BUSINESS SWEDEN
THE SWEDISH TRADE & INVEST COUNCIL

APPENDIX 1:

THE GLOBAL NUCLEAR BUILD-OUT

This is an appendix to Business Sweden's main report delivered in June 2026

EXECUTIVE SUMMARY

Nuclear energy is experiencing its strongest global expansion in decades. The Global Energy Monitor (GEM) Nuclear Power Tracker records 507 pipeline units totalling 365 GW across announced, pre-construction, and under-construction phases, alongside 421 reactors (401 GW) in operation worldwide. This expansion is driven by climate commitments, energy security, and rising electricity demand from data centres and AI infrastructure. However, the build-out is highly uneven: Asia accounts for ~60% of pipeline capacity, compared with 26% in Europe, 6% in the Americas, and 8% in Africa.

The report is structured around four chapters: (1) the global project landscape and trends, including FOAK/NOAK dynamics and partnership models; (2) global demand for nuclear-grade components and services; (3) bottlenecks in Europe's build-out and implications for Sweden; and (4) geopolitical and security-of-supply risks. The analysis draws on Business Sweden's report *Powering the Future: Mapping the Nuclear Value Chain* (November 2025), supplemented by IAEA, IEA, WNA, and other industry sources.

Three findings stand out. First, China and Russia dominate both the construction pipeline and supply chain, accounting for 48 of the 52 reactors that began construction since 2017, while Russia holds ~40% of global uranium enrichment capacity. Second, Europe's FOAK track record is weak: projects such as Olkiluoto 3 and Flamanville 3 saw cost overruns of 2 to 4x and delays exceeding a decade. Third, the global build-out creates significant export opportunities for Swedish companies across fuel services, engineering, automation, digitalisation, lifecycle services, and advanced manufacturing.

To capture this, Swedish companies will need to position early in Western supply chains, qualify for long-term nuclear programmes, and target key bottlenecks such as fuel services, grid infrastructure, components, digital solutions, and long-term operations and maintenance services.

1. GLOBAL PROJECT LANDSCAPE AND TRENDS

1.1. Planned and ongoing projects across geographies

The global nuclear pipeline spans all stages, from announced to construction. The GEM Nuclear Power Tracker records 76 units under construction (82 GW), 140 in pre-construction (107 GW), and 291 announced (177 GW), totalling 507 units and 365 GW.

However, this pipeline is less certain than headline figures suggest. A key limitation is that many projects lack defined timelines: 186 of the 291 announced units (122 GW) have no scheduled construction or operation date, making reliable forecasting difficult.

The pipeline is dominated by pressurised water reactors (PWRs). Small Modular Reactors (SMRs) account for a significant share by unit count but a much smaller share of capacity, reflecting their lower output per unit. At the same time, the market is shifting from FOAK (first-of-a-kind) to NOAK (nth-of-a-kind) deployment, moving away from bespoke projects towards standardised, repeatable reactor fleets.

Research indicates that FOAK SMRs in newcomer countries typically require 7–10 years for deployment, while NOAK units could be delivered in around 5 years as supply chains and regulatory frameworks mature. In established nuclear countries, FOAK SMR deployment may be shorter, at approximately 5–7 years.

Region	Operating	Pipeline Units	Pipeline GW
Africa	2	38	29.9
Americas	120	111	20.6
Asia	132	208	218.2
Europe	167	150	96.5
TOTAL	**421**	**507**	**365.2**

Table 1: Global nuclear pipeline by region (Announced + Pre-Construction + Construction)

Asia

Asia accounts for the majority of the global construction pipeline and hosts the most active nuclear programmes. China leads with 33 units under construction (the highest globally), 23 in pre-construction, and 53 announced (all without defined timelines). China approved 6–10 new reactors annually in 2021–2024 and invested a record CNY 146.9 billion ($20 bn+) in 2024. The Hualong One (HPR1000) is the workhorse design, with its FOAK unit at Fuqing-5 completed in~ 5,7 years, the only Gen III+ reactor delivered on schedule globally. China's CNNC leads the vendor pipeline with 68 all-time pipeline units (75.1 GW total), followed by SPIC with 25 units (33.0 GW). China has also become the world's first country to commercialise a Generation IV Small Modular Reactor, with its pebble bed reactor entering operation in December 2023. Construction of the ACP100 SMR demonstration project began in 2021 and is currently in the final stages of construction.

India has 6 units under construction and 24 in pre-construction (31.5 GW pipeline), combining indigenous PHWR designs with imported Russian VVERs and a planned fleet of 700 MWe PHWRs. South Korea has 4 units under construction (5.6 GW) and demonstrates the strongest NOAK cost discipline among Western-aligned countries, with its APR-1400 design completing construction in approximately 5-6 years domestically. Turkey has 4 Russian VVER-1200 units under construction at Akkuyu and 8 more announced.

