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Case Study on Nuclear Power Infrastructure Development

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NUCLEAR POWER PROGRAMME DEVELOPMENT UTILITY

A. INTRODUCTION

1. General Description

Poweria is a developing country. Certain sectors of its economy are moderately advanced and have a supporting technological infrastructure. Poweria is located on the seacoast and has a warm climate with good agricultural conditions. The country has a narrow, flat coastal plain, which extends inland approximately 50 km, where there is a row of hills which rise to an interior plateau (a ‘piedmont’) at an average elevation of about 300 to 500 meters. The interior boundary of the country is defined by a rugged, high mountain range, and is about 500 km inland from the sea. The coast line of the country is about 500 km in length, so the overall shape of the country is roughly rectangular. Several rivers rise in the interior mountains, feed large lakes in the interior plateau and drain through the coastal plain to the sea. The interior plateau and the mountains are known to be a seismically active area, although specific data are scarce.

The population of Poweria is about 45 million. About one-third of the population lives in cities located on the coastal plain. The cities and coastal plain, while crowded, have generally adequate public services, rail and road transportation. Electrical power is limited and often unreliable, which has limited the growth of tourism and the high-tech, financial and service industries that the government would like to develop to augment the current agriculture- and resource-based economy.

The remainder of the population lives in towns, villages and farms on the interior plateau, which is much more rural in character. It is here that the agriculture, mining and oil and gas industries that are the principal basis of the country’s economy are located. Central-station electricity is very limited in availability and unreliable when it is available, because most of it comes from the coastal plain through long transmission lines. Limited rail and road transportation is available, but is mostly used for transport of agricultural products and minerals from the mines.

2. Government

Poweria is a republic, with a parliamentary form of government. The country has enjoyed several decades of political stability and peaceful transitions of power from one government to another. It is a multi-party state, with two dominant parties, and numerous smaller parties that usually have a role in a coalition government. Elections, while often contentious, are considered to be fair and honest by international observers.

The President of the Republic is Chief of State, but has little real political power. However, the current President is a highly popular and respected figure who exerts considerable influence and moral authority with the people. He must leave office in 2013, due to Constitutional term limitations. The Prime Minister, the Head of the Government, holds the real power to govern. His party holds a comfortable, but not absolute, majority in the

Parliament, so the Government is reasonably responsive to pressure from minority parties, many of which represent the interior of the country.

The Government consists of a number of ministries. In the current context, the most important are the Ministries of Foreign Affairs, Energy, Finance, Industry, Science and Technology and Health. A National Regulatory Authority, part of the Ministry of Science and Technology, has the responsibility for licensing and regulating the use of radioactive sources and radiation-producing machines. Regulation of the electrical power industry is the responsibility of the Electrical Regulatory Authority (ERA), part of the Ministry of Industry. An Environmental Protection Authority, part of the Ministry of Health, is responsible for regulation of such things as land and water use, releases of pollutants on land and into the air and water, and pollution abatement.

Poweria is a Member State of the IAEA and a recipient of Technical Cooperation assistance, primarily in Nuclear Applications. It is expected that up to USD 1 million in Technical Cooperation funds can be applied to TC Projects supporting nuclear power. Even though it does not now possess any nuclear material, it has signed and ratified the Non-Proliferation Treaty and a Comprehensive Safeguards Agreement is in place. It possesses and uses numerous radioisotope sources used in the mining and oil industries, and in medical applications, so it has also signed and ratified the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

3. Economy

The economy of Poweria is primarily based on agriculture, mining of coal and various minerals, oil and gas extraction (sufficient for domestic needs and some export), and manufacturing of small and medium industrial goods, most of which are used to support the domestic industries. There is no heavy industry in the country, and such products must be imported. The country is self-sufficient in food and basic goods, and has sufficient income from exports to support expansion of its infrastructure and improve public services.

A principal goal of the government is to diversify the economy by introducing high-tech industries, a financial services sector and increased tourism in the cities of the coastal plain. Realization of this goal has been limited by the unreliable electrical power in the cities. In addition, the population and industries of the interior plateau have exerted heavy pressure on the government to improve the availability and reliability of electricity in the region. Thus, improvements in the electrical sector have a high priority in the government’s economic planning. It is projected that the equivalent of 1 billion USD/year will be available for expansion of the electrical power sector. Loans and/or credits from outside the country will be needed to raise additional funds.

