Supply Chain Issues in Advanced NPPs

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15th INPRO Dialogue Forum on Sustainable Supply Chain for Advanced Nuclear Power Systems
2-4 July 2018
OUTLINE

- Customer issues
- NPP supplier / technology holder issues
- Special issues / opportunities for SMRs

...all the above, as they relate to new-build projects with advanced reactor technologies
**Terminology (IAEA RTA / CUC)**

**Technology holder (TH):**
Refers to the company/consortium/organization responsible for the design, manufacture, construction and commissioning of the nuclear power plant.

**Supplier:**
A term to denote one or more of the entities in the supplier countries engaging in the supply of nuclear power plants (NPPs) and fuel cycle services.

Examples of the entities are:
1) Government organizations and legislators;
2) **Nuclear plant designers/vendors**;
3) **Project managers**;
4) **Component manufacturers**;
5) Nuclear regulatory bodies;
6) **Fuel designers/vendors**;
7) Fuel cycle service providers;
8) Other support institutions — including financial institutions, research and training centres, etc.

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Nuclear Reactor Technology Assessment for Near Term Deployment, Nuclear Energy Series No. NP-T-1.10 (2013)

Technology Holder = Supplier within the RTA

Decision makers for reactor technology selection and implementation are the ultimate users of RTA

Technology suppliers (but also their suppliers), benefit from an understanding of how their reactor designs and technical proposals/bids are evaluated, judged and selected.

IAEA Member States need to obtain reliable information to make relevant comparisons between nuclear power plant designs. The best source of data should be that provided by the technology holder, including past-performance in delivery.

How does the customer view the NPP “Supplier”?

Nuclear Reactor Technology Assessment for Near Term Deployment, Nuclear Energy Series No. NP-T-1.10 (2013)
The Nuclear Supply Chain (NSSS)

Technology Holder holds Responsibility for the Supply Chain

Issues for Advanced NPPs - FOAK

10-40% of the price of a new plant comes from “FOAK premium” (WNA, 2014)

– New components, systems and/or materials
– Learning curve during construction
– Risk premium (contingencies) on the entire plant
– Uncertainty about follow-up orders

A large portion is risks from “Supply Chain Issues”:

Economics, Capability, Quality
World’s Suppliers for NPPs

International Technology Vendors

Number of NPP Units under Construction (as of June 2018)

Only a few of these are FOAK, but even the others are divided among ~10 suppliers, so each project is rather “unique”. 

Difficult to compare/assess
Trend of Construction Starts (as of June 19, 2018)
**RTA – Key Topic 11: Supplier / technology holder issues**

Strength of the relationship between the technology holder and its suppliers, including an assessment of the capabilities and history of the suppliers, the duration of the relationship, and any quality or schedule issues or advantages based upon current data or relevant experience record.

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**South Korea - Capability**

**Doosan Heavy Industries & Construction (37% owned by Doosan)**

- Contracts from Westinghouse and Shaw to supply reactor pressure vessels and steam generators for 4 new AP1000 reactors in the USA, and 2 being built in China at Sanmen and Haiyang.
- Some steam generator and pressure vessel forgings for the two Chinese AP1000s have been subcontracted to China First Heavy Industries.
- Supplied heavy reactor components and turbines to KEPCO for four APR-1400 reactors at Barakah (UAE) under a $3.9 billion 2010 contract.
- To mid-2017 it had supplied 32 reactor pressure vessels of several different kinds (AP1000, APR1400, OPR1000) with two more under construction, and 108 steam generators, with 16 under construction.

**China - Capability**

<table>
<thead>
<tr>
<th>Company</th>
<th>Heavy forging press</th>
<th>Main nuclear island products</th>
<th>Sets per year</th>
</tr>
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<tbody>
<tr>
<td>China First Heavy Industries</td>
<td>15,000 t</td>
<td>Forgings, RPV, SG, PRZ</td>
<td>5</td>
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<tr>
<td></td>
<td>12,500 t</td>
<td></td>
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<tr>
<td>Shanghai Electric Group Co</td>
<td>16,500 t</td>
<td>Forgings, RPV, SG, PRZ, RCP, CRD</td>
<td>6</td>
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<tr>
<td></td>
<td>12,000 t</td>
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<tr>
<td>China National Erzhong Group Co</td>
<td>16,000 t</td>
<td>Forgings, RPV, PRZ</td>
<td>5</td>
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<tr>
<td></td>
<td>12,700 t</td>
<td></td>
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<tr>
<td>Dongfeng Electric Corp &amp; DFHM</td>
<td>large</td>
<td>RPV, SG, PRZ, RCP, CRD</td>
<td>5?</td>
</tr>
<tr>
<td>Harbin Electric Co</td>
<td>8000 t</td>
<td>SG, PRZ, RCP</td>
<td>4?</td>
</tr>
<tr>
<td>Shandong Nuclear Power Equipment</td>
<td></td>
<td>Containment vessels, modules</td>
<td>6</td>
</tr>
<tr>
<td>Total nuclear plant equipment</td>
<td></td>
<td></td>
<td>About 10</td>
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</table>

- China’s heavy manufacturing plants can make about ten sets of pressure vessels and steam generators per year, more than doubling from 2007, but this is projected to rise to 20 sets per year with a view to export.

