Key Steps in the Development of New Nuclear Programmes

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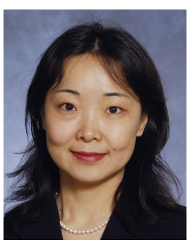

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Step 1: Joining the International Nuclear Community

An increasing number of countries throughout the world are declaring their interest in pursuing peaceful nuclear energy programmes to support their growing populations and energy needs. Many of them are found in the Middle East, North Africa, Asia Pacific and Europe and do not have any existing nuclear power capacity or expertise, but believe nuclear energy programmes will help them achieve energy security, sustainability, and diversity.

Developing a peaceful nuclear energy programme is a complex process. It involves designing and establishing a comprehensive legal, industrial and human infrastructure before a facility is even built.

Our work with clients around the globe points to three key steps that are essential for countries to successfully implement nuclear energy projects: joining the international nuclear community, establishing a national nuclear regulatory framework and following strict procurement and financing guidelines for the development and construction of new nuclear plants. In this article and in two subsequent ones that will run on this Web site during the next two weeks, we'll discuss these steps in detail.

Joining the International Nuclear Community

The international nuclear community is highly regulated and sophisticated and is subject to numerous conventions, standards and practices, principally developed under the auspices of the International Atomic Energy Agency (IAEA).

Established in 1957, the IAEA is the lead intergovernmental agency that promotes the peaceful use of nuclear energy and cooperation in the nuclear field. To date, it has 151 member countries, and joining the IAEA is the first step that countries must take in order to join the international nuclear community and obtain the prerequisite political credibility for the development of a domestic peaceful nuclear energy program.

Non-Proliferation and Safeguards

The essential aspect of the international nuclear regulatory regime is the principle of non-proliferation of nuclear weapons set forth in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The NPT came into force in 1970 with three primary objectives: preventing the proliferation of nuclear weapons, pursuing nuclear disarmament and promoting the peaceful use of nuclear energy.

The NPT makes it obligatory for all non-nuclear-weapon countries to subject all nuclear material in nuclear activities to IAEA safeguards, and file safeguards agreements with the IAEA that allow it to verify that nations are not using their civilian nuclear power programs to develop nuclear weapons.

Some 170 countries have entered into safeguards agreements with the IAEA, and it is desirable for countries seeking to develop peaceful nuclear power programs to ratify the NPT and conclude safeguards agreements with the IAEA as an illustration of their commitment towards the highest standards of non-proliferation.

Safeguards agreements can be "comprehensive," "item-specific" and "voluntary offer" agreements.

Comprehensive safeguards agreements (CSA) cover all nuclear material in a country and are the most commonly used type of the safeguards agreements for non-nuclear weapon countries, with 162 nations having comprehensive safeguards agreements in force.

In contrast, item-specific safeguards agreements only subject nuclear material specified in the agreements to IAEA safeguards and are only implemented in three countries—India, Israel and Pakistan. The third type, voluntary offer agreements, apply only to nuclear weapon nations (China, France, Russia, United Kingdom and United States) as these nations are not required to conclude safeguards agreements under the NPT.

Safeguards measures under the CSAs, including verification (inspection) activities performed at nuclear facilities, enable the IAEA to verify whether all declared nuclear material has remained in peaceful activities and whether there are any indications of diversion of declared nuclear material from peaceful activities. A model "Additional Protocol" to safeguards agreements approved by the IAEA in 1997 further provides the IAEA with the ability to detect undeclared nuclear material and activities in countries with CSAs in force by requiring them to provide broader information to the IAEA as well as provide the IAEA with expanded rights of access to information and sites.

The combination of CSAs and Additional Protocols enables the IAEA to verify both the correctness and completeness of the countries' declarations to the IAEA concerning nuclear material and nuclear-related activities. As of September 2010, 102 countries plus Taiwan and EURATOM had Additional Protocols in force, while 37 more had them approved and signed but not yet in force. Countries with both CSAs and Additional Protocols with the IAEA, illustrate their political commitment and support to the highest standards of non-proliferation.

International Nuclear Conventions

In addition to its safeguards system, the IAEA has developed a body of legal instruments pertaining to safety, cooperation in the case of a nuclear accident, spent fuel and radioactive waste management and civil liability for nuclear damage.

