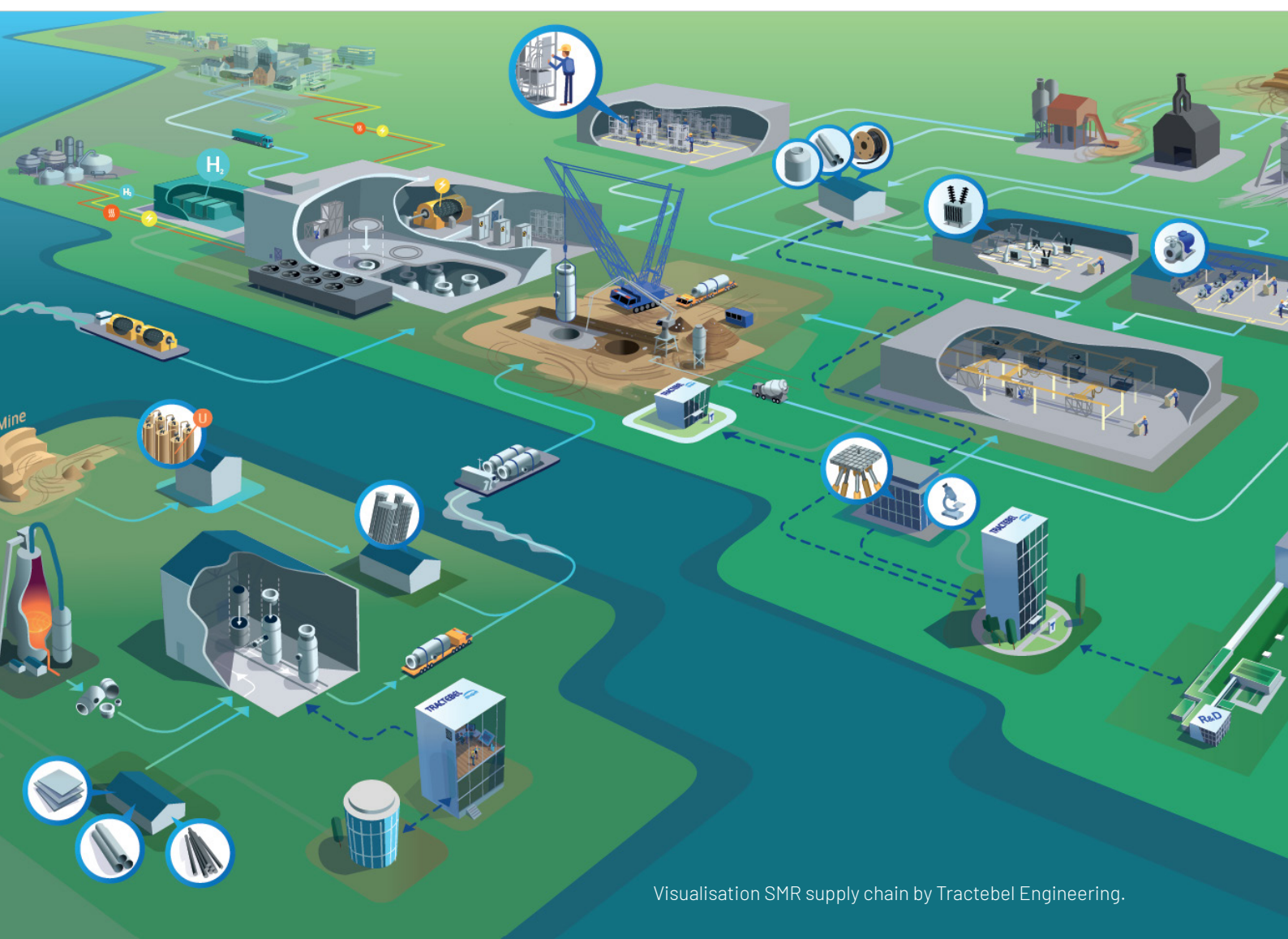




Preliminary Study on the SMR Supply Chain Potential for the port of Rotterdam

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Final Report



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PRELIMINARY STUDY ON THE SMR SUPPLY CHAIN POTENTIAL FOR THE PORT OF ROTTERDAM

Final Report

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Commissioning parties: SmartPort, Deltalings, the Port of Rotterdam Authority, Municipality of Rotterdam, and Province of South Holland

September 2026

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Executive summary

This study, conducted by Tractebel Engineering and Technopolis Group for SmartPort, Deltalinqs, Port of Rotterdam, the Municipality of Rotterdam and the Province of South Holland, assesses the potential role of the port of Rotterdam and its industrial ecosystem in the emerging Small Modular Reactor (SMR) supply chain. The study responds to the growing interest in SMRs in the Netherlands and across Europe, as well as to 2025 Rotterdam City Council resolutions calling for a Rotterdam Nuclear Industrial Agenda.

SMRs are increasingly considered part of future low-carbon energy systems due to their potential applications for electricity generation, industrial heat, hydrogen production and, in the longer term, maritime use. At the same time, their modular and partially prefabricated nature creates new requirements for industrial manufacturing, logistics and integration, positioning ports as potential strategic hubs in future SMR deployment.

The SMR market is still at an early stage of commercial development. While close to one hundred SMR concepts are currently being developed worldwide, only a limited number have entered operation, construction or advanced regulatory review. As a result, the SMR supply chain remains open and evolving, creating opportunities for new entrants. However, this opportunity window is time-sensitive and technology dependent. First-of-a-kind inland SMRs in Europe are expected around 2030, while commercial deployment in the Netherlands is more likely in the late 2030s or early 2040s. Offshore and maritime SMRs are expected to develop later due to lower technology maturity and additional regulatory challenges.

Within this context, the study concludes that the port of Rotterdam has strong potential to position itself in the emerging international SMR supply chain. The port benefits from a large industrial ecosystem, strong logistical capabilities, maritime expertise and a strategic location connected to the European hinterland. In total, 92 companies in or near the port were identified as potentially relevant for the SMR supply chain, mainly in transport and logistics, heavy haul, mechanical and electrical systems, industrial services, specialised components and integrated modules. Most opportunities are expected to concern non-nuclear components and services, as nuclear-specific capabilities within the port remain limited today.

For inland SMRs, the port could play a role in transport and logistics, component supply and selected construction activities, particularly if SMRs are deployed within or near the port or elsewhere in the Netherlands. Stakeholders also highlighted the potential of inland SMRs to support the port's industrial decarbonisation ambitions through the production of electricity, heat and hydrogen.

For offshore and maritime SMRs, the port appears particularly well positioned due to its existing offshore and maritime industrial ecosystem. Potential future roles could include various levels of maintenance or support to nuclear-powered vessels and barges. However, these opportunities are considered longer-term due to the lower maturity of offshore SMRs and the need for further regulatory development.

The study identifies four potential strategic roles that the port of Rotterdam could assume in the SMR supply chain, ranging from lower to higher ambition levels. These include (1) acting as a logistics and transit hub for SMR components and potentially nuclear materials; (2) becoming an industrial ecosystem supporting the construction and integration of SMR modules and components; (3) positioning itself as a strategic European nuclear port for maritime routes and nuclear-powered vessels; and (4) attracting nuclear-related industrial activities linked to fuel, servicing and waste management. These roles are associated with different levels of investment, complexity and regulatory requirements and may be combined over time.

To realise these opportunities, the study recommends that the port of Rotterdam acts proactively and starts positioning itself today. A four-step approach is proposed, illustrated in the figure on the next page. First, the port and its stakeholders should define the desired ambition level and strategic role in line with the port's long-term vision for 2050. Second, a public-private collaboration platform should be established to align stakeholders, raise awareness and mobilise interested companies. Third, the collaboration should develop a shared unique selling point and action plan to position the port and its companies within the SMR supply chain. Finally, the action plan should be implemented through targeted actions such as vendor matchmaking, participation in national nuclear supply chain initiatives, support for workforce development and qualification, and facilitation of an enabling regulatory environment, particularly for maritime SMRs.

Overall, the study concludes that the port of Rotterdam is well positioned to capture emerging opportunities in the SMR supply chain, particularly in logistics, industrial integration and maritime-related activities. However, success will depend on timely strategic decisions, coordinated public-private action and the ability to progressively build nuclear-related capabilities in a rapidly evolving and competitive international market.

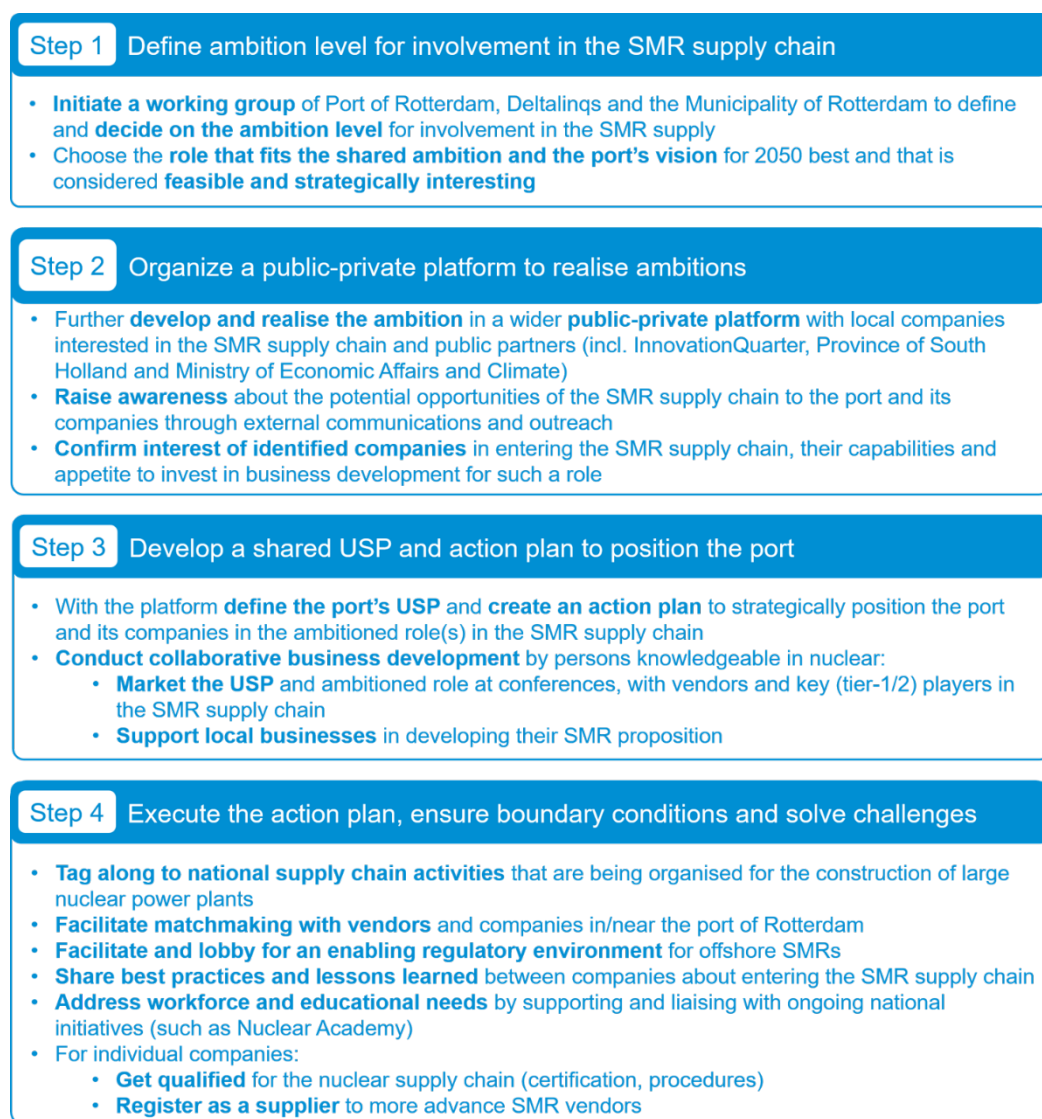


Figure 1: Summary overview of the four steps and associated actions to help the port of Rotterdam to position and prepare itself to play its ambitioned role in the SMR supply chain

Managementsamenvatting

Dit rapport analyseert de mogelijke rol van de haven van Rotterdam en haar industriële ecosysteem in de opkomende toeleveringsketen voor Small Modular Reactors (SMR's). Het is het resultaat van een studie van Tractebel Engineering en Technopolis Group, uitgevoerd in opdracht van SmartPort, Deltalinqs, het Havenbedrijf Rotterdam, de Gemeente Rotterdam en de Provincie Zuid-Holland. Aanleidingen voor de studie zijn de groeiende belangstelling voor SMR's in Nederland en Europa en een motie van de Rotterdamse gemeenteraad uit 2025 om te komen tot een Rotterdamse Nucleaire Industrieagenda.

SMR's worden steeds vaker gezien als onderdeel van toekomstige CO₂-arme energiesystemen, onder meer voor elektriciteitsopwekking, industriële warmte, waterstofproductie en op termijn maritieme toepassingen. Door hun modulaire en deels geprefabriceerde karakter stellen zij tegelijkertijd nieuwe eisen aan productie, logistiek en integratie. Daardoor kunnen havens uitgroeien tot strategische knooppunten voor de toekomstige uitrol van SMR's.

De SMR-markt bevindt zich nog in een vroeg commercieel ontwikkelingsstadium. Wereldwijd zijn bijna honderd SMR-concepten in ontwikkeling, maar slechts een klein aantal is operationeel, in aanbouw of ver gevorderd in de regulatoire beoordeling. De toeleveringsketen is daardoor nog open en volop in ontwikkeling, wat kansen biedt voor nieuwe toetreders. Dit *window of opportunity* is echter tijdgebonden en technologieafhankelijk. De eerste landgebonden SMR's worden in Europa rond 2030 verwacht, terwijl commerciële toepassingen in Nederland waarschijnlijk pas eind jaren 2030 of begin jaren 2040 volgen. Offshore- en maritieme SMR's zullen naar verwachting later komen, door hun lagere technologische volwassenheid en aanvullende regelgevende uitdagingen.

Tegen deze achtergrond concludeert de studie dat de haven van Rotterdam een sterke uitgangspositie heeft om zich te positioneren in de opkomende internationale SMR-toeleveringsketen. Die positie rust op een omvangrijk industrieel ecosysteem, sterke logistieke capaciteiten, maritieme expertise en een strategische ligging met goede verbindingen naar het Europese achterland. In totaal zijn 92 bedrijven in of nabij de haven geïdentificeerd als mogelijk relevant voor deze toeleveringsketen. Zij zijn vooral actief in transport en logistiek, zwaar transport, mechanische en elektrische systemen, industriële dienstverlening, gespecialiseerde componenten en geïntegreerde modules. De grootste kansen liggen naar verwachting in niet-nucleaire componenten en diensten, omdat nucleair-specifieke capaciteiten in de haven momenteel nog beperkt zijn.

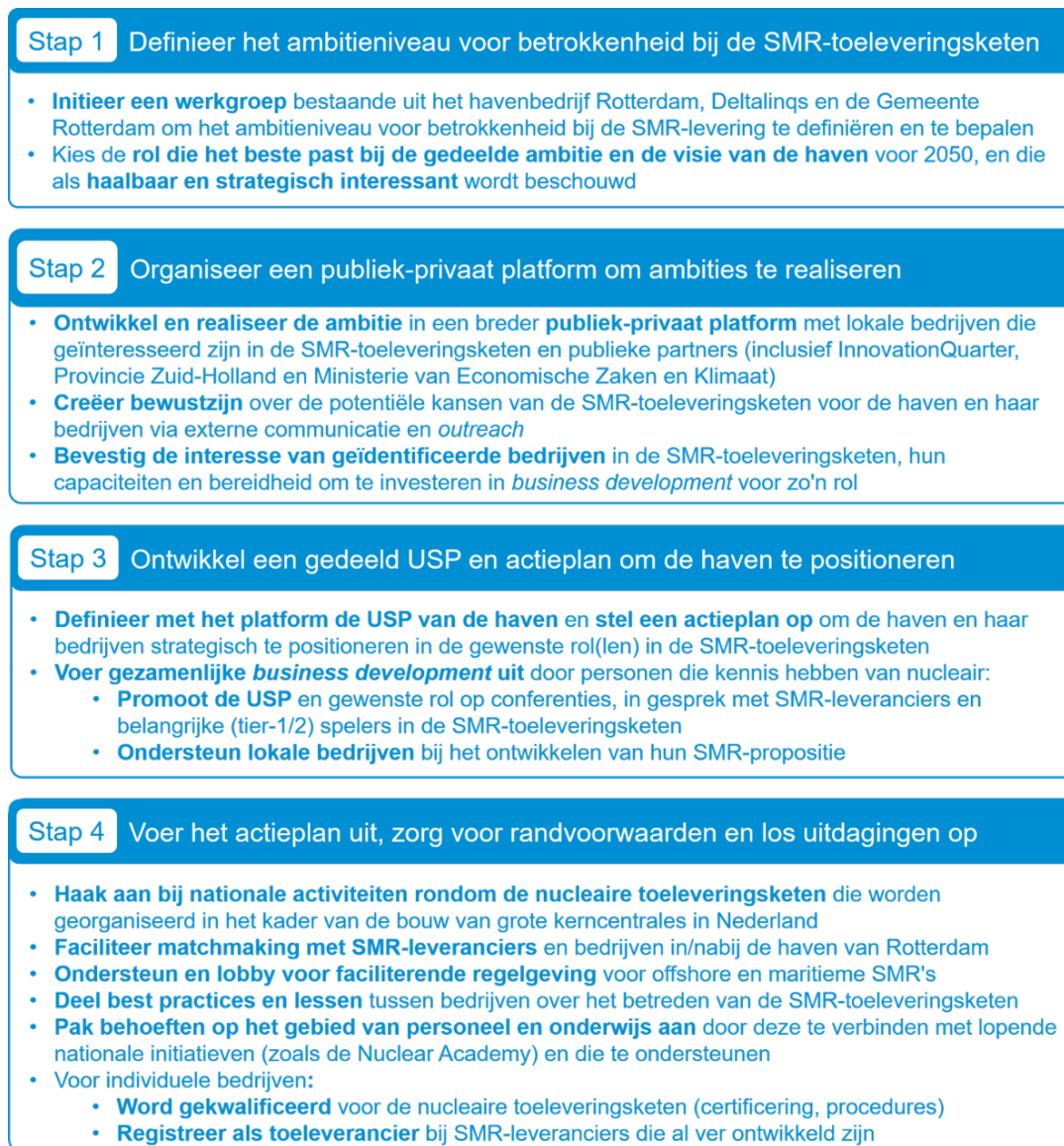
Voor landgebonden SMR's kan de haven een rol spelen in transport en logistiek, de levering van componenten en specifieke bouwactiviteiten, vooral wanneer SMR's in of nabij de haven of elders in Nederland worden gerealiseerd. Belanghebbenden benadrukken daarnaast dat landgebonden SMR's kunnen bijdragen aan de industriële verduurzamingsambities van de haven via de productie van elektriciteit, warmte en waterstof.

Voor offshore en maritieme SMR's lijkt de haven eveneens goed gepositioneerd, dankzij het bestaande offshore- en maritieme industriële ecosysteem. Mogelijke toekomstige rollen zijn verschillende niveaus van onderhoudsactiviteiten of ondersteuning voor nucleair aangedreven schepen en nucleaire pontons. Deze kansen worden echter vooral op langere termijn verwacht, vanwege de lagere technologische rijpheid van offshore-SMR's en de noodzaak van verdere ontwikkeling van regelgeving.

De studie onderscheidt vier mogelijke strategische rollen voor de haven van Rotterdam binnen de SMR-toeleveringsketen, oplopend van een lager naar een hoger ambitieniveau: (1) logistiek en transitknooppunt voor SMR-componenten en mogelijk nucleaire materialen; (2) industrieel ecosysteem voor de bouw en integratie van SMR-modules en componenten; (3) strategische Europese nucleaire haven voor maritieme routes en nucleair aangedreven vaartuigen; en (4) vestigingslocatie voor nucleair gerelateerde industriële activiteiten op het gebied van nucleaire brandstof, onderhoud van SMR's en radioactief afvalbeheer. Deze rollen verschillen in investeringsbehoefte, complexiteit en regelgeving. Ook combinaties van rollen zijn op termijn denkbaar.

Om deze kansen te benutten, adviseert de studie dat de haven van Rotterdam nu al proactief positie kiest. Daarvoor wordt een aanpak in vier stappen voorgesteld, weergegeven in de figuur op de (volgende pagina). Eerst moeten de haven en haar belanghebbenden het gewenste ambitieniveau en de beoogde strategische rol bepalen, in lijn met de langetermijnvisie van de Rotterdamse haven voor 2050. Vervolgens is een publiek-privaat samenwerkingsplatform nodig om belanghebbenden op één lijn te krijgen, bewustwording te vergroten en geïnteresseerde bedrijven te mobiliseren. Daarna moet deze samenwerking een gedeeld *unique selling point (USP)* en een actieplan ontwikkelen om de haven en haar bedrijven binnen de SMR-toeleveringsketen te positioneren. Tot slot moet dit actieplan worden uitgevoerd via gerichte maatregelen, zoals het matchen van lokale bedrijven met SMR-leveranciers, deelname aan nationale initiatieven rond de nucleaire toeleveringsketen, ondersteuning van talentontwikkeling en kwalificatie van personeel, en het bevorderen van werkbare regelgeving, met name voor maritieme SMR's.

De studie concludeert dat de haven van Rotterdam goed gepositioneerd is om kansen in de opkomende SMR-toeleveringsketen te benutten, vooral op het gebied van logistiek, industriële integratie en maritieme activiteiten. Succes hangt daarbij echter af van tijdige strategische keuzes, gecoördineerde publiek-private samenwerking en het vermogen om nucleaire capaciteiten stapsgewijs op te bouwen in de snel veranderende en concurrerende internationale markt voor SMR's.