The ASEAN region is emerging as a significant new market, targeting 8.5 GW of nuclear capacity by 2037. Indonesia plans a 500 MW SMR rollout by 2034, and the Philippines aims for its first reactors by 2032.

Americas and Africa

In North America, the United States is focused on both extending existing capacity and deploying next-generation reactor designs. The market is therefore less about volume and more about technology development and early SMR deployment.

The Biden administration (Nov 2024) set out an “aggressive” plan to triple U.S. nuclear capacity by 2050. The federal roadmap targets ~200 GW of new nuclear (including advanced reactors) by mid-century through new builds, restarts, and upgrades, effectively doubling today’s ~100 GWe, and with milestone goals like ~35 GW by 2035. The restart of Three Mile Island Unit 1 is advancing, supported by a federal loan, to supply Microsoft. FOAK projects include TerraPower’s Natrium (sodium-cooled fast reactor) and Kairos Power’s Hermes (molten salt reactor). X-energy and Energy Northwest plan to deploy up to 12 SMR units by 2039. Canada’s flagship project is the BWRX-300 at Darlington, Ontario, which received a construction licence in 2025 and is targeting first power by late 2029.

In South America, Argentina’s CAREM-25 SMR project is approximately 85% complete, though its 2028 launch remains unconfirmed due to funding delays. In Africa, South Africa mandates 5,200 MW of new nuclear capacity by 2039 and is reviving its Pebble Bed Modular Reactor (PBMR) concept. Ethiopia and Niger have announced reactor commissioning targets in the 2032–2034 timeframe. Russia’s Rosatom has been active in signing agreements across multiple African nations, raising concerns about geopolitical dependencies.

Europe

Europe presents a stark contrast between ambitious policy targets and a limited recent construction experience. In practice, this translates into a gap between planned deployment and actual delivery capacity.

Overall, Europe’s pipeline comprises 150 units (96.5 GW), yet only 10 units (9.3 GW) are under construction. Of these, 7 are Russian-designed VVERs (in Russia, Slovakia, and Hungary), 2 are EPRs at Hinkley Point C, and 1 is in Slovakia, highlighting the region’s limited recent execution experience outside a narrow set of technologies and vendors.

The United Kingdom has selected Wylfa as the site for three Rolls-Royce SMRs and continues construction at Hinkley Point C, while Sizewell C is advancing under a Regulated Asset Base (RAB) financing model. France has tasked EDF with building six new large-scale reactors, with the first unit expected by 2038. The country is also reviewing SMR options including NUWARD and Newcleo’s LFR-AS-200 AMR. In pre-construction, the UK leads with 6 units, followed by Ukraine (4), Poland (3), the Czech Republic (3), and France (2).

Central and Eastern Europe represent the most active near-term deployment zone. Poland aims for its first commercial nuclear power plant by 2033 alongside a fleet of 24 BWRX-300 SMRs operational by 2030 and has the largest overall programme, with 49 pipeline units (15.6 GW) though many remain undated. Czechia has selected the Rolls-Royce SMR for deployment, with early work commencing in 2025, while Estonia is pursuing an accelerated nine-year timeline for its first SMR. Finland is integrating SMRs such as the LDR-50 for urban district heating, with commissioning planned for 2030.

Country	Operating	Construction	Pre-Const.	Announced	Pipeline	Pipeline GW
Poland	0	0	3	46	49	15.6
UK	9	2	6	6	14	8.9
Romania	2	0	8	0	8	1.9
Czechia	6	0	3	4	7	5.7
Ukraine	15	0	4	3	7	8.4
France	57	0	2	4	6	9.9
Sweden	6	0	0	1.5	1.5	1.5

Table 2: Top European countries by pipeline size (Note: Russia excluded from the Top European Countries by Pipeline size due to limited relevance for the present analysis)

The Nordic-Baltic region

The Nordic-Baltic corridor is emerging as Europe's most coherent SMR deployment zone. Sweden, Finland, and Estonia together represent 6–9 GW of pipeline capacity, approaching the 7 GW threshold Tier 0 vendors typically require before investing in regional module manufacturing.

In Sweden, Vattenfall has shortlisted GE Vernova's BWRX-300 and Rolls-Royce SMR for Ringhals, supported by a SEK 220 billion financial framework. The road map targets 5,000 MW by 2035 and 10,000 MW by 2045.

Finland is advancing along two tracks. Fortum signed Early Works Agreements with EDF, Westinghouse-Hyundai, and GE Vernova Hitachi in June-July 2025 for potential deployment in Finland or Sweden in the late 2030s. Separately, Steady Energy's LDR-50 district heating reactor targets construction start in 2029, with 15 reactor agreements already signed across Finnish cities.

