Nuclear Supply Localization
Costs Issues

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Saied DARDOUR
Nuclear Economics Analyst
s.dardour@iaea.org
(+43-1) 2600-25154
Countries considering introduction of nuclear power, or, expansion of their nuclear programme can be classified into two categories:

- Segment A (A like ambitious) consists of countries willing to launch an ambitious nuclear programme, with a fleet of NPPs to build across the country over a decade or two on multiple sites.
- Segment B consists of countries targeting 1, 2, 3, maybe 4 units (and that’s it).

Localization strategies, and the resulting costs and benefits, will depend on the extent of a country’s nuclear programme.
• Potential for national participation
  – Infrastructure development prior to NPP construction
  – Construction phase
  – NPP operation
  – Decommissioning
  – Management – and disposal - of spent nuclear fuel and radioactive waste

• Billions will be spent within a long period (50-100 is a minimum)
  – A responsible government would seek redirection of most of this money to national actors and contractors
Perspective is important when we talk about costs and benefits:
- Who bears the costs?
- Who enjoys the benefits?

From a country’s perspective, multi-billion investments are a synonym of economic growth and job creation.
- This applies also to ‘failed’ projects (never delivered or, delivered late and over budget).
- As long as money is spent locally, there is a good chance of inducing a positive macroeconomic impact.
• There is a positive relationship between the growth of transport and electricity infrastructure and economic growth.

• Policies that promote spending in these areas have a positive impact on growth, provided they do not create excess capacity.
From a vendor, or utility, perspective, cost control is of an utmost importance.

- Power generation costs, the so-called LCOE, is largely driven capital investments during construction.

- Construction represents ~70% of LCOE, ~20% of which are financial charges.

Most of the recurring costs are fixed costs, and related to O&M.

Labor is the biggest contributor to O&M costs.
Once the NPP is built, fuel and O&M costs are low and stable.

High fixed costs, low running costs.

Net present value of future cash flows (grey curves)

Capital costs including IDC account for around 65-85% of the LCOE (WNA)

Excellence in NPP O&M

Plant output, capacity factor and electricity/heat selling prices

‘Cash in’ Electricity/Heat Sales

‘Cash out’ Fuel, O&M, Provisions

End of life expenses

Longer operational life

Plant decommissioning
Disposal of spent fuel and other radioactive waste

Present

Future

Delivering NPP construction projects on time and on budget.
• Localization does, in many situations, reduce and lower supply chain costs.
  – When supply is close to the destination, inventory is minimum, and transportation costs are very low.
  – The upstream supply chain is agile and responsive, resulting in an increased effectiveness and enhanced competitiveness.

• Since many decades now, a lot of industries were leveraging the full potential of “best-cost countries” offering low labor and energy costs.
Comparison of manufacturing and logistics costs\(^1\)

Comparative calculation for a cast iron part for German clients, in euros (2012)

Supply costs are reduced by leveraging the full potential of “best-cost country” sourcing

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*1 Not including other costs (constant)


Illustration: oliverwyman.com (“New Paradigms for ‘Glo-Calizing’ sourcing and supply”)
Nuclear Supply Localization, Costs Issues

• But the global context is evolving…
  – East Asia’s shrinking cost advantage
    • Increase in labor costs, little productivity growth.
  – Cheap energy in North America, unlocked by hydraulic fracturing.
  – Advances in manufacturing technology tend to decrease costs.
  – Increasing complexity and cost of managing global supply chains.

In 2004, the cost of manufacturing on the east coast of China was approximately 15 percentage points cheaper, on average, than in the United States.

In 2016, that gap was down to about 1 percentage point.
Indexed cumulative real wage growth by region since 2000

2000 = 100

Labor and energy cost advantages have diminished in (formerly) low-cost countries

Note: Africa 2008–2011, Asia 2011, Middle East 2009–2011 estimated based on available country coverage
Source: International Labour Organisation, United Nations

Illustration: oliverwyman.com ("New Paradigms for ‘Glo-Calizing’ sourcing and supply")
Nuclear construction, as many other major infrastructure projects, are unique.