*Importance factor HIGH*: This speaks directly to the ability of the technology holder to deliver the plant as specified.

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Evaluation Expectations and Relative Comparisons

• Compare the technology holder’s scope of supply, including programmes on:
  – Quality
  – **Subcontractor relationships**
  – Personnel assignments
  – Employee programmes
  – Safety practices and record
  – Process and schedule controls
Key Questions

1) What kind of delivery contracts would you require/offer?

2) What **supply chain arrangements** have you used/will you use in the project?

3) What **partnerships have been established** or will be established to support this project?

4) Who takes the risk with regard to the **assurance of supply of components and parts**?

5) How will the architect/engineer/technology holder handle **QA for lower level/domestic components**?

6) How will export control issues of sensitive technology be addressed?
Technology Holder Issues

• In view of the lack of NPP projects and exports in recent decades, there may not be a sufficient number of suppliers (to create competition) that satisfy the following conditions:
  – Recent experience in NPP construction (in the last 10 years) in their country and/or overseas
  – A good track record on conforming to the schedules and budgets in these NPP projects
  – Being in sound financial condition to limit the risk of project suspension due to the supplier’s financial problems

• Capable, certified suppliers might be overloaded with other projects and might not allocate sufficient capacity for a particular project → supply bottleneck.
A Feasible Approach for Addressing these Issues by Suppliers / THs?

- In large projects, especially in the nuclear field, a key strategy to achieve good performance [to deliver a NPP on time and on budget] appears to be the standardization of the project delivery supply chain and of the NPP design...

Topical Panel 1
Chair: Mr. Kamal ARAJ (JAEC)
Development of Generic Users Requirements for User Countries

Topical Panel 2
Chair: Mr. Jacques CHENAIS (CEA)
Research, Technology Development and Innovation; Codes and Standards

Topical Panel 3
Chair: Mr. Dario DELMASTRO (CNEA)
Industrialization, design engineering, testing, manufacturing, supply chain, and construction technology

Rotational approach adopted on chairing the topical panels
Provide opportunity for all members to chair
### 14 Members of TWG-SMR

<table>
<thead>
<tr>
<th>No.</th>
<th>Countries</th>
<th>Designated Member</th>
<th>Affiliation</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Argentina</td>
<td>Mr. Dario DELMASTRO</td>
<td>CNEA (Comisión Nacional de Energía Atómica)</td>
</tr>
<tr>
<td>2</td>
<td>Australia</td>
<td>Mr. Mark HO</td>
<td>ANSTO (Australian Nuclear Science and Technology Organisation)</td>
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<tr>
<td>3</td>
<td>China</td>
<td>Ms. Jiejuan TONG</td>
<td>Tsinghua University, Institute of Nuclear Energy Technology</td>
</tr>
<tr>
<td>4</td>
<td>France</td>
<td>Mr. Jacques CHENAIS</td>
<td>CEA (Commissariat à l’énergie atomique et aux énergies alternatives)</td>
</tr>
<tr>
<td>5</td>
<td>India</td>
<td>Mr. Ananta BORGOHAIN</td>
<td>BARC (Bhabha Atomic Research Centre)</td>
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<tr>
<td>6</td>
<td>Indonesia</td>
<td>Mr. Djarot WISNUBROTO</td>
<td>BATAN (National Nuclear Energy Agency of Indonesia)</td>
</tr>
<tr>
<td>7</td>
<td>Iran</td>
<td>Mr. Reza SAYYAREH</td>
<td>AEOI (Atomic Energy Organization of Iran)</td>
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<tr>
<td>8</td>
<td>Italy</td>
<td>Mr. Marco RICOTTI</td>
<td>Politecnico di Milano</td>
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<td>9</td>
<td>Jordan</td>
<td>Mr. Kamal ARAJ</td>
<td>JAEC (Jordan Atomic Energy Commission)</td>
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<tr>
<td>10</td>
<td>Republic of Korea</td>
<td>Mr. Keung-Koo KIM</td>
<td>KAERI (Korea Atomic Energy Research Institute)</td>
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<tr>
<td>11</td>
<td>Pakistan</td>
<td>Mr. Syed BANOORI</td>
<td>PAEC (Pakistan Atomic Energy Commission)</td>
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<tr>
<td>12</td>
<td>Russian Federation</td>
<td>Mr. Konstantin VESHNYAKOV</td>
<td>ROSATOM OKBM Afrikantov</td>
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<td>13</td>
<td>United Kingdom</td>
<td>Mr. Daniel MATHERS</td>
<td>BEIS (Department of Business, Energy &amp; Industrial Strategy)</td>
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<tr>
<td>14</td>
<td>United States</td>
<td>Mr. Timothy BEVILLE</td>
<td>DOE (Department of Energy)</td>
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</table>