Estonia is the most advanced new entrant. Fermi Energia launched the national planning process in May 2025 for two BWRX-300 units (~600 MW) at candidate sites in northern Estonia (Viru-Nigula and Lüganuse), with a construction permit application planned for 2029 and first operation targeted by 2035–36. Samsung C&T signed an EPC teaming agreement in April 2025 and TVO Nuclear Services joined in an advisory role in February 2026.

Norway is the most uncertain part of the corridor. The Norwegian Nuclear Commission published its report in April 2026 recommending that Norway should not initiate a full-scale nuclear power process at this stage, but should build capabilities to enable a future decision. Norsk Kjernekraft continues to site assessments at Tjeldbergodden and Austrheim (up to 1,500 MW), but Norway's contribution to the near-term pipeline remains contingent on a policy shift.

1.2. Priority markets for early Swedish engagement

The global build-out is not only a demand opportunity but a sequencing challenge: supplier positions are being locked in internationally years before Swedish projects reach construction. Swedish companies therefore need to engage in external markets to build credentials, secure vendor roles, and shape future supply chains.

Three priority market categories emerge based on timing, access, and strategic value:

FOAK SMR markets: the primary entry point into global supply chains

First-of-a-kind SMR programmes represent the most important entry point into global supply chains. Canada and the United States host multiple FOAK SMR deployments, and their supply chains are not yet fully consolidated, making them relatively accessible. Early participation enables qualification, reference projects, and positioning for repeat roles across NOAK fleets.

European new-build programmes: the immediate opportunity

European new-build programmes offer the most immediate export opportunity, particularly in Central and Eastern Europe.

Countries such as Poland, Czechia, and the UK are entering execution phases, while domestic industrial capacity is insufficient to deliver planned pipelines. Demand therefore aligns directly with Swedish strengths in switchyard, balance of plant, and engineering services.

Select high-growth markets: scale potential but constrained access

Selected high-growth markets offer long-term scale potential, but access remains structurally constrained. The global build-out is concentrated in Asia and other emerging markets, where China- and Russia-led programmes dominate volumes and are largely closed to Western suppliers.

However, markets such as India, Southeast Asia, and selected emerging economies may offer targeted entry points depending on vendor alignment and delivery models.

2. PARTNERSHIP MODELS

Given the capital intensity and risk profile of nuclear projects, the industry is shifting away from fixed-price turnkey contracts towards collaborative risk-sharing models.

Consortia and Joint Ventures (JVs) are now standard for large projects. The EDF/CGN partnership in the UK involves joint control of entities responsible for the design, construction, and operation of Hinkley Point C and Sizewell C. In Canada, the Darlington New Nuclear Project uses a ‘one team’ model integrating OPG as owner, GE Vernova as developer, AtkinsRéalis as engineer, and Aecon Kiewit as constructor. For SMRs, newcleo and NAAREA formed a strategic partnership in 2024 to accelerate AMR development by sharing R&D and supply chain resources.

Specialised financial and ownership models are also expanding. The Build-Own-Operate (BOO) model, used by Rosatom at Türkiye’s Akkuyu NPP, places full responsibility for financing, construction, and operation on the vendor, while the host country provides the site and infrastructure. This model creates long-term strategic dependency and has drawn criticism from energy security analysts. Finland’s Mankala model allows industrial users and utilities to co-own projects and offtake electricity at cost, providing a stable revenue base. Poland is developing a similar ‘SaHo’ model, where the state initially invests and gradually transfers ownership to private consumers as risk declines.

Integrated Project Delivery and Alliance models are emerging as best practice for managing FOAK risk. IPD integrates people and systems through multi-party agreements and shared risk/reward structures; industry estimates suggest that well-executed IPD can reduce FOAK costs by 30–40%. The MEH Alliance at Hinkley Point C, which integrates four major UK contractors as a single entity for cabling and pipework, is an example of this approach. An emerging concept is the EFI SPV, where a ‘buyers’ club’ of utilities forms a special purpose vehicle to build an orderbook of ten identical SMRs, pooling capital and keeping debt off individual balance sheets.

This shift towards collaborative delivery is closely linked to the structure of the global vendor landscape. As shown in Table 3, deployment capacity remains concentrated among a limited number of players, with Rosatom and Chinese state-owned enterprises dominating both pipeline size and active construction. Western vendors such as Westinghouse, EDF, and GE Hitachi retain strong installed bases but comparatively smaller construction pipelines, reinforcing the need for partnership-based models.

Vendor	All-Time Units	Operating GW	Pipeline Units	Pipeline GW	Under Constr. GW
Rosatom	258	64.4	79	65.1	26.9
CNNC	128	40.2	68	75.1	20.6
Westinghouse	217	87.3	31	32.7	2.5
GE Vernova Hitachi	157	41.9	49	20.1	6.6
SPIC	48	1.5	25	33.0	11.5
EDF	60	47.6	16	26.9	3.4
KHNP/KEPCO E&C	37	24.1	10	12.8	5.6
NuScale Power	60	0	36	2.8	0
Rolls-Royce SMR	2	0	2	0.9	0

Table 3: Top vendors by pipeline size

These structural shifts are reflected in the diversity of partnership models across nuclear projects. As summarised in the following Table 4, the industry is moving toward a hybrid landscape combining contractual innovation, financial engineering, vendor-led delivery, and collaborative platforms.

