China is developing advanced nuclear power concepts

Earlier this year, construction began on China's first experimental high-temperature gas-cooled reactor (HTGR). This 10-megawatt (MW) test facility, based on the German technology employing spherical fuel elements, is designed to lay the basis for future development and commercial application of modular HTGR reactors in China. The reactor is being built by the Institute of Nuclear Technology (INET) of Tsinghua University, at a site near Beijing. The director of the INET, Wu Zongxin, provided answers to some questions about this and other activities of his institute.

EIR: What is China's interest in nuclear power?

Wu: In China, the per-capita energy use is at a very low level—only 0.2 kilowatts of electricity capacity per capita. With the growth of the economy, we must increase the per-capita power generation. But China's population also grows. Now, the total power generation capacity is about 200 gigawatts [GW]. By the year 2000, we are going to reach about 300 GW. According to our government's targets, in 2010 we should reach 580 GW. By 2050, the population will reach 1.6 billion. We need per-capita about 1 kilowatt, so the total capacity must be about 1,600 GW. This is a very huge increase in power generation capacity. So, from a demand-side consideration, we should have more power supply. But also in China, the source is a problem. Coal makes up about three-fourths of primary energy. But 40% of freight transportation, of the railway capacity, is used for the transport of coal. Also, pollution is a very serious problem. In the future, environmental aspects, such as the question of global warming, are important. So, China must consider nuclear energy, because of the environmental problem, the transportation problems, and so on. Thus, we need an expansion of nuclear energy in China, especially for the east coast areas.

We now have two nuclear power stations. One is at Daya Bay, using French technology. The other is Qingshan. Qingshan is domestically designed, but some components came from outside. To develop nuclear power, China must overcome two barriers. First, only a small portion of the necessary components are today manufactured in China. But we want to reach more than 70%. Another problem for China is the intensity of investment required for nuclear energy. Nevertheless, in some respects, the cost of nuclear is comparable to coal power generation, because now in China, with nuclear power stations, the investment cost, considering imports, is about $2,000 per installed kilowatt; whereas with domestic manufacturing, it would be about $1,300 per kilowatt installed; for coal power generation, imported components cost per kilowatt about $1,000. But the fuel cost in nuclear power generation is less. So, the electricity cost from a nuclear power station may be less than for coal power generation. Cost is no problem in the future, if the goal of local manufacturing is achieved.

EIR: How did the INET become involved in high-temperature reactor technology?

Wu: Our institute began to be interested in the concept of the HTGR around 1973. We were impressed with the very good safety characteristic of HTGR, its multi-purpose use—because not only electricity generation is to be considered, but also process heat—and also we considered its very good neutron economics. At that time, our thinking was that China is rich in thorium. So we considered using the high-neutron performance for thermal conversion reactors. The HTGR promised a high conversion rate of thorium to U-233. In those years, this was the prime consideration. But now, the safety and multiple-use aspects are the most important. The earlier director of our institute, Professor Lu, visited Germany, and was very impressed with the German HTGR technology. We also started some concept design work in this period. Then, in about 1978, when China opened to the outside, we invited Prof. Rudolf Schulten from Jülich [University] to visit our institute. He gave lectures for about two weeks, which gave us a direct knowledge of what is involved in the technology of the HTGR. In 1978, we began R&D work, for example on graphite, on some materials and on equipment for the helium coolant cycle. After that, our former director, Prof. Wang Dazhong, went to Germany on a Humboldt scholarship, got his Ph.D. under Schulten, and did a lot of work on the HTGR. When he came back to China, China had just started its high-technology program. So he made the proposal to develop the HTGR in China as part of that program. From 1985 to 1990, we carried out more R&D work. In this period, we had good cooperation with the German company Interatom and the German nuclear research centers, and did some concept design work jointly with them.

EIR: What is the plan for the 10 MW HTGR test reactor?

Wu: We hope that the reactor will be able to go critical by the end of 1998. Before the year 2000, we want to do experiments using the steam cycle. After 2000, we will install additional facilities to test a combined gas turbine and steam turbine concept. We also hope to have a project for building a large HTGR in the future. Most components will be made in China. Chinese manufacturers have the capability to make components such as pressure vessels, containment vessels, circulators, and steam generators for the HTGR-10. We have this capability at the present time. Also, control systems. Some computers may be imported from the outside, but the software we develop ourselves. Concerning the fuel elements, we already began doing R&D work in the 1970s. We have had help to develop the fuel production technology. The German company NUKEM has transferred some equipment, and we have done a lot of experiments. So we are setting up a facility to manufacture the HTGR elements.

EIR: Besides the HTGR, the INET has also developed reactors for heating purposes. Please describe this program.

Wu: China is not only interested in nuclear energy for electric power generation uses, but also as a heat source. In fact, the largest portion of energy use is for heat, particularly space heating. In China, especially in the northern cities, space heating of housing accounts for a large part of the energy use. We have been considering nuclear reactors in place of coal for space heating uses. This led to our developing a concept for a heating reactor. Because it is to supply heat for residential areas, such a reactor has to have very good safety characteristics. So, we carried out a lot of research activities in this area. We developed and put into operation, in our institute, a 5 MW test reactor. We have successfully operated it for heating in the winter seasons. Now we are also studying the application of this heating reactor for seawater desalination, in cooperation with the International Atomic Energy Agency (IAEA). We are looking for its use, not only in the Middle East and Northern Africa, but also for China's east coast area. In the coming century, freshwater supply may be a big problem for China, especially serious in the northern coast area, Dalian city for example.

Since the heating reactor has to be very close to centers of high population density, we must have a high safety standard. So we adopted a lot of advanced technology, for example passive safety systems, full power natural circulation, double vessel construction, and so on. For example, we do not need any electrical power to remove the residual heat of the reactor. This is done by natural circulation. We have a very negative temperature coefficient, which prevents a reactivity accident. We carried out a lot of safety experiments with our 5 MW test reactor. For example, the self-regulation features: When the load changes 50%, for example, you don't need any actions by the personnel. The power follows the load changes by itself. We also did experiments on the self-stabilizing characteristics. When you insert some additional reactivity, then the power stabilizes automatically. When the reactor is under full power, and you suddenly shut down the main cooling pumps in the third loop, then the reactor shuts itself down automatically, and the residual heat is removed automatically, through the passive systems. So, both during normal operation, and in accident situations, you don't need very much intervention by the operators.

EIR: What are your future perspectives for the development and use of this reactor type?

Wu: The 5 MW reactor has operated successfully since 1989. The State Planning Commission has decided to launch an industrial demonstration heating reactor project, in Da Ching city in South China. This will be 200 MW. The site is already decided, and the feasibility study has already been approved by the State Planning Council. This would provide heating for 4 million square meters of housing. We have also participated in IAEA activities concerning desalination. We see a big market in future for freshwater production, so we want to develop this technology in China. We are considering the possibility for Dalian city to use the heating reactor for space heating in the winter, and for freshwater supply in the summer. We are discussing this with Dalian city. We would want to use such a facility to demonstrate nuclear seawater desalination and for training in this area.