SMR Pre-Partnership Study on Supply Chain Adaptation

Webinar for SMR IA Tech. Working Group #3

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With the support of:

Scope of the Study

- What are the ***specific new features*** of a Supply Chain tailored on the SMR business model?
  - ✓ Standardization (series effect)
  - ✓ Extended Shop manufacturing (time saving/quality costs)
  - ✓ Site construction by modules (time saving/financial costs)

- On the basis of a qualitative analysis, which ***bottlenecks c***an be anticipated?
  - ✓ Quantitative analyses were not launched, but a generic survey of the existing supply chain was conducted

NOTE:
For this Webinar:
- we will not report the considerations on Fuel, since it is not in the scope of TWG 3
- we will not deal with the considerations on use of high quality industrial-grade components, which will be the subject of another webinar

Methodology: Collecting Vendor views

- First priority was to listen to SMR Vendors presemt in the European markets and to understand what are their expectations and their plans
- Questionnaire focused on the business model pursued to reach SMR competitiveness
- 6 answers out of the 13 Vendors present in the European market:
  - EdF — NUWARD
  - FALCON Consortium — ALFRED
  - GE –Hitachi — BWRX 300
  - Rolls Royce — RR SMR
  - VTT — LDR 50
  - Westinghouse — W – LFR
- Answers summarized in Appendix 1 available at: https://snetp.eu/wp-content/uploads/2023/07/European-SMR-pre-Partnership-WS4-Appendix-1-Summary-of-Vendor-answer-analysis-1.pdf

QUESTIONS ABOUT:

1. Key features to grant competitiveness
2. How many modules to reach the optimal cost of a series production?
3. "Special Components" significantly innovative in today's market?
4. For such Special Components, European suppliers which could deliver?
5. Impact of Special Components on plant construction schedule?
6. Special factories dedicated to series production of Special Components?
7. Modularization : both of mechanical modules and structural modules?
8. Other ways to standardize construction?
9. Which kind of fuel and fuel supply arrangements ?
10. Standardization vs usage of the local supply chains?
11. What Codes and Standards? any need for additional Codes or Standards?

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Methodology: Collecting Vendor views

Vast consensus on:

- standardization: not only in the design, but also in in all the following phases
- Harmonization of the safety demonstration
- Series effect achievable with a similar number of units than large reactors, so with minor overall expenditure
- Modular construction to keep costs and time under control
- Some flexibility in the approach to Codes and Standards (e.g. through reconciliation)

...but also some differences:

- Simplification not always seen as relevant for competitiveness
- Different opionions on modules (standardised modules vs large modules / civil structures modularization)

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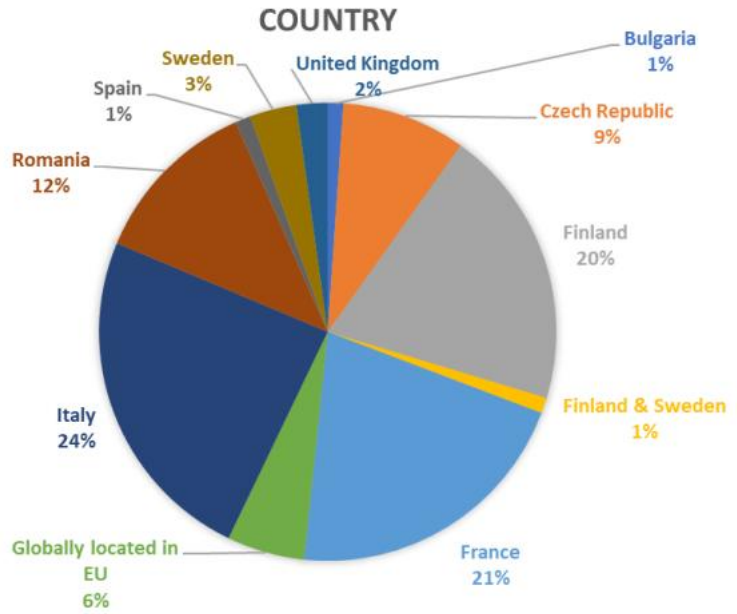
Methodology: Supply chain questionnaire