Key conventions include the following:

- Convention on Nuclear Safety
- Convention on Physical Protection of Nuclear Material
- Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency
- Convention on Early Notification of a Nuclear Accident
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
- Vienna Convention on Civil Liability for Nuclear Damage
- Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage
- Convention on Supplementary Compensation for Nuclear Damage
- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention

Countries seeking to develop nuclear energy programs should review the current status of their international commitments in the nuclear field and consult the IAEA to identify any legal instruments that need to be completed.

IAEA Safety Standards

The IAEA has the authority to establish safety standards for nuclear and radiation-related facilities and activities. These safety standards, issued as the IAEA Safety Standards Series, are binding on the IAEA for its own operations, but are only recommended for use by national authorities in relation to their activities. Member nations may adopt them, at their own discretion, for use in national regulations.

The IAEA Safety Standards Series cover nuclear safety, radiation protection, radioactive waste management, the transport of radioactive materials, the safety of nuclear fuel cycle facilities and quality assurance.

Safety Standards Series publications are categorized into:

- Safety Fundamentals stating basic objectives, concepts and principles of safety and protection
- Safety Requirements, establishing the requirements that must be fulfilled to ensure safety for particular activities or applications
- Safety Guides, recommending actions, conditions or procedures for complying with these safety requirements
- The IAEA Safety Standards Series form the core component of the IAEA integrated regulatory review service (IRRS). The IRRS is designed to enhance the effectiveness of the national safety regulatory infrastructure by comparing the nuclear and radiation regulatory infrastructure in a country against IAEA safety standards and best practices elsewhere. The IRRS peer review is normally conducted at the request of a country. Recommendations and suggestions for improvement may be provided to the host country following an IRRS mission.

Bilateral Agreements

Entering into bilateral agreements with countries where potential reactor vendors and service/equipment suppliers are located is also a prerequisite for countries seeking to develop nuclear energy to conduct nuclear trade with reactor vendors and service/equipment suppliers from those countries.

These bilateral agreements are typically required under national laws which prohibit reactor vendors and service/equipment suppliers from exporting before such bilateral agreements are in place. For example, Section 123 of the U.S. Atomic Energy Act of 1954 requires an agreement for cooperation (commonly known as a 123 agreement) as a prerequisite for nuclear deals between the United States and any other country.

Bilateral agreements may also allow various forms of cooperation or exchange of information between countries and may cover a broad scope of cooperation in the use of nuclear energy for peaceful purposes, such as nuclear energy research and development, nuclear safety and safeguards, supply of nuclear technology, equipment and material, exchange of scientists or other areas of mutual interest.

Parallel to a country's efforts to join the international nuclear community, it must develop a comprehensive national nuclear legal framework that complies with international obligations but also takes into account existing domestic legislative and regulatory structures. We'll discuss the development of a domestic legal framework next week.

Step 2: Establishing a National Nuclear Regulatory Framework

Developing a peaceful nuclear energy program is a complex process that involves designing and establishing comprehensive legal, industrial and human infrastructure before a facility is built. As we discussed in last week's article, a country embarking on this endeavor must be accepted as a member of the international nuclear community.

This week, we'll outline some of the key components of creating a national nuclear legal framework, including licensing, nuclear liability, export controls and waste management.

Institutional Structure

A national legal regime needs to be supported by an institutional structure, which includes an independent regulatory agency responsible for nuclear safety regulation.

Different models exist regarding the function of the safety regulatory agency, and copying those models may or may not be suitable. As a starting point, the International Atomic Energy Agency (IAEA) safety standards about the legal and governmental infrastructure for nuclear, radiation, radioactive waste, and transport safety (No. GS-R-1 2000) provide detailed requirements for establishing a desirable governmental infrastructure for nuclear safety purposes. An IAEA-compliant structure, or one that incorporates the essential elements of the IAEA guidance, would secure necessary international acceptance of the national legal regime.

Licensing

Licensing is the central component of a national legal regime and encompasses technology design licenses as well as site, construction and operation licenses. Countries with no nuclear licensing expertise face significant challenges and can greatly benefit from international cooperation and assistance.

