Project for Construction of a New Nuclear Unit in Armenia

June 2010
Why WorleyParsons? Experience in New Nuclear Construction Projects

Why Armenia needs the NNU?

Project Overview

Bankable Feasibility Study

Main Issues in the implementation of new nuclear projects
A unique combination of extensive global resources, world recognized technical expertise and deep local knowledge

- Canada: 8,180
- Europe: 2,200
- Middle East: 2,420
- Africa: 850
- Asia: 4,800
- Australia/New Zealand: 7,600

37 countries, 120 offices, 28,800 project services personnel
WorleyParsons is a recognized leader in successful project delivery with distinguished technical experience, project management and control system, know-how and resource, which enables the group to provide the customers with a wide range of decisions tailored to suit the project requirements on each stage.
Power

Nuclear
Coal-Fired Plants
Gas Turbine/Combined Cycle
Integrated Gasification Combined Cycle (IGCC)
Renewable – Solar, Wind, Biomass
Air Quality Control
Transmission networks
Operations & Maintenance

740
Power Generating Units

192,800 +
Total MW of Capacity

16
Nuclear Units
Engineer of Record

30,000+
MW Nuclear Projects
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1988 earthquake - both Nuclear Units of Metzamor NPP were shut down
1991 – 1994 - electricity was available for one or two hours a day
Blockades of the Armenian border by Turkey and Azerbaijan stopped the flow of natural gas across these borders;
The lack of infrastructure to supplement fuel supplies via energy import routes through Iran and Russia through Georgia
The lack of proven reserves of oil and natural gas
The existing Metzamor Unit 2 was restarted in 1995, but is planned for permanent shutdown sometime after 2016.

A nuclear power station that has the capability of sustained operation for extended periods of time without refueling is considered a proven source of secure and reliable supply of electrical energy.
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WorleyParsons Project Description

- Scope of work: “Management Services for Implementation of the Project on Construction of New Nuclear Unit(s) in the Republic of Armenia”
- Client: Ministry of Energy and Natural Resources (MENR), Republic of Armenia
- Contract signed on 29 of May 2009
- Project divided into 4 Phases
- Addendum 1 covers phase I and II signed on 27 of July
- Contract entered into force 7 of August
# Project Overview

## Key Project Data

<table>
<thead>
<tr>
<th><strong>Scope of work:</strong></th>
<th>“Management Services for Implementation of the Project on Construction of New Nuclear Unit(s) in the Republic of Armenia”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client:</strong></td>
<td>Ministry of Energy and Natural Resources (MENR), Republic of Armenia</td>
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<tr>
<td><strong>Project specifics:</strong></td>
<td>4-phase implementation approach</td>
</tr>
<tr>
<td><strong>Important dates:</strong></td>
<td></td>
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<tr>
<td></td>
<td>Contract with WorleyParsons signed 29 May 2009</td>
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<tr>
<td></td>
<td>Contract entered into force on 07 August 2009</td>
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<tr>
<td></td>
<td>Addendum 1 covering phases I and II signed on 27 July 2009</td>
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<td></td>
<td>Adoption of the Act on construction of a New Nuclear Unit on 27 October 2009</td>
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<td>Governmental decision to establish a joint venture ZAO Metzamorenergoatom 24 Dec 2010</td>
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<tr>
<td></td>
<td>Selection of the AS-92 nuclear island 03 December 2009</td>
</tr>
<tr>
<td>Phase I</td>
<td>Development of a Bankable Feasibility Study (BFS) as a basis for the implementation of the Project and for the selection of Strategic Investor(s)</td>
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<tr>
<td>Phase II</td>
<td>Managing and assessing the tender process for selection of Strategic Investors for the project</td>
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<tr>
<td>Phase III</td>
<td>Organize and manage a tender for selection of Contractor(s) for the design and construction of the NPP and recommend EPC contractors</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Provide consulting services to the Ministry during the design, construction, and start-up of the project</td>
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</table>