- Large, complex, long-term projects.
- Involve a large number of stakeholders entering the project at different stages with different roles and responsibilities.
- Multinational in nature, involving equipment suppliers from vendors’ countries and local contractors.
- Interface risks are significant.
- Poor project structuring and risk management resulted in cost overruns, delays, failed procurement, or unavailability of financing.
# Nuclear Supply Localization, Costs Issues

<table>
<thead>
<tr>
<th>Example</th>
<th>Budget vs actual, € billion</th>
<th>Delays and start-up problems</th>
<th>Incorrect capacity and revenue plans</th>
<th>Total value lost vs plan, € billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurotunnel</td>
<td>7.5</td>
<td>• 6-month delay</td>
<td>• Overestimated market-share gain in freight and passengers by 200%</td>
<td>~7.5</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>• 18 months of unreliable service after opening</td>
<td></td>
<td></td>
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<tr>
<td>High-speed rail</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frankfurt-Cologne</td>
<td>4.5</td>
<td>• 1-year delay of construction</td>
<td>• Unforeseen capped government funding</td>
<td>~1.5</td>
</tr>
<tr>
<td></td>
<td>6.0</td>
<td>• Legal and technical issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Betuwe Line NL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(cargo rail)</td>
<td>2.3</td>
<td>• 1.5-year(^1) delay of construction</td>
<td>• Annual revenue shortfall of €20 million</td>
<td>~3.0</td>
</tr>
<tr>
<td></td>
<td>&gt;5.0</td>
<td>• Technology choices still not finalized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuala Lumpur Airport</td>
<td></td>
<td></td>
<td>• Handles only ~60% of current capacity</td>
<td>~1.5</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>• Initial issues with connectivity to downtown area</td>
<td>• Losing market share to Singapore</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>• Complaints about facility hygiene levels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Project still not finalized and costs could go even higher.

Source: Annual reports; Jane’s Airport Review; McKinsey analysis; Reuters

Illustration: McKinsey, “A risk-management approach to a successful infrastructure project”.
Learning is key in reducing costs

Evidence from the French nuclear programme

FIG. 8. Time reduction between commitment for reactor unit and connection to grid for standardized 900 MW plant.

+ Improved learning
+ Knowledge spillover effect stimulating technological improvements

FIG. 12. Manufacturing cycle time of nuclear reactor components.
There should be a **demand** for standardized NPPs **sustained over time**, and ongoing orders for the nuclear supply chain, for NPP projects to be delivered in time and within budget.

Keeping production alive is key here, and that applies to every industry.

If providers of nuclear components and services close due to **lack of orders**, there will be a huge **loss of knowledge, experience, competencies and qualifications**.

“Airbus needs a minimum of six to eight orders a year to keep production alive at the A380’s final assembly plant near Toulouse.”

What would be the figure (minimum number of orders) for nuclear? 1 every 5 years?
Nuclear Supply Localization, Costs Issues

• Megaprojects fail because of technical reasons (46%), execution factors (73%), organizational factors (65%) and other factors related to market and political situation.

• For nuclear, long construction times, high regulatory and safety standards, the need for standardized and complex quality control processes and FOAK issues tend to raise costs and requirements on labour.

• Successful nuclear projects are backed by vendors and supply chains with steady inflow of projects in the past, which allowed them to develop and retain experienced teams.

• In some countries, project might get prohibitively expensive due to low labour productivity. Maximizing local content – a priority for public stakeholders – might significantly increase project risks and costs.
  
  – Maximizing local content must be negotiated in the early stages and reflected in the price.
Access to information about potential suppliers is critical.