A number of models for licensing technology have been developed. The United Kingdom uses a generic design assessment (GDA) approach to evaluating technical aspects of the reactor designs. Once the GDA is complete and the safety regulator concludes that a design meets regulatory requirements, the approved design may be constructed without further regulatory review. However, before plant operators can build and operate a design that has satisfactorily completed the GDA process, they need to obtain a Nuclear Site Licence and a number of other authorizations and consents, including a construction security plan, site security plan, discharge authorization and a number of environmental permits.

In the United States, the Nuclear Regulatory Commission (NRC) must approve a design by issuing a design certification that addresses the various safety issues associated with the proposed nuclear power plant design. By issuing a design certification, the NRC approves a nuclear power plant design independent of an application to construct or operate a plant. A design certification is valid for 15 years from the date of issuance, but can be renewed for an additional 10 to 15 years.

Prior to the construction and operation of an approved design, plant operators must obtain from the NRC a combined Construction and Operating License (COL), which authorizes the construction and conditional operation of a nuclear power plant. A COL is valid for 40 years and can be renewed for an additional 20 years.

Different countries may have differing regulatory requirements for reactor designs and reactor vendors may be required to make significant design changes in order to meet various regulatory requirements.

To facilitate the exchange of information, a number of international regulatory cooperative efforts are developing.

For example, a multinational design evaluation program (MDEP) was created by the Organization for Economic Cooperation and Development's (OECD) Nuclear Energy Agency with a view to share information and cooperate on specific design evaluations. So far, ten countries have participated in the MDEP and two working groups studying EPR and AP1000 reactors have been formed. In Europe, reactors may be certified as compliant with European Utilities Requirements (EUR) which include utilities' wish list of some 5000 items needed for new nuclear plants.

While many of these international collaborative efforts may result in design harmonization across jurisdictions, licensing will ultimately remain a national regulator responsibility subject to national laws, regulations and requirements.

Many countries use a multi-stage licensing approach for site selection, construction and facility operations. The global trend, however, is towards simplifying and streamlining the licensing process in order to avoid duplication and unnecessary delays.

Nuclear Liability

Liability for nuclear damage is another chief component of the national legal regime. In general, reactor vendors often judge the adequacy of a national nuclear liability regime in these terms: Whether liability with regard to claims by third parties alleging personal injury or property damage as a result of a nuclear incident is channelled to the operator of the nuclear power plant (or other nuclear installation).

- Whether the operator must maintain an adequate amount of mandatory insurance and/or have other financial protection. Also the extent to which the country's government guarantees payment of the operator's amount, as well as any additional funds the government commits to pay in claims that may exceed the operator's mandatory financial protection.
- Whether the definition of "nuclear damage" is broad enough to apply to most claims likely brought by persons alleging personal injury or property damage.
- Whether the country has a judicial system that has an established record of adjudicating claims in a fair, equitable and efficient manner.

- Whether claims are treated in a non-discriminatory way irrespective of the citizenship or domicile of the claimants and defendants.
- The Vienna Convention (world-wide application developed by the IAEA), the Paris and Brussels Conventions (limited application primarily to OECD countries), the Convention on Supplementary Compensation (not yet in force) and national legislation modelled on basic principles embodied in those international conventions (such as the U.S. Price Anderson Act) represent internationally acceptable approaches to nuclear liability. The approach taken by a country to the nuclear liability issue is crucial to attracting reactor vendors, service/equipment suppliers and financiers in the procurement stage of the nuclear programs. Countries have to study in detail and weigh the pros and cons of each approach.

Adequate nuclear liability protection requires the maintenance of insurance or provision of other financial security. When developing nuclear liability legislation, regulators should also consider establishing a domestic nuclear insurance pool or joining international nuclear pools.

More than 20 countries with civil nuclear capabilities have domestic nuclear pools, with the largest being Nuclear Risk Insurers Ltd. (NRI) in the UK that has a capacity of around £400 million. While each pool is only able to offer direct insurance within its own country, a reciprocal arrangement can be made between countries to spread risk and maximize funding capacity.