For Swedish companies, this shift toward collaborative and alliance-based delivery models has important implications. Rather than acting as standalone EPC providers, Swedish firms are more likely to capture value as specialised technology, engineering, automation, electrification, fuel, digitalisation, and lifecycle partners within larger international consortia. This increases the importance of early qualification into vendor ecosystems, long-term framework agreements, and participation in standardised reactor programmes.

Models such as IPD, framework alliances, and SMR orderbooks favour suppliers capable of long-term partnership, standardisation, and multi-project delivery rather than one-off execution.

Summary of nuclear construction partnership and collaboration models

Model Category	Model Name	Key Characteristics & Stakeholder Roles	Context / Example	Implications for Swedish Companies
Delivery Models (Contractual Arrangement)	EPC Turnkey	A single contractor or consortium takes overall technical responsibility for design and construction, providing price and schedule guarantees.	Traditional industry standard; often expensive due to high risk premiums.	Limited opportunity as prime contractor; stronger positioning as specialised Tier 1/Tier 2 technology supplier.
	Multi-Contracting	The owner acts as project manager, coordinating multiple Tier 1 contractors for specific work packages (e.g., civil, turbine, nuclear island).	Used by experienced owners like EDF (Hinkley Point C, Flamanville 3).	Creates opportunities for Swedish engineering, automation, electrification, HVAC, and digital solution providers to contract directly into packages.

	Split Package (Hybrid EPC)	Responsibility is divided between a few major contractors, typically one for the "nuclear island" and another for the balance of plant.	Common when owners want to manage high-level interfaces without full turnkey costs.	Favours companies capable of delivering integrated subsystems and balance-of-plant technologies.
	Integrated Project Delivery (IPD)	A "one-team" collaborative approach integrating people, systems, and structures. Uses shared risk/reward pools and joint decision-making.	Darlington SMR Project (OPG, GE Hitachi, AtkinsRéalis, Aecon Kiewit).	Early ecosystem integration and long-term collaboration capabilities become critical competitive advantages.
Ownership & Financial Models	Special Purpose Vehicle (SPV)	An independent legal entity (often an LLC) created to own the plant and isolate project financial risk from project sponsors' balance sheets.	Used for the Polish Nuclear Programme and proposed for SMR orderbooks.	May create financing and co-investment opportunities for Swedish industrial and infrastructure investors.
	Mankala Model (Customer-led)	A cooperative model where utilities and industrial power users form a JV to build a plant and offtake power at cost.	Widely used in Finland (Olkiluoto 3).	Relevant model for large Swedish industrial power consumers seeking long-term stable electricity supply.
	SaHo Model	The state acts as the initial sole investor to handle high-risk phases, then divests shares to large electricity consumers as construction milestones are met.	Proposed for the Polish nuclear program.	Reduces early project risk and may improve bankability for Swedish suppliers entering new nuclear markets.
	Dynamic Refinancing	Shares of public and private ownership change at predefined technical milestones; ownership is incrementally transferred from the public to private sector.	Conceptual model proposed by the NEA to lower financing costs.	Creates opportunities for phased private-sector participation and long-term industrial partnerships.
Vendor-Integrated Models	Build-Own-Operate (BOO)	The vendor/donor country assumes full responsibility for financing, design, construction, ownership, and operation. The host provides the site.	Akkuyu NPP (Türkiye) involving Rosatom.	Limited accessibility for independent suppliers due to vertically integrated vendor ecosystems.
	Manufacturer Model (SMR)	Similar to traditional NPPs; vendor focuses on design and licensing, selling the reactor to a separate operator.	Prevalent model for large-scale grid applications.	Favors standardised component suppliers able to scale across multiple reactor deployments.
	Energy-as-a-Service (SMR)	Vendor provides a turnkey solution, owning and operating the reactor while selling heat or electricity directly to the end consumer.	Targeted at industrial clusters and off-grid data centers.	Creates opportunities in industrial heat, off-grid power, and data center applications where Sweden has strong industrial capabilities.
Collaboration Platforms	Orderbook / Buyers' Club	A consortium of buyers commits to a bulk order of identical reactors to capture learning effects and eliminate first-mover disadvantages.	Proposed as a way to "kickstart" the SMR industry.	Standardisation and repeat orders could strongly benefit Swedish advanced manufacturing exporters.
	MEH Alliance	Four major contractors working as a single entity to manage complex mechanical, electrical, and HVAC installations.	Used at Hinkley Point C.	Alliance structures favour suppliers with proven multi-project execution and long-term delivery capabilities.
	Framework Alliance Contract	An "umbrella" contract that integrates bilateral project contracts, holding all members accountable to shared overarching objectives.	Proposed for large infrastructure to bridge gaps between bilateral agreements.	Long-term framework positioning and qualification become more important than one-off project bidding.