- Engineering - Approximately 48 Months in Duration
- Procurement - Approximately 57 Months in Duration
- Construction - Approximately 48 Months in Duration
- Commissioning – Approximately 21 Months in Duration
## Schedule Highlights

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Duration</th>
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</thead>
<tbody>
<tr>
<td><strong>Total Service duration</strong></td>
<td>-</td>
<td>96 months</td>
</tr>
<tr>
<td><strong>Phase I</strong></td>
<td>Development of Bankable Feasibility Study</td>
<td>8 months</td>
</tr>
<tr>
<td><strong>Phase II</strong></td>
<td>Selection of Strategic Investor</td>
<td>12 months</td>
</tr>
<tr>
<td><strong>Phase III</strong></td>
<td>Contractor Selection</td>
<td>12 months</td>
</tr>
<tr>
<td><strong>Phase IV</strong></td>
<td>Project Execution</td>
<td>72 months</td>
</tr>
</tbody>
</table>
Agenda

- Why WorleyParsons? Experience in New Nuclear Construction Projects
- Why Armenia needs the NNU?
- Project Overview
- Bankable Feasibility Study
- Main Issues in the implementation of new nuclear projects
Under US AID
- Environmental Background Information Document (EBID) September 2008
- Initial Planning Studies (IPS)

EBID and IPS provide justification of the new unit as the best solution for both security of energy supply and diversification of primary energy resources in Republic of Armenia

Under IAEA
- Seismic Safety Review Mission July 2006

Under ARM005 Program:
- Feasibility Study Chapter related to human resources management developed with the IAEA cooperation
- Feasibility Study Chapter on site selection for the new nuclear unit has been developed by the Armenian party and includes information on seismology, geophysics and volcanology of the site
Site studies - need of additional investigations
Licensing Issues Considered

- Predictability in the nuclear regulatory process based on established nuclear regulatory rules and processes
- Application of the “demonstrated licensability” concept helping to reduce the safety risk
  - recommended use of a licensed reference plant
  - advised cooperation with regulatory bodies of countries of origin of reference plants
  - recommendation for harmonization of existing nuclear regulation system of Armenia with international practices
- Action Plan identifies the major regulations, and guidance documents on licensing processes, information submittals, and guidelines that need to be developed for the new reactor program
Construction considerations

- Transportation and Logistics - availability of transportation infrastructure for moving of heavy loads, incl. potential border issues
- Production Services - need for on-site production facilities
- Utilization of Site Infrastructure - existing shop and storage facilities, available space for fabrication and pre-assembly activities
- Material and Technical Support of Construction:
  - local and regional support from engineering and craft skills during construction and start-up
  - availability of commodities such as steel, stainless, concrete, rebar, etc.
  - labor availability studies and labor skills analysis for available labor
  - survey of all potential suppliers/providers in the region
Armenian power needs and grid stability
Selection of most suitable technology
Site evaluation
Concept of design
Organization of construction
Management of plant operation
Project management
Capital cost estimates
Operating and other cost estimation
Options for the project development and funding
Economic assessment
Assessment of relevant socio-economic issues
Evaluation of potential options and sub-options of energy sources

Evaluation of:
- alternate energy sources
- ability to meet the power demands and availability requirements
- performance reliability

Considered options of energy sources:
- Nuclear
- Coal
- Natural gas
- Hydro-Electric
- Renewables (wind, solar, others)

NPP advantages:
- Seasonal independence of capacity
- Stable prices of the nuclear fuel and independence from fluctuations in prices and the serious consequences of an interruption in the supply of coal/gas
- Produce almost no carbon dioxide or other greenhouse gases (fossil-fired plants)
- Considerably small working area
- Competitive economically

Within the above considered options Nuclear Power Plants are a reliable option, providing a large source of base-load power with availability over 90%.

