduction of iron ore, and the production of hydrogen. These process heat applications will help conserve the finite supply of fossil fuels.

The major efforts in breeder reactor development have been on the Liquid Metal Fast Breeder Reactor (LMFBR). Although the GCFR design is not as detailed as that of the LMFBR, the Edison Electric Institute has noted that the GCFR may have greater potential for producing power at low cost than any breeder reactor commercially available by the 1990s. GCFR development will be relatively less expensive than for the LMFBR because it is not based on completely new technology. The technology for the nuclear steam and containments systems is but an extension of

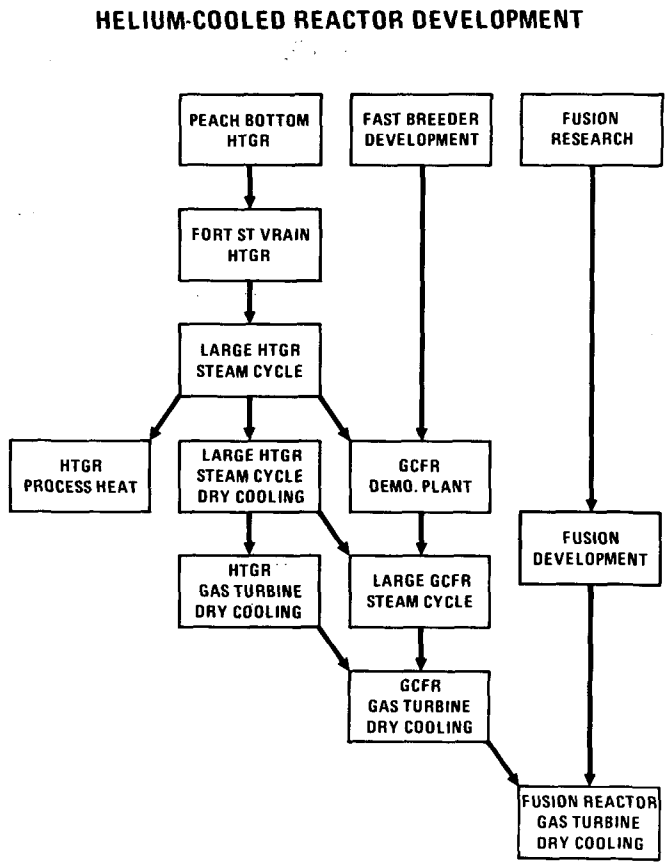

FIGURE 4—Helium-cooled reactor development.

that already proven for the HTGR, and the fuel will be essentially the same as that developed for the LMFBR.

A thermonuclear fusion power plant is still in the embryonic stage. Although recent experiments are very encouraging, scientific feasibility of a sustained thermonuclear reaction has yet to be proven. Thermonuclear research is now underway at Gulf General Atomic. If all goes as expected, using the Doublet concept, scientific feasibility will be demonstrated by about 1980.

In summary, a number of energy sources will coexist for many years. Coal gave way to the predominance of oil and natural gas in the 1950s, which in turn, are yielding to LWRs. The HTGR advanced converter reactor is now competing with the LWRs and will be followed by the Direct Cycle HTGR in the near future. (The development and interrelation of gas-cooled reactor "family tree" is shown in Fig. 4.) During the 1990s the fast breeder reactors will begin to play a significant role. Fusion reactors should join the spectrum shortly after the turn of the century.