Table 4: Summary of nuclear construction partnership and collaboration models

3. GLOBAL DEMAND FOR NUCLEAR-GRADE COMPONENTS AND SERVICES

The global nuclear build-out is generating unprecedented demand for highly specialised components and systems. This chapter focuses on the hardware required for construction of new reactors, the long-lead items, safety-critical equipment, and structural materials that will determine whether the global pipeline can be delivered on time and on budget. Business Sweden's Powering the Future: Analysis of Sweden's Nuclear New Build Value Chain (November 2025) structures the supply chain across six segments: Development, Construction, Primary Circuit (nuclear island), Secondary Circuit (turbine island), Balance of Plant, and Switchyard.

3.1. Key component and service categories with high global demand

Primary Circuit: The most constrained components

The nuclear island (the primary circuit) accounts for approximately 15% of total project costs and contains the most technically demanding and supply-constrained components. It is also the segment where Sweden remains fully dependent on international Tier 0 OEMs, with no domestic entity holding the intellectual property or recent large-scale new-build experience required to lead this scope independently.

Reactor pressure vessels

Reactor pressure vessels (RPVs) represent the most critical bottleneck. Gen III+ RPVs require forging presses of 140–150 MN capacity accepting 500–600 tonne steel ingots. Global manufacturing capacity stands at approximately 42 RPV sets per year, concentrated in a small number of suppliers: Japan Steel Works (~12/year), Doosan Enerbility (~5/year), three Chinese facilities (~16/year combined), and Russia's OMZ Izhora and Atommash (~9/year combined). Europe's only significant capacity is Framatome's Creusot Forge (~2 sets/year). Lead times run 3–5+ years from order to delivery.

Based on the GEM Nuclear Power Tracker pipeline (507 units, 365 GW) and applying credibility weights by project status, Europe alone will require approximately 43 LSR reactor pressure vessel sets between 2028 and 2040 under a central scenario, against a domestic supply ceiling of roughly 26 sets from Framatome Creusot Forge at its current throughput of around two sets per year. The structural shortfall of 15–17 sets cannot be closed by European capacity alone and must be sourced from Asia. The full methodology and annual breakdowns are provided in Appendix 1.

The consequences of this concentration became starkly visible at Flamanville 3, where abnormal steel composition was discovered in the RPV head from the Le Creusot facility, and where extensive welding defects reflected the broader erosion of industrial expertise that results from decades without construction. Together these issues contributed to a 12-year delay and a final cost approaching €20 billion.

Additional capacity in the UK (Sheffield Forgemasters) is expected later this decade, but remains insufficient to close the gap. The press installation is scheduled to begin in July 2027 and is estimated to take 12 months to complete. Final commissioning by Mitsubishi Nagasaki Machinery will add further lead time before nuclear-grade production can start. Given the limited public information on additional capacity, Sheffield Forgemasters is referenced qualitatively but not incorporated into the bottleneck estimate.

Steam generators, pressurizers, and reactor coolant pumps

In PWR designs, they are replaced after 20–30 years of service, creating significant demand from life-extension programmes on top of new-build requirements. Pressurizers maintain required pressure within the primary coolant loop, while reactor coolant pumps (some exceeding 110 tonnes) circulate primary coolant under extreme pressure and temperature in a radiation environment. All three components require specialised nuclear-grade qualification and are sourced almost exclusively from global Tier 0 OEMs. Their long lead times mean that delivery delays cascade directly into schedule overruns and accumulating financing costs.

3.2. The heavy forging deficit: Europe’s structural industrial bottleneck

The deficit in heavy forging capacity is Europe’s most critical manufacturing constraint. It is not just a procurement challenge, but the result of decades of underinvestment that have created dependence on external markets and a structural vulnerability in achieving energy sovereignty. Europe now has very few facilities meeting this standard. Framatome’s Creusot Forge maintains some capacity, but only a handful of facilities globally (mostly in Japan, China, and South Korea) can handle the ultra-large forgings required for the most advanced designs. Historically, Japan Steel Works was the only forge capable of processing certain large nozzle shell ring components for the EPR.

This dependency creates compounding risks. Asian manufacturers face record domestic demand as China’s construction programme accelerates, which could divert supply away from European customers at exactly the moment Europe needs it most. Any disruption to trans-Pacific supply chains, whether from geopolitical tensions, trade restrictions, or capacity constraints could delay European nuclear projects by years. The situation is worsened by a structural deadlock: suppliers hesitate to expand forging capacity without firm orders, while customers are reluctant to commit without a proven supply chain in place. Breaking this cycle requires the long-term programmatic demand signal that only a coordinated multi-reactor programme can provide.