- Limitations in worker qualifications
- Availability of highly engineered equipment
- Operational complexity of daily interactions
- Labor productivity

“Risk-informed procurement”
Assess supply chain ability to meet financial, legal, safety, quality, and environmental regulations and expectations.

A chain is only as strong as its weakest link.

Who is the weakest runner?
Recommendations

- **Government**
  - Determine most suitable project delivery models
    - e.g. PPA vs. market model; open tender vs. govt-to-govt deal; etc.
  - Promote establishment of “coalition” of stakeholders
    - Strengthen collaborative behaviours throughout project delivery by creating an environment where vendor, subcontractors and their respective governments take an active role in project ownership and financing
  - Assure effective and stable regulatory environment
    - Reach a regulator-to-regulator agreement with country of origin (seek acceptance of reference plant design and licensing)
  - Take active role in enabling areas (e.g. import regulations) to further de-risk the project
    - Enable vendor to bring his tested subcontractors (do not impose localization)

- **Owner**
  - Assure effective vendor selection process
  - Promote culture of positive motivation towards achievement of the milestones (rather than punishment)
  - Involving vendor subcontractors and their respective governments in project ownership and financing
  - Build and maintain interfaces with the local government and regulator:
    - Selection, licensing and construction processes
  - Establish high-level oversight role during construction (rather than detailed supervision)

- **Vendor**
  - Base construction on stable design with existing reference plant and maximize design readiness
  - Accept active participation of the vendor in project ownership and financing
  - Provide licensing documents compliant with local regulatory requirements
  - Bring experienced project and construction management team ready to react promptly to challenges
  - Provide detailed project schedule to the owner
  - Assure transparency over achieved milestones

thank you!

Saied DARDOUR  
Nuclear Economics Analyst  
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## FOAK Projects: Risks and Mitigation Strategies

### Risks of FOAK projects

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<tr>
<th>Risk</th>
<th>Description</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical volumes</td>
<td>Additional materials (especially cables and pipes) and equipment due to poor design</td>
<td>🔄 $</td>
</tr>
<tr>
<td>Rework</td>
<td>Rework driven by collisions in detailed documentation</td>
<td>🔄</td>
</tr>
<tr>
<td>FOAK equipment</td>
<td>Delays in procurement, development of technical documentation and production of equipment, rework due to poor QC results</td>
<td>🔄 $</td>
</tr>
<tr>
<td>Low pace of construction</td>
<td>Extended duration of technical decisions approval and commissioning of new solutions</td>
<td>🔄</td>
</tr>
<tr>
<td>Collisions in schedules</td>
<td>Sequence of construction and installation can be unusual due to preliminary FOAK design</td>
<td>🔄</td>
</tr>
<tr>
<td>Discoveries at commissioning</td>
<td>New information is revealed at the commissioning phase, as feasibility of design is not proven</td>
<td>🔄</td>
</tr>
<tr>
<td>Contingency contracts</td>
<td>Contractors don’t sign EPC LSTK(^1) contracts and add a significant contingency to the price if they sign</td>
<td>🔄 $</td>
</tr>
</tbody>
</table>

\(1\) LSTK – Lump sum turnkey

### Mitigation strategies

- Avoid FOAK risk by choosing proven/reference design or separate modules unless new design provide significant advantage
- If new design provides substantial advantage, start FOAK project with experienced project team which has gained substantial experience in nuclear construction before embarking on the FOAK project. Additionally,
  - Prepare for overruns in both schedule and budget
  - Plan contingencies and optimization measures in the initial financial models
  - Plan contingencies and compensating measures in project schedule
  - Structure major contracts carefully especially pricing arrangements and liabilities

Successful constructors of FOAK projects are able to limit the FOAK risk to 1-2y of delay

From the presentation made by Stephan Solzhenitsyn, McKinsey & Company during the IAEA’s Technical Meeting on “Nuclear Power Cost Estimation and Analysis Methodologies”, Vienna, April 24-26 2018.