Evaluated as the only solution for the Armenia situation.
<table>
<thead>
<tr>
<th>Vendor</th>
<th>Reactor Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Russian Federation</strong></td>
<td>WWER 1000 (AS-91)</td>
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<tr>
<td><strong>Atomstroyexport</strong></td>
<td>WWER 1000 (AS-92)</td>
</tr>
<tr>
<td></td>
<td>WWER 1200 (AS-2006)</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td>AP1000</td>
</tr>
<tr>
<td><strong>Westinghouse</strong></td>
<td></td>
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<tr>
<td><strong>Europe &amp; Japan</strong></td>
<td>ATMEA1</td>
</tr>
<tr>
<td><strong>Mitsubishi &amp; Areva</strong></td>
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<tr>
<td><strong>China</strong></td>
<td>CNP-600</td>
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<tr>
<td><strong>CNNC (China National Nuclear Corporation)</strong></td>
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</table>
Potential exclusion of nuclear reactors based on:

- factors specific to the general site location (transmission grid stability concerns)
- requirements for electricity
- need to minimize project risks and costs
- design life of major components < 60 years

Reactor technology selection criteria established by the Armenian Government:

- consideration of Pressurized Water Reactor (PWR) only
- nuclear power plant size of 1200 MWe or less
- reactor design belonging to Generation III or III+
- compliance with Armenian and international requirements and standards
BFS – Pre-assessment of Candidate Technology

Assessment basis:
- legislative requirements of the Republic of Armenia
- detailed information on the candidate NPPs

Assessment methods:
- qualitative engineering judgment

Candidate Nuclear Reactors complying with the selection criteria:
- AP 1000 (Westinghouse).
- WWER 1000 (AS-92).
- WWER 1200 (AS-2006).
- ATMEA 1 (Mitsubishi, & Areva) – under design.

Assessment goal: arrive at general suitability ranking of the candidate NPP configurations for more in-depth technical and economic analyses
BFS-Technology Assessment

- Full Assessment of NPP Technology
  - NSSS Systems
  - Controls
  - Turbine Generator and Ancillary Systems
  - Waste Treatment Systems
  - Balance of Plant Systems
  - Fuel Handling Systems
  - HVAC
  - Containment Structures

- Assessment with respect to specific considerations
  - Nuclear Fuel Strategy
  - Waste Handling Strategies
  - Physical and Nuclear Protection
  - Emergency Planning
  - Localization of NPP Equipment and Services
  - Long Term Operations Support by Vendors
  - Site Integration
  - International Experience of Vendors
  - Local experience and factors
All four considered options, AS-92, AS-2006, AP1000 and ATMEA1 can be recommended for further detailed estimation.

AS-92 nuclear technology has a minimum construction and operation risk compared to AS-2006, AP1000 and ATMEA1 nuclear technologies.

- Other advantages of the use of AS-92:
  - available long-term experience on WWER that is used in Armenia
  - availability of competent staff
  - procured industrial and intellectual resources etc.

Considering all of the above, the use of AS-92 nuclear technology is judged to be preferable. However, the final conclusion may be reached after a complete financial and economical analysis assessment of all the four listed technologies is performed.

WWER 1000 (AS-92) Chosen by Government Decision (Decree 1458/03.12.2009)
Key assumptions for the cost estimate:

- Capital costs
  - include all work inside the plant fence from the start of construction until commercial operation
  - all equipment and materials are new and of sufficient quality to meet current industry standards
  - use of current technologies and techniques
  - the capital costs are for a “Greenfield site” despite proximity of the existing site, i.e. there are no other major structures to be reused or removed
  - the costs represent a complete, successfully working at full design capacity plant including all costs that can be capitalized including commissioning costs (start-up and testing)
  - Includes Owner Costs
  - Cost Accuracy to be +/- 15% for Final BFS
Non-fuel operating costs:
- wages and salaries of engineering
- technical support
- maintenance and administration staff
- consumable operating materials and equipment
- maintenance and repair costs
- purchased services
- insurance and taxes
- fees, inspections and review expenses
- radioactive waste management costs
- miscellaneous costs