Innovations are emerging to partially address these constraints. Local Electron-Beam Welding (LEBW) is being explored as an alternative to traditional forging for some vessel components. This technology can perform full-thickness welds in a single pass, potentially reducing vessel assembly time from roughly one year to less than 24 hours, effectively removing the RPV from the critical path in certain SMR designs.

3.3. SMR components: A different industrial paradigm

Small Modular Reactors are increasingly viewed as a structural solution to the industrial bottlenecks that have historically plagued large-scale nuclear projects. By shifting the construction paradigm from bespoke megaprojects to standardised factory manufacturing, SMRs aim to bypass the most acute physical constraints of Gen III+ reactor designs, most notably the heavy forging deficit.

Overcoming the forging constraint

The most significant component advantage of SMRs is that their smaller Reactor Pressure Vessels and internal components allow a wider pool of Tier 1 and Tier 2 manufacturers to participate in the supply chain. Required forging press capacities and ingot sizes fall within the capabilities of standard heavy industrial facilities rather than the ultra-specialised forges that LSRs require. Facilities in North America and Europe that cannot produce ultra-large forgings are already repositioning themselves for the SMR market: in the US, North American Forgemasters and Allegheny Technologies Inc. are specifically targeting SMR supply chains. LEBW technology, which can reduce vessel assembly time from a year to less than 24 hours, is particularly suited to SMR-scale components and is being developed specifically to enable series production.

Modularity, passive safety, and factory assembly

SMR designs emphasise prefabricated modules weighing up to 1,000 tonnes that are transported to site and lifted into place. Moving much of construction into a controlled factory environment mitigates the risks seen at Flamanville 3 by replacing thousands of specialised site welds performed under adverse conditions with repeatable factory quality control. Many SMR designs also incorporate passive safety systems that rely on natural circulation and gravity-driven cooling rather than active pump-driven circuits, directly reducing the number of safety-certified pumps, valves, and piping systems required per unit. This eases the burden on the highly concentrated pool of certified nuclear-grade vendors that represents one of the most persistent supply chain constraints for large reactors.

SMR business models depend on serial construction logic, building identical units in a factory setting to leverage Wright’s Law: a 10–15% cost reduction for every doubling of production volume, driven by factory-based learning rather than site-specific civil engineering. Realising these benefits requires multi-unit deployment programmes that provide suppliers with sufficient long-term demand visibility to justify investment in dedicated manufacturing capacity.

3.4. Secondary circuit, balance of plant, and switchyard

Beyond the nuclear island, significant demand exists across the secondary circuit, balance of plant, and switchyard, segments where Sweden’s industrial base holds genuine competitive advantage, as confirmed by Business Sweden’s *Powering the Future* (November 2025).

Steam turbines for nuclear applications are low-speed designs (1,500–1,800 rpm) optimised for wet steam conditions. Sweden has full dependency on global OEMs for core rotating equipment (GE, Siemens Energy, Mitsubishi Power, Doosan Skoda Power) but delivers strong auxiliary scope.

The Balance of Plant (HVAC, pumps, condensers, and I&C) accounts for approximately 15% of project costs. The primary gap is the absence of nuclear-specific EPCM experience to package these into a fully integrated BoP offering.

The switchyard represents Sweden’s most competitive value chain segment. Global demand for Generator Step-Up (GSU) transformers has risen approximately 274% since 2019, with lead times now stretching to 3–4 years, creating a bottleneck that can delay entire nuclear and renewable projects. Powering the Future (November 2025) rates Sweden’s switchyard capabilities as ‘Very Strong’ on a Nordic basis, with low international dependency, making this the highest-confidence export opportunity.