- **The questionnaire is designed** to capture a comprehensive picture of the European supply chain's readiness for SMR deployment. It delves into the specifics of each company's capabilities and challenges, providing insights into the industry's strengths and areas needing improvement.
- Questionnaire sections:
  - **General Overview:** Company name, country, turnover, percentage of turnover on nuclear business and R&D, number of employees, production units and their locations
  - **Capability:** Nuclear technologies experience, internal design expertise, installation, commissioning, testing capabilities, maintenance services, experience in nuclear quality systems, reconciliation capability
  - **Capacity:** Actual production capacity, ability to expand production capacity, logistic challenges, supply challenges, areas needing investment for factory preassembling and integral testing



Studied by analyzing

- supplier questionnaire containing 32 questions answered by 91 suppliers located in 10 European countries.
- a sample of 118 companies from the publicly available database of European contractors kept by Nuclear Engineering International (NEI).

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Methodology: Supply chain questionnaire

- **Focus** on key questions aims for relevant and targeted data. By exploring various aspects of nuclear technologies, design expertise, maintenance services, and digitalization, the questionnaire provides a holistic view of the supply chain's capabilities. Question subjects:
  - **Technologies:** PWR, BWR, LFR, SFR, HTGR, Fusion Reactor, Fuel Cycle Facilities, Naval Reactors
  - **Design Expertise:** Concept engineering, basic engineering, detailed engineering, construction engineering
  - **Maintenance Services:** Long Term Service Agreements, defect liability period, on-demand services
  - **Automation and Digitalization:** IoT, Big Data Analytics, Additive Manufacturing, Cybersecurity, Machine Learning, Autonomous Robotics, Augmented Reality
  - **Building Information Modelling** (BIM): Certification and experience
- **Result highlight:** Almost 70% of respondents indicated specific technologies such as additive manufacturing, augmented reality, autonomous robotics, Big Data analysis, cybersecurity, IoT, AI, machine learning, and digital twin modelling.
- **Improvement areas:** Investments are needed in areas such as automatic assembly/welding, auxiliary systems for integrated working tests, human resources, inspections, factory laydown areas, machining capabilities, material monitoring, and transport logistics.

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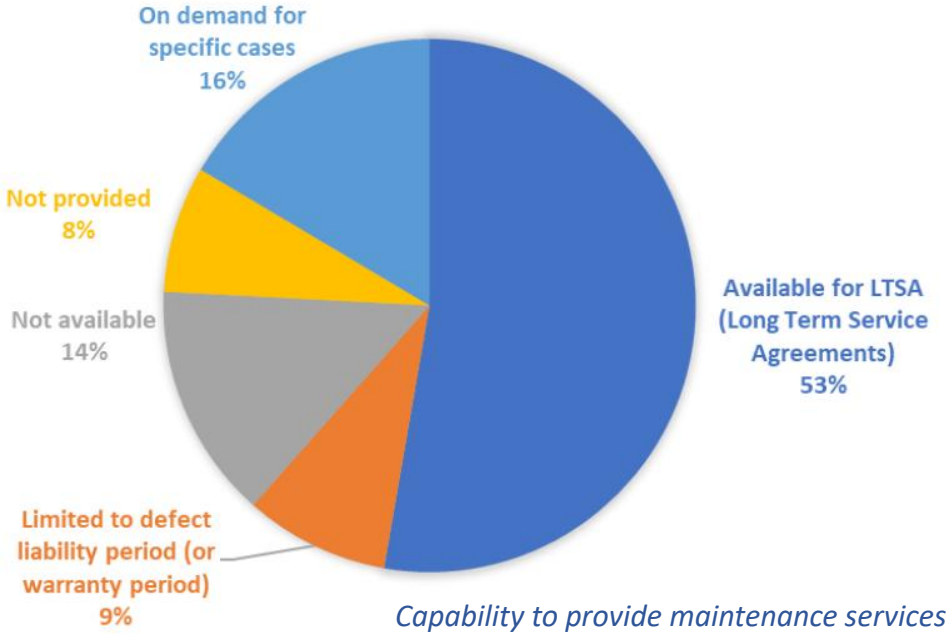
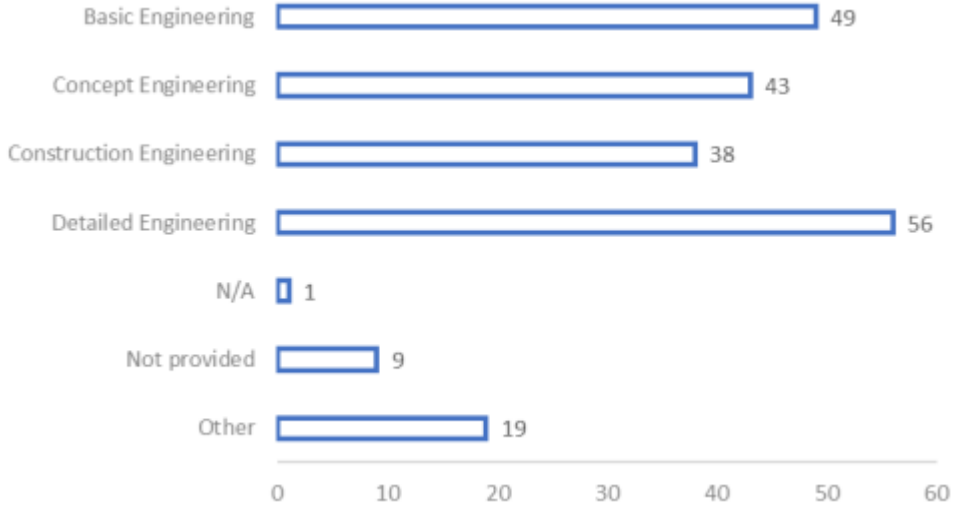
Result insights to capability