Figuur 2: Samenvattend overzicht van de vier stappen en bijbehorende acties om de haven van Rotterdam te positioneren en voor te bereiden voor de gewenste rol in de toeleveringsketen voor SMR's

Abbreviations

AMR	Advanced Modular Reactor(s)
ANVS	Dutch Authority for Nuclear Safety and Radiation Protection (Autoriteit Nucleaire Veiligheid en Stralingsbescherming)
ARDP	Advanced Reactor Demonstration Program (U.S. Department of Energy)
BWR	Boiling Water Reactor
COVRA	Dutch Central Organisation for Radioactive Waste (Centrale Organisatie Voor Radioactief Afval)
EPC	Engineering, Procurement and Construction
EU	European Union
FOAK	First-Of-A-Kind
FPU	Floating Power Unit
GDA	Generic Design Assessment (United Kingdom)
Gen	Generation (e.g., Gen III/III+, Gen IV)
GIF	Generation IV International Forum
GSR	General Safety Requirements (IAEA safety standards series)
GW	Gigawatt
HALEU	High-Assay Low-Enriched Uranium
HTGR	High-Temperature Gas-Cooled Reactor
HTR-PM	High-Temperature Reactor – Pebble-bed Module (China demonstration project)
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
IEA	International Energy Agency
ISO	International Organization for Standardization
ITNS	Important To Nuclear Safety
JER	Joint Early Review
LEU	Low-Enriched Uranium

LFR	Lead-cooled Fast Reactor
LMFR	Liquid Metal Fast Reactor
LWR	Light Water Reactor
LWR-SMR	Light-Water Reactor Small Modular Reactor
MWe / MW(e)	Megawatt electric (electrical output)
MSR	Molten Salt Reactor
MSR-SMR	Molten Salt Reactor Small Modular Reactor
MOX	Mixed Oxide (fuel)
NEA	Nuclear Energy Agency (OECD NEA)
NPP	Nuclear Power Plant
NQA	Nuclear Quality Assurance (as in ASME NQA-1)
OECD	Organisation for Economic Co-operation and Development
OSGE	ORLEN Synthos Green Energy
PWR	Pressurised Water Reactor
QA	Quality Assurance
QAP	Quality Assurance Program
QMS	Quality Management System
R&D	Research and Development
SFR	Sodium-cooled Fast Reactor
SMR	Small Modular Reactor
TL	Transport & Logistics
TNO	Netherlands Organisation for Applied Scientific Research
TRISO	TRI-structural ISOtropic (particle fuel)
UK	United Kingdom
U.S.	United States

Introduction

1.1 About this report

1.1.1 Context of the study

This study was conducted by Tractebel Engineering and Technopolis Group for a consortium of SmartPort, Deltalinqs, Port of Rotterdam, the Municipality of Rotterdam and the Province of South-Holland. The consortium is interested in better understanding the emerging opportunities related to Small Modular Reactors (SMRs) for the port of Rotterdam and the companies in or near the port. With this study the consortium proactively prepares for these emerging opportunities, as the interest in SMRs continues to grow in the Netherlands and across Europe.

SMRs are increasingly considered as part of future low-carbon energy systems, with potential applications ranging from industrial energy supply and heat production to hydrogen generation and longer-term maritime use. The modular and partially prefabricated nature of SMRs implies a strong reliance on industrial manufacturing and logistics chains, positioning ports as potential strategic hubs. At the same time, the port of Rotterdam hosts a broad industrial ecosystem that could participate in different segments of the SMR supply chain.

At the regional level, political and institutional interest in nuclear energy is increasing, supported by recent municipal initiatives and stakeholder engagement with knowledge institutions. This study addresses the current lack of clarity regarding the role of ports in the SMR supply chain, and specifically the potential of the port of Rotterdam and its industry, and represents a first step toward supporting the Rotterdam Nuclear Industrial Agenda. This agenda stems from two resolutions passed by the City Council of Rotterdam in 2025.

From the council resolution “SMRs, da’s pas gers” of 5 June 2025: the municipal executive is requested to “develop a Rotterdam Nuclear Industrial Agenda aimed at realisation [of SMRs] before 2035 in collaboration with the Port Agency, Deltalinqs, the Province of South Holland and other relevant partners”. The quantitative assumptions used in this study are intended as indicative inputs and starting points for analysis, recognising that SMR markets and technology developments remain dynamic.

1.1.2 Objectives of the study

The objectives of the study are to provide insights in the emerging SMR supply chain and to assess the potential of the port of Rotterdam and its companies in this supply chain. The study recommends actions that the port and its stakeholders can take to capture the identified potential roles in the SMR supply chain.

The study’s main questions are:

- To what extent can the port of Rotterdam play a role in the future supply chain of SMRs?
- What are the potential roles that the port of Rotterdam could assume within this supply chain?
- How can the port of Rotterdam position and prepare itself to effectively fulfil these roles?

More detailed research questions are listed in Appendix A: Methodology.

The study is geographically scoped to the area of the port of Rotterdam and its direct surroundings. The study explores the potential of the port as a logistical hub and of the companies located in the port of Rotterdam for playing a role in the future supply chain for SMRs in relation to SMR modules/components and handling of SMR fuel/waste.

1.1.3 Reading guide

This report is structured in four chapters. This first chapter introduces the study and introduces SMRs, the different types of SMRs and the potential and developments in SMRs in the Netherlands and Europe. The second chapter introduces the SMR supply chain and explains the structure, actors and differences in these supply chains, as well the phases of SMR construction. This chapter serves to introduce the key frameworks that are used for the analysis in chapter 3. The third chapter analyses the potential role of the port of Rotterdam in the SMR supply chain, providing an assessment of the positioning of identified relevant local companies in the SMR supply chain and phases, as well as the role that the port could play in the SMR supply chain. The final chapter presents the conclusions and recommendations based on the analysis and suggests potential actions for the port and its stakeholders to take to position themselves in the SMR supply chain.

1.2 Small Modular Reactors (SMRs)

1.2.1 Introduction

According to the International Atomic Energy Agency (IAEA), Small Modular Reactors (SMRs) are advanced nuclear reactors with a capacity typically up to 300 MW(e), whose systems and components can be factory-fabricated as modules. This modular approach enhances transportability and aims to reduce on-site construction time and overall project costs.

SMRs are expected to provide flexible power generation solutions for a broader range of users and applications. They can be deployed either as single-unit installations or as multi-module plants, and they offer the possibility of integration with alternative energy sources, including renewables.

While the 300 MW(e) threshold is commonly used as a reference, there are designs with higher power outputs that are still often categorised as SMRs. This is typically due to their advanced safety features, modularisation strategy, and deployment model, which align with the core characteristics associated with SMR technology.

Small Modular Reactors encompass a broad and diverse range of technologies, and they can be classified in several different ways – for example by coolant type, power range, neutron spectrum¹, fuel cycle strategy², or intended application.

For the purpose of this report, we focus on the four principal technology families that currently structure most of the global SMR landscape. Section 1.2.3 explains the following categories:

- Light Water Reactors (LWRs),
- High-Temperature Gas-Cooled Reactors (HTGRs),
- Liquid Metal Fast Reactors (LMFRs), and
- Molten Salt Reactors (MSRs).

1 Some reactors use slow (thermal) neutrons, which are easier to control and are common in today's nuclear plants. Others use fast neutrons, which move at higher energy and can extract more energy from the fuel or even help reuse certain nuclear materials.

2 In an open fuel cycle, fuel is used once and then stored as waste. In a closed fuel cycle, some of the used fuel is recycled and reused to produce more energy.

These technologies also fall within the broader classification of **third generation (Gen III/III+)** and **fourth generation (Gen IV)** nuclear systems, which reflect different levels of technological maturity, safety philosophy, and fuel cycle strategy.

Applications

Several SMR concepts are designed to deliver multiple energy services, in contrast to conventional nuclear power plants that primarily dedicated to electricity generation. Beyond power production, SMRs may support:

- High-temperature heat;
- for industrial processes;
- hydrogen production;
- synthetic fuels and e-fuels;
- Steam supply;
- Cogeneration;
- Maritime propulsion.

This multi-product capability could be relevant in energy-intensive industrial environments where electricity, heat, and chemical feedstocks are closely interconnected. Depending on technical and economic feasibility, SMRs may contribute to the decarbonisation of both power and process heat demand.

Figure 3 illustrates the relative complexity of integrating SMRs with different industrial sectors, based on both the required process temperature and the ease of coupling. Industries located on the right side of the graph, such as district heating, paper production, refineries, and chemical clusters, are generally easier to integrate with nuclear systems, as they rely on lower-temperature heat and often allow direct on-site retrofit or plug-in solutions compatible with near-term LWR technologies. In contrast, industries on the left side, such as steel, cement, glass, and certain ceramics applications, require very high process temperatures and deeper reengineering of industrial processes, making integration significantly more complex and more dependent on advanced Generation IV reactor technologies. The size of the bubbles reflects the scale of potential heat demand, while the colour coding indicates the maturity level of the reactor technologies likely needed for each application.

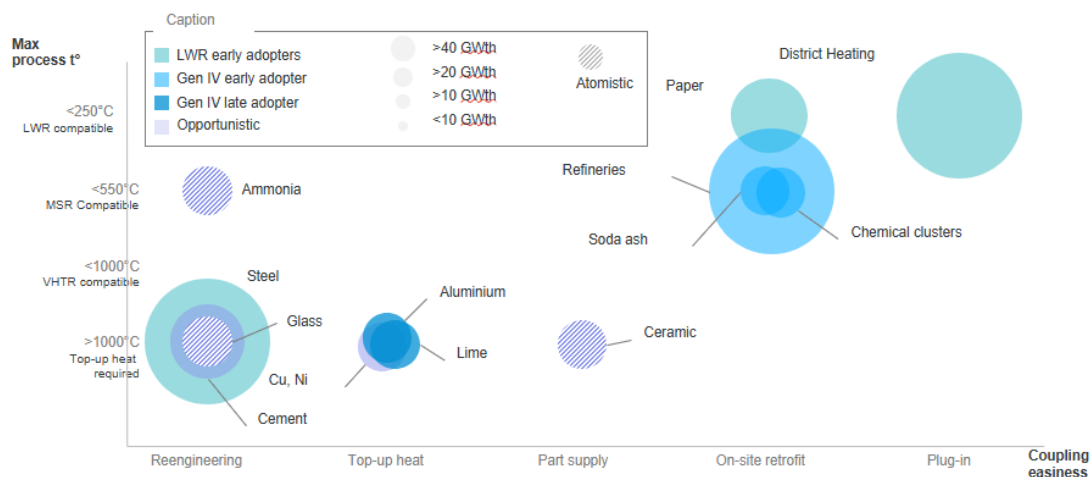


Figure 3: Industrial sectors affinity with SMR based co-generation

SMR versus conventional large-scale nuclear power plants

Aside from the application versatility and sector coupling, SMRs are often presented as offering several potential advantages compared to conventional large-scale nuclear power plants. Especially in the context of integrated low-carbon energy systems.

Modularisation and industrialisation

SMRs are intended to benefit from increased standardisation and more centralised factory-based fabrication. By transferring a significant portion of construction activities to controlled manufacturing environments, this approach aims to improve quality assurance, reduce on-site construction complexity, shorten construction timelines and enable repeatable, standardised deployment. The extent to which these advantages translate into measurable cost reductions will depend on deployment volume and the development of a sufficiently large market. While most SMR developers describe their designs as modular, the concept of modularity can refer to different approaches in practice. In some cases, the reactor itself is not modular, but the plant is constructed using modular construction techniques, as proposed by Rolls-Royce SMR. Other designs involve factory-fabricated reactor modules transported to site for installation. Certain concepts use several reactor modules connected to a single turbine, such as HTR-PM, while others rely on multiple self-contained modules, each coupled to its own turbine, as in the case of NuScale Power. Some SMR concepts also combine multiple modular approaches within the same plant design.

In principle, modularisation and factory-based construction are expected to reduce construction time, improve standardisation and contribute to lower overall project costs.

Safety characteristics

Many SMR designs incorporate intrinsic and passive safety features that rely on natural physical principles (e.g., gravity-driven cooling, natural circulation, and negative reactivity feedback) rather than active systems or operator intervention. In addition to that, several concepts operate at lower pressures and include simplified system configurations. The smaller core size and reduced radioactive inventory of certain SMR designs may influence emergency planning considerations.

Siting flexibility and infrastructure integration

SMRs have a relatively smaller physical footprint and scalable output. SMRs may therefore offer greater flexibility in site selection compared to gigawatt-scale nuclear power plants. The same may hold true for the required lower cooling water volumes, depending on reactor type and configuration. This siting flexibility allows for deployment in proximity to industrial demand centres, the integration within existing energy infrastructure, Behind-the-meter supply models and the redevelopment of brownfield or former fossil-fuel sites.

Grid compatibility and scalability

The modularisation allows for additional units that can be added gradually instead of constructing one large power plant all at once. This makes it easier to expand electricity generation step by step as demand increases, better matching new capacity with actual energy needs. SMRs may also be compatible with constrained or evolving grid environments. Certain designs are capable of load-following operation to enable grid stability, which could support electricity systems with increasing shares of variable renewable energy, subject to operational and economic conditions.

Financing and phased development

Compared to conventional large nuclear projects, SMRs involve lower capital investment per individual unit. While multi-unit configurations may result in comparable total investment levels, phased deployment could allow progressive capital allocation and staged project development. This approach may provide increased flexibility in investment planning and risk distribution, particularly in environments where energy demand evolves over time.

1.2.2 Status of SMR development and deployment

The SMR sector has moved beyond the purely conceptual design phase and entered a phase of demonstration, regulatory engagement, and early site preparation in several countries. Nevertheless, the industry remains at an early commercial stage. The current SMR market is expected to undergo significant global consolidation in the coming years. Today, around one hundred SMR developers are competing for limited financial resources, skilled workforce, testing facilities, deployment sites, fuel access, and commercial contracts. However, it is anticipated that 80–90% of these companies may not survive in the long term. Only a limited number of frontrunners, likely around 10 to 15 globally, with advanced technologies, strong organisational capabilities, and sufficient financing are expected to successfully enter the market.

Figure 4 provides an overview of the many SMR concepts currently under development. The coming decade will be decisive in determining whether SMRs transition from first-of-a-kind (FOAK) projects to replicable and economically competitive infrastructure solutions. Successful cost validation, regulatory streamlining, supply chain scaling, and market uptake will be central to this transition.

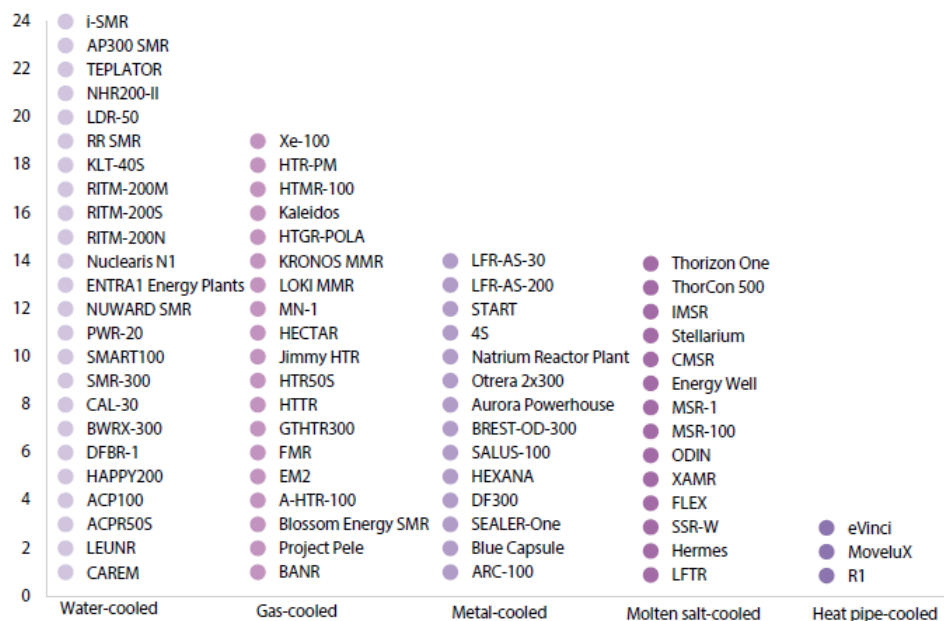


Figure 4: SMR concepts currently under development³

Global development landscape

According to the OECD's most recent SMR Dashboard⁴, there are currently 127 different SMR concepts worldwide. Of these, 99 are currently being actively developed, and 74 are being monitored by the OECD. These span both Generation III/III+ light water reactor (LWR) designs and a broad range of Generation IV advanced reactor technologies. The diversity of concepts reflects differing strategic priorities, including grid decarbonisation, industrial heat applications, hydrogen production, energy security, and long-term fuel-cycle sustainability.

The same edition of the SMR Dashboard identifies 25 projects making real progress at specific sites with commercial customers in six near-term markets. Figure 5 shows the locations of these projects around the world and lists some of the most promising SMR.

³ OECD Nuclear Energy Agency (OECD NEA)(2025). The NEA Small Modular Reactor Dashboard: Third Edition. NEA No. 7737. Paris: OECD NEA.

⁴ OECD Nuclear Energy Agency (OECD NEA)(2025). The NEA Small Modular Reactor Dashboard: Third Edition. NEA No. 7737. Paris: OECD NEA.

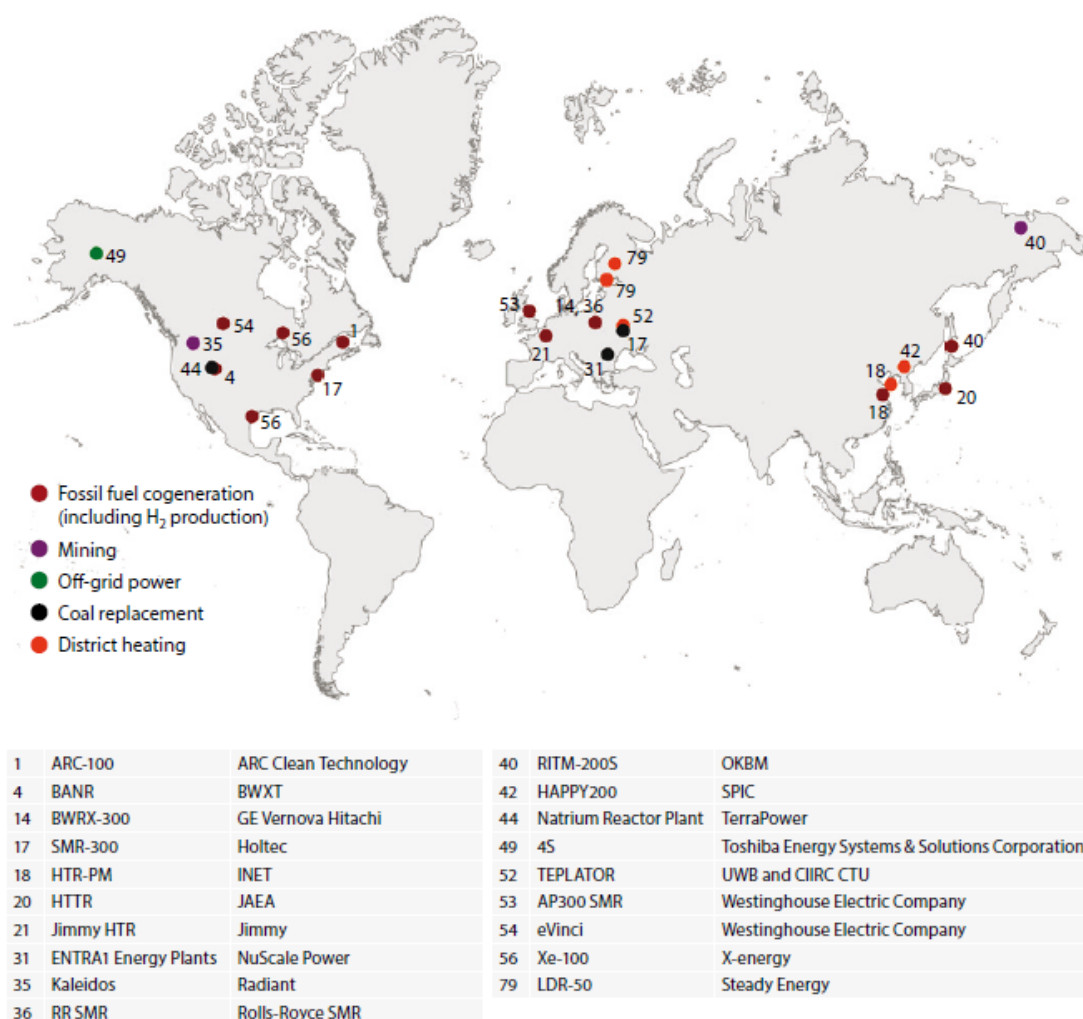


Figure 5: Map of near-term markets for SMRs⁵

Projects in operation

To date, only a limited number of SMRs are in commercial operation. The most prominent example is the floating nuclear power plant in the Russian Federation, based on two KLT-40S reactors, which has been supplying electricity and heat since 2020 (see Figure 6).

5 OECD Nuclear Energy Agency (OECD NEA) (2025). The NEA Small Modular Reactor Dashboard: Third Edition. NEA No. 7737. Paris: OECD NEA.



Figure 6: SMR Akademik Lomonosov, the floating power unit (FPU), based in Pevek, Chukotka (Russia's Far East), photo credits Rosatom.

China has also connected its high-temperature gas-cooled reactor demonstration project (HTR-PM) to the grid, representing the first commercial-scale deployment of a Generation IV-type SMR system.

Projects under construction

In North America, the BWRX-300 project at the Darlington site in Ontario is among the most advanced Western SMR deployment initiatives, with site preparation activities progressing and construction targeted later in the decade. In Poland, cooperation agreements have been signed for potential deployment of the same technology.



Figure 7: Construction site of BWRX-300, Darlington site in Ontario. Photo credits GE Vernova

In the United Kingdom, the Rolls-Royce SMR programme is progressing through regulatory review and site identification, supported by national government funding mechanisms.

In addition, advanced reactor developers such as TerraPower (Sodium sodium-cooled fast reactor) and X-energy (Xe-100 HTGR) are advancing demonstration projects in the United States, supported by federal funding programmes.

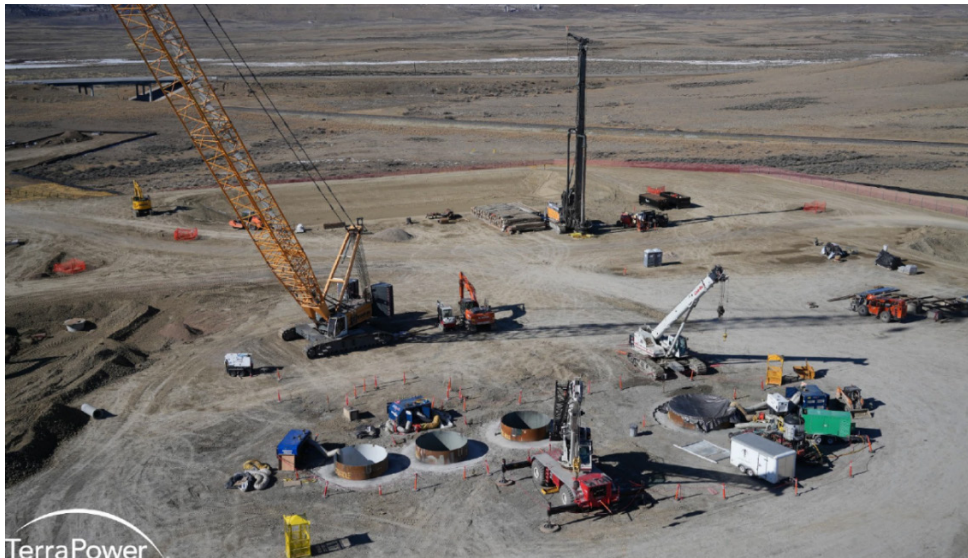


Figure 8: TerraPower construction activities in 2025 at the Kemmerer site. Photo credits TerraPower

1.2.3 Generations and technology families

The next sections describe the **third generation (Gen III/III+)** and **fourth generation (Gen IV)** nuclear systems and the main technology families, outlining their defining characteristics.