Component category	What it covers	Typical procurement timing	Global supply status & Swedish angle
Reactor Pressure Vessels (RPVs)	Ultra-heavy forgings (350–500 tonne ingots; 15,000+ tonne presses); primary radioactive containment barrier	Early project phase after design finalisation; long-lead item requiring early fabrication slot reservation	Critically thin globally. Framatome (Creusot Forge), Japan Steel Works, Doosan are the primary Western suppliers. Sheffield Forgemasters (UK) adding 13,000-tonne press; operational later this decade. Sweden has no domestic RPV manufacturing capability, making projects dependent on imports.
Steam Generators & Pressurizers	Massive PWR heat exchangers transferring heat between primary and secondary circuits; pressurizers maintain coolant pressure	Early-to-mid construction phase; typically part of nuclear island procurement package	Concentrated supply in East Asia (Doosan, MHI) and France (Framatome). Replacement demand rising as life extension programmes require swap-out after 20–30 years. Long-lead items with cascade schedule risk. Sweden has no primary role.
Reactor Coolant Pumps	High-precision pumps circulating primary coolant at extreme pressure under radiation; some exceeding 110 tonnes	Early construction phase following reactor design freeze	Specialised global supplier base (Flowserve, Curtiss-Wright EMD, KSB/Sulzer, and Framatome). SMR passive-circulation designs can eliminate this requirement, easing pressure on a constrained supply chain.
Nuclear-Grade Valves	Thousands of certified shut-off, gate, globe and check valves per reactor; must withstand radiation and ensure absolute leak-tightness	Staggered procurement across design and construction phases following qualification	Only 4–7 qualified European suppliers for some critical categories. Qualification opportunity for new entrants. SMR passive safety designs reduce valve count per unit. Sweden has limited direct nuclear qualification capacity, but industrial valve and sealing ecosystem can support qualification pathways if nuclear certification is developed.
Control Rod Drive Mechanisms & Reactor Internals	CRDMs, fuel assembly structures, core support plates and pressuriser heaters, all safety-critical and subject to full nuclear-code qualification	Early-to-mid construction phase after nuclear island definition	Dominated by Tier 0 OEMs (Westinghouse, Framatome, GE Hitachi). Limited independent supplier base; multi-year qualification cycles required. Sweden is not a supplier of reactor internals
Steam Turbines & Secondary Circuit	Low-speed nuclear turbines), moisture separator reheaters, condensers, feedwater systems	Mid construction phase aligned with grid connection and commissioning planning	Full dependency on global OEMs: GE, Siemens Energy, Mitsubishi Power. Sweden has strong auxiliary capabilities but must source core rotating equipment internationally
Electrical, I&C & Switchyard Equipment	Digital I&C systems, turbine-generators, high-voltage transformers (GSU demand +274% since	Continuous procurement across design and construction	Sweden world-class in this segment: lead in transformers and switchgear; HV cabling. Lead times now 3–4 years globally, a direct export opportunity.

	2019), switchgear (AIS/GIS), HV transmission cables	due to qualification constraints	
Specialty Materials & Structural Components	Low-cobalt stainless steel, nuclear-grade graphite, zirconium alloys (fuel cladding), high-grade pressure-vessel steels, reinforced concrete	Post-orderbook / post-design freeze, aligned with serial manufacturing ramp-up	Low-cobalt steel produced in 50–100 tonne batches far exceeding typical 5–20 tonne repair orders (procurement challenge). Graphite dominated by China.
SMR Factory Modules (Types 1–3)	Type 1: concrete rebar cages. Type 2: large steel frames (containment rings, pipe racks). Type 3: equipment pods with pumps, piping, cabling pre-installed and factory-tested	Post-orderbook / post-design freeze, aligned with serial manufacturing ramp-up	Entirely new supply category with no established supply chain. Early movers gain supply chain influence. Sweden's civil and engineering base is competitive for Type 1, 2; Type 3 viable at ~7 GW regional orderbook.

Table 5: Nuclear build-out component categories – global demand, supply chain status, and Swedish angle

3.5. Fuel cycle services

Fuel cycle services represent a growing and strategically sensitive demand category. Global uranium demand could rise sharply by 2050 under nuclear tripling scenarios, far exceeding current production levels. Conversion and enrichment services face tightened market conditions due to geopolitical pressure to reduce Russian supply. High-Assay Low-Enriched Uranium (HALEU), enriched between 5% and 19.75%, is essential for many SMR and AMR designs but is not yet produced at commercial scale in the West, creating a critical bottleneck for next-generation deployment. Bespoke fuel fabrication, unlike commodity products, requires multi-year qualification programmes for new suppliers and cannot be easily substituted between reactor designs.

For Sweden, this increases the strategic importance of securing long-term access to Western fuel supply chains and strengthens the relevance of domestic nuclear fuel capabilities, particularly through fuel fabrication activities in Sweden. The shift away from Russian enrichment and fuel services may also create opportunities for Swedish and European suppliers to expand their role in the regional nuclear fuel ecosystem.

3.6. Life-cycle and professional services

Approximately 80% of nuclear companies now provide maintenance through Long Term Service Agreements (LTSAs). The operations and maintenance market for SMRs alone is estimated at US$20–30 billion per year by 2050. The global market for nuclear plant construction and refurbishment for Long-Term Operation (LTO) is projected at approximately $30 billion per year through 2030. Decommissioning services represent a growing multi-billion-dollar segment, with total investment needs estimated at approximately $95 billion through 2030 as older units reach end-of-life. Professional services including nuclear engineering design, digital twins, AI-based simulations, and regulatory licensing support are also in strong demand as countries launch new programmes. For a full assessment of Swedish capabilities across operations, maintenance, upgrades, decommissioning, and waste management, see the accompanying Promoting Swedens Nuclear Value Chain analysis report.