- 60% familiar with more than one nuclear technology (30% more than 2)
- Most of them with internal engineering capabilities
- Largely familiar with main C&S (e.g. ASME and RCC for mech. components)
- > 50% open to qualifying their products to a different C&S, however changing the established process naturally has a cost.



Capability to provide maintenance services after delivery of own products and/or systems



Nuclear specific internal design expertise

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Experience with different technologies

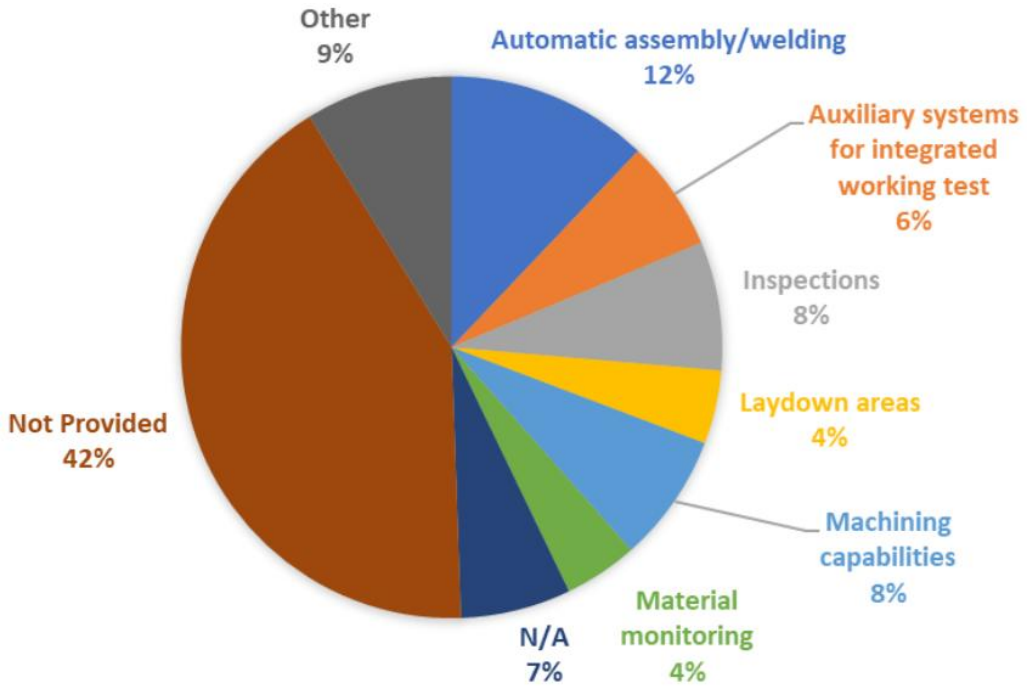
- **The diversity of experience** of suppliers with different nuclear technologies shows the industry's adaptability and expertise. This breadth of knowledge is a significant asset for SMR deployment, as it ensures that suppliers can handle various challenges and requirements. The results reveal a strong foundation of experience.
- Technologies:
  - Light Water Reactors (LWR): PWR, BWR2.
  - Advanced Modular Reactors (AMR): HTGR, LFR, SFR2.
  - Fusion Reactors: Experience in handling high-temperature and high-energy environments.
  - Fuel Cycle Facilities: Expertise in managing the entire fuel cycle.
  - Naval Reactors: Specialized knowledge in compact and efficient reactor designs.

