LOCALIZATION OF NUCLEAR POWER PLANT TECHNOLOGY

Fred Z. Stiteler, Terry G. Rudek
ABB Combustion Engineering Nuclear Systems
a business unit of Combustion Engineering, Inc., U.S.A.

ABSTRACT

Asia, and particularly China, has an enormous need for power and must deal with the practicalities of building large base load units. In China, as in other countries, there are limitations on the use of large quantities of fossil fuel. This raises the possibility of turning to nuclear power to satisfy their energy needs. Other issues tend to point to the nuclear option for these growing economies, including economic considerations, environmental concerns, energy independence and raising the technological capabilities of the country. When a country embarks on a nuclear power program with the intention of localizing the technology, a long-term commitment is necessary to achieve this objective.

Localization of nuclear technology is not a new phenomenon. The nature of the industry from the early beginnings has always involved transfer of technology when a new country initiated a nuclear power construction program. In fact, most previous experiences with this localization process involved heavy governmental, political and financial support to drive the success of the program. Because of this strong governmental support, only the receiving nation's companies were generally allowed to participate in the local business operations of the technology recipient. What is new and different today is the retreat from heavy financial support by the receiving country's government. This change has created a strong emphasis on cost-effectiveness in the technology transfer process and opportunities for foreign companies to participate in local business activities.

ABB is a world-wide company with two parent companies that have been very active over many years in establishing cost-justified local operations throughout the world. Today, ABB has become the largest electrical engineering company in the world with respected local operations in nearly every country. Lessons learned by ABB in their world-wide localization initiatives are being applied to the challenge of cost-effective localization of nuclear power in Asia.

Nuclear power is more capital intensive than most other power generation options. This results in the electricity cost to the end user being more influenced by the initial cost than fuel, and other operations and maintenance expenses. Because developing nations typically have lower wages, it's a natural conclusion to maximize local capabilities to drive the capital cost as low as possible. To facilitate localization, new approaches to expediting the formation of a credible nuclear technology infrastructure in these emerging commercial nuclear power nations is discussed.

This paper will examine localization of nuclear technology as one of the most promising methods to make nuclear power more affordable to the emerging markets in Asia. Localization will allow for the utilization of lower cost, local labor in the design, manufacture and construction of new nuclear power plants. ABB's practical localization philosophy is discussed with reference to previous experience and future expectations.

1.0 INTRODUCTION

Over the years, Combustion Engineering Inc. (ABB-CE) has provided complete systems design and major components for 15 Nuclear Steam Supply Systems (NSSS) in the U.S., as well as eight units in operation or under construction in the Republic of Korea. ABB-CE is also a world leader in the localization of nuclear technology. Since 1987 it has been working with the Republic of Korea to help it achieve its goal of 95 percent technical self-reliance in nuclear systems design and manufacturing – *the only major nuclear technology self-reliance program currently underway in the world.*

Basic methods of technology transfer include classroom training, on the job training, joint work participation, documentation transfer, computer code transfer, R&D program participation, and consultation. Over 400 individuals have received training in project management, system and component design, manufacture, procurement and installation, both in Korea and at ABB-CE facilities. The original technology transfer agreements included licenses to design and manufacture products based on ABB-CE's System 80® technology and participation in new product development.

In 1997, the cooperation between the Korean companies and ABB-CE was expanded further to include the joint development of a new generation of nuclear reactors for Korea based upon ABB-CE's 1400 MWe System 80+™ Advanced PWR. This new design has been termed the Korean Next Generation Reactor (KNGR) and it is anticipated that the first project will get started around the year 2000.

2.0 ABB-CE AND THE PEOPLES REPUBLIC OF CHINA

Up to this point, minimal efforts have been made to implement a truly self-sufficient nuclear program in China. The Peoples Republic of China currently has three operating nuclear plants, including two 300 MWe units (Qinshan I & II) of its own design, and another eight under construction or on order, totaling 10,850 MWe. Because the majority of the equipment in these first units was imported, the overall price for these plants is considered to be high when compared to other locally-supplied power generation options. To drive the cost of nuclear power down to levels competitive with other sources, planners have now focused on exploiting lower cost local sources for most plant equipment.

To spearhead this drive towards localization, China intends in the near-future to select a limited number of advanced, standardized designs for a major, 20-year nuclear power development program called the "Driven Project". ABB-CE is uniquely suited to meet this aggressive nuclear power plant development program. It has two advanced PWR designs that meet all of the safety and operational goals for the 21st century. These designs are also large enough to make nuclear power competitive with other sources of electricity production.

In the 1970s, Combustion Engineering developed the System 80® nuclear steam supply system and has updated it over the years to meet current standards. The three operating System 80 units at the Palo Verde site in Arizona are currently setting performance records. There are eight more System 80 units in operation or under construction in the Republic of Korea. Of these, the first two units are now on-line. With the five units operating and six more under construction, the System 80 design is a proven success.

