A CHARACTERIZATION OF THE FINANCIAL RISK PROFILE OF FAST SMRs

Comparison with SMRs of the PWR type

“Technical Meeting on the Benefits and Challenges of Fast Reactors of the SMR Type”

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Nuclear investment risk

**Traditional NPPs**
- Invested capital amount
- Pay Back Time (PBT)
- construction delay and cost overruns (size/complexity)
- price-taker technology
- public opinion and public opposition

**SMRs**
- reduced investment amount (higher €/kWe ?)
- lower PBT and self-financing of fleets
- smaller size of components
  + simplification
  + modularity
  + standardisation
  + factory fabrication
  \[= \text{higher control on construction costs and time}\]
- increased passive safety
  - \(\rightarrow\) better public acceptance
  - \(\rightarrow\) less active components (availability)
Basics of the method

1. “Measurement” of qualitative factors
2. Risk breakdown
3. Expert elicitation
4. Pairwise comparison of Fast SMRs with PWR SMRs

1\textsuperscript{st} level

- **LIFECYCLE PHASE**
  - weight [%]

2\textsuperscript{nd} level

- **RISK FACTORS**
  - score [1-5]

3\textsuperscript{rd} level

- **Performance of Fast vs. PWR SMR**
  - rating [1-7]

[Diagram showing the levels with corresponding factors and scores]
# Financial risk break-down

## 1st level

<table>
<thead>
<tr>
<th>Licensing</th>
<th>Construction</th>
<th>Operation</th>
<th>D&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory activity</td>
<td>Regulatory activity</td>
<td>Regulatory activity</td>
<td>Regulatory activity</td>
</tr>
<tr>
<td>Political support</td>
<td>Political support</td>
<td>Political support</td>
<td>Political support</td>
</tr>
<tr>
<td>Public acceptance</td>
<td>Public acceptance</td>
<td>Public acceptance</td>
<td>Public acceptance</td>
</tr>
<tr>
<td>Supply chain mgt</td>
<td>Plant maneuverability</td>
<td>Fit with cogen. opt.</td>
<td>Project mgt.</td>
</tr>
<tr>
<td>Project mgt</td>
<td>Fit with energy storage</td>
<td>Exposure to fuel price</td>
<td>On site work</td>
</tr>
<tr>
<td>On site work</td>
<td>Unplanned outages freq.</td>
<td>Planned outages freq.</td>
<td>Security</td>
</tr>
<tr>
<td>Factory fabrication</td>
<td>Outages duration</td>
<td>Outages duration</td>
<td>Plant layout pro dismantling</td>
</tr>
</tbody>
</table>

## 2nd level

- Security
- Security
- Security
- Security
- HLW management
- Special D&D techniques
# Financial risk measurement

## 1st level

<table>
<thead>
<tr>
<th>weight</th>
<th>%</th>
</tr>
</thead>
</table>

## 2nd level

<table>
<thead>
<tr>
<th>Score</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not at all important</td>
</tr>
<tr>
<td>2</td>
<td>Slightly Important</td>
</tr>
<tr>
<td>3</td>
<td>Important</td>
</tr>
<tr>
<td>4</td>
<td>Fairly Important</td>
</tr>
<tr>
<td>5</td>
<td>Very Important</td>
</tr>
</tbody>
</table>

## 3rd level

<table>
<thead>
<tr>
<th>Rating</th>
<th>Meaning for Fast SMR</th>
<th>Complementary meaning for PWR SMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PWR SMR much better</td>
<td>Fast SMR much worse</td>
</tr>
<tr>
<td>2</td>
<td>PWR SMR fairly better</td>
<td>Fast SMR fairly worse</td>
</tr>
<tr>
<td>3</td>
<td>PWR SMR slightly better</td>
<td>Fast SMR slightly worse</td>
</tr>
<tr>
<td>4</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>5</td>
<td>Fast SMR slightly better</td>
<td>PWR SMR slightly worse</td>
</tr>
<tr>
<td>6</td>
<td>Fast SMR fairly better</td>
<td>PWR SMR fairly worse</td>
</tr>
<tr>
<td>7</td>
<td>Fast SMR much better</td>
<td>PWR SMR much worse</td>
</tr>
</tbody>
</table>

**Expert elicitation**
1st level: the risk in lifecycle phases
2nd level: risk factors in LICENSING

LICENSING

4.44
Regulator activity

3.69
Public acceptance

3.75
Political support
2nd level: risk factors in CONSTRUCTION
2nd level: risk factors in OPERATION

- Regulator activity
- Security
- Political support
- Public acceptance
- Plant manoeuvrability
- Fit with cogeneration options
- Fit with energy storage options
- Exposure to the fuel price volatility
- Unplanned outages frequency
- Planned outage frequency
- Outages duration
- Robustness to natural events
2\textsuperscript{nd} level: risk factors in D&D

\begin{itemize}
  \item High level waste management and conditioning
  \item Plant layout to facilitate dismantling
  \item Special dismantling/cutting/decontamination techniques
\end{itemize}

- Security
- On site work
- Project management
- Public acceptance
- Political support
- Regulator activity
3\textsuperscript{rd} level: comparative risk performance in LICENSING
3rd level: comparative risk performance in CONSTRUCTION
3rd level: comparative risk performance in OPERATION

- Regulator activity
- Security
- Political support
- Public acceptance
- Plant maneuverability
- Fit with cogeneration options
- Fit with energy storage options
- Exposure to the fuel price volatility
- Planned outage frequency
- Unplanned outages frequency
- Outages duration

PWR-SMR

Fast-SMR
3rd level: comparative risk performance in D&D

DECOMMISSIONING AND DECONTAMINATION

- Special dismantling/cutting/decontamination techniques
- High level waste management and conditioning
- Plant layout to facilitate dismantling
- Regulator activity
- Political support
- Public acceptance
- Project management
- Security
- On site work

For PWR-SMR and Fast-SMR
Concluding remarks

• **Overall:**
  – Fast SMRs pay for the **novelty of their concept** with higher financial risk perception
  – **PWR SMRs** rely on the experience of PWR technology and keep a competitive advantage in terms of risk perception over Fast SMRs

• **Operation:**
  – Fast SMRs should ensure higher efficiency, flexibility and lower exposure to fuel price, with lower financial risk than PWR technology
  – **higher expected risks of unplanned outages and outage duration** (no track record on operating performance)

• **Construction:** uncertainty on the supply chain planning, scarce knowledge/trust and lack of experience in project management of Fast SMRs.
Concluding remarks

• Information and communication effort, the technology demonstration program to increase the knowledge of Fast SMR performance

• Risk-compensation measures to fill the gap with traditional nuclear plants
  – New business models such as Contract for Difference, Regulated Asset Base (RAB), the Mankala approach implemented at Olkiluoto-3, etc.

• Government backing to support the technology transition and overcome the free market inefficiency in allocating the resources to long-term, strategic projects with high innovation content.