Fuel Costs:
- Fresh fuel costs based on costs for reference plants with adjustments for:
  - fuel enrichment
  - depth of burning
  - refueling cycle
- Spent fuel costs assumed based on available information on spent fuel processing and management.
BFS- Socio-Economic Considerations

- Impact to Local Employment (within 100 km area):
  - during Unit construction
  - during Unit operation
  - in the service field

- Training of specialists:
  - Social, economic and legal sciences
  - Mathematics, natural sciences and IT
  - Technical sciences
  - Health sciences and sport
  - Security and defense

- Public opinion results:
  - Identified public attitude towards nuclear and the new NPP construction
  - Fears, concerns and preferences
  - Perceived positive and negative effects of the investment project

- Macro-Economic Impacts on:
  - Gross domestic product
  - National income dynamics
  - Employment growth & unemployment reduction
  - Increase of the average individual income
  - Improvement of Armenia’s external trade balance and balance of payment
  - Long-term energy and economic independence
  - Economic activity and business climate improvement
  - Meeting climate change objectives
  - Regional effects
Key issues with nuclear investments:

- Considerable investment making the investment less attractive in today's capital market focused on short-term returns
- A strong financial plan is required to address all aspects of the project, including extensive up-front costs, and allowance for the costs of decommissioning
- Usually strong sovereign support required, especially in the case of nuclear where some of the risks cannot adequately be assumed by private entities

Possible ownership options at the preliminary BFS stage:

- 100% Armenian Government-Owned
- Public Private Partnership with possible partners:
  - Companies experienced in power business (construction, operation)
  - Strategic investors with whom other projects may be developed as well
  - Vendors of equipment
  - Major consumer(s)
  - Independent Power Producers
  - Public shares
  - Combined approach
Potential sources of financing for large power projects:

- Multilateral Agencies, such as:
  - Euratom
  - EBRD
  - IBRD
  - Other Trade and Development Banks

- Export Credit Agencies (ECAs) depending heavily upon equipment selection and its source of supply

- Supplier Credits - vendor financing usually through ECAs

- Commercial Banks:
  - participating as agent for ECA
  - other forms of participation

- Bonds

- Institutional Funding

- Combination of above sources

Each ownership structure favors certain financing approaches, and suggests limits of equity/financing amounts.
Project Execution Approaches
EPC on Islands

Owner

Owner’s Engineer

Nuclear Island
- Primary System
  - Reactor Control
  - Core Cooling
  - HVAC
  - Other
  - I&C

Turbine Island
- Turbine
  - Generator
  - Condenser
  - I&C

Secondary Island
- Feed Water
  - Steam System
  - Condensate
  - I&C

Auxiliary Island
- Cooling System
  - Service Water
  - Compressed Air
  - Other
  - I&C

I&C Requirements for Homogenization and Interfaces
FINAL Bankable Feasibility Study

- Additional Hydrology studies – under way
- Geology, Volcano and Seismic study – expected finish
- Transportation study - under way
- Update of Cost Estimates
- Update Economic Analysis
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Observance of time and budget frames for the main stages:
- Design schedule
- Main equipment delivery
- Construction, installation works, commissioning

Provision of trained personnel for the project:
- Design and engineering companies
- Construction and installation organizations
- Operators for the new units

Quality assurance:
- Elaboration of efficient project organization
- Development of documentation in adherence to the requirements for NPP construction
- Adequate training and certification of the personnel;
- Strict inspection for conformity between specifications and products

Licensing of the different stages:
- Use of broad experts’ base for issuance of permits
- Compliance with the requirements of the regulatory bodies
The Formula of Success

Yesterday:

Cost + Profit = Price

Today and Tomorrow:

Competitive Price - Cost = Profit/Loss
THANK YOU!