With the support of:

Result insights to capacity

- >60% respondents confident they can increase their capacity. However, more visibility for the business and investment feasibility is required.
- **Identified bottlenecks:** availability of raw materials and components, specialized workforce and training
- Expectation for more harmonized requirements

- SMRs' reduced reactor size and series approach may require increased manufacturing. However, SMRs rely on fewer highly safety-classified systems and components compared to large NPPs due to their smaller scale and passive safety features. Utilization of serially produced high-quality industrial standard items for low- and mid-safety applications is essential.
- *Leveraging markets: SMR fleets can tap into existing industrial suppliers with available mechanical, electrical, and digital equipment. Improving also utilization of the potential of the local suppliers.*



Areas for investments if increasing capacity

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Experience with Codes and Standards

- Suppliers' familiarity and ability to navigate with various codes and standards is essential. Suppliers' reconciliation capability ensures that products meet stringent requirements across different markets, enhancing their competitiveness and positioning.
- Codes and Standards:
  - International Standards: IEC, IEEE, ISO2.
  - Nuclear Pressure Vessel Codes: AFCEN, ASME BPVC2.
  - Regional Standards: EN standards in Europe.
- **Result highlight:** Over 50% of suppliers can qualify their products to different codes and standards without major issues, and less than 15% have no experience with nuclear quality systems.
- Suppliers still need to invest in reconciliation capabilities to ensure seamless qualification of products to different codes and standards.

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Product Innovation capability

- The industry's focus on and ability for product development is vital. The adoption of enabling technologies showcases the industry's commitment to enhancing efficiency and quality. The results reveal a proactive approach to innovation.
- Enabling Technologies:
  - Additive Manufacturing: Enhancing production processes.
  - Augmented Reality: Improving maintenance and repair.
  - Autonomous Robotics: Increasing efficiency and safety.
  - Big Data Analytics: Optimizing operations.
  - Cybersecurity: Ensuring data protection.
  - IoT and AI: Integrating smart technologies.
- **Result highlight:** Almost 70% of respondents are actively working on or planning to invest in these technologies.
- **Improvement areas:** Suppliers need to further invest in digitalization and automation to support increased production at a sufficient quality level.

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Modularization

- Modularization of an NPP is quite different from other industrial sectors, because of
  - Need to cope with the several layout costraints (safety/ALARA/inspectability...)
  - Need to proper control and to certify the construction
- Limiting the number of different types of modules would be advisable: each type represents an additional structure/subsystem to certify (in addition to the single components)
- Modularization can allow for more parallel construction scheduling: but in order to achieve this the Supply Chain shall be properly organized to support
- The extent of modularization is a key design choice, to be properly optimized at various stages of the design & construction process

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New tools and methods

- Shop manufacturing can enable greater use of advanced and digitised manufacturing techniques, but Supply Chain should be properly involved in innovation activities to achieve proper qualification from the regulators
- Passive safety systems could require new technologies for production, maintainance and repair, e.g. underwater or in harsh environment:
    - Robotic handling
    - Virtual or augmented reality
    - Human-machine technologies
- Increased testing (including commissioning) at the manufacturer shop would be of interest