Export Control

At a minimum, a country's export control regime should implement national commitments under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

In addition many countries, as members of the Nuclear Suppliers Group (NSG), agree to coordinate their nuclear export control regime and voluntarily implement the export control guidelines established by the NSG. The NSG has established two sets of guidelines. The first set governs exports of nuclear materials and equipment and contains the so-called "trigger list." Exporting items on the "trigger list" would set off the requirements for IAEA safeguards.

The second set governs exports of nuclear-related dual-use equipment and materials contained on a "dual-use list." NSG member countries normally implement these two sets of guidelines on a voluntary basis, and regulate exports of items on the "trigger list" and the "dual-use list" in accordance with their national export control laws and practices.

It is important to both supplier countries and recipient countries that transfers of nuclear material, equipment and technologies (including dual-use items) take place in a secure, safe and responsible manner and that such transfers do not directly or indirectly assist in non-peaceful activities.

Accordingly, supplier countries normally require assurances from recipient countries that the supplier country's nuclear exports will not be diverted to non-peaceful or unsafe activities. Recipient countries that do not have adequate export and import controls can not expect to receive the fullest nuclear trade and cooperation from supplier countries.

Nuclear Waste Management

The two main issues for nuclear waste management involve allocating waste disposal liabilities and funding waste management costs. Final disposal of nuclear waste is typically the responsibility of government which may create a separate agency to assume responsibility for the construction and operation of the central waste repositories, as well as assuming liability for waste storage after the waste is physically transferred. In countries with new nuclear power capabilities, central repositories will likely not be operational for years, so plant operators will likely have to store waste on site before the final transfer of liability takes place.

Plant operators are typically required to entirely fund or at least contribute to the costs of waste storage. In many cases, segregated funds are created solely for the purpose of waste disposal (and sometimes decommissioning). Administering waste management funds varies from country to country.

Some allow the plant operators to manage the fund directly (i.e. France), while in others, the government assumes direct control of the fund (i.e. Spain). Regardless of how the funds are administered, countries must build capacity to accommodate the types of radioactive waste generated by nuclear power plants and ensure that adequate funding be available for ultimate waste disposal and management.

Step 3: Procurement and Financing a Nuclear New Build

The procurement and financing activities for a peaceful nuclear energy programme typically follow the prerequisite legal and governmental infrastructure activities. The International Atomic Energy Agency (IAEA) estimates that for a country with a little-developed technical base, the time from the initial policy decision to the operation of the first nuclear power plant ranges between 10 to 15 years.

In some countries, however, recent experience shows that the implementation time line can be reduced to less than 10 years when the procurement and financing are carried out in tandem with the establishment of the nuclear regulatory regime.

Selection of Reactor Designs

Selecting an appropriate reactor design is crucial to a nuclear program's the success. In today's market there are two main types of reactors available: light-water reactors (LWR) and heavy-water reactors.

LWRs are the most deployed type in the world, with years of operating experience, several vendor options and a robust supply chain. LWRs fall into two design types: pressurised water reactors (PWR) and boiling water reactors (BWR). Heavy water reactors use heavy water as a neutron moderator and the main supplier of heavy water reactors is Atomic Energy of Canada Limited (AECL).

The major technology options that are currently being offered are: ABWR and ESBWR (GE-Hitachi), ABWR (Toshiba), AP1000 (Westinghouse), APR1400 (KHNP), APWR (MHI), ATMEA (MHI/Areva), AES2006/VVER1200 (Atomstroyexport) ACR1000 (AECL), EPR (Areva), and KERENA (Areva & E.ON).

Small modular reactors (SMRs) are also at different stages of development and will soon become available in the market. Safety, availability and the ability to get a licence are the main criteria used when selecting reactor designs. Safety is the primary goal and is technically measured by core damage frequency.

A rector design must have less than a 1-in-10,000 reactor years (10E-5) core damage frequency in order to meet minimum safety criteria set by the nuclear industry. Availability is measured by capacity factor or the amount of time the plant is capable of producing electricity over a set period. The recent operating records of currently available designs show that capacity factor normally ranges from 85 per cent to more than 90 per cent. A design must also be capable of being licensed to the safety standards established by the country's safety regulators. A design that has been licensed in a country with a recognized nuclear regulatory body and safety standards provides a high degree of confidence.