Generation III / III+

Generation III reactors are evolutionary improvements over Generation II reactors. The **Gen III reactors** were largely designed and constructed from the 1970s through the 1990s and of which many are still operating today. Generation III designs began emerging in the 1990s and early 2000s.

Generation III+ designs incorporate enhanced passive safety systems, simplified plant configurations, longer operational lifetimes (typically 60 years or more), and improved resistance to severe accidents.

Key characteristics include:

- Proven water-cooled technology - Typically based on light water reactor technology, using ordinary water as coolant and moderator, building on decades of operational experience;
- Strong reliance on passive safety features - Safety systems that function through natural physical principles (e.g., gravity, natural circulation) without requiring external power or operator action;
- Established regulatory frameworks - Designed within mature licensing regimes, with well-defined safety standards and prior certification experience in multiple countries;
- Open fuel cycle (in most cases) - A once-through fuel strategy in which spent fuel is not reprocessed but managed as waste for long-term storage and disposal;
- Incremental innovation rather than disruptive change - Evolutionary improvements over previous reactor generations, focusing on enhanced safety and reliability rather than fundamentally new reactor concepts.

Within the SMR landscape, **most Light Water SMRs** fall into the Generation III/III+ category, as they build upon conventional pressurised or boiling water reactor technology.

Generation IV

Generation IV reactors represent a more advanced and transformative class of nuclear systems. The concept was formalised under the Generation IV International Forum (GIF)⁶, with the objective of developing reactors that:

- Improve fuel use – Increase resource efficiency by extracting more energy from uranium (and potentially thorium), including through breeding (the reactor creates more usable material in the fuel) or higher burnup.
- Enable closed fuel cycles – Allow reprocessing and recycling of spent fuel to recover usable materials and reduce the need for fresh uranium.
- Reduce long-lived (>1,000 years) radioactive waste – Minimise the volume and radiotoxicity of high-level waste, particularly by the conversion of long-lived radioactive elements.
- Enhance inherent and passive safety – Rely more strongly on physical properties of materials and reactor physics (e.g., negative reactivity feedback) and passive systems to maintain safe conditions.
- Increase resistance to proliferation⁷ – Incorporate design features and fuel cycle approaches that limit diversion or misuse of nuclear materials.
- Support high-temperature industrial applications – Deliver higher outlet temperatures suitable for process heat, hydrogen production, desalination, or other industrial uses.

Generation IV nuclear systems typically use alternative coolants—such as helium gas, liquid sodium, lead, or molten salts—instead of conventional water. These materials allow the reactor to operate at higher temperatures and with different physical properties. Many Generation IV designs also operate in what is called a fast neutron spectrum, meaning the nuclear reaction is sustained by high-energy (fast) neutrons rather than slowed-down neutrons as in most current reactors. This enables more efficient use of nuclear fuel and can contribute to reducing certain types of long-lived radioactive waste.

Within the SMR domain:

- **HTGRs** are often considered part of the Gen IV family (Very High Temperature Reactor concept).
- **LMFRs** correspond to the Sodium-cooled Fast Reactor (SFR) and Lead-cooled Fast Reactor (LFR) concepts.
- **MSRs** are directly aligned with the Molten Salt Reactor concept under Gen IV.

Figure 9 provides an overview of the different technology families for SMRs.

	Light Water Reactors	High Temperature Gas-Cooled Reactors	Liquid Metal Fast Reactors	Molten Salt Reactors
	✓ Late-2020s (operating in Russia)	✓ Late-2020s (operating in China)	? Early '30s	✗ Mid-to-late 2030s
	✓ Excellent passive safety			
	? Possible load-following Low T _{out} & efficiency	✓ Load-following & high T _{out} & efficiency		
	? Not long-term waste solutions		✓ Closed fuel cycle and transmutation	✓ Prospects for waste solution
	✓ Large experience	? Some experience	? Low experience	✗ Very low experience

Figure 9: Overview of SMR technologies

6 GIF Technology Roadmap Update for Generation IV Nuclear Energy Systems (2014) Paris: OECD

7 The spread of nuclear technology, fissile material and nuclear weapons to states or non-state actors that not yet possess them.

In addition to these four technology families, smaller concepts such as heat pipe-cooled reactors, also known as microreactors, represent another emerging category. These microreactors are typically designed for very low power outputs and specialised applications.

1.2.3.1 Light-Water Reactor SMRs (LWR-SMRs)

Light Water SMRs are based on conventional water-cooled reactor technology and represent an evolutionary step from today's large nuclear power plants. Like traditional reactors, they use water both to cool the core and to control the nuclear reaction.

Among all SMR concepts, LWR-based designs are the most mature. Some units are already in operation (in Russia), while others are expected to begin operation in the late 2020s. Their main strengths include strong passive safety features, simplified system layouts, and compatibility with existing regulatory frameworks.

GE Vernova Nuclear Energy BWRX-300, a 300 MWe boiling water SMR currently progressing toward first construction at the Darlington site in Canada, with additional interest expressed for construction in Poland, the United States, and other markets. The design leverages extensive operating experience from conventional BWR technology while incorporating simplification and modularisation principles intended to reduce capital cost and construction timelines.

The Rolls-Royce SMR programme in the United Kingdom, developing a 470 MWe pressurised water reactor-based SMR, is currently undergoing the UK Generic Design Assessment (GDA). The project emphasises factory fabrication, modular construction, and strong localisation of supply chains within the UK industrial base.

Due to the physical limits of water cooling, LWR-SMRs operate at lower temperatures than some advanced reactor designs. This makes them less suitable for very high-temperature industrial processes, such as large-scale hydrogen production, petrochemical cracking, or certain chemical manufacturing processes. However, they are well suited for electricity generation, district heating networks, desalination, steam supply, and moderate-temperature industrial applications such as for the paper and pulp industry, food processing, and light industrial heat demand.

Most LWR-SMRs operate within an open fuel cycle, meaning the fuel is used once and then stored as spent fuel. They are not specifically designed to reduce long-lived radioactive waste through fuel recycling.

Overall, LWR-SMRs represent the lowest technological risk among SMR technologies and are currently the closest to large-scale commercial deployment.

1.2.3.2 High-Temperature Gas-cooled Reactor SMRs (HTGR-SMRs)

High-Temperature Gas-cooled Reactors use helium gas instead of water to cool the reactor, and graphite to control the nuclear reaction. This design allows them to operate at much higher temperatures than conventional water-cooled reactors, improving efficiency and expanding their potential industrial uses. Several demonstration and early commercial HTGR projects are expected to enter operation in the late 2020s.

The X-energy Xe-100 is a leading HTGR example. The Xe-100 is an approximately 80 MWe modular high-temperature gas-cooled reactor using TRISO particle fuel and helium coolant, designed to deliver both electricity and high-temperature industrial process heat (up to ~750–800°C). The project is supported by the U.S. Department of Energy's Advanced Reactor Demonstration Program (ARDP), with initial deployment planned at the Dow Seadrift site in Texas. X-energy is also investing in domestic TRISO fuel fabrication capacity through its subsidiary TRISO-X.

Because they can produce high-temperature heat, HTGRs are particularly attractive for energy-intensive industries. Potential applications include hydrogen production, chemical manufacturing, oil refining, steel production, cement manufacturing, and other industrial processes that require large amounts of heat rather than only electricity.

However, compared to light water reactors, HTGR technology has less long-term commercial operating experience. Most current designs are based on an open fuel cycle, meaning the fuel is used once and then stored.

Overall, HTGRs are seen as a promising option for industrial decarbonisation, offering higher-temperature capabilities than LWR-SMRs while maintaining a moderate level of technological and regulatory risk compared to more advanced reactor concepts.

1.2.3.3 Liquid Metal Fast Reactor SMRs (LMFR-SMRs)

Liquid Metal Fast Reactors are a type of advanced nuclear reactor that use liquid metals, such as sodium or lead, instead of water to cool the reactor. They also use a different type of neutron energy (fast neutrons), which allows them to extract more energy from the same amount of nuclear fuel.

Fast reactors have been built and operated in the past, but there has been limited recent experience in commercial operation. New LMFR designs are currently under development, with some projects aiming for deployment in the early 2030s.

The TerraPower Natrium™ reactor is among the most prominent LMFR projects globally. It combines a 345 MWe sodium-cooled fast reactor with an integrated molten salt energy storage system, allowing flexible output up to 500 MWe to support grid balancing in high-renewables systems. The project is advancing in Wyoming under U.S. federal cost-sharing arrangements through the ARDP programme. Licensing engagement with the U.S. Nuclear Regulatory Commission is ongoing.

Hexana is developing a compact sodium-cooled fast reactor concept (in the 160 Mwe range) aimed primarily at industrial heat and hydrogen production. The company is positioning its design within the French nuclear innovation ecosystem and engaging in early-stage regulatory discussions. The project remains in conceptual and pre-licensing phases, with supply-chain partnerships still under structuring.

Unlike most conventional reactors, they can potentially reuse part of the material found in spent nuclear fuel. This means that some of the long-lived radioactive elements normally considered waste can be transformed into useful energy. As a result, LMFRs could reduce both the volume and the long-term hazard of nuclear waste.

Because they can make better use of fuel and potentially reduce long-term waste, LMFRs are seen as promising for long-term sustainability. However, they are technically more complex and face greater regulatory challenges compared to more conventional small modular reactors based on light-water technology.

1.2.3.4 Molten Salt Reactor SMRs (MSR-SMRs)

Molten Salt Reactors are an advanced type of nuclear reactor that use a special liquid salt instead of water to cool the system. These reactors operate at very high temperatures, which can make them more efficient at producing electricity and industrial heat.

MSRs are considered promising because they may offer new ways to manage nuclear waste and make better use of fuel. Some designs could potentially reduce certain long-lived radioactive materials. In addition, the physical properties of the liquid salt can contribute to built-in safety features – for example, in certain situations, the fuel can naturally cool down without relying heavily on mechanical systems.

However, MSRs are still at an early stage of development. Very few have been operated, and most designs are still being tested or refined. Large-scale commercial deployment is generally expected no earlier than the mid-to-late 2030s.

Thorizon's Thorizon One concept represents European MSR development. The design is a molten salt reactor in the ~100 MWe class using a cartridge-based fuel system intended to incorporate recycled nuclear materials from spent fuel streams. Thorizon is progressing through developing strategic industrial partnerships in France and the Netherlands.

For these reasons, MSRs are seen as highly innovative and potentially transformative, but they also involve more technical uncertainty and regulatory challenges compared to more established reactor technologies.

Comparative perspective

In summary, the four SMR technology families can be differentiated along two main axes: technological maturity and long-term strategic potential (see Figure 10).

- LWR-SMRs are the most mature and closest to commercial deployment.
- HTGRs provide high-temperature capabilities suitable for industrial applications, such as hydrogen production, chemical manufacturing, or supplying heat to heavy industries.
- LMFRs enable closed fuel cycle strategies and improved fuel utilisation, reducing the amount of long-lived radioactive waste.
- MSRs represent a more innovative but less mature technological pathway.



Figure 10: Positioning of SMR technologies over the axes strategic potential and technological maturity

Each category may therefore play a complementary role in future nuclear energy systems, depending on deployment timelines, regulatory developments, and specific end-user requirements.

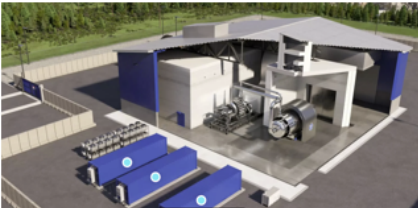
1.2.4 Illustrative examples of inland and maritime SMR concepts

Building on the technology and generation overview presented in the previous sections, this section provides illustrative examples of both inland (Figure 11) and maritime (Figure 12) SMR concepts currently under development worldwide.

These examples highlight the diversity of approaches being pursued across Generation III and Generation IV technologies, as well as the wide range of targeted applications, from baseload electricity generation and industrial heat supply to offshore energy hubs and maritime propulsion. They also illustrate the broad spectrum of reactor sizes, deployment models and modularity strategies currently proposed by developers, reflecting the evolving and still highly dynamic nature of the global SMR landscape.

Figure 11 and Figure 12 additionally provide indicative timelines for first-of-a-kind (FOAK) projects and potential commercial deployment, based on publicly available vendor information and current industry expectations.

Generation 3 (examples)

Large SMRs (> 250 MWe)		Micro SMRs (< 50 MWe)	
			
Examples	- Rolls-Royce – RR SMR 470 MWe - GE Hitachi – BWRX-300 300 MWe - Westinghouse – AP300 300 MWe - Nuward – Nuward SMR 2 x 200 MWe - NuScale – 4NPM 4 x 77 MWe - Holtec – SMR-300 2 x 320 MWe - KHNP – i-SMR 4 x 170 MWe	For district heating - Steady Energy 50 MWth - Calogena 30 MWth	Thermal power
Applications	- Baseload electricity - Some load following (down to 50%) - Also for cogeneration, hydrogen production and/or district heating	- Small-scale electricity (behind the meter) - District heating only	
When?	- First-of-a-kinds (FOAKs) 2030-2032 - Commercial deployment in NL after 2035, more likely 2040	- FOAKs 2032-2035 - Commercial deployment in NL after 2040	

Generation 4 (examples)

Large SMRs (> 250 MWe)		Small & micro SMRs (< 250 MWe)	
			
Examples	- X-Energy – Xe-100 4 x 80 MWe - Newcleo – LFR-AS-200 2 x 200 MWe - Terrestrial – IMSR400 2 x 195 MWe - Terrapower – Sodium Reactor 335 MWe	- Kairos Power – KP-FHR 2 x 75 MWe - Thorizon – Thorizon One 100 MWe - Oklo 75 MWe - Hexana 50 MWe - Copenhagen Atomics 40 MWe - Westinghouse - eVinci 5 MWe	
Applications	- Electricity, cogeneration, hydrogen - More possibilities for heat storage and load following - High temperature (350-600+°C) steam	- Electricity, cogeneration, hydrogen - More possibilities for heat storage and load following - High temperature (350-600+°C) steam	
When?	- FOAKs 2031-2035 - Commercial deployment in NL after 2037	- FOAKs 2031-2035 - Commercial deployment in NL after 2037	

Figure 11: Representative Generation III and IV Inland SMR Concepts

Generation 3 (examples)

Floating Nuclear Power Plants Large SMRs (> 100 MWe)		Floating Nuclear Power Plants Small SMRs (< 100 MWe)	
 ACP100S marine nuclear power platform			
<i>Examples</i>	• VBER-300 (Russia) 325 MWe • ACP100S (China) 125 MWe	• KTL – 40S (Russia) 2x35 MWe • RITM – 200M (Russia) 50 MWe • BANDI (Korea) 60 MWe • ABV- 6E (Russia) 9 MWe	
<i>Applications</i>	• Coastal electricity supply • Industrial heat & cogeneration • Desalination • Marine nuclear propulsion	• Remote regions • Ports & industrial hubs • Offshore support vessels • Icebreakers	
<i>When?</i>	• FOAKs 2030–2035 • Commercial deployment after 2035	• KLT-40S already in operation • FOAKs during 2030s	

Generation 4 (examples)

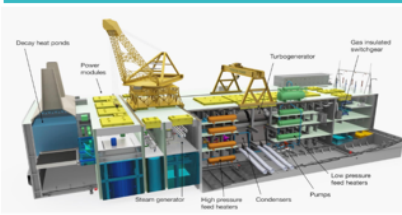
Floating Nuclear Power Plants Large SMRs (> 100-150 MWe)		Nuclear Civil Propulsion Small SMRs (< 100-150 MWe)	
			
<i>Examples</i>	• ThorCon (USA) 2x250 MWe • Saltfoss (Denmark) 200 MWe • SMART 100 (South Korea) 100 MWe	• Allseas (Netherlands) 25 MWe	
<i>Applications</i>	• Offshore energy hubs • Hydrogen & e-fuels • Large maritime & industrial applications	• Offshore platforms • Maritime auxiliary power • Nuclear-powered commercial shipping	
<i>When?</i>	• FOAKs 2032–2038	• FOAKs 2030–2037 • Wider deployment after 2040	

Figure 12: Representative Generation III and IV Maritime SMR Concepts

1.2.5 Potential of SMRs for the Netherlands and Europe

1.2.5.1 Potential and developments in the Netherlands

In the Netherlands, the potential role of Small Modular Reactors (SMRs) is increasingly being assessed within long-term energy system modelling and industrial decarbonisation strategies. The interest in SMRs is growing within the broader context of long-term energy system planning and industrial decarbonisation.

The relevance of SMRs in the Dutch context is closely linked to:

- Concentrated industrial heat demand in major industrial clusters
- Ambitions for large-scale hydrogen production
- Increasing electrification of industrial processes
- Grid congestion constraints in certain regions
- The progressive phase-out of fossil-based industrial heat sources

A recent study by TNO examined the role SMRs could play in achieving national climate neutrality by 2050.⁸ Depending on assumptions regarding industrial heat demand, electrification pathways, hydrogen production, and system integration, the modelling indicates that deployment ranging from **several units up to approximately 10–13 SMRs by 2050** could contribute to a cost-effective net-zero trajectory in the Netherlands. The upper end of this range is associated with scenarios in which SMRs are used not only for electricity generation but also to supply industrial process heat and support hydrogen production at scale. In more moderate scenarios, the required number of units would be lower.

It should be noted that these figures are derived from scenario-based modelling and do not constitute policy commitments. The actual deployment level would depend on regulatory feasibility under Dutch nuclear legislation, economic competitiveness relative to alternative decarbonisation technologies, public acceptance, financing conditions, and integration into national infrastructure planning.

Policy developments

At present, the Dutch approach remains largely exploratory, and no dedicated SMR deployment programme or formal vendor selection process has been launched. However, the newly installed government has set ambitions to build four new nuclear reactors, which could explicitly include SMRs as part of the future nuclear energy mix. In addition, a market consultation on the financing of SMRs has been started in June 2026⁹. The realisation of such ambitions will depend on regulatory feasibility under Dutch nuclear legislation, economic competitiveness, financing frameworks, public acceptance, and alignment with national energy and climate strategies.

In October 2025, the ministry of Climate and Green Growth shared their SMR Strategy. This strategy sets out the position of the Dutch government on SMRs. Even though the Dutch provinces are responsible for decisions on local SMRs, the national government has chosen to take the lead in the first SMR project in the Netherlands. This allows to overcome initial bottlenecks and should help provinces in subsequent SMR projects (for which they are the competent authorities).

The strategy describes four different areas where SMRs are considered most relevant and has the highest potential for the Netherlands according to the Dutch government:

1. Energy production within the national energy system;
2. Applied within industrial clusters (especially using heat);
3. Small-scale SMRs for so-called cluster 6 companies (i.e. large regional industrial companies outside of the main five industrial clusters);
4. Innovation projects (esp. Gen IV reactors or AMRs).

⁸ TNO (2024). Small Modular Reactors in the Dutch Energy System (study summary and supporting materials). The Hague: TNO.

⁹ See: <https://www.overkernenergie.nl/actueel/nieuws/2026/04/16/oproep-aan-bedrijven-marktconsultatie-over-financiering-kleine-modulaire-kernreactoren-smrs>—call-market-consultation-on-financing-small-modular-reactors-smrs

There is a strong interest in SMRs in the Netherlands, especially at regional level. The national government is not funding SMR initiatives and leaves the initiative for SMRs with provinces. Several provinces and municipalities in the Netherlands are exploring or have been exploring the potential of SMRs in their region. One municipality, Opmeer, has the concrete ambition to have an SMR constructed in its municipality between 2035-3040 and is working with Allseas to explore whether its first of a kind SMR can be constructed in Opmeer.¹⁰

1.2.5.2 Potential and developments in Europe

Across Europe, SMRs are moving from “concept interest” to structured policy initiatives, regulatory engagement, and early project development, although commercial deployment is still expected mainly in the 2030s. The European outlook is shaped by:

- I EU-level coordination to build an enabling ecosystem and
- II a growing set of national programmes and bilateral partnerships.

The IEA sees demand for clean dispatchable power from the private sector as a major driver for the interest in SMRs.¹¹ Based on current plans and further modelling, the IEA expects that worldwide SMR capacity reaches 40-120 GW by 2050. Their expectation is that in the 2030s the first SMRs will be installed in the EU. The IEA’s models predict 6 GW of installed capacity of SMRs in the EU by 2040 and over 15 GW by 2050. Based on these models, the IEA expects 56 SMRs in the EU by 2040 and 101 SMRs by 2050 (see Figure 13). This suggests a clear potential for SMRs in the EU and a market for SMRs that is developing and scaling beyond 2030.

The global market size for SMR technology is estimated by the IEA to be 670 billion USD over 2024-2050 assuming a successful development path.¹² This should be considered as a 2025 estimate of the potential market size for SMR technology worldwide, as the current stage of SMR development, construction and regional differences imposes still a lot of uncertainty in SMR realisation and market size.

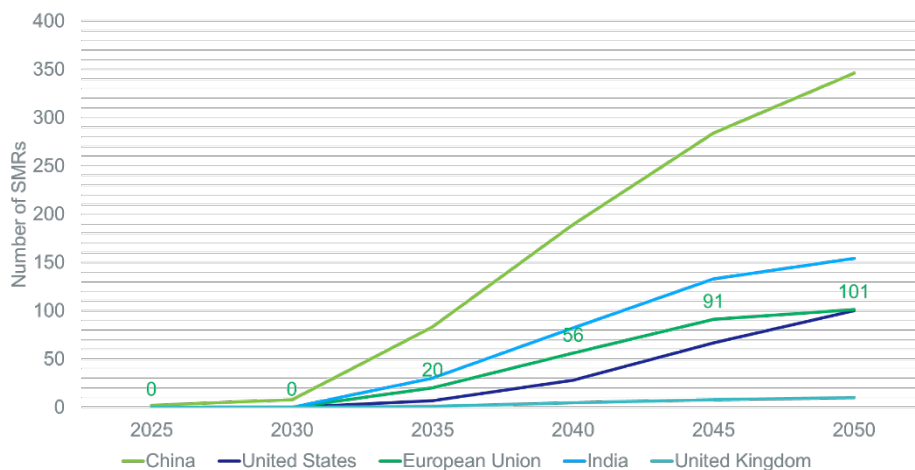


Figure 13: Number of installed SMRs projected by the Announced Pledges Scenario by the IEA (source: IEA, 2025)

10 ANP (2026). Opmeer wil eerste mini-kernreactor huisvesten. <https://www.binnenlandsbestuur.nl/ruimte-en-milieu/opmeer-wil-eerste-mini-kernreactor-huisvesten>

11 IEA (2025). The Path to a New Era for Nuclear Energy. Paris: IEA. <https://www.iea.org/reports/the-path-to-a-new-era-for-nuclear-energy>

12 IEA (2025). The Path to a New Era for Nuclear Energy. Paris: IEA. <https://www.iea.org/reports/the-path-to-a-new-era-for-nuclear-energy>

EU-level initiatives

In March 2026, the European Commission launched a strategy for the development and deployment of SMRs in Europe.¹³ In this strategy the Commission highlights the potential of SMRs to contribute to Europe's industrial competitiveness, decarbonisation, strategic autonomy and energy security goals. The strategy consists of nine coordinated actions from EU institutions, the EU's member states, industry, and research organisations. These include actions to develop a competitive European supply chain for SMRs (esp. focused manufacturing). Regional supply chains are emphasised as well as the involvement of industrial domains such as shipbuilding. Other actions focus on regulation, standards, funding and support schemes, removing barriers and international collaboration.