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AMR specific needs

AMR critical component	Supply Chain challenges
Nuclear fuel	Complementary studies for new fuel licensing and manufacturing
Fuel subassemblies and racks	New designs to face new conditions considered for the new types of fuel and new coolant characteristics
Fuel handling, control rods and mechanisms	New designs adapted to new fuels, although existing suppliers have the technology to develop these components.
Reactor core and internals	Materials to support new conditions (coolants, corrosion, erosion, etc.). Innovative manufacturing techniques may be beneficial.
Reactor pressure vessel(s) and safety vessel(s)	Experience for large vessels is applicable but shall be tailored to special conditions.
Reactor coolants (e.g., sodium, lead, helium, molten salt)	Typically not produced in large quantities, experience in handling and treatment systems in the conventional sector may be beneficial.
Reactor coolant pumps	Pump design shall be implemented for new coolants.
Primary heat exchangers	Special design or innovative technologies might be required.
Primary coolant special components (filters, seals, heaters, etc.)	Complementary studies to be performed to evaluate the impact of the new fast reactor conditions in order to adapt the current equipment.
Radwaste Systems	Gaseous, liquid and solid radwaste treatment and storage systems considering new fuel and radiation source characteristics to be developed.
Instrumentation and monitoring for systems and components	Current radiation monitoring equipment to be adapted.
Inspection tools condition monitoring and repair techniques	New fast reactors shall incorporate robotic tools and service inspection instrumentation.

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A Robust Supply Chain: potential bottlenecks

- SMR business model not only needs increasing capacity in short time, but also to creare a ro bust supply chain to properly serve an enlarged customer market over an extended life span.
- Bottleneck identification and sizing require quantitative investigations, nevertheless there are areas with limited number of suppliers in Europe:

Nuclear grade pumps	RPV Flanges & nozzles
Nuclear valves	Pressurizer heaters
Turbogenerators	Spray nozzles
Reactor internals	Criticality monitors
Control rods	Radiation resistant electronics

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A Robust Supply Chain: how to promote it

- Vendor specific components
  - maximize local manufacturing in dedicated EU factories from non- European Vendors
  - foster EU supply even in terms of semi-finished items or special subcomponents

- Components procured from the broader market
  - Early interaction between Vendors and potential suppliers (not only the usual ones)
  - Promote the use of serially produced high-quality industrial standard components
  - Support initial investments from new entry companies (e.g. quality monitoring, testing tools)
  - Develop the capacity for technical services, which appear to be the most critical weak point for an effective SMR broad deployment

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Evolution of the value chain

- The SMR business model is broadly moving the value chain from site (and the from project and construction management) to factories (and then to shop production management)
- Typical example is Modularization: its goal is to largely increase the productivity and to reduce costs, by maintaining full quality control
- Further area to explore would be an increased testing, including pre-operational aand functional commissioning, at manufacturer’s shop: specific facilities would be needed
- New manufaturing techniques (eg electron beam weling, innovative NDE techniques) would increase the value built into the shop products, and thus the competitiveness of the European Suppliers

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Conclusion hightlights

- The Pre-Partnership study had not the ambition to measure the EU Supply chain, as now requested to TWG3 from the Industial Alliance
- However, more than measuring what exists, it is important to understand how to expand the present capacity to face the future needs
- Factory manufacturing is a very promising area to reduce cost and time of future New Built in Europe: SMR can facilitate such an approach
- Reduced costs in manufacturing shall be properly transferred to the final Customer: a much tighter interaction between Vendor and manufacturers is required for SMR, in order to create a win-win situation, where both are getting proper profit from increased, stable market perspectives

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Links to report

European SMR pre-Partnership

- European SMR pre-Partnership – WS4 – Supply Chain Adaptation -Final Report
- European SMR pre-Partnership WS4 – Appendix 1 – Summary of Vendor answer analysis
- European SMR pre-Partnership WS4 – Appendix 2 – Summary of analysis of the Supplier
- European SMR pre-Partnership – WS4 – Annex A – Vendor Questionnaire
- European SMR pre-Partnership WS4 – Annex B – Questionnaire, European supply chain in the context of SMR deployment
- European SMR pre-Partnership WS4 – Annex C – Product Categories (List of activities and their rank of relevance)

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