TRANSFERRING NUCLEAR POWER TECHNOLOGY TO FOSTER CHINESE SELF-RELIANCE

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Being convinced that nuclear energy will play an important role in meeting its huge future energy demands, China considers that the development of a very strong national nuclear industry capable of covering all aspects of a major national nuclear power program is of paramount importance.

In this context, China has invited its foreign partners to propose contributions to the studies for this development, in view of establishing a suitable cooperation program with the entire Chinese nuclear power industry, including design institutes, equipment manufacturers, construction companies, and plant operators.

One of the main objectives defined by the Chinese authorities for the further development of their nuclear industry with some international cooperation is the achievement of a very high level of self-reliance by Chinese industry in all of the following areas:

- project management, design, and engineering
- construction
- equipment design and manufacturing
- operation and maintenance.

The major key to reaching this target of overall and long-term self-reliance lies in the implementation of thorough design know-how transfer towards all partners of the Chinese nuclear industry, who shall acquire the necessary capabilities so as to completely master nuclear engineering. While this policy might entail fairly high front-end investments by the technology receivers, in terms of industrial infrastructure and engineering capabilities it is expected to pay off over the longer term with the development of a substantial nuclear power plant construction program.

Transferring nuclear power technology is therefore a key issue for anyone expecting to cooperate with the Chinese in the development of their national nuclear industry.

Framatome and the French nuclear industry were among the first to be confronted with this issue in China. Framatome has been fortunate enough to look at the issue of technology transfer from the vantage point of the receiver as well as that of the transferor. Almost 30 years ago, we started the construction of our first 900 MWe class PWRs and of our specific nuclear industrial infrastructure as a licensee of the PWR NSSS vendor, Westinghouse. We know, besides the financial compensation, how much effort we had to put into the process in order to fully assimilate and master the technology step-by-step, to a point where we could stand on our own two feet and develop and license new models, thus reaching full technical independence from Westinghouse.

This effort has paid off nicely because of the large series of nuclear power plants that were built in France, which allows the country today to produce one of the cheapest kWh in the European Union.

Taking into account its design and manufacturing capabilities for all the heavy NSSS components and its huge experience in project management, construction, commissioning, and maintenance of nuclear power plants in France and other countries, Framatome has been fortunate to have been exposed to the full range of concerns raised by the Chinese objectives and has been able to enter into effective and comprehensive cooperation programs with its Chinese partners through several technology transfer agreements.

Let us recall that Framatome received its first big contract in China for Daya Bay 1 & 2 (2 x 985 MWe) in Guangdong Province in 1986, a second large contract for Ling Ao 1 & 2 (also 2 x 985 MWe) in the same province, near to Daya Bay, in 1995, and a number of smaller contracts to support the construction of Qinshan Phase I (1 x 300 MWe) and Qinshan Phase II (2 x 600 MWe) in Zhejiang Province.

The first large-scale technology transfer was initiated in 1991 in the field of fuel assembly design and fabrication. Through a cooperation agreement signed between CNEIC (China Nuclear Energy Industry Corporation) and Fragema, manufacturing technology was transferred to the Yibin fuel fabrication plant of the CNNC (China National Nuclear Corporation) in the southern part of Sichuan Province and design technology was transferred to NPIC (Nuclear Power Institute of China).

This agreement was based on the AFA 2G fuel assembly technology.

It has allowed upgrading of the Yibin factory to enable supplying nuclear fuel assemblies for Daya Bay. This agreement covered in particular training of the Yibin staff, delivery of some components and equipment, and the transfer of numerous computer codes and fabrication processes to our Chinese partners.

The first full reload fabricated in Yibin was delivered to Daya Bay Unit 2 in 1995, just in time for its second operating cycle. Since that time, no less than 350 fuel assemblies have been produced with the transferred technology and delivered to both units at Daya Bay, where they are performing to the full satisfaction of the Owner and Operator.

This example is, in some ways, a case study illustrating what can be achieved in a total climate of trust, in a relatively brief period.

Erection and startup testing of the Daya Bay units, systems and equipment were carried out in cooperation with the 23rd Company of the CNNC in the framework of a general Erection Contract signed in 1988 and were the opportunity to transfer the related technologies. The transfer of technology in this area will be perfected and fully mastered by the 23rd Company with the erection of Ling Ao. Refueling outages, which were initially performed by Framatome on a more or less turnkey basis in the framework of a general maintenance contract signed in 1993, have also been gradually turned over to the Customer under its responsibility and with personnel trained on the job by Framatome. The quality of the maintenance performed has been demonstrated by the very smooth and successful operation of the units, which produced more than 12 billion kWh in 1997.

On the engineering side, a far reaching technology transfer agreement, involving not only Framatome but also the French national utility Electricité de France (EDF), was signed in 1992 with the CNNC. It has allowed implementation of the French PWR technology by two design institutes approved as « Nominated Users », the Beijing Institute of Nuclear Engineering (BINE) and the above-mentioned NPIC, for the design of the Qinshan Phase II units (2 x 600 MWe), now under construction in Zhejiang Province.

The way Framatome is transferring its nuclear steam supply system technology and helping in its assimilation by the receiving entities is also illustrated by two other cooperation agreements signed in 1996 with the NPIC. The first agreement will enable NPIC to perform plant modifications and improvements studies on Daya Bay Units 1 & 2. The other agreement, in the area of nuclear fuel, enlarges the previous cooperation started in 1991 and covers new fuel management strategies, nuclear fuel operating experience feedback, and miscellaneous nuclear fuel services.