EU SMR Strategy: Nine Actions at a Glance



Figure 14: Visualisation of the actions under the EU SMR Strategy (source: presentation European Commission SMR IA: Present Status and Key Issues A. AL MAZOUZIEDF R&D/ SNETP-General Secretariat)

The most visible EU initiative is the European Industrial Alliance on Small Modular Reactors, launched to accelerate the development, demonstration, and first deployments of SMRs in Europe in the early 2030s, with a strong emphasis on revitalising supply chains, skills, financing conditions, and regulatory cooperation. The Alliance published its Strategic Action Plan in 2025, setting out a multi-annual work programme and concrete actions to support market readiness.

United Kingdom (deployment and regulation)

The UK has one of Europe's most advanced SMR regulatory pathways via the Generic Design Assessment (GDA). The Rolls-Royce SMR has completed GDA Step 2 and progressed into the next phase, indicating sustained regulatory engagement. In parallel, the UK government selected Rolls-Royce SMR as the preferred bidder to partner with Great British Energy – Nuclear for SMR deployment (subject to final approvals and contracting), signalling strong state-backed intent to move toward delivery in the mid-2030s.

13 EC DG Energy (2026). Strategy for the development and deployment of SMRs in Europe. https://energy.ec.europa.eu/publications/strategy-development-and-deployment-smrs-europe_en

France (design development and multi-regulator early review)

France is advancing SMR development primarily through the NUWARD programme, led by EDF, which is currently engaged in design optimisation and regulatory preparation. A notable European initiative associated with this programme is the Joint Early Review (JER) process, conducted with several European nuclear safety authorities, aimed at identifying and addressing key regulatory topics at an early stage to facilitate future licensing efficiency. More broadly, France has positioned SMRs and advanced modular reactors as part of its long-term nuclear innovation strategy under the France 2030 investment plan.

In addition to NUWARD, this framework supports several initiatives across different technological pathways, including Hexana (sodium-cooled fast reactor with cogeneration focus), Calogena (heat-dedicated small pressurised water reactor), Newcleo (lead-cooled fast reactor with closed fuel cycle ambitions), Jimmy Energy (high-temperature microreactor for industrial heat), Thorizon (molten salt reactor concept focused on recycling nuclear materials), Otrera Nuclear Energy (sodium-cooled fast modular reactors), among others. In total, eleven innovative reactor projects were selected under the national programme, reflecting France's strategy to maintain capabilities across both evolutionary SMRs and Gen. IV technologies.

Czech Republic (site-specific progress and industrial partnership)

The Czech programme is among the clearest examples of a state utility advancing toward SMR deployment. ČEZ (the Czech state-controlled energy utility company) and Rolls-Royce SMR announced a strategic partnership (including an equity stake) aimed at developing SMRs and have since signed an Early Works Agreement to start site-specific work at Temelín.

Poland (fleet ambition and site selection)

Poland is pursuing a large SMR programme via ORLEN / Synthos (OSGE) based on the BWRX-300. Recent announcements confirm site selection (Włocławek) and ongoing steps to progress environmental and siting work, supported by earlier national decisions-in-principle for multiple locations.

Romania (first-mover intent in Southeast Europe)

Romania continues to advance an SMR project at Doicești based on NuScale technology, with public reporting highlighting continued project development and investment-decision planning.

Nordics (early-stage ecosystem building)

In Northern Europe, activities are progressing through a mix of national policy work and developer/site initiatives. Sweden, for example, has several SMR-related developments (including site development efforts by private actors and broader national work on enabling new nuclear). Finland is also directly engaged at the regulatory level through participation in multi-country early review activities for NUWARD.

SMR supply chain

2.1 Structure of the SMR supply chain

In this study we structure the SMR supply chain using an industrial tier-based segmentation.

This approach reflects the hybrid nature of SMR deployment, which combines characteristics of nuclear-grade manufacturing with those of large-scale infrastructure projects. It reflects an industrial ecosystem perspective rather than a purely technical system breakdown.

While traditional nuclear analyses often segment supply chains by technical systems (e.g., nuclear island, turbine island, balance of plant), such system-based categorisation does not fully capture the industrial layering, contractual interfaces, and value-chain distribution that determine deployment performance, scalability, regional industrial participation and logistics and infrastructure integration.

This structure enables a targeted assessment of how companies based in the port of Rotterdam can integrate into the emerging SMR supply chain, whether at the level of system integration, component manufacturing, fabrication, logistics, or raw material processing. It therefore supports identification of realistic positioning opportunities and value capture potential for the regional industrial cluster.

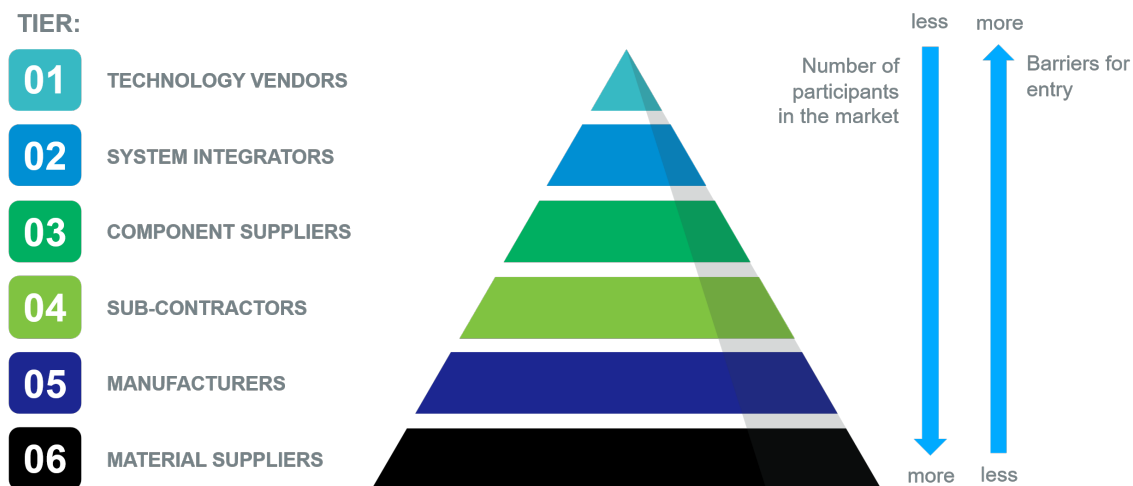


Figure 15: SMR supply chain segmentation

The segmentation adopted in this study is organised into six industrial tiers (Figure 15). The higher the tier the closer a company is to the final customer and generally the higher the value that is added. More unique products and services are generally provided at higher tiers, making the number of participants in the market smaller and the barriers to enter the market higher. At the bottom of the supply chain pyramid companies provide more generic products (or even commodities). These companies face stronger competition, as there are generally more competitors since the barriers to enter the market are lower.

The following table describes the different tiers in the pyramid.

Tier	What they do	Illustrative companies & typical scope
Tier 1: Technology Vendor	The Technology Vendor represents the design authority and intellectual property holder of the SMR technology. The Technology Vendor typically retains control over design standardisation and fleet replication strategy. This tier operates primarily within the nuclear-grade manufacturing domain. This tier is responsible for: - Reactor design and engineering - Safety case development - Licensing documentation - Configuration management - Long-term technical responsibility	Rolls-Royce SMR, Allseas, GE-Vernova, TerraPower, X-energy, Thorizon, Saltfoss
Tier 2: System Integrators	System Integrators bridge nuclear manufacturing and site-based project execution. Given the modular nature of SMRs, effective system integration is critical to maintaining schedule discipline and realising anticipated cost efficiencies. Their responsibilities typically include: Overall plant integration - Engineering, procurement and construction (EPC) coordination - Interface management between modules and civil works - Project delivery sequencing	Bechtel, Fluor Corporation, Kiewit, GE Vernova Nuclear Energy, AtkinsRealis
Tier 3: Component Suppliers (OEMs)	Component Suppliers provide the nuclear and conventional equipment necessary for plant operation. This tier includes both nuclear-qualified suppliers and conventional industrial manufacturers, depending on component classification and safety relevance. Components include: - Reactor internals - Mechanical and electrical systems - Instrumentation and control - Auxiliary and safety systems	Framatome and ENSA (Nuclear Island components, steam generators), Doosan Enerbility (reactor pressure vessels), Siemens Energy (steam turbine-generator sets when supplied as discrete equipment), GE Vernova (electrical systems), Emerson (I&C systems), Schneider Electric, Rolls-Royce Controls (I&C)
Tier 4: Sub-contractors	Subcontractors operate primarily within the infrastructure and construction domain. This tier reflects the infrastructure-project dimension of SMR deployment and plays a significant role in site-specific cost and schedule performance. Their scope typically includes: - Civil engineering works - Site preparation - Installation and assembly - Local construction services	Cavendish Nuclear (nuclear installation and maintenance), Laing O'Rourke (modular construction and civil works), BAM Infra (civil engineering), Dura Vermeer (site infrastructure and civil works)

Tier	What they do	Illustrative companies & typical scope
Tier 5: Manufacturers	Manufacturers encompass fabrication workshops and industrial facilities responsible for producing modules, subassemblies, and major components. For SMRs, this tier is strategically important due to the emphasis on factory-based fabrication and serial production. Manufacturing capability, qualification, and scalability within this tier are key determinants of fleet deployment potential.	Škoda JS, Ansaldo Nucleare, Tenaris, Saint-Gobain PAM, Vallourec (nuclear-grade piping and tubes)
Tier 6: Materials Suppliers	The Materials Suppliers tier captures upstream industrial dependencies, including: • Nuclear-grade steels and forgings • Advanced alloys • Graphite • Liquid metals or molten salts • Uranium and enrichment services	Urenco and Orano (uranium enrichment and conversion), ArcelorMittal (specialty steels), Industeel (nuclear-grade steel plates and forgings), Mersen and Tokai Carbon (nuclear-grade graphite), Heidelberg Materials and Holcim (cement and concrete)

2.2 Functional segments in the SMR supply chain

The SMR supply chain can be functionally described in five functional chains:

- **The modules chain:** covering segments related to the industrial manufacturing of components and modules to be integrated into the SMR. These segments concern generic and specialty components, parts and modules that can be supplied irrespective of the location where the SMR is being build. This provides potential for companies in the port of Rotterdam that are involved in the design, fabrication and transport/logistics of mechanical and electrical components and/or the integration of these into functional modules of SMRs.
- **The construction chain:** covering segments related to the construction of an SMR from inception to commissioning. These segments are mostly conducted on the site where the SMR is being constructed, which can for maritime SMRs also be the shipyard where the nuclear vessel/yard is being constructed. For inland SMRs these segments usually require companies that are sufficiently close to the construction site. Potential for involvement of companies in the port of Rotterdam is therefore mainly if construction takes place in or near the port.
- **The service chain:** covering services related to operational SMRs from the inspection to the maintenance of SMRs. These services are conducted on-site and may relate to the components and modules supplied in the modules chain. Many service providers are likely to be near the SMR's location, apart from specialised service providers or services delivered by the original manufacturers. Potential for the involvement of companies in the port of Rotterdam is therefore mainly for SMRs in or near the port or for those companies that have supplied components or modules to SMRs.
- **The fuel chain:** covering segments related to the production of nuclear fuel used in the SMR. This chain requires very specific nuclear expertise that is currently covered by a limited number of companies in Europe. New entrants in this chain are unlikely due to high barriers to enter these segments. Logistics and transport between these segments concern radioactive materials and therefore require specific licensing and requirements. Potential for companies in the port of Rotterdam is therefore limited to transport and logistics (including potentially support in fuel loading and additional on-site or transport security), depending on the logistic routes for the fuel – which relies on the locations of SMRs.

- **The waste chain:** covering segments related to the radioactive waste generated by the SMR. This chain is largely dependent on the fuel supplier for reprocessing and the legally appointed waste management organisation – which is in the Netherlands COVRA. Logistics and transport between these segments concern radioactive materials and therefore require specific licensing and requirements. Potential for companies in the port of Rotterdam is therefore limited to transport and logistics (including potentially support in removal of spent fuel and additional on-site or transport security), depending on the logistic routes for the fuel – which relies on the locations of SMRs.

Each of these chains provide distinct products and services for SMRs and have generally different companies involved. Between the various segments in these chains transport takes place. At the start of each chain raw materials and feedstock is required. This might provide some potential for companies in the port of Rotterdam that can deliver these materials, but as these are generally commodities, it is likely that only supply to local companies in the construction and module chain can be realistically expected. In Figure 15 the four functional chains of the SMR supply chain, with their segments, are linked. Transport and logistics between segments are indicated with TL.

2.3 Description of phases of SMR projects

Apart from the supply chain, it is also useful to consider the phasing of SMR projects. The phasing can help to understand in which phase of the development of an SMR the port of Rotterdam or its companies can be involved.

The following figure provides an overview of the different phases from start to construction of an SMR. This figure holds for inland SMRs and with some slight modification (merely in the interpretation of a phase) also for maritime SMRs. For each phase some examples of typical organisations and companies involved in the phase are provided. We have clustered these phases into a stage of preparation, a stage of manufacturing and construction and a stage of (pre)operation.

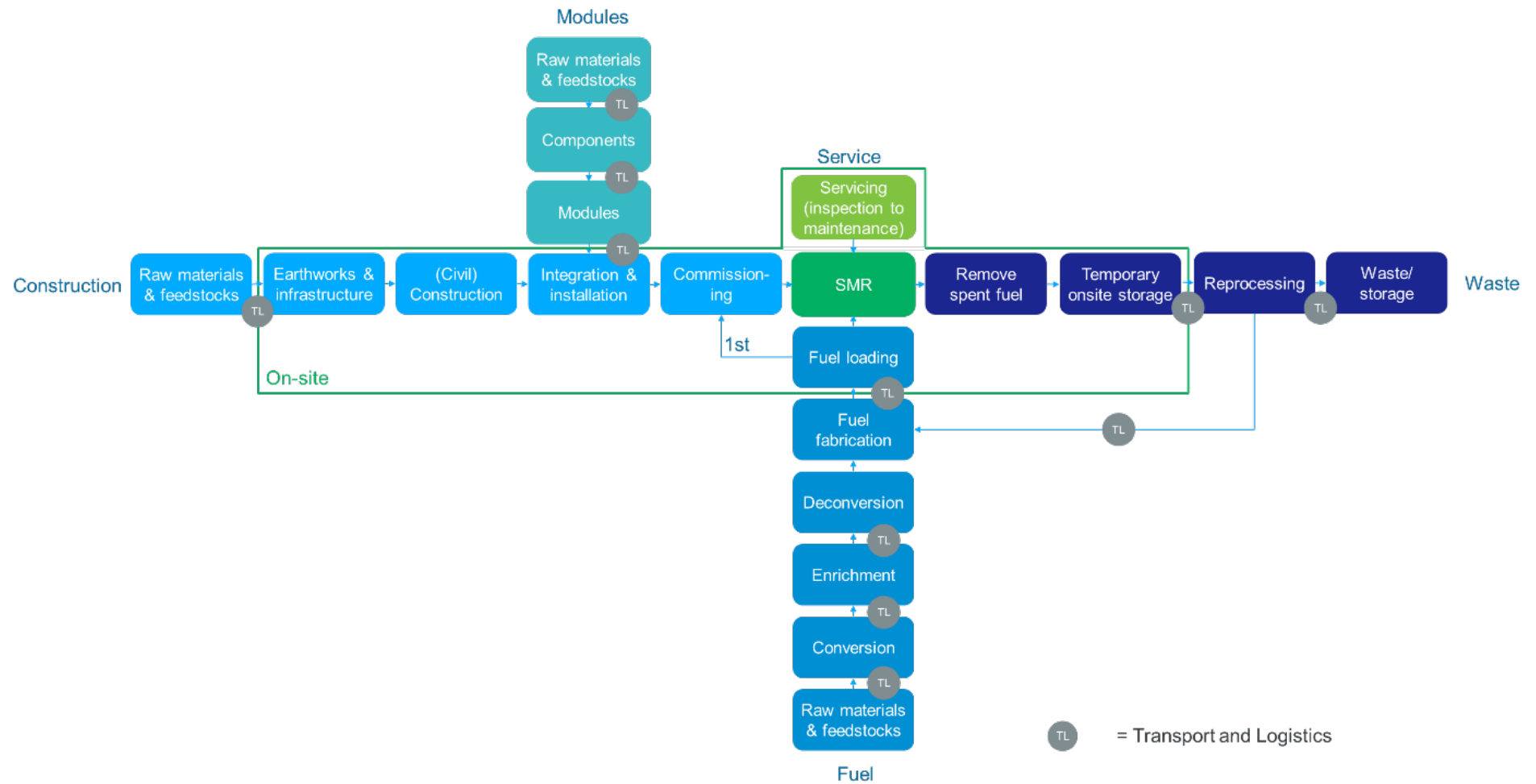


Figure 16: Functional segments of the SMR supply chain

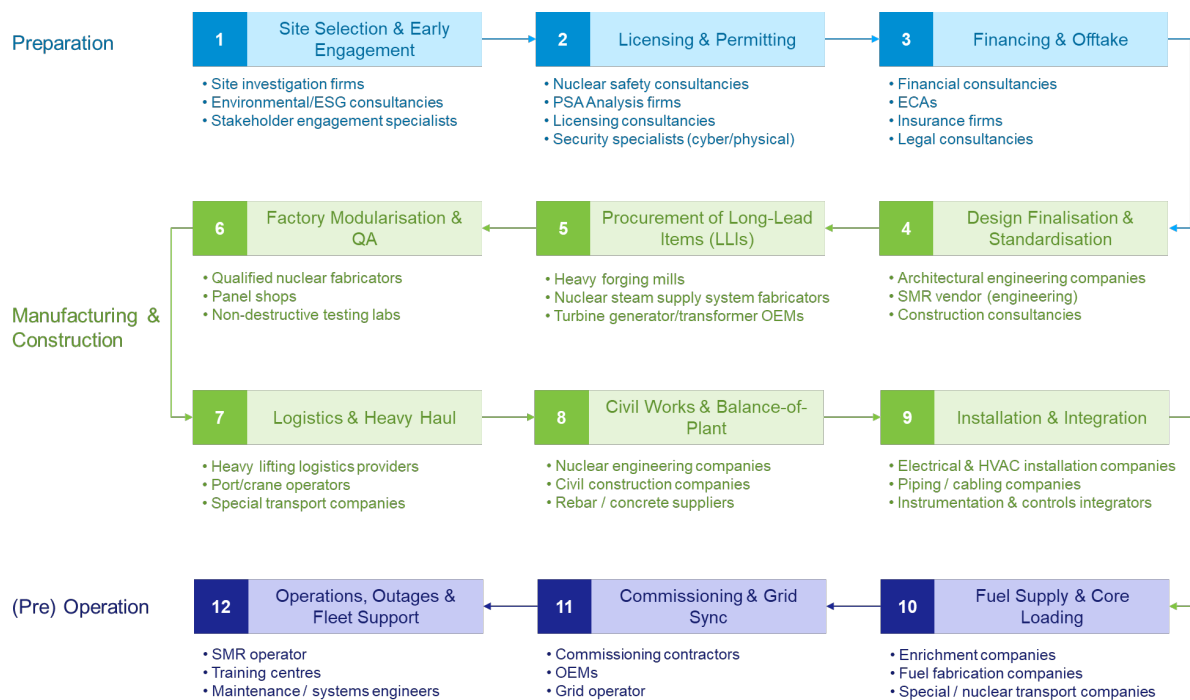


Figure 17: Phasing of SMR projects

2.3.1 Preparation

The preparation stage prepares the SMR project before production starts. The preparation stage consists of three phases:

- 1. Site Selection & Early Engagement:** in this phase a potential site for an inland SMR is investigated in terms of suitability, environment, and external hazards. Preparations also include public acceptance and engaging with relevant stakeholders.
- 2. Licensing & Permitting:** in this phase studies are conducted regarding safety, security and environment to provide required information for licensing and permitting. Interaction with the nuclear regulator (ANVS), environmental and other regulators take place to acquire licences and permits.
- 3. Financing & Offtake:** in this phase financing, contracting and insurance is arranged before the SMR project can fully kick-off.

In this stage the port of Rotterdam would only play a role as stakeholder but has no direct involvement. There is no concrete business potential for companies in the port of Rotterdam in this stage.

2.3.2 Manufacturing & Construction

The manufacturing and construction stage concerns the procurement of materials, components and services, manufacturing of parts, integration of parts and modules, logistics and construction of the SMR.

- 1. Design Finalisation & Standardisation:** in this phase the design of the SMR and its modules is finalised. In principle the design is standardised to allow production in series. Where needed site-specific changes are made to accommodate local specificities or requirements for inland SMRs, these should not concern modules, but rather the on-site construction.
- 2. Procurement of Long-Lead Items:** in this phase components with long lead-times are ordered in advance to ensure timely delivery. These concern mostly specialised, nuclear and safety-critical components at higher tiers. Generally, only a limited number of suppliers can produce these components according to the needed specifications. These include for example steam generators, nuclear valves, nuclear panels, major heat exchangers, turbine generators.

- 3. Factory Modularisation & QA:** in this phase several centralised factories produce modules for the SMR. They order components, produce parts and integrate them into the module. These modules are often designed in such a way that a module can be transported via road, rail or water. They can be taken apart to fit a sea container or standard truck. Only a few large components may require special transport.
- 4. Logistics & Heavy Haul:** in this phase components, modules and fuel are transported. It takes place throughout the manufacturing and construction phase. It includes transport over water, rail and road, heavy lifting, specialist transport, convoy escorts, storage, terminal handling, customs etc. Modules will be transported to the construction site or shipyard (for maritime SMRs), while components will be transported from suppliers to factories where the modules are produced.
- 5. Civil works & Balance-of-Plant:** in this phase the ground works, infrastructure and construction is created on-site. This is relevant for inland SMRs. It includes laying concrete foundations, buildings in which modules will be placed, local infrastructure, etc.
- 6. Installation & Integration:** in this stage the different modules are installed and integrated on-site. For maritime SMRs this can be in shipyards for barges and ships, for inland SMRs this will be at the construction site.

In this stage the port of Rotterdam could play a role as a logistics hub, but also companies in the port of Rotterdam could have potential to be a supplier in some of these phases.

2.3.3 (Pre) Operation

The (pre) operation stage concerns activities that need to be done after construction of the SMR and before operations and activities during operations.

