the steam generator, analysis of different cases of accidents, exchange of design information, standardization of fuel elements, etc. If such international collaboration can be materialized and produce positive results, then the HTR will have a good prospect in some of the developing countries. In parallel, the suppliers should realistically firm up their cost estimation and also the fuel cycle cost. International cooperation in solving the problem of financing is yet another area, which needs urgent attention.

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HIGH TEMPERATURE GAS COOLED REACTORS IN CHINA

Jiachen HE, Jihui QIAN
Nuclear Power Bureau,
Ministry of Nuclear Industry,
Beijing, China

Abstract

China has plentiful energy resources, but it is unevenly distributed geographically. 60% of coal resources are concentrated in North China, 71% of hydro- power resources in the hardly accessible Southwest China, whereas the densely populated and highly industrialized 15 provinces/municipalities along the coast, yielding 73% of the gross national product, posses only 10% of national energy resources, which makes our railway system hard pressed. In fact, about 40% of the railway transport and 50% of the main waterway transport are committed to fuel. Yet the needs of energy in the coastal regions can not be met.

To develope nuclear power is a naturally expected approach to solving energy problems in China, particularly in the near term for the coastal regions, where the demand of electricity increases sharply and fuel transport from other regions is already tense.

Chinese nuclear circle is interested in MHTGR due to following reasons.

1. Small capacity of MHTGR is suitable for small power grid in certain areas.
2. Chinese manufactures are able to provide whole package of conventional island of MHTGR nuclear power plant.
3. multipurpose MHTGR is attractive for Chinese heavy industries.
4. MHTGR nuclear power plant can be built in suburbs due to inherent safety features.

Regarding the users' requirements in China, it can be summarised as:

1. Mature technologies and easy to get license from nuclear safety authority.
2. Emergency zone as small as possible, even unnecessary.

3. 200-300 MWe size desirable.
4. Big portion of domestic share in engineering and component supply.
5. Slightly higher electricity price than coal fired.
6. Investment and favourable financing conditions from overseas.
7. Reimbursement of hard currency by countertrade.

At present, four working groups, including users, manufactures and nuclear industry circle, have been established for performing independent feasibility study on building MHTGR demonstration nuclear power plant in China.

RESOURCES OF ENERGY AND DEVELOPMENT OF ELECTRICITY IN CHINA

China has plentiful energy resources. The total explored coal resources and the hydro power resources are at the third and the first rank respectively in the world. The assured uranium reserves are sufficient to sustain a nuclear capacity of at least 15000 MWe running for 30 years, with large areas of the territory not yet explored, most probably valuable new uranium deposits will be explored in the coming years.

Geographically, the energy resources in our country are unevenly distributed, 60 % of coal resources are concentrated in North China, more than 70 % of hydro power resources are in the hardly accessible southwest of China, whereas the densely populated and highly industrialized 15 provinces/municipalities are along the coast which yield more than 70 % of the gross national product and possess only 10 % of national energy resources. Consequently, transporting the northern coal to the south has become a daily occurrence, which makes our railway system hard pressed. In fact, about 50 % of the railway transport and 40 % of the main waterway transport are committed to fuel. Yet the needs of energy in the coastal regions cannot be fulfilled.

At present, the shortage of energy, particularly the shortage of electricity has become one of the restrictions of economic drive in China. Therefore, our government pays great attention to electricity generation, as a key issue in China's modernization. For instance, in 1986 and 1987 the average growth rate of electricity production had reached 11.3 % per annum, but this figure is far from the demand of economic growth.

CHINA'S POLICY OF DEVELOPING NUCLEAR POWER

To develop nuclear power is a naturally expected approach to mitigate energy shortage in China, particularly for the coastal areas, where demand of energy increases sharply and fuel transport from other regions is already tense.

At present, two PWR nuclear power plants are under construction in coastal regions. One is 300 MW Qinshan plant, designed and being constructed by Chinese efforts. Most of the equipment are supplied by domestic manufacturers with some important compnents imported. This nuclear power plant is expected to put into operation in 1990.

The second is 2 x 900 MW Guangdong nuclear power plant, which is owned and will be operated by the Guangdong Nuclear Power Joint Venture Company, invested by the Guangdong Nucelar Investment Company and the Hong Kong Nuclear Investment Company.

The Nuclear island package of this plant is supplied by Framatome of France.

The conventional island package - by GEC of United Kingdom.

The project services are entrusted to EdF of France, and the BOP, civil works and erection are called for tenders internationally.

The first unit is scheduled to commercial operation in 1992, and the second one nine months later in 1993. 70 % of generated electricity will be sold to Hong Kong, the income will pay off the hard currency loaned from banks, the remaining 30 % of electricity will transmit to Guangdong province.

The second stage Qinshan project is 2 x 600 MW PWR which has been approved by our Government. This project will be based on Chinese efforts in cooperation with foreign company and is under negotiation and site preparation.

China's policy of developing nuclear power has selected PWR as main reactor type. Our target is to achieve domestic and standardisation of 600 MW PWR through building first lot of 600 MW units in cooperation with foreign technically advanced company and to promote 600 MW PWR as essential nuclear unit in our country. We are also improving the design of 300 MW PWR to commercial stage, applied in regions with limited power grids.