Selection of Reactor Vendors

Given the significant risk of construction delays and cost overruns associated with building a nuclear power plant, the vendor selection process should focus on the vendor's ability to meet scheduled completion deadlines and the ability to provide a full scope of services.

Reactor vendors have taken various steps to reduce the overall construction span and make the construction schedule more predictable. Nevertheless, delays and cost overruns represent the biggest risk perceived by investors and the nuclear industry.

It is important during the selection process that a reactor vendor can demonstrate its ability to meet deadlines and ensure that construction will be on time and on/under budget. A vendor's poor record in these areas would seriously shake its credibility and capacity to succeed in constructing a new plant.

A reactor vendor's ability to provide a full scope of services is highly desirable in countries lacking experience and resources. Vendors that can manage construction, operations and maintenance as well as meet ongoing supply needs and personnel training are highly prized.

While traditionally nuclear power plants were built under contracts to various entities with divided roles and responsibilities, the market trend is shifting the overall responsibility for design, procurement and construction to one general contractor (EPC contractor) or to a consortium acting as a general contractor that can provide a cadre of services. Various restructuring arrangements have been put in place through either government or industry initiatives to meet this need from the demand side.

Although technical and economic attributes are major drivers in the selection process, national strategic security interests also play a role in international nuclear tenders and affect the final decision on vendor and technology selections.

Human Resource Development

The vendor selection decision very often depends on the extent to which a vendor can provide assistance in building the staffing needed throughout the entire construction, commissioning and operations phases. Human resource development should be linked with vendor and technology selection as part of the procurement strategy.

Personnel training programmes form an important part of the EPC contract. The EPC contractor may contractually be obliged to provide the required training for all key management, operations, maintenance and technical support staff to enable them to perform assigned tasks with the necessary skill and knowledge after construction is complete and the plant enters into the operations phase.

Training programmes need to be designed and implemented to meet all operating license requirements and any other regulatory requirements of a host country and relevant international standards. Reactor vendors may also offer assistance to the host country in developing the nuclear education infrastructure needed for the construction and operation of nuclear power plants.

Cooperation may be channelled in areas like establishing nuclear graduate schools, developing nuclear academic programs or creating qualifications frameworks for nuclear technicians that are aligned with international accreditation standards.

Fuel Procurement

Uranium is one of the world's most abundant metals. Organization for Economic Cooperation and Development (OECD) and the IAEA recently produced a report concluding that uranium resources are adequate to meet nuclear energy needs for at least the next 100 years at present consumption levels.

In addition, uranium conversion, enrichment and fabrication services are adequate to cover anticipated demand although they are provided by a limited number of specialist companies around the globe.

Nevertheless, to ensure nuclear fuel security of supply and to mitigate market risks nuclear plant owners must develop a long-term procurement strategy. Some prefer to secure their fuel supply through long-term, multiannual contracts with fuel suppliers and build inventories. Others choose to purchase most of their requirements on the spot market and maintain a minimal inventory.

Equity investment in uranium mines or in uranium processing companies is also a popular option. When deciding on appropriate procurement strategies, plant owners need to balance their need for supply security and diversity with their desire for low cost and price stability.

Financing Arrangements

Concerns about high capital costs, long construction periods, complex legal and regulatory issues, and responsibility for nuclear accidents, environment, and waste management have driven the options for plant financing. Traditionally nuclear power plants have been financed through direct or indirect government funding (including through export credit agencies), corporate balance sheets or a combination of both. Limited or non-recourse project financing has not been used to finance the construction of the nuclear power plants.

While the conventional financing approach still dominates the market, some innovative financing structures involving private sector funds are emerging. These include small-scale equity participation by private investors in projects funded by reactor vendors and partnership between plant operators and a consumer consortium.

An example of the latter is to invite major industrial electric consumers to invest in plants in return for electric supply. Debt financing introduced at different phases of the projects and phased financing are also structures being pursued by the private sector. With traditional sources of government-based funding being insufficient to meet the industry's increasing demand, private sector investments in the nuclear industry have become absolutely necessary and are essential to the successful global use of nuclear power.

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