- 1. Fuel Supply & Core Loading:** this phase includes the delivery of fabricated nuclear fuel to the SMR and the loading of fuel into the reactor core. This phase includes the secured transport of nuclear fuel and on-site safety measures.
- 2. Commissioning & Grid Sync:** this phase concerns the testing of all components and systems to ensure that the SMR operates as intended and trainings to the operational staff are finalised. During this phase criticality is established and connection to the grid is made and tested for inland SMRs or offshore barges. This should make the SMR set for safe operation.
- 3. Operations, Outages & Fleet Support:** this phase the SMR is in operation. During operation it requires maintenance, refuelling, training and inspections.

In this stage the port of Rotterdam could potentially play a minor role, very much depending on the location of the SMR. For inland SMRs located at the port or maritime SMRs constructed at the port there may be business potential for local companies to be involved.

2.4 Differences inland and maritime SMR supply chains

The distinction between inland and maritime SMR deployment is not merely a matter of location. It fundamentally affects how the supply chain is structured, where industrial value is created, how logistics are organised, and how risks are distributed. While the reactor technology may be identical in both cases, the delivery model determines whether the centre of gravity of the project lies in inland construction ecosystems or in maritime industrial hubs. The core difference between inland and maritime SMRs lies in the location of final integration and the industrial ecosystem activated. This distinction is particularly relevant when assessing positioning opportunities for port-based industrial clusters.

The following table provides an overview of the differences between inland and maritime SMR supply chains.

	Inland	Maritime
Location and Installation	Installed at land-based sites and integrated into onshore infrastructure. Final installation and system integration occur within civil structures constructed at the deployment site.	Integrated within floating or marine structures prior to deployment. Configuration shifts a larger share of fabrication and integration activities to shipyards or coastal industrial facilities.
Industrial Configuration	In inland deployment: • Reactor modules are fabricated in factories • Transport (potentially maritime for international vendors) • Inland logistics • Civil engineering and installation at site If modules are manufactured outside Europe and shipped to a European port, maritime transport becomes part of the upstream supply chain. However, the project remains structurally inland because: • Foundations, buildings, and cooling systems are constructed on land • Grid interconnection is land-based • Final integration occurs at the deployment site The industrial ecosystem activated by inland SMRs therefore includes nuclear-grade manufacturers, inland logistics providers, civil contractors, and grid infrastructure actors.	In maritime deployment: • Reactor modules are fabricated in factories • Reactor modules are integrated into marine platforms in shipyards • Mechanical and electrical systems are installed prior to deployment • Pre-commissioning can occur in controlled industrial environments This concentrates value creation in maritime industrial clusters rather than at dispersed inland sites. Ports and shipyards become central actors in: • Heavy module assembly • Marine integration • Deployment preparation • Offshore installation support
Logistics and Constraints	Inland transport constraints (road, rail, and inland waterways) influence module size and sequencing. Heavy transport permits, route planning, and dimensional limits may affect design decisions and installation strategy. Even when maritime transport is used for long-distance delivery, the final inland segment remains a structural constraint.	Sea transport removes many inland dimensional constraints. Larger integrated structures can be fabricated and transported directly to the deployment location. This reduces dependence on inland heavy transport corridors and can simplify installation sequencing.

	Inland	Maritime
Risk and Scalability	Inland SMRs retain exposure to: • Site readiness delays • Coordination between manufacturing and construction • Weather impacts on outdoor works • Site-specific permitting and stakeholder processes Although serial manufacturing improves standardisation, each site introduces variability. As a result, scalability depends not only on factory output but also on local construction and permitting performance.	Maritime projects introduce additional regulatory interfaces, including maritime authorities and coastal permitting regimes. Risk shifts from civil construction delays to marine operational factors, such as: • Weather windows for offshore installation • Mooring and anchoring operations • Marine safety compliance However, because integration occurs in controlled shipyard environments, fabrication risk may be more predictable. Maritime SMRs may benefit from greater centralisation of fabrication and integration. Standardised marine platforms and repeated shipyard processes can support fleet replication with reduced site-specific variability.
Level of establishment	The supply chain to some extent resembles the supply chain for large nuclear power plants. Some vendors have started to establish supply chains, but none of the supply chains are yet fully established.	The supply chain for maritime SMRs is not yet established. Maritime SMRs are in a lower stage of development than inland SMRs.
Potential for new entrants	Good potential for new entrants, mainly for the construction and module chains. The first is however location dependent. For the fuel and waste chains opportunities are limited, possibly only for transport and logistics.	Very good potential for new entrants as supply chain needs to be largely developed. The potential for new entrants is in the construction and module chains, again the fuel and waste chains have too high barriers for entry beyond transport and logistics.

In the box below provides a summary overview of the comparison between inland and maritime SMRs focussing on several key dimensions. It signals that the potential for the port of Rotterdam to be involved in the SMR supply chain is higher in maritime SMRs and roles that the port can play more diverse. For maritime SMRs a port provides a relevant industrial ecosystem for integration, deployment and logistics, with more activities being conducted in the port. However, maritime SMRs provide more (unexplored) regulatory challenges.

Dimension	Inland SMR	Maritime SMR
Final Integration	Land-based site	Shipyard / marine platform
Role of the Port	Logistics gateway	Integration and deployment hub
Inland Transport Dependence	High	Low
Civil Works Intensity	Significant	Limited at deployment site (integration)

Dimension	Inland SMR	Maritime SMR
Regulatory Scope	Primarily nuclear & environmental	Nuclear + maritime + coastal
Primary Risk Exposure	Construction sequencing	Marine operations
Scalability Model	Factory + site replication	Centralised fabrication replication

2.5 Supply chains of the different types of SMRs

While SMRs are often presented as a homogeneous category defined by reduced unit size and modular construction philosophy, the underlying reactor technologies drive fundamentally different supply chain configurations. The extent of industrial transformation required varies significantly across technology families. Some designs leverage decades of established nuclear manufacturing capability, while others necessitate the development of new materials ecosystems, chemical processing capacity, or advanced fuel infrastructure.

This section examines the supply chain implications of four principal SMR technology families. The analysis focuses on structural differences in industrial requirements, manufacturing constraints, fuel cycle dependencies, and scalability. The table below provides a summary overview of these supply chain dimensions before we go into further details for each of the different types of SMRs.

Dimension	LWR-SMRs	HTGR-SMRs	LMFR-SMRs	MSR-SMRs
Level of establishment	High, can rely on existing manufacturing base for large NPPs	Medium, can only partly rely on existing manufacturing base	Low, requires significant changes and additions to existing manufacturing base	Low, requires significant changes and additions to existing manufacturing base
Structural differences in industrial requirements	Low, can rely largely on existing industrial requirements	Medium, requires high-temperature materials and qualified graphite, stringent leak-tight cooling systems	High, requires different materials, including corrosive and chemically reactive liquids and industrial procedures	High, puts demanding requirements to materials and requires high-quality liquid salt production
Manufacturing constraints	Scaling nuclear-qualified manufacturing capacity	Scaling fuel fabrication and qualified materials	Development of industry capabilities for liquid materials and specialised alloys and welding procedures	Development of industry capabilities for molten salts and specialised materials and storage/conditioning infrastructure
Fuel cycle dependencies	Small, relies on existing fuel cycle	Medium, limited industrial base for TRISO fuel	Medium-high, increased fabrication and repressing capabilities required, potentially closed fuel cycle to be established	High, requires significant changes to the fuel supply chain with different materials and processes

Dimension	LWR-SMRs	HTGR-SMRs	LMFR-SMRs	MSR-SMRs
Scalability	Depends on industrial scaling, standardisation and cost/schedule benefits	Depends additionally on scaling of fuel fabrication and specialised industrial capacity for high-temperature materials	Depends additionally on fuel fabrication, fuel reprocessing and industrial capabilities for liquid and corrosion/ chemical resistant materials	Depends additionally on fuel fabrication and industrial capabilities for molten salts and high-temperature and corrosive-resistant materials
Potential for new entrants	Medium, vendors still seeking suppliers for diversification and scaling	High, less developed concept with less developed supply chain	High, less developed concept (enter at R&D stage) and supply chain, but challenging requirements	High, less developed concept (enter at R&D stage) and supply chain, but challenging requirements

1. Light-Water Reactor SMRs (LWR-SMRs)

Light-water SMRs represent the closest continuation of the existing commercial nuclear industry. These designs, whether integral pressurised water reactors or small boiling water reactors, retain the fundamental characteristics of conventional water-cooled systems. As such, their supply chains are largely rooted in the established nuclear manufacturing base.

The nuclear island components – including the reactor pressure vessel, internal structures, steam generators (in PWR variants), containment systems, and safety-class piping – are based on well-known design principles and established nuclear codes and standards. Qualified suppliers for these components already exist within the global nuclear industry, and manufacturing techniques, inspection regimes, and quality assurance processes are mature.

The fuel supply chain for LWR-based SMRs typically relies on conventional low-enriched uranium (LEU), which benefits from an extensive global infrastructure for conversion, enrichment, fabrication, transport, and licensing. This continuity significantly reduces fuel-related deployment risk compared to advanced reactor concepts requiring novel fuel forms or higher enrichment levels.

The primary transformation introduced by LWR SMRs lies not in component technology but in the manufacturing model. Modularisation shifts a substantial portion of construction work from the site to factory environments. This requires stable design configuration control, repeatable manufacturing processes, and disciplined supply chain coordination to enable serial production. Industrial constraints therefore emerge not from technological novelty but from scaling nuclear-qualified manufacturing capacity while maintaining rigorous quality standards.

Overall, LWR-based SMRs represent an evolutionary adaptation of the existing nuclear supply chain rather than a structural reconfiguration. The main challenges relate to industrial scaling, standardisation, and ensuring that modularisation achieves its intended cost and schedule benefits.

2. High-Temperature Gas-cooled Reactors SMRs (HTGR-SMRs)

High-temperature gas-cooled reactors introduce more substantial differentiation within the supply chain, particularly through their fuel form and materials requirements. Operating at significantly higher temperatures than water-cooled reactors and using helium as a coolant, HTGRs shift the industrial emphasis toward high-temperature materials and specialised fuel production.

The defining feature of HTGR technology is TRISO fuel, composed of coated fuel particles embedded within a matrix. The fabrication of TRISO fuel requires highly specialised industrial processes, including kernel production, multiple coating stages, compaction, and extensive quality assurance. Compared to conventional LWR fuel fabrication, the global industrial base for TRISO production is limited and not yet scaled for large commercial deployment. In many designs, the use of higher enrichment levels further constrains fuel supply readiness.

In addition to fuel, HTGRs rely extensively on graphite for moderation and structural purposes. This introduces a distinct materials supply chain, requiring qualified graphite manufacturing capacity and high-temperature materials testing. Helium coolant systems must meet stringent leak-tightness requirements, and high-temperature heat exchangers must withstand demanding thermal and mechanical conditions.

Unlike LWR-based SMRs, the principal supply chain constraints for HTGRs are not heavy forgings or pressure-boundary components, but rather the maturity and scalability of fuel fabrication and high-temperature materials qualification. Deployment at scale would therefore depend heavily on expanding specialised industrial capacity in these areas.

3. Liquid Metal Fast Reactor SMRs (LMFR-SMRs)

Fast reactors represent a more pronounced structural departure from conventional nuclear technology. By operating without a neutron moderator and using liquid metal coolants such as sodium or lead, these systems introduce new supply chain requirements that extend beyond the traditional light-water industrial base.

The coolant itself becomes a central supply chain consideration. Industrial-scale procurement, purification, and handling infrastructure for liquid sodium or lead must be established, alongside compatible storage and safety systems. Materials used in primary system components must be resistant to corrosion and chemical interaction with the chosen coolant. This necessitates specialised alloys, tailored welding procedures, and dedicated inspection methodologies.

Fuel cycle considerations further differentiate fast reactors. Many designs envision the use of metallic fuel or mixed-oxide (MOX) fuel, and some incorporate closed fuel cycle strategies. These approaches may require reprocessing capability, fuel recycling infrastructure, or advanced fabrication facilities that are not widely available. As a result, fuel supply chain readiness can become a strategic and regulatory issue, particularly in jurisdictions without existing fast reactor or reprocessing infrastructure.

Although fast reactors typically operate at lower pressure than water-cooled systems, reducing reliance on large pressure-boundary forgings, the broader industrial ecosystem required for coolant management, materials compatibility, and fuel cycle integration is less mature in commercial terms. Scaling fast reactor deployment would therefore require coordinated development of both manufacturing capability and regulatory familiarity.

4. Molten Salt Reactor SMRs (MSR-SMRs)

Molten salt reactors introduce the most significant transformation of the supply chain among SMR technologies. Operating at high temperature and low pressure and using molten fluoride or chloride salts as coolant — and in some cases as fuel carrier — MSRs shift industrial emphasis from mechanical pressure-boundary manufacturing toward high-temperature materials science and chemical process engineering.

In solid-fuel salt-cooled variants, the reactor retains conventional fuel assemblies but requires molten salt coolant systems, high-purity salt production, and corrosion-resistant materials. In liquid-fuel MSR, the fuel is dissolved directly in the circulating salt, fundamentally altering the traditional fuel fabrication model. Instead of discrete fuel assemblies manufactured offsite, nuclear material must be converted into salt form and may be chemically processed during operation. This introduces a hybrid nuclear-chemical supply chain, requiring expertise in salt chemistry, online processing systems, and safeguards-compatible material accountancy.

MSRs impose demanding materials requirements. The chemically aggressive nature of molten salts at high temperature necessitates nickel-based superalloys or other advanced corrosion-resistant materials. Long-duration materials testing, alloy qualification, and specialised welding processes become critical supply chain components. The constraint shifts away from heavy forgings toward metallurgy and corrosion management capability.

In addition, industrial-scale production of nuclear-grade molten salts is not yet widely established. Scaling MSRs for commercial fleet deployment would require development of salt purification, storage, and waste conditioning infrastructure. Regulatory frameworks must also evolve to address liquid fuel management and novel safety approaches.

Consequently, MSRs require not only expansion of manufacturing capacity but partial reconfiguration of the industrial ecosystem, integrating nuclear engineering, advanced science, and chemical processing industries.

2.6 Requirements for entering the SMR supply chain

For the port of Rotterdam ecosystem, meaningful participation in the emerging SMR market will largely depend on the ability of local companies to meet nuclear-specific quality and qualification requirements. These requirements are defined through a combination of regulations, design codes, and vendor-specific expectations, and are not yet fully harmonised across projects. As a result, companies need to navigate certification processes, customer qualification, and compliance with applicable standards, which can require time and targeted investment. In practice, entering the nuclear supply chain involves several elements, including Quality Management System (QMS) certification, customer or vendor qualification (such as approved vendor lists and audits), compliance with design codes and standards, and, depending on the scope, specific licensing or authorisations (e.g. transport or security-related approvals).

At the core of these requirements are robust Quality Management Systems. The International Atomic Energy Agency, through IAEA GSR Part 2, defines high-level expectations for safety and quality, while allowing countries to adopt specific standards aligned with their regulatory frameworks and design codes. In practice, this results in a layered approach to quality management across the nuclear sector. The required QMS and associated evidence levels are determined by a combination of factors, including national regulatory frameworks (legal requirements or licensee expectations), the vendor's selected design codes, and the safety classification assigned to the scope. Requirements become more stringent for components important to nuclear safety (ITNS) and vary depending on the design codes and standards selected by the vendor.

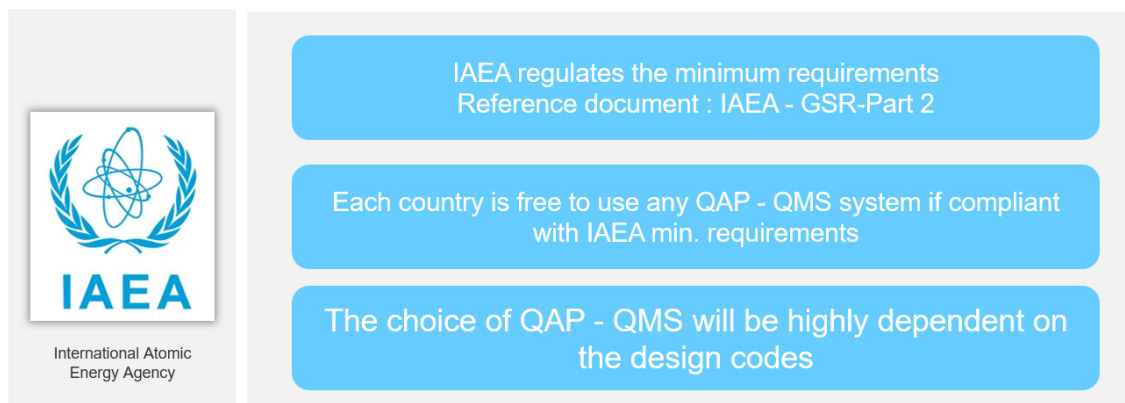


Figure 18: Regulatory framework for quality management systems in the nuclear supply chain (IAEA perspective).
QAP=Quality Assurance Program, QMS=Quality Management System

While ISO 9001 forms the baseline for most industries, the nuclear sector requires additional, sector-specific standards. A key example is ISO 19443, which extends ISO 9001 to address nuclear-specific requirements such as safety culture, traceability, and reliability. Developed through international harmonisation efforts, it reflects the elevated expectations placed on nuclear suppliers.

Regulatory obligations primarily fall on the licensee, who is responsible for demonstrating compliance with national authorities. The licensee selects the applicable frameworks, standards, and codes, which are then cascaded down the supply chain through technical specifications and contractual requirements. In this context, ISO 19443 focuses on the supply chain rather than on the licensee's overall management system and is mainly applied through contractual requirements.

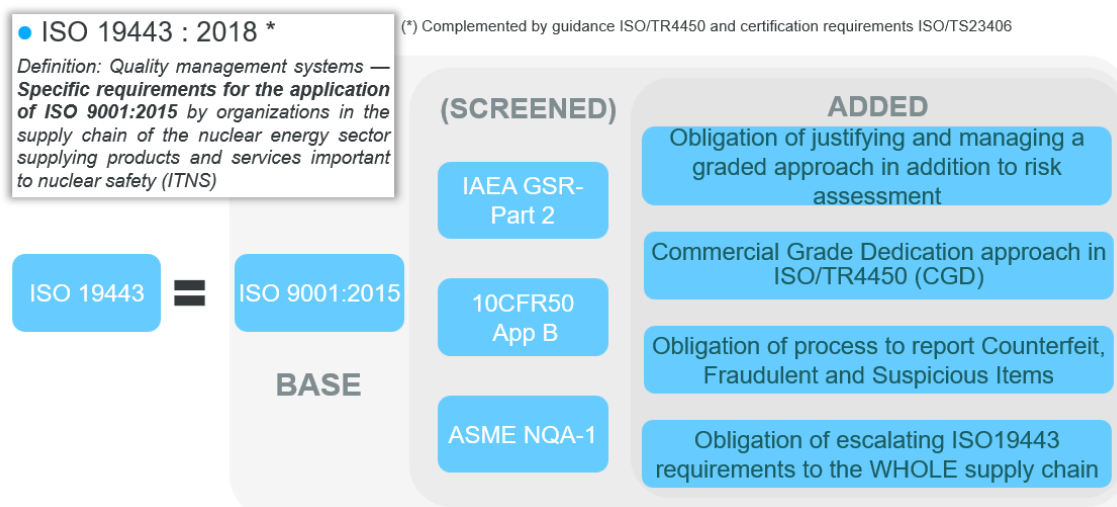


Figure 19: Positioning of ISO 19443 within nuclear quality management standards and its added requirements

Certifications represent the practical entry point into the nuclear supply chain. It allows suppliers to demonstrate compliance and to be considered by customers. However, certification alone is not sufficient. Customers typically require additional qualification evidence depending on the safety classification and scope, including process qualifications, welding qualifications, audits of internal processes and sub-suppliers, and tailored traceability records.

The certification process typically follows a structured pathway, starting with a gap analysis or pre-assessment, followed by audit phases to identify required improvements, the implementation of corrective actions, and finally a third-party certification audit. Achieving certification enables suppliers to access the market and participate in SMR-related opportunities.

Quality standards such as ISO 19443 are not inherently mandatory. Their mandatory character depends on how they are enforced – through regulation, technical codes, or contractual requirements. For example, 10 CFR 50 Appendix B (U.S. regulation defining quality assurance requirements for nuclear facilities) is mandatory as part of U.S. law, while ASME NQA-1 (standard specifying quality assurance requirements for nuclear projects and suppliers) is typically required by vendors or projects using U.S. nuclear standards. In contrast, in France there is no single “mandatory” quality standard as such; even when applying RCC codes, requirements exist but without a unified reference QMS standard. However, in practice, organisations such as EDF may impose ISO 19443 contractually on their Tier 1 and Tier 2 suppliers, effectively making it mandatory within specific projects.

This creates a structural “chicken-and-egg” situation for suppliers. They are expected to prepare in advance by implementing quality systems and obtaining certifications, but the exact requirements depend on the vendor and technology selected for a given project. For example, a project led by EDF may require ISO 19443, while a project involving Westinghouse Electric Company would typically rely on ASME NQA-1. This uncertainty makes it difficult for suppliers to decide where to invest.

As a result, supply chain readiness is closely linked to vendor selection and project visibility. The lack of harmonisation across projects and limited visibility on timelines and volumes can slow down preparation efforts.

In practice, many new entrants follow a gradual approach. They start with non-safety-related scopes and progressively expand toward ITNS-relevant deliverables as their capabilities and qualification evidence develop, in line with a graded approach.

Potential role for port of Rotterdam

This chapter analyses the potential roles that the port of Rotterdam and its companies could play in the SMR supply chain. The analysis is primarily based on the current company base and capabilities in the port of Rotterdam. For this analysis, we have identified relevant companies in or near the port of Rotterdam and had various interactions with companies, stakeholders and experts.

3.1 Strengths and weaknesses of the port

The port of Rotterdam possesses several characteristics that could support a future role in European SMR supply chains, particularly through its strong industrial base, logistics capabilities, maritime ecosystem, and strategic position within the European energy and transport network. At the same time, important limitations remain, notably related to the absence of nuclear-specific infrastructure and frameworks, limited nuclear expertise within the port's ecosystem, and uncertainties surrounding the future pace and scale of SMR deployment in Europe.

The following sections provide an overview of the main strengths and weaknesses identified during the study regarding the potential positioning of the port of Rotterdam within future SMR-related supply chain.

3.1.1 Strengths

World-class logistics and industrial hub

One of the main strengths of the port of Rotterdam is its position as a world-class logistics and industrial hub. The port has extensive experience in handling heavy lift operations, oversized cargo, industrial equipment, and complex international supply chains. These capabilities are particularly relevant in the context of SMRs, where modularisation is expected to play a central role in future deployment models. Transportation, staging, storage, assembly, and integration of large modules and components are areas in which the port already possesses substantial expertise.

Large and diversified industrial ecosystem with capabilities in energy industry

The port also benefits from a large and diversified industrial ecosystem, including engineering companies, offshore specialists, fabrication yards, maritime service providers, and major energy and industrial actors. Existing capabilities developed through offshore wind, hydrogen, petrochemical, carbon capture and storage (CCS), and maritime industries could provide a strong basis for participation in future nuclear-related activities. Several stakeholders highlighted that opportunities linked to industrialisation and modular integration could become particularly relevant if Europe moves toward serial deployment of SMRs.