- Some Member Countries sent Observers
- More countries potentially designate Member in 2018: Canada, Japan, Kazakhstan, Saudi Arabia, Tunisia and Ukraine
SMR: Approaches to Solutions

1 of 3 topics for discussion (Panel 3):

“how to realize enabling features of SMRs (e.g. volume production) to industrialize the supply chain, design eng., construction, etc”

• What could the IAEA do?
SMR: Approaches to Solutions

1. Realize supply chain diversification with the aim of:
   • Reducing costs of component manufacture and construction
   • Localization of supply

2. How to maximize these opportunities:
   • Vendor country to move from stick build to factory build / mass production.
   • Country of deployment to industrialize.
   • Transfer technologies from other sectors.
   • Broaden supply chain (N-Stamp capability)
   • Option to have both vertical integration and horizontal supply chain
3. Key mechanisms to be addressed
   - Regulators
   - Safety classification of components
   - Many nuclear standards exist – how are these understood by broader supply chain
   - Quality assurance and quality control for nuclear components (e.g.: graded approach, maximizing “Commercial Grade” for non-safety equipment)
   - Learning from other industries, e.g. oils and gas, what are the QA gaps

4. Specific technology challenges / solutions:
   - Floating platforms
   - Integral components/systems
   - Factory production
   - Very small technologies (single shot, long lived cores)
   - Fuel cycle / fuel
   - Different coolants
### Panel-3: Industrialization, design engineering, testing, manufacturing, supply chain, and construction technology

<table>
<thead>
<tr>
<th>1. Clarify the ‘families of technology’ considered as near term deployable</th>
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<tbody>
<tr>
<td>• Focus on where the information widely available, <em>e.g.</em> water-cooled</td>
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<tr>
<td>• Coordinate with other TWGs that consider Generation-4</td>
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<td>• Have Generation-4 in scope as perspective topics</td>
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<th>2. Identify neutral/common areas of supply chain <em>e.g.</em> construction and manufacture</th>
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<tr>
<td>• Common areas of technology across NSSS and balance of plant</td>
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<tr>
<td>• Instrumentations</td>
</tr>
<tr>
<td>• Reference case study</td>
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<th>3. Learning from other industries <em>e.g.</em> oils and gas</th>
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<tr>
<td>• How can companies go into nuclear, considering the cost</td>
</tr>
<tr>
<td>• How can companies remain in nuclear for many years.</td>
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<tr>
<td>• Importance of early sight of opportunities for supply chain (not detailed design as you go)</td>
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</table>
Panel-3: Industrialization, design engineering, testing, manufacturing, supply chain, and construction technology

4. Nuclear class standards and quality for manufacture and construction

- What is the range of current standards in nuclear, including QA/QC
- How can nuclear learn from other regulatory regimes to support a diversified/larger supply chain and enable factory construction.
- Quality assurance gaps between other industry and nuclear quality assurance (can inform the cost of upskilling).

5. Identify relevant existing IAEA standards and guidance and forums

- Review the relevant documents and relevance for SMRs.
- Make suggestions/ comments on SMR requirements for the work of other groups (e.g. NS Dep’t).

6. Evaluation and fit of local infrastructure and supplier capability

- To suggest that IAEA develop a generic database standard that could be utilized by nuclear projects to help them to identify supply chain landscape
HTGRs technology is mature
- but the historical supply chain no longer exist (Germany, USA, and to some extend in the Russian Federation and Japan)
- in the construction of the HTR-PM it is being re-established (China); but faced some FOAK challenges

The following present unique technical challenges:
- High temperatures and (very dry) helium environment
  - Self welding of metals require special coatings
  - Leak tightness require special seals
  - In future may need high temperature alloys or CFCs for in-core components
- Code and standards
  - Existing vessel codes may need extensions for increased temperatures
  - Graphite core structure codes were developed and updated
Specific Supply chain challenges for HTGRs

- **Nuclear grade Graphite**
  - Old grades historically used is no longer available
  - New graphite grades are being developed with some irradiation behavior tests performed
  - New ASME code for graphite structures was developed

- **Coated particle fuel suppliers**
  - Takes a long time to establish manufacturing of; and qualification of coated particle fuel to the required quality and quantity to proof performance and accident behaviour
  - Currently established in China with industrial scale manufacture coated particles being irradiated in USA (AGR programme); some capabilities in Japan, South Africa, Russia and Korea

- **Unique equipment:**
  - Helium circulators (pumps)
  - Helium valves (at pressure and temperature)
  - Helical-coil Steam Generators
    - Inspectability challenges
    - Increased wall thickness
    - Manufacturing challenges
  - Very large reactor vessels
    - limited suppliers
Thank you!