The Ling Ao contracts and the related technology transfer (TT) agreement signed jointly in late 1995 by Framatome and EDF with the China Guangdong Nuclear Power Company (CGNPC) go much further. The scope of the TT is very comprehensive, for these « royalty free » transfers, covering the nuclear island, nuclear fuel, NPP unit operation and maintenance, and providing access to the most advanced nuclear reactor technology, concerning the most powerful reactors now operating in the world (the N4/1450 MWe units). Framatome is thus currently cooperating with no less than 15 different factories in numerous Chinese provinces. Many key heavy nuclear components or parts are being manufactured under cooperative arrangements with Chinese companies fully benefiting from Framatome's comprehensive technology transfer. To name a few: reactor internals are being made by the Shanghai Machine Tool Works No.1 (SMTWNo.1) factory of the Shanghai Electric Corporation (SEC) Holding company; steam generators, pressurizers, accumulators, and boron injection tanks are being made by Dongfang Boiler Works (DBC), a subsidiary of the Dongfang Electrical Corporation (DEC), in Sichuan Province; heavy component supports are being produced by the Erzhong factory in that same province; fuel handling equipment by the Xian 524 factory in Shaanxi Province; control rod drive mechanisms by the Xianfeng factory and boilerworks by SPEC, both of them being subsidiaries of SEC in Shanghai; primary coolant pumps by the Shenyang pump factory in Liaoning Province ; and cable trays in two factories in Zhejiang and Jiangsu Provinces.

The Chinese partners have been selected after a number of technical audits involving QA organization and procedures, adequacy of their equipment, technical capability for the manufacture and inspection operations, and the willingness of management to meet the most stringent nuclear standards and invest in people training and factory improvements. Not surprisingly, there have been a number of problems to overcome, and new ones will certainly arise, as the tasks are very ambitious and demanding. However, we can say today that, with tremendous commitments from all parties concerned, delivery schedules will be complied with, and quality standards will be met.

All these above-mentioned technology transfers are important steps towards complete self-reliance of the Chinese industry in the field of nuclear power plant design, construction, operation and maintenance, which Framatome and its partners have endeavored to support with all their technical resources.

Such a long list of cooperation actions between the Chinese and French industries reflects the strong efforts already made and the progress already achieved by China in the march towards self-reliance in nuclear energy.

In the future, we will have to cope more and more with technology transfer and local manufacturing. From our experience in China, we have learned how this process can be efficiently worked out to the mutual benefit of both parties.

From our Chinese experience, I will try now to draw some conclusive remarks that may be of interest to anyone who expects to cooperate and contribute to the development of the Chinese nuclear energy program.

Allow me to start with a very common-place remark, but one that we have learned over and over again to be true: technology is not transferred only through the physical transmission of documents, drawings, specifications, computer codes, etc. To be effectively transferred, it takes time with good and sincere cooperation and communication between people, often of different cultures. It requires resolving practical problems together, under the pressure of very tight project schedules.

Another important lesson is that, although there might be orders of magnitude of differences in labor costs between our home country and the country where we localize or transfer the technology, as a consequence of the differences in national economical backgrounds, this does not mean that, in the initial phase, localized equipment will necessarily be cheaper, when all costs are fairly accounted for, than components manufactured by the usual experienced suppliers.

The first reason is that nuclear quality standards accept no compromise. We therefore have to provide all training and technical assistance that might be necessary to ensure that the quality of the components leaving a factory with little previous nuclear experience will meet these stringent standards. This technical assistance is usually provided by senior expatriate engineers.

Furthermore, so as not to jeopardize the overall project schedule, in many instances only a limited number of typical tasks are performed by the technology receivers for the first project to be localized. Therefore, the cheaper labor costs in the TT receivers' country do not generally compensate for the impact of localization.

Another reason is to be found in the initial productivity gap between the home country factory and the country where localization is performed. This can be easily understood considering their different positions on the learning curve.

A last reason is the more complex procurement scheme, which often leads to breaking down manufacture between our home factories and factories where localization is performed. This results in more facilities to be supervised at a greater distance from headquarters, in the setting up of decentralized procurement offices, and in many additional interfaces to be managed.

The remarks made above would apply also to engineering studies broken down between two teams in two different countries, with different positions on the learning curve.

With this in mind, it is easy to understand that localization and technology transfer require a lot of dedication and motivation both on the part of the transferor and the receiver. This motivation can most easily be found when both embark on a full program that gives some degree of insurance that the initial investment in people training, organization and facility improvement could be amortized, and the initially unfavorable cost situation can be reversed to take full advantage of the cheaper labor costs of the receiving party, when technical assistance is no longer necessary and productivity has risen to the level of our home facilities.

In conclusion, I would like to mention that localization and technology transfer have had an important impact on our business philosophy. We have learned to view them not as an impoverishment of Framatome's technological base, but as an opportunity to enlarge this base through cooperation with our licensees. A technology cannot survive in file cabinets. It has to be applied, wherever applications can be found, if it is to progress. In the course of time, it seems natural that a relationship that starts with subcontracting arrangements, should evolve towards technology transfer and full cooperation on an equal footing. This last phase can be best achieved if both parties find ways to solidify their relationship in setting up jointly-owned entities in which truly « seamless » cooperation can be promoted and if they are able to continue their cooperation, on the basis of equality and mutual benefit, together making the best use of joint research and development (R & D) activities, allowing respective specializations in some fields to reduce costs, and fully sharing their respective experiences.