Electrical power in Poweria is generated by assets owned by GEN-ELEC, a government-owned corporation. Another government-owned corporation, TRANSCON, owns, operates and maintains the national electrical grid. Local distribution is handled by local companies or cooperatives. Rates are regulated by the ERA, but are generally high enough that the cost, along with unreliable supply, is a significant deterrent to economic growth in some energy intensive industries.

Poweria’s electric power sector is characterized by insufficient generating capacity, unreliable long-distance transmission lines, and high rates due to high fuel costs. The current (2010) installed capacity is 6000 MWe, 85% of which is fossil-fired stations, and the balance is hydroelectric and renewable sources. The fossil-fueled power stations are all situated along the coast, and their output is directed to the coastal cities. Several of these stations are old, inefficient and polluting. The hydroelectric assets are located in the hills below the piedmont and their output is limited by seasonal variations in the available water flow. Grid connections with neighbouring countries are very limited in capacity, but could be expanded. However, no neighbouring countries have excess generating capacity at this time, and are more likely to want power exports from Poweria than sales to Poweria.

Poweria's electrical generating system provides an average of about 30 TWh of energy per year, half of which is available to the cities, and half to the interior towns and villages. Thus, there is about 1000 kWh per capita available in the cities and about 500 kWh per capita in the rural areas. The government wishes to increase electrical production by a factor of three over a ten-year period, partly by improving the performance of the existing system and partly by increasing installed capacity. An increase in installed capacity of about 1 Gwe/year is projected for the decade through 2020. Most of this expansion will have to be in fossil-fired plants, nuclear plants or renewable sources. Possible expansion of hydroelectric output is very limited.

4. Education

Poweria has one major university having undergraduate and graduate programmes in agriculture, engineering (civil, mechanical, chemical, electrical, mining and petroleum) and earth sciences. Isotope and radiation applications are taught in the various technical curricula; a survey course in nuclear reactor technology is taught as part of a programme in energy engineering in the mechanical engineering department. The medical school teaches nuclear medicine, but advanced training in the specialty must be obtained abroad. The government of Poweria sends students abroad for advanced training in foreign universities, and sends participants to IAEA training events under its TC Projects.

Poweria also has two technical institutes that train technicians for the mining and oil industries, and for various positions in the medical community, including X-ray and nuclear medicine technicians.

5. The Nuclear Power Programme

While on a state visit to Oecdia, a developed country with which Poweria has long standing cultural, economic and political ties, the President of Poweria was shown a new nuclear power plant and briefed on the advantages of nuclear power. Oecdia's well-developed nuclear industry has built several 1000 Mwe-class nuclear power plants, and has a small modular reactor of about 250-300 Mwe/module under development. It is anxious to enter the export market with either of the reactor designs. The President, anxious to show progress towards improvement of Poweria's electricity problems before he leaves office in three years, has publically announced that nuclear power will be introduced at the earliest possible time, and has asked the Prime Minister to undertake a nuclear power programme designed to lead to starting construction of a new nuclear power plant at the earliest possible date; if possible, before he leaves office.

Because of the popularity and influence of the President, the nuclear power programme has considerable popular support. Although he is sceptical of the feasibility of the schedule, recognizing that little or no groundwork has been laid for a nuclear power project, the Prime Minister has decided on an aggressive approach to the problem, involving the Government, the existing National Regulatory Authority, and the electricity generating company GEN-ELEC. He has taken the following actions:

- The Ministry of Energy has been charged with setting up a Nuclear Energy Programme Implementation Organization (NEPIO) called the Nuclear Power Authority (NPA). This group will coordinate the work of the Government and other entities. It has the responsibility of making a final recommendation to the Prime Minister on the feasibility and schedule of the nuclear power programme.
- The National Regulatory Authority is charged with developing a new, independent nuclear regulatory body which will have the current functions of the NRA, plus the responsibility for regulating the new nuclear power programme. The immediate mandate is to develop the legal framework, a regulatory approach, the regulatory framework, and the human resource strategy.
- The national electricity generating company, GEN-ELEC, has been asked to define a strategy and assess the schedule and costs of acquiring approximately 2000 Mwe of nuclear capacity over the next ten years, with the first increment to be commissioned at the earliest possible time. GEN-ELEC should also consider the available technologies and those under development and recommend whether Poweria should procure one or two large plants, or several smaller plants over a longer period of time.
- The national electricity generating company, GEN-ELEC, has been asked to define a strategy and implement siting activities. GEN-ELEC is therefore asked to determine siting options, considering the needs for power, site characteristics, transmission lines, transportation, and other relevant factors.

B. EXERCISE

1. Work to be Performed

The national electricity generating company, GEN-ELEC, has been asked to define a strategy and assess the schedule and costs of acquiring approximately 2000 Mwe of nuclear capacity over the next ten years, with the first increment to be commissioned at the earliest possible time. GEN-ELEC is also asked to determine siting options, considering the needs for power, site characteristics, transmission lines, transportation, and other relevant factors. GEN-ELEC should also consider the available technologies and those under development and recommend whether Poweria should procure one or two large plants or several smaller plants over a longer period of time. The financial model for acquisition of the plant(s) is also to be defined.

In order to satisfy the President’s desire to make significant progress towards realizing a nuclear power plant in the country by the time he leaves office, preparatory work for issuing the call for tenders should be complete by 2013. The call for tenders is expected to be issued in 2014 and a contract is expected to be signed in 2016.

1.1. Fundamental Project Issues and Assumptions

1.1.1. Licensing Prerequisites

Licensing assumptions are likely to impact project schedules significantly. It appears unlikely that owners will be willing to take on the risks of carrying out licensing in parallel with procurements and extensive site preparation work.

1.1.2. Cash Flow

Cash flow is assumed to be an unlimited resource within each schedule and is a key requirement to achieve short construction schedules. Utilities and investors will ultimately need to decide whether the tradeoffs between large early expenditures is countered by short schedules and early commercial operation

1.1.3. Labour/Resource Availability

Unlimited quantities of skilled labour are assumed to be readily available near the construction sites. Finding qualified labour may be a significant hurdle for new construction projects, especially if multiple plants are being constructed.

1.1.4. Labour Shift Structure

A shift structure that allows for more management oversight and greater contingencies for delays would be preferred from a schedule maintenance point of view

1.1.5. Labour Agreements

Each vendor has discounted the possibility of work stoppages due to strikes or other labor problems. We consider this assumption to be reasonable and should not constitute a major risk to the schedules.

1.1.6. Reference Location

The location of new NPPs will have a significant impact on schedule issues such as transportation (land vs. water accessibility), extent of site clearing and excavation required, and social receptivity to nuclear power.

1.1.7. Site-Specific Assumptions

1.1.7.1.Site Conditions

The proposed plant assume that the plant site will require minimal effort to clear and grade, have no special geological, topographical, or environmental problems, and is readily accessible by road, rail, and, in some cases barge.

1.1.7.2.Seismic Requirements

The proposed plants that list seismic requirements generally assume that they are relatively mild. Locating a plant in an area with high seismic requirements could result in significant delays due to required re-analysis of the plants seismic response and equipment design.

1.1.7.3.Accessibility/Transportation

The importance of plant site accessibility has increased significantly due to the use of large modules and large preassembled plant components that have special transportation requirements. For example, if a site is water accessible, then very large modules may be transported to the site intact, while if road and rail are the only means of transportation to the site, then on-site assembly of modules is required.

1.1.8. Engineering and Procurement Assumptions

1.1.8.1.Engineering

All vendors assume that the majority of engineering work will be completed prior to any physical work. All vendors currently have a gap between the status of the engineering that is completed and the status that is assumed at the start of their schedules.

1.1.8.2.Procurement Relationships and Contracts

NSSS vendors must establish relationships with component and module vendors. The schedules generally assume that these relationships will be in place very early. The first plants to be constructed are likely to require significant use of foreign vendors.