Well-connected strategic location of the port

Another important advantage is the strategic geographic location of the port. As Europe's largest port and a major access point to European industrial regions, Rotterdam provides direct access to industrial regions in the Netherlands, Belgium, Germany, and Central Europe through maritime transport, inland waterways, rail, and road connections. This multimodal connectivity could become valuable for the transportation of large components, equipment, and potentially nuclear materials requiring specialised logistics solutions.

Experience in handling hazardous materials and with highly regulated industry

The port also has significant experience in handling hazardous and highly regulated industrial activities. Rotterdam already manages large volumes of chemicals, LNG, fuels, and other regulated materials under strict safety and security requirements. Although this experience does not directly translate into nuclear readiness, it demonstrates the presence of a strong industrial safety culture and experience with complex regulatory and operational environments.

Position as major European energy transition hub

In addition, the port of Rotterdam has positioned itself as a major European energy transition hub. Existing initiatives related to hydrogen, low-carbon fuels, electrification, offshore wind, and CCS contribute to the credibility of the port as a platform for future low-carbon industrial activities. Some stakeholders also noted that industries located within the port could eventually become off-takers of SMR-generated electricity and heat, particularly in the context of industrial decarbonisation and growing energy demand.

Strong maritime and offshore industrial ecosystem

Finally, the strong maritime and offshore ecosystem present within the port could create opportunities related to floating SMRs, offshore applications, or future nuclear-powered vessels. Existing shipbuilding, vessel servicing, offshore integration, and maritime engineering capabilities may provide a foundation for supporting emerging nuclear maritime applications if these markets develop further in Europe.

3.1.2 Weaknesses

Despite its strong industrial and logistical base, the port of Rotterdam currently faces several limitations that could constrain its positioning within future SMR supply chains.

No nuclear infrastructure, governance frameworks and licensing arrangements

One of the main weaknesses is the absence of nuclear-specific infrastructure, governance frameworks, and licensing arrangements within the port's ecosystem. At present, the port does not possess dedicated infrastructure or established procedures for handling nuclear materials, fuel logistics, floating nuclear power plants, or nuclear-powered vessels. Similarly, there is currently no clearly defined framework regarding the responsibilities and regulatory oversight that would apply to future nuclear maritime activities within the port environment.

Limited nuclear expertise within the port's ecosystem

Another limitation is the relatively limited nuclear expertise currently available within the broader port's ecosystem. While many companies possess advanced industrial capabilities, only a limited number currently operate under nuclear-specific quality assurance and qualification frameworks. Participation in nuclear supply chains typically requires compliance with demanding standards related to traceability, quality management, documentation, and safety culture. Qualification processes can be lengthy, costly, and resource-intensive, particularly for companies with no prior nuclear experience.

Fragmented stakeholder landscape

The stakeholder landscape associated with potential nuclear activities is also fragmented. Future positioning would require coordination between multiple actors, including the port authority, industrial companies, regulators, ministries, local authorities, and emergency planning organisations. At present, no single entity appears to hold a clearly defined coordinating role for nuclear-related activities linked to the port ecosystem.

Uncertain future market demand and business opportunities

Another important weakness concerns the limited visibility regarding future market demand and business opportunities. Many of the opportunities identified during the study, particularly those related to modular integration, serial manufacturing, or logistics hubs, would only become economically viable under large-scale European SMR deployment scenarios. However, the timing, pace, and scale of future SMR deployment in Europe remain uncertain, making investment decisions difficult for industrial actors.

Societal acceptance in dense urban and industrial area

Public sensitivity and societal acceptance could also represent constraints for future nuclear-related activities in the port's environment. The transportation or handling of nuclear-related materials in a dense urban and industrial area may raise concerns related to safety, security, emergency preparedness, and environmental risks. In addition, nuclear activities involve strict security, liability, and operational requirements that could increase complexity and costs for future port operations.

Competing ports in countries with established nuclear ecosystems and infrastructure

Finally, the port of Rotterdam faces competition from other international ports and industrial regions seeking to position themselves within future nuclear and SMR supply chains. Ports located in countries with more established nuclear ecosystems or existing nuclear infrastructure may initially benefit from stronger regulatory familiarity, industrial qualification, and institutional support.

3.2 Opportunities and challenges of the port

3.2.1 Opportunities

Strategic positioning and hub development

Strategic positioning and hub development is seen as an important opportunity area for the port of Rotterdam in an emerging European SMR supply chain. Early positioning for this supply chain could provide a first-mover advantage, particularly in logistics, transport and integration activities linked to the modular nature of SMRs. Rotterdam has potential to develop into a European logistics and transit hub for SMR modules and components, building on its existing industrial base, connectivity and experience in large-scale industrial supply chains. These opportunities are international in nature and not dependent solely on Dutch SMR deployment.

Additionally, geopolitical developments, energy security concerns and the increasing focus on European strategic autonomy could strengthen Rotterdam's positioning as a frontrunner nuclear port and broader SMR hub. However, achieving such a position would require a clear long-term nuclear vision and active strategic positioning by the port and relevant stakeholders.

Industrial supply chain, integration and services

Another opportunity area relates to the potential for an industrial supply chain, integration and services. More specifically, there is a potential role in the off-site integration and assembly of SMR modules and components, supported by the port's strong specialised transport and hinterland logistics network. Existing industrial actors could also participate in non-nuclear components and niche certified

component markets, as well as in longer-term maintenance and industrial support activities. More broadly, alignment with large nuclear power plant supply chains in Europe could help Rotterdam-based companies build capabilities and strengthen the port's position in future SMR value chains, as well as attracting new companies and industries to the port.

Maritime nuclear operations and servicing activities

The future deployment of nuclear-powered vessels and floating nuclear power units, such as power barges, could create a new maritime opportunity for the port of Rotterdam. In this context, the port could position itself as a European hub capable of hosting, servicing, and supporting these assets through its existing maritime, industrial, and logistical infrastructure. Potential activities could include vessel accommodation, refuelling support, maintenance, inspection, and specialised operational services associated with maritime nuclear applications.

Energy system integration and industrial offtake

SMRs could play a broader role in supporting the integration and decarbonisation of the Rotterdam industrial cluster. The production of low-carbon electricity and heat may provide direct value for industrial off-takers within the port, particularly for energy-intensive sectors seeking to reduce emissions. SMRs could also contribute to reducing pressure on the electricity grid by providing stable baseload generation and local energy supply. In addition, they could contribute to the production of hydrogen for industrial and large transport applications in or near the port. In doing so, SMRs may further reinforce Rotterdam's strategic position as a European energy and industrial hub.

Capability building, qualification and regulatory leadership

The development of SMR-related activities in Rotterdam also creates opportunities for capability building and strategic positioning within the wider nuclear ecosystem. Existing and future nuclear projects, including large nuclear power plants, SMRs and research reactors, may help companies build relevant qualifications, certifications and operational experience. This could support the development of a credible Dutch nuclear track record and strengthen the competitiveness of local supply chain actors. In parallel, the Netherlands and Rotterdam could play a role in shaping future regulatory frameworks, standards and operational guidelines, while leveraging relatively efficient administrative and permitting processes as a competitive advantage.

Expected demand for nuclear fuel and supporting infrastructure activities

A separate opportunity could emerge around the development of supporting nuclear infrastructure linked to fuel-cycle and servicing activities. Expected increased demand for such fuel-cycle activities – if the expectations of SMR deployment will be met – requires enlargement of and innovation in current fuel-cycle capabilities in Europe. For the port to tap into this opportunity would require attracting businesses with nuclear fuel-cycle expertise to the port, as this is currently absent. Building on its industrial base and logistical connectivity, the port could support selected front-end fuel-cycle activities, including advanced fuel manufacturing, fuel conversion, and specialised fuel-handling services, with potential opportunities linked to TRISO fuels. The development of such capabilities could strengthen Rotterdam's attractiveness for international nuclear fuel and technology companies and support the emergence of dedicated nuclear logistics and servicing infrastructure within the port's ecosystem.

3.2.2 Challenges

Regulatory uncertainty and governance

International regulatory frameworks, particularly for maritime nuclear applications, remain underdeveloped and fragmented. At the same time, uncertainty persists regarding Dutch government ambitions for SMRs and deployment plans for SMRs in or near the port of Rotterdam. In the early stages of supply chain development, investment decisions are strongly dependent on government policy, licensing

procedures and regulatory stability. While future regulatory development could create opportunities for Dutch leadership in standard setting and governance, the current lack of policy clarity complicates strategic planning and long-term investment decisions, particularly for local deployment and construction activities.

Market and technology uncertainty

The future development of the SMR market remains uncertain across several dimensions, including deployment timelines, long-term demand, technology maturity and commercial viability. Companies require confidence in long-term market growth and vendor stability before committing to major investments or qualification processes. This challenge is reinforced by the fact that many SMR vendors are still relatively early-stage companies, making long-term partnerships and investment certainty more difficult. In addition, uncertainty remains regarding which reactor technologies and vendors will ultimately emerge as commercial frontrunners (market consolidation), while supply chain requirements may differ significantly across reactor generations and technology types.

Investment and qualification barriers

Participation in the nuclear supply chain requires substantial investments in certification, qualification, compliance and business development activities. The main barrier for many companies is therefore not necessarily awareness, but rather the high threshold associated with qualification and regulatory requirements. Even suppliers of relatively standard industrial components may face significant certification obligations before being able to participate in nuclear projects. The development of nuclear fuel-chain activities may be particularly challenging due to high regulatory, insurance and investment costs. Currently, nuclear experience and qualifications within the port ecosystem are concentrated among a relatively limited number of companies.

Knowledge and capability limitations

The port of Rotterdam's industrial ecosystem currently has limited direct experience with the nuclear sector, particularly among companies outside existing specialised nuclear supply chains. Awareness regarding potential roles within the future SMR ecosystem also remains relatively limited among many companies and local actors. In addition, familiarity with nuclear technologies and associated risks remains constrained among parts of the wider stakeholder environment, including public authorities. Perceived nuclear risks may therefore exceed the actual risk profile when compared with other industrial activities already present in the port. Building the required nuclear capabilities, certifications and operational credibility is consequently expected to require significant time and sustained investment.

Competition and strategic positioning

Rotterdam faces increasing competition from other international ports and industrial regions seeking to position themselves within future SMR value chains. International frontrunners such as the Port of Hamburg, the United Kingdom and South Korea are already actively developing capabilities and strategic positioning in this domain. Delayed strategic action could weaken Rotterdam's potential first-mover advantage and reduce its ability to attract investment and supply chain activities. At the same time, strategic positioning remains complicated by uncertainty regarding which role Rotterdam is best placed to fulfil within the broader SMR ecosystem, including logistics, fuel-cycle activities, maritime applications, industrial integration or wider ecosystem coordination.

Infrastructure and system constraints

Several infrastructure-related constraints may affect the future development of SMR-related activities in the port of Rotterdam. Existing energy availability issues and grid congestion may limit industrial expansion and the development of new logistics activities. In addition, nuclear supply chains require highly reliable and resilient coordination mechanisms, where disruptions can have significant operational

and safety implications. Specialised transport and hinterland logistics linked to modular reactor construction may also create additional complexity. Furthermore, fuel and waste storage, handling and refuelling activities would require dedicated infrastructure and additional regulatory approvals.

3.3 Potential for companies in the port of Rotterdam

We have identified 92 companies in the port of Rotterdam ecosystem that could potentially play a role in the SMR supply chain (see Figure 20 for approach). For these companies we assessed their supply chain relevance as medium or high. We further classified these companies along tier, sector, value chain segment, phase and fit with the inland or maritime SMR supply chains.

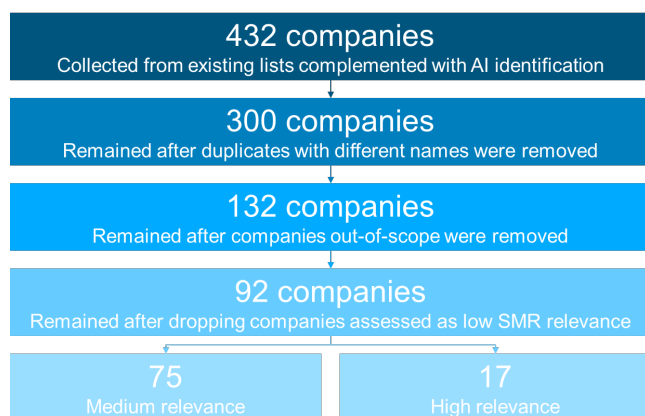


Figure 20: Approach to identify and select relevant companies in the port of Rotterdam

3.3.1 Sectors involved in the supply chain

In the SMR supply chain different sectors could play a role. In this study we analyse eight different sectors that are relevant to the various functional segments of the supply chain and can be involved in the various phases of SMR projects. Figure 21 provides an overview of these sectors and describes each of the sectors.

NUCLEAR	CONCERNS NUCLEAR COMPONENTS / KNOWLEDGE
MECHANICAL	CONCERNS MECHANICAL ENGINEERING, WELDING, EQUIPMENT MANUFACTURING ETC.
ELECTRICAL	CONCERNS ELECTRICAL SYSTEMS AND COMPONENTS
CONSTRUCTION	CONCERNS CIVIL WORKS FOR THE CONSTRUCTION OF THE SMR ITSELF
INFRASTRUCTURE	CONCERNS CIVIL WORKS RELATED TO ROADS, LAND, WATER ETC.
TRANSPORT & LOGISTICS	CONCERNS TRANSPORT, LOGISTICS, STORAGE, SHIPPING ETC.
MARITIME	CONCERNS MARITIME INDUSTRIES
MATERIALS	CONCERNS RAW OR REFINED PRODUCTS

Figure 21: Description of the different sectors that are included in the study to analyse the SMR supply chain

3.3.2 Potential in supply chain

The identified companies are mapped on the SMR supply chain per sector in Figure 22.¹⁴ For each tier and sector, the first number (in corresponding colour) is the total number of companies assessed in a specific tier and sector combination, while the second number corresponds to the number of companies that could be relevant for maritime SMRs or both.

Key findings

Most companies in the port of Rotterdam ecosystem that are considered relevant for the SMR supply chain are in the sector Transport & Logistics (39), followed by Mechanical (17) and Electrical (15). Only few companies (<10) are in the Infrastructure, Construction and Materials sectors. The Infrastructure and Construction sectors are mostly relevant for inland SMRs, as few companies in these sectors have been identified that could be relevant for maritime SMRs (as well).

Most companies are assessed in tiers 2-4. This shows that most companies in the port of Rotterdam ecosystem could operate in tiers where significant value is added and where vendors and system integrators are seeking multiple suppliers to mitigate supply chain risks and to enable production scaling. This provides good potential for the port of Rotterdam to secure a position in the SMR supply chain with one or more companies.

Very few companies (<3) are assessed in tier 1 and few companies (<10) in tiers 5 and 6. The first tier concerns Technology Vendors, that could directly procure products and services for an SMR or any of its key workstreams. Here Allseas is a prime example that is in/near the port of Rotterdam. As this concerns a maritime SMR, Allseas would additionally benefit from a port-based industrial ecosystem beyond Transport & Logistics. The lower tiers concern Manufacturers and Materials Suppliers. The latter face strongest competition, however, for inland SMRs that would be constructed in/close to the port of Rotterdam large amounts of materials like concrete need to be produced locally creating clear business opportunities for local suppliers.

For Transport & Logistics most companies are put in tier 3. These companies do not act as Component Suppliers but rather as Logistics Node. Their services can be procured by higher as well as lower tier companies from various sectors. Transport and Logistics companies in the port often offer some sort of integrated services, furthermore their competition is in part location-based – reducing competition when the port of Rotterdam manages to be a key logistic node for importing and exporting SMR modules and parts in or outside European mainland. For these reasons those companies have been allocated to the middle of the supply chain.

The nuclear sector is not much represented in the port of Rotterdam, although several companies (11) serve nuclear markets and thus have nuclear competences (knowledge and expertise) within their (international) company. These companies have been allocated to the Nuclear sector. Most can be found at the level of System Integrator (tier 2) or Subcontractor (tier 4).

¹⁴ Note that companies can be active in multiple sectors, so that the total number of companies in the supply chain mapping is higher than the 92 companies in the port's ecosystem that were identified.

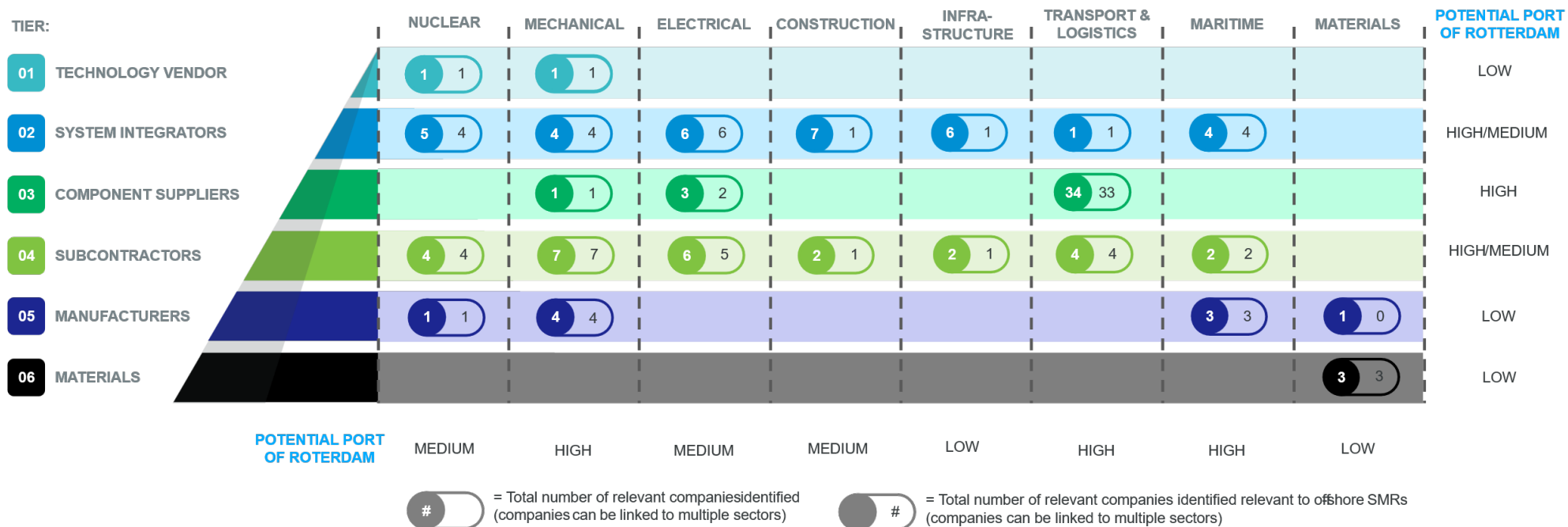


Figure 22: Mapping of relevant companies in the port of Rotterdam ecosystem on the SMR supply chain per sector

Potential in the SMR supply chain

The potential for the port of Rotterdam is considered highest for the Transport & Logistics, Maritime and Mechanical sectors. Here we have identified most companies in the port of Rotterdam that could supply both inland and maritime SMRs.

The potential for the port of Rotterdam is considered highest at tiers 2–4. When being a logistics/transit node for SMR parts and components the highest potential is by far at tier 3. When being an industrial ecosystem that contributes to the construction and integration of parts and components for (maritime) SMRs, the potential shifts more towards tiers 4 and 2.

The port of Rotterdam has a low potential for involvement in the SMR supply chain in Infrastructure or Materials. Here we see potential for a relatively small number of companies, mainly for inland SMRs. Similarly, the potential is low at the lowest tiers: here we found few relevant companies, which are likely to face fierce competition unless they supply to an inland SMR that is built in or near the port of Rotterdam – as procurement at these tiers will likely be more local. Tier 1 has also been assessed at low potential, since only two companies have been identified at this level. Nevertheless, when successful they may further drive a supply chain that involves other companies in the port of Rotterdam.

The potential for individual companies will depend on their specific service offering and their ability to compete with similar companies. That is not assessed in this analysis. Here we focus on the port of Rotterdam as a whole.

3.3.3 Potential in SMR phases

Identified relevant companies in the port of Rotterdam's ecosystem are mapped along the phases of SMR projects in Figure 23.¹⁵ For each phase, the first number is the total number of companies assessed in a specific phase, while the second number corresponds to the number of companies that could be relevant for maritime SMRs or both.

Key findings

Most companies that are considered relevant for SMR projects are in the Manufacturing & Construction stage. Here companies can contribute to the construction of components, modules, logistics, transport, construction and integration. In the Preparation stage only few companies could potentially be involved. These primarily concern companies that are involved in engineering, environment, or other advisory services. In the (Pre) Operation stage slightly more companies could potentially be involved, mainly for operational support and maintenance. Involvement in the Preparation and (Pre) Operation stage will depend on the location of SMRs – involvement in SMRs in or near the port is most feasible.

Phases 7 (Logistics & Heavy Haul), 9 (Installation & Integration) and 6 (Factory Modularisation & QA) hold most potential for the port of Rotterdam's ecosystem. Here we have identified most companies that could potentially play a role. For Logistics & Heavy Haul we have identified most relevant companies. In these phases, most companies could also be relevant to maritime SMRs.

Some specialised companies in the port of Rotterdam could play a role in phases 4 (Design Finalisation & Standardisation) and 5 (Procurement of Long-Lead Items). Phase 4 includes vendors and companies that could engineer parts of the SMR (e.g. balance of plant) or site-specific constructions. Phase 5 includes large companies for which generally few alternatives exist. These companies provide large and specialised products, such as steam and turbine generators, nuclear valves and major heat exchangers.

¹⁵ Note that companies can be active in multiple phases, so that the total number of companies in these phases is higher than the 92 companies in the port's ecosystem that were identified.

Companies assessed in phase 8 (Civil Works & Balance-of-Plant) are mostly relevant for inland SMRs and contain activities that are on-site. Some of these companies can also conduct activities that are relevant to maritime SMRs, mostly related to mechanical construction.

No relevant companies in the port of Rotterdam's ecosystem have been identified that could play a role in phases 3 (Financing & Offtake) and 10 (Fuel Supply & Core Loading).