Evolving from the System 80, the 1400 MWe System 80+™ standard plant design includes many advanced features, including the Nuplex 80+™ advanced control complex that uses digital protection, control and monitoring systems based on proven, commercially available hardware and incorporates a modern, human factors engineered control room that utilizes modern man-machine interface devices. ABB-CE received a Final Design Approval (FDA) of the System 80+ design from the U.S. NRC in July 1994 and Design Certification in May 1997 – the first and only ones issued for a pressurized water reactor (PWR) – thereby allowing it to be built with the new "one step" licensing process of 10CFR52.

3.0 TECHNOLOGY TRANSFER—A NEW APPROACH

Technology transfer has been ongoing since the beginnings of the nuclear power industry. In most cases, the transfer has been performed in accordance with a technology license agreement and associated training activities. The cost to the receiving country or organizations typically varied, depending upon the scope and depth of self-reliance desired. In most cases, the company supplying technology was not allowed to enter into a participatory business arrangement in the receiving country and was therefore limited to technology transfer and license fees as compensation. As was ABB-CE's experience in Korea, the schedule for attaining self-reliance in these cases has been very deliberate and formulated in a clearly defined structure, otherwise termed as a "step by step" approach.

For China, a new approach to self-reliance has emerged. The new concept involves compensating the technology supplying companies by allowing them to *become part of the local nuclear business community, thus providing clear market access well into the future.* This long-term commitment provides the foreign companies with new opportunities, but it also carries a much higher business risk. To effectively exploit this opportunity, the foreign company must plan on devoting significant resources for many years to fully realize the market potential.

4.0 ABB PHILOSOPHY

The need to dedicate significant local resources mirrors the ABB Group's business philosophy. Since ABB is a multi-domestic company, it develops local business in direct proportion to the local market situation. ABB presently has partial ownership in 19 corporations through its China organization. Because Asia is the most active marketplace for nuclear power, ABB is looking to establish nuclear marketing capabilities in this region beyond its Korean experiences.

ABB-CE's goal in entering the local PRC nuclear industry will be to encourage localization as much as possible for the China Driven Project to create a natural need for technology transfer. To maximize intra-ABB support, "clustering" of different ABB product groups in selected PRC locations has already begun. The clustering concept involves linking up with another ABB company that already has a presence in China. This reduces the difficulties of setting up a new business within the country, such as obtaining the necessary construction and/or business permits, etc. This will also facilitate the establishment of a local platform for foreign partners and subcontractors.

5.0 QUALITY ASSURANCE AND CODES AND STANDARDS

A major part of China's technology transfer program will also involve the establishment of quality assurance codes and standards. As a technology supplying company looking to help develop China's nuclear infrastructure, ABB-CE must help implement the international standards necessary for assurance of safety in the nuclear power industry. Most developing countries considering locally-produced nuclear equipment have already been introduced to some quality requirements from other industries.

For example, the potential shops to be upgraded to supply nuclear heavy components probably have already produced boilers. Boiler producers commonly use the ASME Pressure Vessel Code, Section VIII. Therefore, the process for upgrading to the nuclear standards in the ASME code (i.e., Section III) can be appreciated based on previous boiler experience. This familiarity with the boiler code should allow a company to shorten the preparation time required to achieve the necessary additional qualification for nuclear certification.

This example highlights a key issue when upgrading China's industries to nuclear quality standards – what codes and standards should be used. There are several options. One involves developing a new, original set of codes and standards. This probably will not be attempted due to the vast amount of work and time involved and considering the current availability of proven international codes and standards.

U.S. nuclear codes and standards have been used by most countries as a pattern for their own system. There are several reasons for China to consider the U.S. nuclear codes and standards. First, these codes are typically very specific and prescriptive in nature. Second, they were developed over many years with a significant amount of experience fed back into the development process. Third, they encompass all the areas of nuclear technology through all aspects of design, construction and operation. Finally, they are well documented and readily available for use.

6.0 ASSESSING LOCAL CAPABILITIES

Obviously then, a major step towards technological self-sufficiency involves assessing China's current design and production capabilities—a process ABB-CE has already begun. ABB-CE has historically been a significant manufacturer of major nuclear components in the U.S. and has amassed a large body of knowledge and experience that can benefit the manufacturing infrastructure in China. For example, ABB-CE has supplied more than twice as many commercial reactor pressure vessels as any other manufacturer in the world. These have been used in both Westinghouse and General Electric (BWR) plants, in addition to those of ABB-CE.

Chinese companies have already acquired a significant ability to design and manufacture the items necessary for a nuclear power plant. Their involvement in Qinshan I and II has provided good opportunities for acquiring some nuclear power technology.