Besides, we are exploring a way of construction of nuclear power plants in certain areas and for specific application by local government investment with introducing overseas funds. One of them probably is Modular HTGR.

HIGH TEMPERATURE GAS-COOLED REACTOR IN CHINA

Since 70s Chinese nuclear engineers became interested in HTGR. The studies on reactor physics, research and development works on coated fuel particles and helium circulation have been carried out in research institutes in China.

In early 80s Chinese research institutes began to contact with foreign organizations and participate a number of symposia and mutual visits of experts have been organized during past years.

In 1985 a joint prefeasibility study on the perspective of HTGR application in China has been performed by Beijing Institute of Nuclear Engineering and INNOTEC in Federal Republic of Germany. The outcome of this joint prefeasibility study shows, that HTGR has potential market in certain conditions in our country due to the following reasons.

1. At present time, there are only four power grids, which have installed capacity, exceeding 10 GW. It is impossible for a certain regions, not covered by these large grids, to house PWR's with unit size in excess of 300 MW. Modular HTGR of about 100 MW may be used to meet the needs of power in these regions.

2. Modular HTGR with inherent sfety features and small size can be built in densely populated areas.

3. Steam parameters of Modular HTGR are the same, as that of coal fired plants, so that the whole package of conventional island can be supplied by domestic manufacturers.

4. Multipurpose Modular HTGR is attractive for chemical and oil industry.

Therefore, we decided to perform an independent feasibility study on possibility of building Modular HTGR demonstratin plant in China, based on information provided by foreign organization, including INNOTEC, INTERATOM of Federal Republic of Germany and GA, GCRA of United States respectively.

The purpose of independent feasibility study is :

- to evaluated the technical concept;
- to estimate domestic share in engineering and equipment supply;
- to estimate total cost, including amount of hard currency;
- to make economic analysis, including the price of generated electricity and ways of reimbursing hard currency;
- to explore the resources of funds and possible favourable financing terms;
- to explore the cooepration mode, regarding investment, technology and management;
- to make comprehensive comparison of foreign companies in technical, economical and financing aspects and to select a foreign company, as a partner to perform joint feasibility study.

In April this year, four working groups have been established to perform independent feasibility study, participated by Chong-Qing municipality, as potential utility, Dong-Fang manufacturing group, as domestic equipment supplier, Beijing Institute of Nuclear Engineering and Southwest Reactor Research and Design Institute, as engineering supplier, and Nuclear Power Bureau of Ministry of Nuclear Industry, as coordinator.

First working group is responsible for studying resources of funds and financing.

Second working group is responsible for studying domestic share of equipment and engineering, as well as economic analysis.

Third working group is responsible for studying technical evaluation and boundary conditions of plant size and site.

Fourth working group is responsible for studying cooperation mode.

The independent feasibility study is intended to be completed by end of this year or a little bit later.

If the outcome of independent feasibility study is positive and approved by relevant authorities, we will select a foreign company as partner to carry out a more deeper joint feasibility study.

USER REQUIREMENTS FROM CHINA

It can be summarised as :

- mature technologies; approved already by nuclear regulatory institutation;
- minimum environment impact, favouring selection of site;
- appropriate plant size of 200-300 MWe, flexible to limited power grids or to specific application;
- certain portion of domestic share in equipment and engineering supply;
- acceptable price of generated electricity or slightly higher than that of electricity, generated by coal fired plant of the same size;
- investment and favourable financing terms from foreign organization;
- reimbursement of hard currency through ways of barter trade;
- joint share of risks by both utility and suppliers.

It must be pointed out that China only began to explore the possibility of building Modular HTGR demonstration plant and a number of problems will be faced in further proceeding.

STATUS OF THE HTR RESEARCH AND DEVELOPMENT PROGRAMME IN CHINA

Yuanhui XU
Institute of Nuclear Energy Technology,
Beijing, China

Abstract

In the seventh Five Year Plan China has identified various high priority research areas which also include development work for the High-Temperature Gas-Cooled Reactor. For the coordination of technology development contributions from different institutes an expert team was appointed by the State Scientific Technology Commission. The paper contains a description of HTGR relevant research and development work and the main data of the HTGR test module planned for construction at the Institute of Nuclear Energy Technology.

As high technologies will exert an enormous impact on the future economic growth and lay the ground for China's economic leap around the turn of the next century, they deserve China uttermost attention now.

As an immediate part of the strategic objectives within this century. China's high technology research and development constitute a component of the Seventh Five Year Plan (1986-1990). It's projects has planned to serve economic development at the close this and start of the next centuries, The projects aims to pool together the best technological resource in China over the next 15 years to keep up with international high technology development, bridge the gap between China and other countries in several most important areas and wherever possible for breakthroughs. The programme also aims to provide technological backup for economic development and train large numbers of talents for the future.

Seven priority research area are included in this programme. One of them is energy technology area, which includes two subjects that is, coal-fired MHD power generation technology and advanced nculear reactor technology. In veiw of the development of nuclear energy in the 21st century a choice will be made to develop a safe, economically viable and highly fuel efficient type of reactor among fast breeder