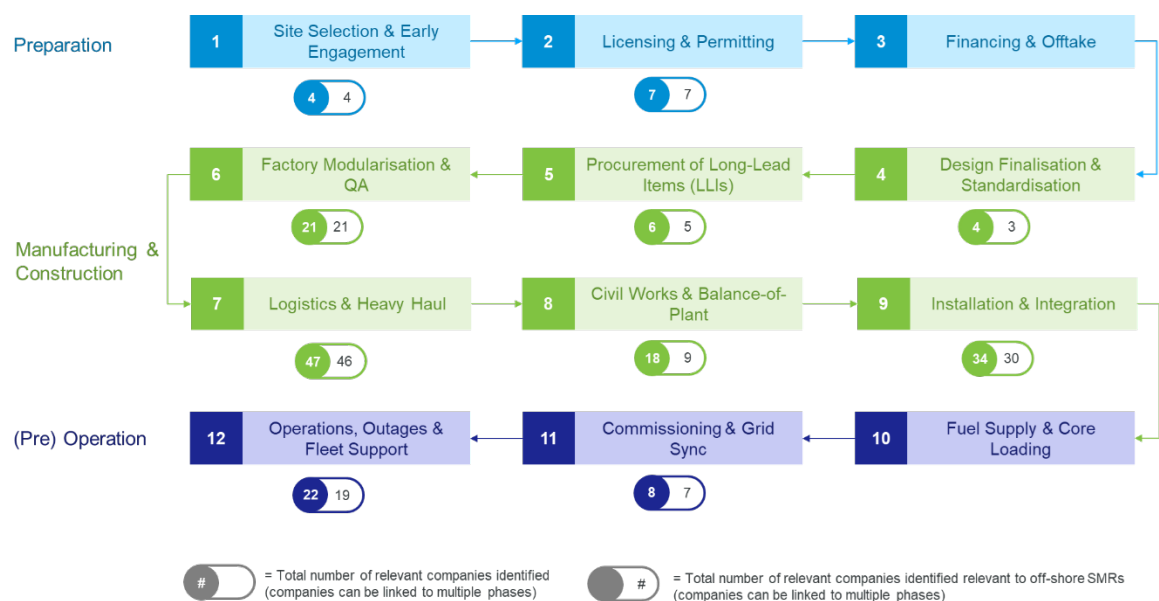


Figure 23: Mapping of relevant companies along the phases of SMR projects

Potential in SMR project phases

The potential for the port of Rotterdam is considered highest in the Manufacturing & Construction stage. Here we have identified various relevant companies, both for inland as well as for maritime SMRs. A clear potential role for the port in Logistics & Heavy Haul – which clearly aligns with a port's main function. Industrial capabilities in the port could enable involvement in the production of parts, modules and the integration thereof (phases 6 and 9).

The Manufacturing & Construction phase is for some close-to-market inland SMRs approaching. In the next 5 years opportunities for the port of Rotterdam may thus arise. For maritime SMRs, which do align well with the port's industrial ecosystem and function, opportunities are expected further ahead in time.

3.3.4 Overall potential

The overall potential for the port of Rotterdam differs for inland and maritime SMRs. To analyse the overall potential, we consider the identified companies currently in the port of Rotterdam across the supply chain and SMR phases and reflect on the functional segments in the SMR supply chain.

3.3.4.1 Inland SMRs

The overall potential for the port of Rotterdam in the inland SMR supply chain lies primarily in Transport and Logistics and the Modules chain, especially in the supply of components. This is visualised in Figure 24.

The construction chain is very dependent on location. For SMRs constructed in or near the port of Rotterdam, or at least in the Netherlands, companies in the port may be involved in earthworks, infrastructure, civil construction, integration, installation and commissioning. Materials will then likely be supplied locally as well. In addition, for port-based SMRs, fuel loading and removal would need to take place in the port with potentially some involvement of local companies in handling, transport and security.

Similarly, the service chain provides opportunities at the site of an SMR. Some companies in the port could potentially provide services related to supplied components and modules – this is however dependent on involvement in the Modules chain. Providers of more generic maintenance services could likely only supply to SMRs operational in the port/the Netherlands.

The role of the port of Rotterdam in the construction and integration of components into modules for SMRs is uncertain. This will depend on the vendor and their strategy. Currently, the factorisation of SMRs is foreseen by other companies than we have identified in the port.

The fuel chain and waste chain require specific nuclear capabilities that are not available in the port and are challenging to be established in the port. These chains are most likely to be captured by suppliers that currently cover these chains for large nuclear power plants. The Transport and Logistics in these chains may partly be covered by the port depending on the location of the SMR and the required logistic routes. Currently some enriched materials and fuel are already moving through the port, while for spent fuel different logistic routes currently exist (mostly via road and rails).

Nevertheless, the value chain for fuel and waste needs to be further strengthened to meet the demand for SMRs once the expected adoption of SMRs materialises. Specialised nuclear companies currently involved in these chains need to upscale their activities. Such companies are not in the port of Rotterdam. However, attracting such companies to the port of Rotterdam could be an avenue that may be explored to enlarge involvement in the SMR supply chain.

3.3.4.2 Maritime SMRs

For the maritime SMR supply chain the overall potential for the port of Rotterdam is wider. Here we assume that the port of Rotterdam will be a location where nuclear vessels or barges are assembled and serviced. The port would then act as an industrial site for maritime SMRs, independent whether these SMRs will be used in the port or elsewhere. The port therefore has potential to be involved in the Construction, Modules and Services chain with additional involvement in Transport and Logistics in other chains. This is visualised in Figure 25.

As maritime SMRs may be constructed in port areas, the companies and capabilities in the port of Rotterdam are well-suited to play a role here. The fact that Allseas, which has the ambition to develop maritime SMRs, is close to the port could further enlarge the potential role of the port of Rotterdam. The actual construction of maritime SMRs may however be limited to more specialised components and integration, as generic shipbuilding is generally taking place in less expensive regions. Nevertheless, components, modules, parts of construction and integration could potentially take place in the port of Rotterdam.

If regulatory and liability challenges regarding nuclear maritime applications are overcome, the port of Rotterdam may also be involved in the nuclear fuel loading and removal of spent fuel. The port of Rotterdam could then act as an all-round service hub for nuclear vessels where such vessels are refuelled and maintained. This provides improved opportunities for involvement in servicing and maintenance in equipment, systems and supplied components/modules. Business models where nuclear reactor ownership and ship ownership are split – ship owners would effectively lease nuclear propulsion – would further strengthen a nuclear port role if the reactor owner is based in the port of Rotterdam.

The fuel chain and waste chain would still require specific nuclear capabilities that are not available in the port and are not easily established in the port. These chains will most likely remain covered by current suppliers for large nuclear power plants or research reactors. Nevertheless, the port could explore attracting such businesses to the port.

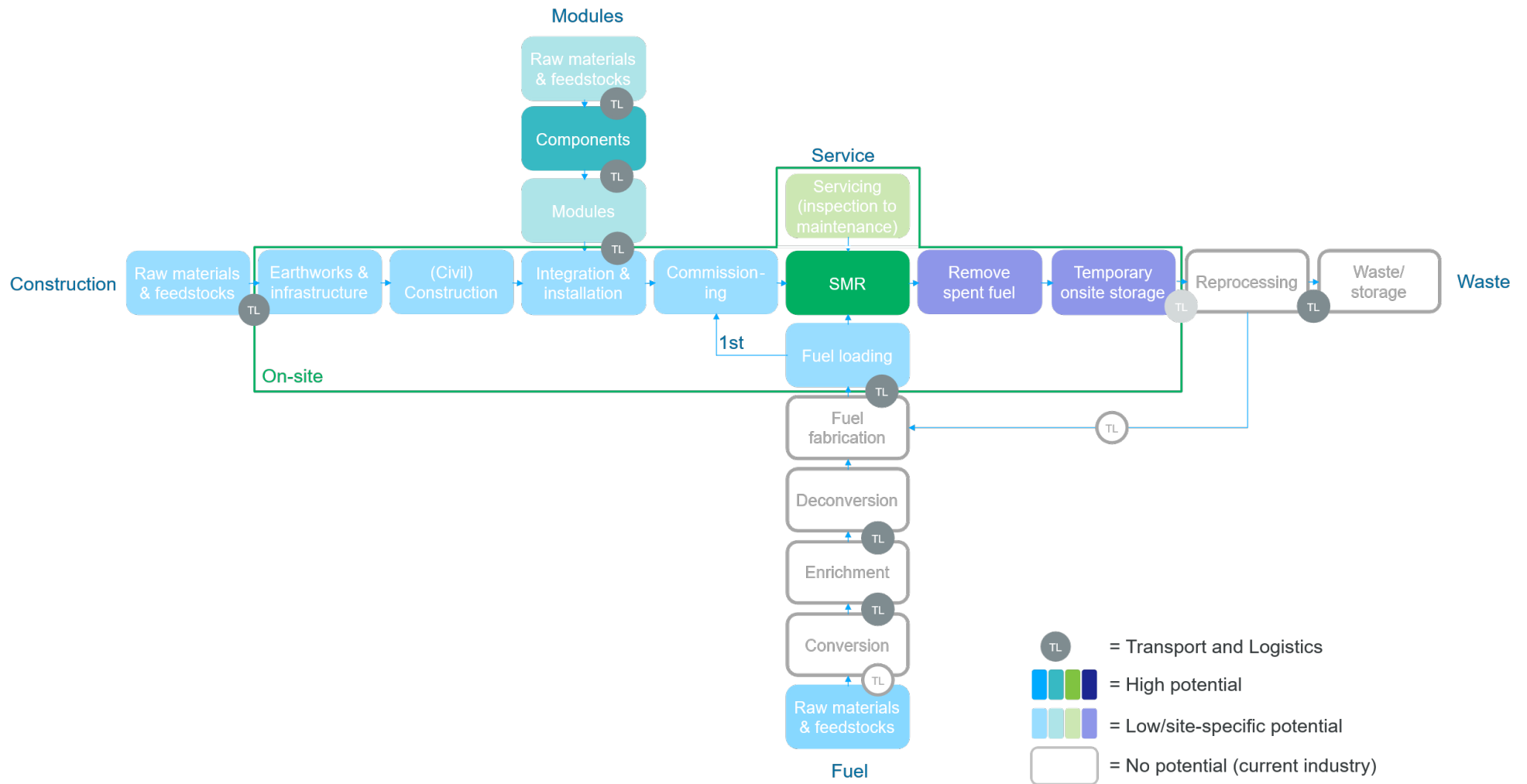


Figure 24: Mapping of potential for the port of Rotterdam per functional segment in the inland SMR supply chain

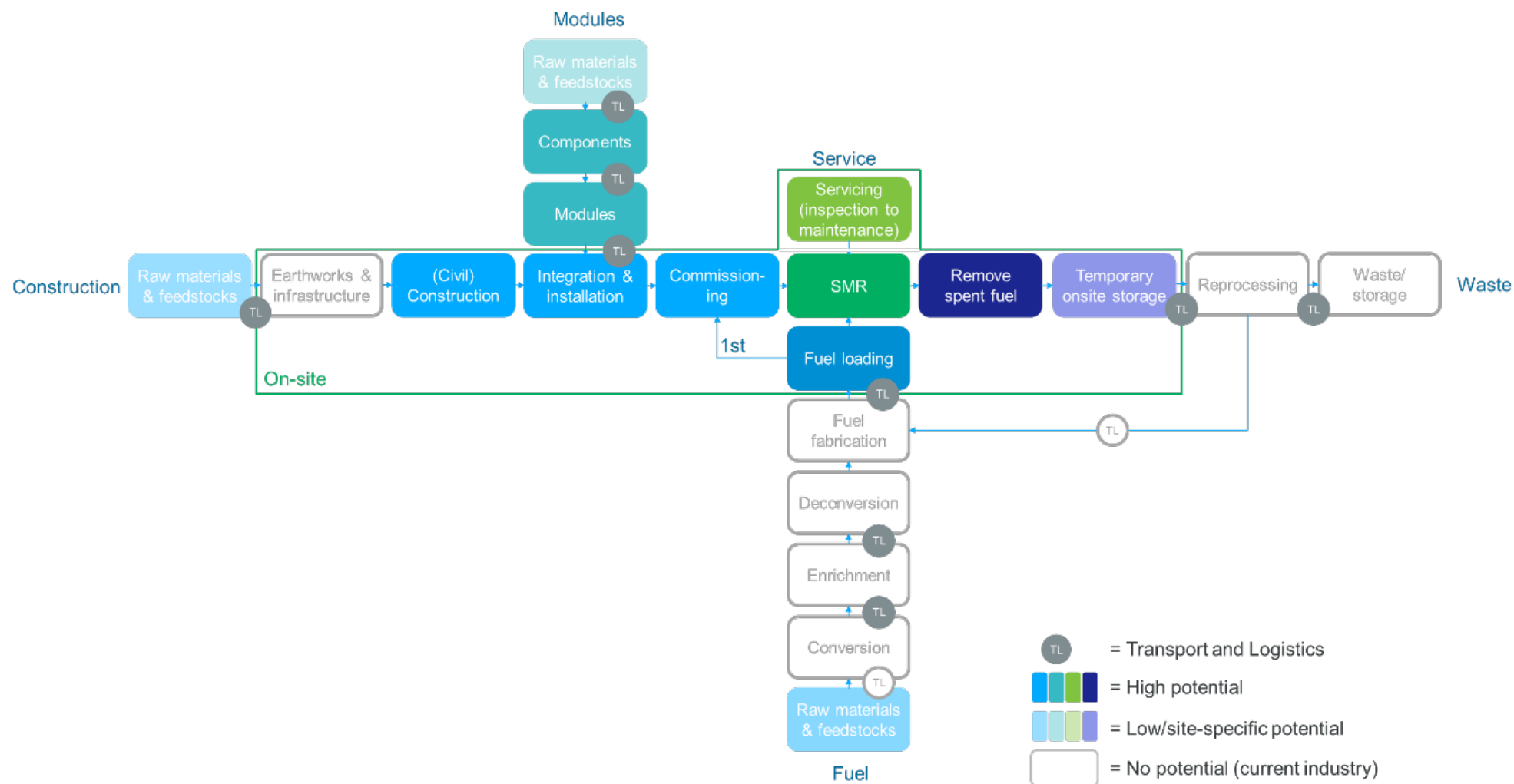


Figure 25: Mapping of potential for the port of Rotterdam per functional segment in the maritime SMR supply chain

3.4 Potential roles for the port in the SMR supply chain

The port of Rotterdam has potential to capture a role in the SMR supply chain. We have identified four roles that the port of Rotterdam could assume depending on its ambition (see Figure 26). These roles and ambitions can be aligned with the port's vision for 2050¹⁶. This vision contains five strategic themes in which clean logistics, climate neutral industry, strategic autonomy and energy security are keywords. SMRs, both inland and maritime, can contribute to these ambitions. In addition, the vision makes note of ships with nuclear propulsion in the port. Being involved in the SMR supply chain can give direction to this vision.

The possible roles for the port of Rotterdam differ in ambition level, strategic benefits and required efforts. Some roles are closer to business as usual in the port, being a logistics hub and industrial ecosystem, and relying on the existing conventional company base. Other roles require the port to facilitate more nuclear capabilities and to overcome challenges in terms of regulation and liabilities, and possibly societal acceptance for nuclear activities in the port.

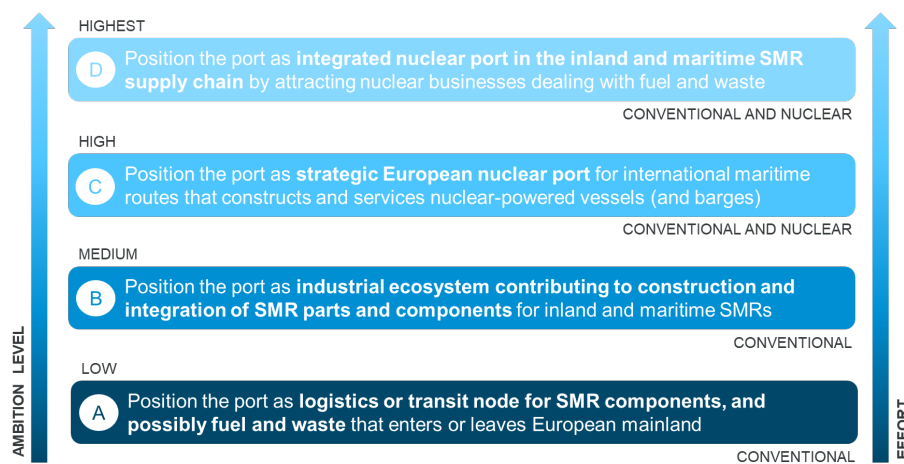


Figure 26: Roles that the port of Rotterdam could ambition in the SMR supply chain ordered by ambition level and effort

The four potential roles of the port of Rotterdam in the SMR supply chain can be ordered in terms of ambition level and effort (see Figure 26, here presented from low ambition/effort to high ambition/effort):

A. Position the port as a logistics or transit node for SMR components, and possibly fuel and waste, that enters or leaves European mainland.

This role would align well with the current logistics role of the port of Rotterdam. Many companies in the port are involved in transport and logistics, providing good potential to capture such a role in the SMR supply chain. It would be a natural role for the port that likely requires least effort and resembles the lowest ambition in terms of role in the SMR supply chain.

In inland SMR deployment scenarios, the port of Rotterdam could function as a strategic entry point for reactor modules and large industrial components manufactured internationally and transported toward European deployment sites. Its deep-water access, established logistics infrastructure, and strong inland connectivity through waterways, rail, and road networks provide favourable conditions for this role. In this configuration, the port would primarily act as a controlled logistics gateway linking global manufacturing hubs with future SMR deployment projects across Europe.

16 Havenvisie Rotterdam (2025), <https://www.portofrotterdam.com/sites/default/files/2026-01/Havenvisie-Rotterdam-2050.pdf>

This role could also extend to transport activities associated with the nuclear fuel cycle. Depending on future regulatory frameworks and the scale of SMR deployment in Europe, the port could support transport and transit operations involving enriched uranium, fuel assemblies, advanced fuels such as HALEU or TRISO-related materials, as well as spent fuel logistics. The port of Rotterdam is already involved in certain nuclear material transport activities today, providing an initial operational basis for future expansion in this area.

B. Position the port as an industrial ecosystem contributing to the construction and integration of SMR parts and components for inland and maritime SMRs.

A more advanced positioning would involve the port functioning not only as a logistics hub, but also as an industrial ecosystem contributing to the construction and integration of SMR parts, components, and modules for both inland and maritime applications. This role is at a higher ambition level and requires more effort to obtain.

Local companies in higher tiers are better positioned to compete and enter the supply chain, while other companies need to make more effort to secure a position (e.g. in business development and certification). With the current company base in the port the role would be mainly for non-nuclear, conventional components. Companies in the port could play a role in both inland and maritime SMRs, but their location in the port makes them best placed for maritime SMRs.

In offshore and floating SMR scenarios, the role of the port could become significantly broader. Rather than serving only as a transit point, the port could support industrial integration activities such as assembly of floating structures, installation of conventional systems, and pre-deployment integration of modules and components. Its existing maritime and offshore engineering ecosystem provides transferable competencies in heavy marine fabrication and system integration.

Successes of local SMR vendors and local SMR construction projects may help in successfully entering the SMR supply chain – especially as roles in construction are very much site-bound.

C. Position the port as a strategic European nuclear port for international maritime routes that constructs and services nuclear-powered vessels (and barges).

This would be a very strategic role that aligns well with the strong current international position of the port and would enable long-term involvement in the maritime SMR supply chain both in operational phases, and potentially in construction phases. This position is, however, dependent on the successful development and adoption of nuclear-powered vessels and nuclear barges and requires a longer-term perspective.

Under this ambition, the port could support the long-term operation and servicing of maritime SMRs, floating nuclear power plants, and nuclear-powered vessels. Potential activities could include maintenance operations, refuelling activities, maritime nuclear logistics, return of floating units for overhaul, and eventually decommissioning-related services.

The local maritime SMR developer/vendor Allseas and companies in the NuclearDrive consortium could provide the basis for such a cluster of both conventional and nuclear companies.

At the same time, this role would require substantial evolution of the current port framework. Dedicated nuclear regulatory arrangements, specialised security measures, liability frameworks, emergency preparedness planning, and nuclear fuel and waste handling and storage capabilities would all be necessary. This makes both the ambition and required efforts significant, especially for major maintenance or refuelling activities

Notwithstanding, it should be expected that nuclear-powered vessels would request to enter or transit in the port in the mid- to long-term horizon (even without needing any nuclear maintenance or servicing).

D. Position the port as an integrated nuclear port in the inland and maritime SMR supply chain by attracting nuclear businesses dealing with fuel and waste.

The most ambitious positioning identified during the study would involve the port of Rotterdam evolving into a broader nuclear-industrial ecosystem extending into the fuel cycle and waste management supply chains. Under this scenario, the port would not only support logistics and industrial integration activities but also seek to attract specialised nuclear companies involved in fuel fabrication, advanced fuel development, waste treatment, and associated nuclear services.

The capacity in the fuel supply chain and capabilities to develop specific fuel (esp. TRISO) for certain SMR designs are currently limited. With the wider adoption of inland and maritime SMRs across Europe, additional capacity would be needed. The port could act as an enabler by attracting specialised business with competencies in the fuel and waste supply chains (e.g. Framatome, Westinghouse, Orano) – such companies are not in the port yet. It would also redirect logistical routes for nuclear fuel and waste through the port of Rotterdam, enabling a larger role in transport and logistics.

However, this option would also require the highest level of industrial, institutional, and regulatory transformation. Dedicated nuclear infrastructure, land allocation, long-term policy alignment, security frameworks, and significant private-sector investments would be necessary. In addition, attracting major nuclear fuel cycle companies outside their existing industrial locations would remain uncertain and would likely require targeted incentives and long-term market visibility. The feasibility of this high-ambition option should be explored first, and this role should be viewed as a long-term strategic ambition rather than a near-term positioning opportunity for the port of Rotterdam.

Conclusions and recommendations

4.1 Conclusions

Close to a hundred Small Modular Reactor (SMR) concepts are being developed worldwide, using different technologies. Most are being developed for inland use and some for maritime use. The majority of these SMR concepts are still under development. Some concepts have entered a phase of demonstration, are engaged in regulatory reviews or have started early site preparation. Only in Russia and China are SMRs already operational. There is one SMR under construction in Canada and in the UK regulatory review and site identification take place. Although the Netherlands has no SMR deployment programme in place, SMRs are explicitly considered part of the future energy mix at national and regional level and various studies and consultations to assess potential and costs are ongoing.

The SMR industry is still at an early commercial stage and the supply chain for SMRs is under development. The window of opportunity for new entrants to the supply chain is still open but is time-sensitive and technology dependent. First-of-a-kind inland SMRs in Europe are expected around 2030, while commercial deployment in the Netherlands is expected in the late 2030s or early 2040s. The IEA expects over 50 SMRs in the EU by 2040 and over 100 by 2050. The global market size for SMR technology is estimated by the IEA to be 670 billion USD over 2024-2050 assuming a successful development path of SMRs. The market size and actual number of operational SMRs are, however, uncertain and hard to predict well at the current stage of SMR development.

Offshore SMRs are at a lower stage of development and face additional regulatory challenges. Their demonstration and commercial deployment are therefore expected 5-10 years later than for inland SMRs.

The SMR market can be characterised as developing and maturing. Over time, the market is likely to consolidate, with fewer vendors and clearer market leaders. This currently makes it difficult to determine which vendors or companies to engage with to secure a position in the SMR supply chain. In this context, first to market will likely be a key success factor. Expectations for demand will also have to be confirmed once the market has matured further.

To what extent can the port of Rotterdam play a role in the future supply chain of SMRs?