ABB-CE is now proposing to upgrade this capability to the latest, world-class, state-of-the-art level with the objective of attaining the highest possible degree of localization on the initial plant, and full localization as soon as possible thereafter. To achieve this, ABB-CE performed a preliminary localization assessment of the entire scope of a proposed nuclear power plant. The analysis placed the required services, systems and equipment into 20 categories. ABB-CE then evaluated a process and schedule for the transfer of the required technologies necessary in each of these categories.

To validate the preliminary localization assessment, ABB-CE conducted localization surveys of Chinese manufacturing companies and design institutes. During each visit, the results were discussed with the local company and concurrence on program modifications were determined. In general, the surveys revealed that the manufacturing companies and design institutes are very capable, but recommendations were made for nominal improvements to handle large-scale manufacturing for a rapidly expanding nuclear industry.

7.0 LOCALIZATION OF MANUFACTURING

ABB-CE is confident, based on its knowledge of current nuclear power development in the PRC and its investigations of boiler works in Harbin, Sichuan and Shanghai, that localization of NSSS manufacturing can develop quickly. Given this information, it appears possible that the program's initial units would contain a high degree of NSSS components manufactured locally with subsequent units containing nearly all NSSS components manufactured locally, thereby reaching full NSSS manufacturing localization.

The localization plan involves expanding upon existing Chinese manufacturing capabilities to implement the manufacture of selected components to the extent possible for the first two units, while remaining consistent with the plant construction schedules and while preparing for the manufacture of the balance of NSSS components for subsequent units.

The equipment selected for the localization covers the entire spectrum of a nuclear plant, with initial efforts focused on:

- NSSS heavy component manufacturing (reactor vessel, steam generators, pressurizer, piping)
- Local material sourcing (forgings, plate, tubing)

- Precision steel component manufacturing (reactor vessel internals, CEDMs and fabrication materials)
- Instrumentation and controls systems hardware (panels, boards, sub-components
- Other NSSS pressure boundary components (tanks, vessels, heat exchangers)
- Process equipment packages (concentrators, gas strippers)

ABB-CE will provide the necessary technologies through a variety of business arrangements, which include:

- Subcontracting – As a major part of the technology transfer program, ABB-CE will facilitate the localization of supply by subcontracting to local Chinese companies.
- Joint ventures – ABB-CE has prior experience with local joint ventures and the interest in further developing joint ventures with Chinese partners to produce NSSS related hardware.
- License agreements – ABB-CE has provided license agreements for the manufacture of both its fossil and nuclear generating equipment all over the world and stands ready to enter into similar agreements regarding nuclear technology with the Chinese as opportunities arise.
- Establishment of foreign-owned corporations – There are some nuclear plant components that are not already being produced in China. It may be advantageous to establish a foreign owned corporation, staffed by local people, to expedite the formation of a new production facility.

By establishing these business arrangements, a mechanism will be created to accumulate the initial costs of technology transfer and training. Then, in the future, the operation of these arrangements can gradually pay back the initial investment, thus unburdening the initial nuclear plant owners from paying all these costs.

8.0 LOCALIZATION OF DESIGN

As was the case with manufacturing facilities, potential local PRC partners for NSSS engineering, project management and startup functions were also identified and assessed. A variety of working relationships are possible to localize the necessary design and management skills and receive the related technology. ABB-CE anticipates that a mix of consulting contracts, license arrangements and even the formation of teaming arrangements will be utilized to provide a high degree of localization in design.

ABB-CE's standard process for localizing design and management, proven by the System 80 technology transfer program implemented in the ROK, involves a program of training and joint participation in the design of units actually being constructed. As a result, the recipient builds upon its present capability to achieve the prerequisite level of self-reliance in its particular role.

For new self-reliance building programs, such as China, ABB intends to modify the localization process to incorporate modern computer and communications tools. For example, the design process will be performed by several participants concurrently. Plans are now in place to connect via modem ABB U.S. offices in Windsor, Connecticut, with ABB offices in China. From these locations there will be connections to several teaming organizations. For example, the local Chinese design institutes will be connected as will ABB's Korean licensees. In the U.S., several ABB entities will be connected as will U.S. architect/engineer teamates. As the project develops, other connections will be made to the owner's home office and the job site. With all the participating organizations on line, the process of obtaining approvals and transmitting information will be greatly expedited.

Principal among the Chinese entities to receive this training and participate in the design process are the CNNC design institutes, such as the Beijing Institute of Nuclear Engineering (BINE) and the Shanghai

Nuclear Engineering Research Design Institute (SNERDI), the plant owner's management and operations organizations, and various local architect engineering entities for balance of plant engineering and construction support. The business arrangement to be used to cooperate on nuclear design could be structured in a number of ways.

9.0 CONCLUSION

As a world leader in the localization of nuclear technology, ABB-CE has set forth a program that will provide China with the deep localization it needs while building the Driven Project without placing an undue financial burden on the project. Because its business philosophy fully reflects China's localization plan, ABB-CE will continue to work with local companies to finalize project details that will result in the lowest possible costs and highest possible quality