1.1.8.3.Long-Lead Components

NSSS vendors have performed research into lead times for some of these items, which enables them to make fairly accurate estimates.

1.1.8.4.Manufacturing Durations

The use of modules in nuclear power plant construction is an unproven process that is still under development. Therefore, fabricators, owners, construction managers, and NSSS vendors must work closely to validate schedule assumptions made regarding equipment manufacturing durations.

1.1.9. Construction Assumptions

1.1.9.1.Extent of Modular Approach

The selection of the construction methods need be done in the conceptual stage if selected. This requires that the prefabrication and pre-assembly of modules be made prior to installation, thus initiating the construction after the end of the NPP design.

1.1.9.2.Specialized Equipment

The use of new construction technologies to decrease construction schedules requires specialized equipment such as Very Heavy Lift (VHL) cranes and the automated rebar machines to be available early in the construction process.

1.1.10. Licensing and Permitting Assumptions Licensing Environment

Vendors assume the latest country's regulatory processes.

1.1.11. Other Assumptions

Government will provide 1000 ton/day for construction and electricity according to request. Also sea water from sea side will be used for cooling water for the secondary system (Turbine- Condenser). Sea water temperature will be less than 25 C at all times.

1.2.Issues to be Addressed by the Working Group

Your team is the planning group for GEN-ELEC. You are requested to start developing the plans for acquiring the new NPPs, considering siting options, the needs for power, site characteristics, transmission lines, transportation, and other relevant factors. You should also consider the available technologies and those under development and recommend whether Poweria should procure one or two large plants or several smaller plants over a longer period of time. The financial model for acquisition of the plant(s) is also to be defined as well as the workforce needed to actively participate in the construction and operation of the NPP(s) at the owner-Operator side. Please describe the major points to be considered.

Part 1: Overview

1) Relevant Aspects of the Choice of Technology (see below for example to be considered)
   - Safety
   - Energy Security
   - Nuclear Non-proliferation
   - International technology development trend
   - Assurance of Choice
   - Social Acceptability
2) Relevant Environmental Aspects
3) Available Advanced Technologies
4) Construction Time
5) Supply of Nuclear Fuel
6) Possibilities and Cost of the Radioactive Waste and Spent Fuel Management, Storage and Disposal
7) Site Availability for the Construction of a New NPP
8) Human Resource Planning
9) Evaluation of Plant Performance for Selected Technologies

Part 2: Feasibility

(1) Identify the critical tasks to be held by the Utility Company (Owner - Operator in phases 2 and 3;
(2) Identify the type of contractual approach that needs to be adopted by GEN-ELEC as well as the possible contracting structures.
(3) Identify key advantages and challenges of possible contracting structures.
(4) Identify special project risks that are unique to nuclear power plant developments.
(5) Propose an organization and staffing that will be established with the aim to ensure the construction, commissioning and safely operation of nuclear power plants from 2020.
(6) Identify critical competencies required in each Department of the Owner-Operator and when they need to be available;
(7) At what point in the development of a nuclear power programme can the procurement be commenced.
(8) "Fast-tracking" and the "paradigm shift" to focus on procurement – impact?

2. Terminology and Assumptions

NPA	= Nuclear Power Authority
GEN-ELEC	= Owner-Operator
NRA	= Nuclear Regulatory Authority
ERA	= Electrical Regulatory Authority
EA	= Environmental and Land Management Authority
TRANSCO	= National Transmission Company
NGO's	= Non-Government Organizations and Anti-nuclear

2.1. Government's Responsibilities

The Government will be responsible for building the required NP infrastructure able to support and absorb the output from the countries' first NPPs and has delegated its coordinating responsibilities to NPA.

2.2. GEN-ELEC's Responsibilities in the NPP building

GEN-ELEC will be the Owner-Operator of the NPPs with the entire responsibility for procurement, construction, commissioning and operation of the NPPs to be built.