Within this context, the study shows that the port of Rotterdam has strong potential to play a role in the emerging international SMR supply chain. Its current industrial ecosystem, strong logistical capabilities and strategic location make the port of Rotterdam well-positioned to be involved in transport and logistics as well as the supply of components and industrial services. This will concern mostly non-nuclear components and services, as nuclear capabilities within the port's industrial ecosystem are rare.

In the port's ecosystem, 92 companies have been identified that could be relevant for the SMR supply chain. Most of these companies were assessed to have the potential to assume a role in medium-high tiers of the SMR supply chain, mainly in the transport and logistics, mechanical and electrical sectors. The

manufacturing and construction phases of SMR projects are the most promising phases in which these companies could be involved. Based on the characteristics of the identified companies, a potential involvement for the port is seen in logistics and heavy haul and in the supply of specialised components and (integrated) modules.

The offshore and maritime industrial ecosystem and function of the port make it well-placed for involvement in the offshore SMR supply chain. The port, with its current industrial ecosystem, could capture more segments of the offshore SMR supply chain than of the inland SMR supply chain, with roles in construction, modules and servicing. The presence of a nearby maritime SMR vendor/developer strengthens the case for involvement in the offshore SMR supply chain. Maritime SMRs are, however, in a lower stage of development and face regulatory challenges, making this a longer-term perspective.

For inland SMRs, the port could be involved in the supply of components and in transport and logistics. Involvement in SMR construction will depend on the location where SMRs will be constructed. For inland SMRs involvement is feasible for some companies in the port when the construction site is in or near the port (at least within the Netherlands). This makes repeat supply to inland SMRs limited. Nevertheless, during this study, stakeholders have consistently stressed the potential of inland SMRs to produce electricity, heat and hydrogen for the port's current activities. Construction of an SMR at an early stage of adoption (e.g. a FOAK) could help position the port early in the inland SMR supply chain.

What are the potential roles that the port of Rotterdam could assume within this supply chain?

We see four potential strategic roles that the port of Rotterdam could assume, each with varying ambition levels, efforts, challenges and strategic gains. These roles for the port, ordered from low to high ambition level/effort, are:

- A. Being a logistics or transit node for SMR components, and possibly fuel and waste, that enter or leave the European mainland.
- B. Being an industrial ecosystem contributing to the construction and integration of SMR parts and components for inland and maritime SMRs.
- C. Being a strategic European nuclear port for international maritime routes that constructs and services nuclear-powered vessels (and barges).
- D. Being an integrated nuclear port in the inland and maritime SMR supply chain by attracting (new) nuclear businesses dealing with nuclear fuel and waste.

Combinations of these roles are possible, for instance to capture roles in both the inland and maritime SMR supply chain at different timescales.

Roles in which the port handles nuclear materials (fuel or waste) or nuclear installations will require nuclear licensing as well as specific nuclear infrastructure, safety measures, regulations and liabilities. These are associated with significant investments.

4.2 Recommendations

We recommend that the port of Rotterdam acts now, as the SMR supply chains are still open and establishing a strategic position takes time.

How can the port of Rotterdam position and prepare itself to effectively fulfil these roles?

To realise the potential of the port of Rotterdam in the SMR supply chain, we recommend the following steps:

- **Step 1:** Define the ambition level for involvement in the SMR supply chain in line with the port's overall strategic vision for 2050.

- **Step 2:** Organise a public-private collaboration to realise ambitions in the SMR supply chain.
- **Step 3:** Develop a shared USP and action plan to position the port and its companies in the SMR supply chain.
- **Step 4:** Execute the action plan and ensure boundary conditions are met and challenges are solved.

Under these four steps, specific actions can be undertaken to position the port in the SMR supply chain. In the following sections we describe each of these recommended steps and associated actions in more detail.

4.2.1 Step 1: Define the ambition level for involvement in the SMR supply chain in line with the port's overall strategic vision for 2050

In the conclusions above, we outlined four roles (A-D) that the port of Rotterdam could assume in the SMR supply chain depending on its ambition level, each with different levels of effort, strategic gains and feasibility.

The first step should be to decide on the role that fits the port's ambition and that is aligned with the port of Rotterdam's vision for 2050. This role should be considered feasible and strategically interesting. We recommend taking this decision within a working group consisting of Port of Rotterdam, Deltalinqs and the Municipality of Rotterdam, each representing the port, the companies in the port and the local government.

To support the decision-making in this phase, we propose to consider nine factors listed in the following table. For each of these factors, we have provided our initial assessment per role in Appendix B.

Decision-making factor	Description
Strategic fit	To what extent does the role align with the port of Rotterdam's long-term vision, existing strategies, energy transition ambitions and desired position within the European SMR ecosystem?
Economic value	To what extent does the role potentially strengthen the port's competitiveness, generate business opportunities, and attract investments?
Market potential	To what extent does the role improve the potential for the port of Rotterdam to enter the global/European SMR market and supply chain and capture a meaningful market share?
Feasibility	How realistic is the implementation of the role considering existing industrial capabilities and the complexity of implementation (infrastructure, investments, legal requirements etc.)?
Investment need	To what extent are investments by various stakeholders needed, or is (public/ financial) support required?
Infrastructure and space need	To what extent is new infrastructure needed, or are there specific requirements for land/space (footprint)?
Societal and political acceptance risk	To what extent is there a risk for reduced public acceptance or political support that should be addressed for successful implementation?
Regulatory complexity	What is the level of regulatory readiness and what licensing requirements and institutional frameworks would be needed to enable the role?
Risks and liability	What operational, financial and legal risks are associated with the implementation of the role?

Observation from stakeholder consultations related to ambition level

Although outside the scope of this study, the potential deployment of an SMR within the Port of Rotterdam was raised repeatedly during stakeholder interviews. Several stakeholders identified local SMR deployment as a potential long-term opportunity to support industrial decarbonisation and provide reliable low-carbon electricity and process heat. While this study does not assess the feasibility of such deployment, the level of stakeholder interest suggests that it could be the subject of dedicated future work and may be considered in terms of ambition level.

4.2.2 Step 2: Organise a public-private collaboration to realise ambitions in the SMR supply chain

The chosen ambition and position in Step 1 should be further developed and realised. We recommend doing this in a wider public-private collaboration with interested local companies and public partners (such as the Province South Holland, the Ministry of Economic Affairs and Climate and the regional development agency InnovationQuarter), to ensure support, alignment and capacity to implement actions.

To establish this public-private collaboration, we recommend first raising awareness of the opportunities in the SMR supply chain for the port and companies in the port. The aim is to primarily raise awareness among relevant companies. This can be done through the existing communication activities of SmartPort, Deltalinqs and Port of Rotterdam, but also through the organisation of an event for interested companies (e.g. following the publication of this report or the decision-making in Step 1). Further awareness raising can be continued by the public-private collaboration as needed.

In this study, we identified companies that could potentially play a role in the SMR supply chain based on available information and our assessment. We recommend confirming their interest in entering the SMR supply chain, their capabilities and appetite to invest in business development to enter the SMR supply chain. Interested companies can be invited to the collaboration platform.

4.2.3 Step 3: Develop a shared USP and action plan to position the port and its companies in the SMR supply chain

With the collaboration platform, a shared unique selling point (USP) for the port of Rotterdam should be developed towards key external stakeholders in the SMR supply chain (e.g. tier-1/2 companies such as vendors and their industrialisation partners, and potentially the national government). This USP is derived from the role that the port of Rotterdam aspires to have in the SMR supply chain and the strengths and opportunities identified in Chapter 3, aligned with the needs of key stakeholders (need for qualified suppliers, logistics, strategic locations, etc.).

An action plan should be developed to position the port and its companies in the SMR supply chain. This should include conducting collaborative business development by a group of people who are knowledgeable about the nuclear sector, so that business development can be conducted based on a correct understanding of the sector, SMRs, regulations and requirements. Business development includes the marketing of the USP and envisioned role in conversations with key stakeholders in the SMR supply chain (including vendors) and at relevant SMR conferences. Furthermore, these collaborative business developers can assist local companies in developing their SMR propositions and aligning them with the port's USP and ambition. Finally, the governance of the collaboration platform and its external communication channels should be clear to help companies or vendors to navigate to the platform.

Further recommendations for actions under the action plan are provided under Step 4.

4.2.4 Step 4: Execute the action plan and ensure boundary conditions are met and challenges are solved

The action plan should be executed by the public-private collaboration. This can be done in working groups, responsible for specific actions or action lines, or by a support organisation. We recommend executing the following actions under the action plan, targeted at preparing for and positioning in the supply chain, but also at ensuring required boundary conditions (e.g. regulatory and workforce) are met and identified challenges are solved:

- **Tag along to national supply chain activities that are being organised for the construction of large nuclear power plants by the national government.** This can complement local activities for the SMR supply chain and help companies in the port prepare for working for the nuclear sector. In addition, inspiration can be obtained from other regions as well: the regional development agencies in Zeeland, Noord-Brabant and Gelderland/Overijssel are undertaking various business development activities to better position their local companies in nuclear energy supply chains.
- **Facilitate matchmaking with vendors and companies in/near the port of Rotterdam.** Matchmaking of companies in the port with supply chain managers at SMR vendors, especially those close to market, can help to position them in the supply chain better.
- **Facilitate and lobby for an enabling regulatory environment for offshore SMRs.** Regulation is considered a key barrier for offshore SMRs and for ports wishing to be involved in offshore SMRs. If the port/collaboration platform has this ambition, Deltalinqs and Port of Rotterdam should lobby and facilitate clear and workable regulations for offshore SMRs at national and international level.
- **Share best practices and lessons learned between local companies about entering the SMR supply chain.** The collaboration platform, together with the help of associated companies, could collect best practices and lessons learned from local companies that already work for the nuclear sector or that managed to enter the SMR supply chain already. Often there is no conflict of interest in doing this, but a mutual interest in building a strong ecosystem of (sub)suppliers in the port.
- **Address workforce and educational needs by supporting and liaising with ongoing national initiatives (such as Nuclear Academy).** Workforce and education are a general concern for industry that is addressed in many national initiatives, also specifically for nuclear. Supporting and liaising with these initiatives seems most efficient to tackle initial challenges faced.

For individual companies:

- **Get qualified for the nuclear supply chain (certification, procedures).** Here the collaboration platform could consider organising professional support.
- **Register as a supplier to more advanced SMR vendors.** Here the collaboration platform could share information on how to register as a supplier.

4.2.5 Financing of steps and actions

The recommended steps and actions require investments from involved public and private stakeholders in the platform and external financing. Opportunities for external public financing are limited under existing programs and regulations, as the activities are not targeted at product or process innovation, but rather at business development, market creation and industrial development. Some of the actions can meet requirements of existing public funding programmes (e.g. related to human capital) or may qualify for support for regional development or foreign investments (e.g. to attract foreign companies to the port).

We recommend:

- To explore the willingness of participants in the platform to provide an in-kind or cash contribution. Considering the added value of strategic cooperation and shared activities, we expect that this is feasible.
- To discuss with local and national governments opportunities for public co-funding specifically for the platform and action plan. Considering the strategic contribution of the public-private platform and its actions to public economic and energy policy goals, also in relation to strategic autonomy, industrial competitiveness and national ambitions in nuclear energy, public co-funding may be justified.
- To explore the feasibility of contributions from existing funding programmes for selected activities under the action plan. Interesting programmes to explore are JTF Rijnmond and ERDF "Kansen voor West".

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Appendixes

Appendix A: Methodology

A.1. Detailed research questions

#	Research question
SMRs (introduction)	
1	What are SMRs?
2	What are the different types of SMRs?
2A	What is the status of these types of SMRs?
3	Which companies/actors develop/supply SMRs?
4	To what extent is there already a supply chain for SMRs?
5	What company certification or licensing is (likely) needed to operate in the SMR supply chain?
Supply Chain	
6	What does the SMR supply chain look like?
6A	What does the supply chain for the fuel of SMRs look like? (companies/actors)
6B	What does the supply chain of the components of SMRs look like? (companies/actors)
6C	How do these supply chains differ for different SMR technologies?
6D	To what extent is the supply chain for onshore and offshore application of SMRs different?
Roles and potential	
7	Which companies in the port of Rotterdam provide relevant services and products for the SMR supply chain?
8	What are potential roles that the port of Rotterdam could play in the SMR supply chain?
8A	What is the potential of the port of Rotterdam for SMR component production and pre-assembly?

#	Research question
8B	To what extent could the port of Rotterdam's existing maritime and offshore expertise be relevant for supporting SMR module manufacturing and deployment?
8C	What role could the port of Rotterdam play in the safe import, transit, and storage of (enriched) uranium and nuclear fuel for SMRs?
8D	How could the port of Rotterdam support SMR decommissioning through dismantling, recycling, or returning used modules?
Opportunities, challenges and recommendations	
9	What are the opportunities and challenges for the port of Rotterdam to play a role in the supply chain of SMRs?
9A	Are there any regulatory barriers for the port of Rotterdam to play a role in the supply chain of SMRs, esp. in the handling and logistics of nuclear fuel and radioactive waste?
10	How can the port of Rotterdam acquire a role/position itself in the supply chain of SMRs?
10A	Which actions and funds can help with this ambition?

A.2. Methodological approach

This study was conducted between January and July 2026 by Tractebel Engineering and Technopolis Group. A mixed-methods approach, using qualitative and quantitative methods, was used in the study. Multiple methods were used to answer each of the research questions ensuring robustness of our findings. An overview of the methodological approach is provided in Figure 27.

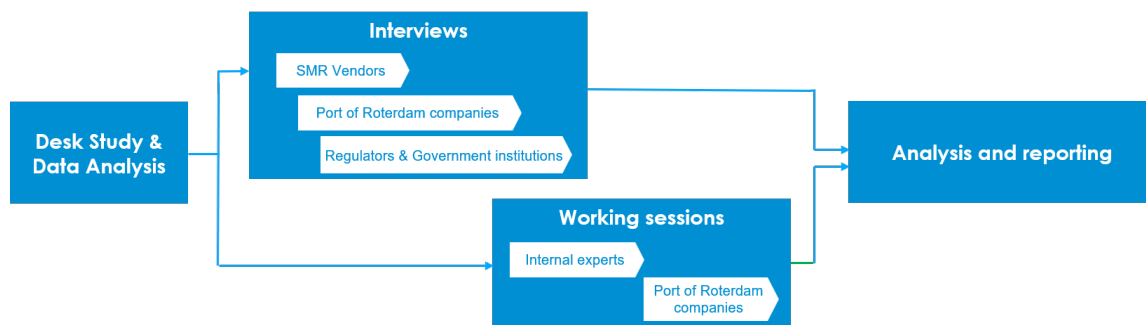


Figure 27: Overview of the methodological approach

Desk Study and Data Analysis: the desk study consisted of analysing publicly available information from recognised national and international sources to develop a first answer to the research questions and to develop analytical frameworks for the study. The desk study was complemented with data analysis in which a list of companies in the port of Rotterdam's ecosystem was constructed based on websites with existing lists of companies in the port and further completed with companies identified through desk study, interviews and the study team's internal data science tools (making use of AI). This list was cleaned, checked and enriched with further categorisation and assessments making use of AI and checked with expert assessments. Companies out of scope were removed and the SMR relevance of the remaining companies were assessed. Companies with medium or high relevance were included in the analysis and further categorised along the analytical frameworks for the SMR supply chain used in this study.

Interviews: to complement and enrich the desk study, a series of semi-structured interviews were conducted online. The aim of these interviews was to provide insights to support the strategic positioning of the port and its companies in the SMR supply chain and to identify opportunities. Fourteen organisations, including SMR vendors, companies in the port of Rotterdam, regulators and public authorities, were interviewed and are listed in section A.3.

Working sessions: internal and external work sessions were organised to tap into the knowledge of experts and stakeholders. Three internal work sessions were organised with Tractebel's in-house experts to discuss research questions, collect technical insights, validate findings, conduct collective sense-making, check assumptions, identify white spots, refine interpretations and to gather expert advice. One external work session was organised with companies and relevant stakeholders of the port of Rotterdam, which are listed in section A.3, and hosted physically in Rotterdam. The aim of the interactive and facilitated work session was to share, discuss and validate our preliminary findings, identify and validate opportunities and challenges, identify and validate actions to position the port of Rotterdam in the SMR supply chain, and prioritise next actions and potential involvement. This external work session was attended by twenty stakeholders from relevant local companies, business associations, the port, public authorities, SMR vendors/developers and regulators.

Analysis and reporting: the findings collected from the described methods were analysed, synthesised and reported in the current report. The draft final report was reviewed by the client's consortium and subsequently finalised and translated into Dutch.

A.3. Consulted stakeholders

Interviews

In total, fourteen organisations have been interviewed. This includes seven companies within the port of Rotterdam's ecosystem, five SMR vendors/developers, one public authority and one regulator. The following table provides an overview of the specific organisations, the type of stakeholder, and the sector they are active in.

Organisation	Type of stakeholder	Sector
Damen Shipyards Group	Company	Shipbuilding
Siemens Energy	Company	Energy technology
BAM	Company	Construction and infrastructure contractor
Huisman	Company	Heavy engineering and equipment manufacturing
Bilfinger Engineering & Maintenance BeNe	Company	Industrial services and maintenance contractor
Broekman Logistics / Broekman Project Services	Company	Logistics
Mammoet	Company	Heavy lifting and transport
Gemeente Rotterdam	Public Authority	Other
ANVS	Regulator	Other
Thorizon	Vendor/developer	Nuclear/SMR
Allseas	Vendor/developer	Nuclear/SMR
Rolls-Royce SMR	Vendor/developer	Nuclear/SMR
ULC-energy	Vendor/developer	Nuclear/SMR
Saltfoss	Vendor/developer	Nuclear/SMR

Work session

In total, twenty stakeholders from twelve different organisations participated. This included five companies within the port of Rotterdam's ecosystem, two SMR vendors, two public authorities, a port authority, a regulator and a business association. The following table provides an overview of the specific organisations, type of stakeholder, and the sector they are active in.

Organisation	Type of stakeholder	Sector
Huisman	Company	Heavy engineering and equipment manufacturing
Bilfinger Engineering & Maintenance BeNe	Company	Industrial services and maintenance contractor
Broekman Logistics / Broekman Project Services	Company	Logistics
Bureau Veritas	Company	Testing, inspection and certification
Royal Haskoning	Company	Engineering, design, and project management consultancy
Deltalinqs	Business association	Port and Industry
Port of Rotterdam	Port Authority	Other
Municipality of Rotterdam	Public Authority	Government
Ministry of Economic Affairs	Public Authority	Government
DCMR	Regulator	Environment
Thorizon	Vendor/developer	Nuclear/SMR
ULC-energy	Vendor/developer	Nuclear/SMR
SmartPort	Association	Port and Industry

Appendix B:

Assessment matrix for decision-making factors

Figure 28 provides an initial assessment of each of the suggested decision-making factors introduced under Step 1 in section 4.2 (Recommendations). This matrix is intended to facilitate decision-making on the ambitioned role of the port in the SMR supply chain with its key stakeholders in line with the port's overall strategic vision for 2050.

	A - A logistics or transit node for SMR components, and possibly fuel and waste, that enters or leaves European mainland	B - An industrial ecosystem contributing to the construction and integration of SMR parts and components for inland and maritime SMRs	C - A strategic European nuclear port for international maritime routes that constructs and services nuclear-powered vessels (and barges)	D - An integrated nuclear port in the inland and maritime SMR supply chain by attracting nuclear businesses dealing with fuel and waste
Strategic fit Alignment with existing strategies and ambitions	MODERATE Aligns with ambition to remain leading in logistics but does not further reinforce industrial cluster.	HIGH Aligns with ambition to have competing industrial cluster and will contribute to logistics role of the port.	POTENTIALLY HIGH Aligns with ambition to have competing industrial cluster, remain leading in logistics. However: is strong nuclear role also ambitioned?	POTENTIALLY HIGH Aligns with ambition to have clean/climate neutral industry and competing industrial cluster. However: is strong nuclear role also ambitioned?
Economic value Potential to strengthen competitiveness, generate business and attract investments	MODERATE Revenues expected in transit activities esp. if it concerns non-radioactive components (low complexity).	HIGH In addition to A, stronger business generation for industry if SMR market develops.	VERY HIGH If nuclear propulsion develops, this could lead to strong competitive position, new business & investments.	VERY HIGH If SMR market and nuclear propulsion develops, new businesses, investments and competitive position expected.
Market potential Potential to enter SMR market and supply chain and capture significant market share	HIGH Potential to be one of main ports for transport/logistics.	HIGH Potential to play a role in industrial supply, integration and qualified manufacturing.	POTENTIALLY VERY HIGH If frontrunner potential to capture significant market share with specialized role/USP, depends on nuclear propulsion development	POTENTIALLY VERY HIGH Existing market, but likely scaling, integration provides strategic potential to capture market share and build industrial ecosystem.
Feasibility To what extent is the implementation of this role feasible	VERY HIGH Does not differ from current activities esp. if it concerns non-radioactive components (low complexity).	HIGH Builds on existing industrial, engineering and maritime capabilities (low/moderate complexity).	MODERATE Requires specific nuclear maritime capabilities, safety arrangements and dedicated infrastructure (high complexity).	MODERATE Requires attracting nuclear businesses, develop licensing pathways, managing fuel/waste requirements (high/very high complexity).
Investment need Level of investment or support required	LOW Does not require much investment beyond business development/marketing.	MODERATE Requires more extensive business development and potentially some investments by companies.	HIGH Next to business development investments in nuclear propulsion capabilities, infrastructure, regulation, etc.	VERY HIGH Next to business development investments to attract businesses and in infrastructure, compliance etc.
Infrastructure and space need Footprint and infrastructural requirements	LOW Existing infrastructure, little/no additional footprint, possibly dedicated areas for sensitive cargo.	LOW Largely existing infrastructure and industrial capacity.	HIGH Requires dedicated servicing areas, security arrangements, potentially specialized berthing infrastructure.	VERY HIGH Requires land for new facilities/businesses, potentially special areas for fuel/waste related activities.
Societal/political acceptance risk Risk for reduced acceptance and public support	LOW Not materially different from current situation, esp. if mainly component logistics.	LOW Concerns non-radioactive components, leads to further industrial development.	POTENTIALLY HIGH Depends on acceptance of nuclear vessels and their servicing in the port.	POTENTIALLY HIGH Depends on acceptance of nuclear industry, fuel/waste activities in the port.
Regulatory complexity Regulatory readiness, requirements and licensing	LOW Not materially different from current situation, esp. if mainly component logistics.	MODERATE Mainly nuclear quality assurance, standards and supplier qualification for companies.	HIGH Nuclear marine safety, security, international regulatory interfaces, servicing requirements, etc.	VERY HIGH Full nuclear licensing, safeguards, security and liability requirements.
Risks and liability Operational, financial and legal risks	LOW Not materially different from current situation, esp. if mainly component logistics.	LOW Not materially different from normal business operations in these industries.	HIGH Servicing nuclear-powered vessels incur financial, operational, legal and reputational risks.	VERY HIGH Fuel/waste handling/storing and regulatory responsibilities impose significant operational, financial and legal risks.

Figure 28: Initial assessments per role and decision-making factor to support decision-making on ambition level

Colophon

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