2.3. NRA's Responsibilities in regulating NPPs

The NPA in its role as the NEPIO should draft legislation that will establish the NRA as an independent nuclear regulator with the authority and resources to effectively regulate the NPPs. In accordance with IAEA Standards, the NRA should be responsible for:

- establishing and conduct a licensing process;
- developing regulations and guidance material;
- reviewing and assessing safety documentation;
- conducting inspections and enforcing its regulations;
- communicating with the public and other stakeholders; and
- coordinating off-site emergency preparedness and response.

The NPA should also initiate action, in cooperation with the Ministry of Foreign Affairs, to sign the Convention on Nuclear Safety and secure its prompt ratification.

The National Regulatory Authority, in its current role as the regulatory of sources and radiation-producing machines, has issued a set of documents, sufficient to cover current industrial and medical activities. The current staffs at NRA are well trained and experienced in radiation safety, emergency response, safety, security and control of sources, physical protection of sources, management of low-level radioactive waste, etc. It is not, however, experienced in nuclear and reactor safety.

The NRA has held discussions with the IAEA and other regulatory bodies experienced in regulation of NPPs, and have decided to follow the IAEA guidance for licensing and identified five major points in the life cycle of the plant at which licenses will be required, as shown in Figure 1 below.

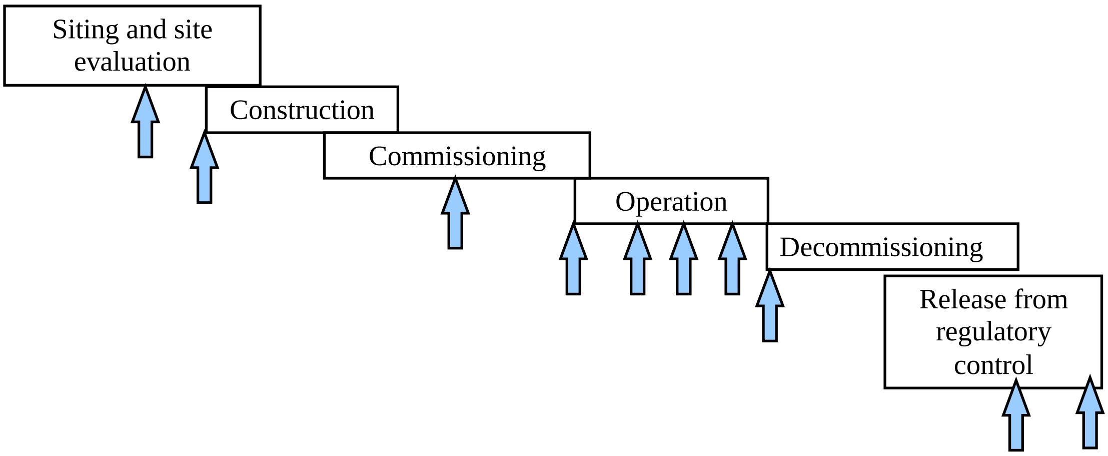


Figure 1- Stages in NPP Life Cycle When Licensing Will Be Required

2.4. EA's Responsibilities in regulating environmental and land issues in POWERIA

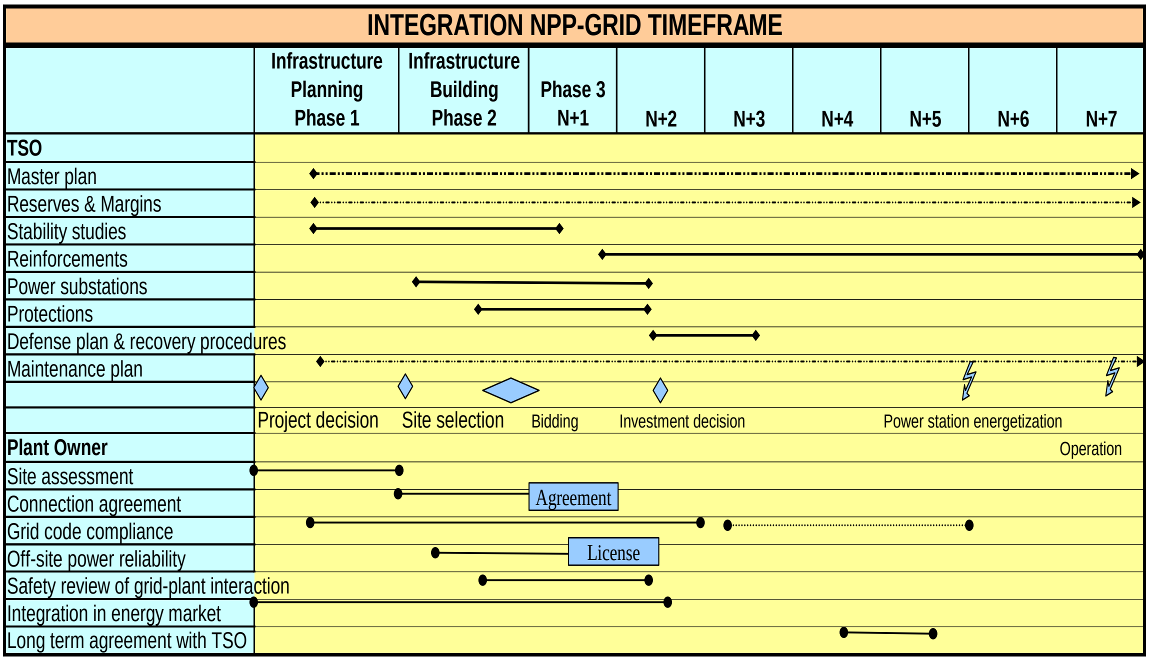
The EA is responsible for the permitting and licensing related to land acquisition, land use and water use. The EA sets environmental standards and reviews the environmental impact assessments produced by organizations wishing to undertake major projects. The EA is also responsible for managing the relevant environmental impact assessment discussions with communities and all stakeholders. For the NPP programme, the NPA or GEN-ELEC should prepare an environmental assessment for the candidate sites, submit it to the NRA for its approval, and then to the EA for final approval.

2.5. Management of the Grid

1. ***ERE's Responsibilities in regulating the Grid***
   The ERE is established with the responsibility to regulate the electrical sector and the grid.

2. ***TRANSCO's Responsibilities in managing the Grid***
   TRANSCO is fully established with the responsibility to manage the electrical grid and ensure the transport of electricity.

3. ***Integration NPP - Grid plans***
   The current grid is not able to absorb the three-fold expansion of the electrical generating capacity projected by 2020. It is therefore necessary that the following activities are implemented by ERE and TRANSCO:



2.6. Contracting Approaches

Typical lead responsibilities for the different contractual approaches are presented in the following Table : **Typical lead responsibilities for different contract types**

Activity	**Contract types**		
	Turnkey	**Split package**	**Multiple package**
Pre-project activities	U	U	U
Project management	MC	AE or U	U + AE
Project engineering	MC	AE or U + SS	U or AE
Quality assurance / Quality control	MC + U	AE + SS + U	U + AE
Procurement	MC	AE or U + SS	U or AE
Application for license	U	U	U
Licensing	RA	RA	RA
Safeguard, physical protection	U	U	U
Manufacturing	MC	SS + EM	EM
Site preparation	U or MC	U or AE	U or AE
Erection	MC	AE + SS	U or AE
Equipment installation	MC	AE + SS	U or AE
Commissioning	MC	AE + U	U or AE
Plant operation and maintenance	U	U	U
Fuel procurement	U	U	U
Fuel fabrication	FS	FS	FS
Waste management	U	U	U

Symbols:
AE: Architect engineer
EM: Equipment manufacture
FS: Fuel supplier
MC: Main contractor
RA: Regulatory authority
SS: System supplier
U: Utility

The selection of the type of contract is one of the basic decisions to be taken concerning the construction of nuclear power plants. It should, therefore, receive great attention and be based on a careful analysis of all aspects. These aspects include:

- Potential vendors and their particular experiences and attributes

- Standardization and proven quality
- Government and industrial relationships
- Competitive and economic considerations
- Foreign financing possibilities
- Guarantee and liability considerations
- Planning and implementation of the project and subsequent projects
- Availability of qualified project management, co-ordinating and engineering manpower
- Development of national engineering and industry capability
- Owner experience in handling large projects.