3.7. Requirements across construction, commissioning and operations

Delivering a nuclear project is an enormous industrial undertaking across three distinct lifecycle phases, each with its own critical requirements, risks, and bottlenecks, as highlighted in the project timeline heatmap below.

Construction phase

Construction is the most capital-intensive phase, representing ~50–75% of total lifecycle costs. A fully stabilised design before first concrete is critical; failure to do so has driven major cost overruns in Gen III+ projects. Delivery is increasingly based on Integrated Project Delivery (IPD), aligning stakeholders under shared risk and incentives.

A typical 1,200 MWe PWR requires ~400,000 tonnes of concrete, 66,000 tonnes of steel, extensive cabling, and thousands of nuclear-grade components. Modularisation is becoming standard especially for SMRs, shifting work to factory-based assembly to reduce on-site complexity. All components must meet stringent nuclear standards (e.g., ASME N-stamp, RCC-M).

Commissioning phase

Commissioning serves as the bridge between construction and commercial operation, verifying that systems perform as designed. A comprehensive contractual testing and commissioning regime must be agreed upon with technical advisors before contracts are signed. To reduce site schedules, requirements are moving toward increased testing at the manufacturer's shop rather than on site.

For modular designs, this includes factory pre-assembling and integral testing of complex multidisciplinary systems. Final milestones include obtaining a licence to operate from national regulatory authorities, requiring exhaustive safety analysis reports and verification of Safeguards by Design. Digital twins and AI-driven predictive analytics are increasingly required to provide virtual copies of the plant during commissioning, shortening approvals and enabling predictive analysis.

Commissioning requires 12–24 months of systematic testing covering cold hydrostatic tests, hot functional tests, fuel loading, and criticality milestones.

The operational phase (typically 60+ years with life extensions) generates steady demand for instrumentation upgrades, fuel reloads (18–24-month cycles), steam generator inspections, and periodic safety reviews. The analog-to-digital I&C upgrade wave across the aging global fleet (average age 30+ years) is one of the fastest-growing service segments.

Operations phase

The operations phase is the longest stage of a plant's life, typically lasting 60 to 80 years and requiring nearly a century of continuous lifecycle support. Operators must maintain a nuclear safety culture characterised by continuous improvement and supported by international organisations such as INPO and WANO. Long-term fuel procurement strategies covering conversion, enrichment, and fabrication are required from day one, since fuel assemblies cannot easily be substituted between reactor designs.

Maintaining a high-performing operations team requires roughly 600 direct employees for a standard large reactor. Operators are shifting toward proactive and predictive maintenance (PdM) models using sensors and data science to identify potential failures before they occur, requiring interdisciplinary expertise across traditional nuclear engineering and AI capabilities. Utilities must maintain minimal stock levels of long-lead and critical spare parts, with particular focus on Single Point Vulnerabilities (SPVs), components whose failure could immediately trip the reactor.

3.8. Nuclear aftermarket demand

The long-term availability of spare parts and maintenance capacity is a critical strategic element, particularly as modern reactor designs are engineered for operating lifetimes of 60 to 80 years. This extended lifecycle creates a requirement for nearly a century of continuous support, highlighting a structural gap as suppliers often have asset lifecycles of only 20 to 40 years.

The shift toward NOAK SMR designs means a growing proportion of standardised components will be required to support serial production. Repeatability reduces risk for suppliers and enables dedicated factories for critical parts.

However, for the existing global fleet, high demand persists for replacement parts to manage the obsolescence of systems and components originally designed in the Generation II era. A growing sub-set of components is no longer manufactured, original drawings or qualification data may be incomplete, and re-qualification cycles for new suppliers can take 18–36 months per component. The exposure is most acute in three areas: analogue and digital I&C systems (the analogue-to-digital upgrade wave); Single Point Vulnerability (SPV) components; and specialty materials. Procuring certain spare parts is further complicated by highly specific technical requirements, such as low-cobalt stainless steel for components in contact with primary coolant. This material is produced in large batches (50–100 tonnes) that far exceed typical repair order sizes (5–20 tonnes), making mills reluctant to fulfil small custom orders and resulting in high costs and long lead times.

The maintenance and professional services market is large and growing. Roughly 80% of surveyed nuclear companies now provide life-cycle maintenance services through LTSAs and Operation Support and Maintenance (OS&M) contracts. Advanced predictive maintenance technologies using digital twins, AI-powered analytics, and remote sensors can extend asset life by 33–60% while reducing overall maintenance expenditures by 35–60%, partially offsetting the physical scarcity of replacement parts. Open-architecture digital I&C platforms are increasingly replacing obsolete analogue systems with independently supportable, upgradeable architectures that break proprietary single-vendor dependency. Remote and robotic solutions for underwater repair and VR for just-in-time workforce training are becoming essential. Suppliers are often hesitant to expand capacity without firm commitments and long-term demand visibility, creating a ‘chicken and egg’ dilemma for the industry.

With 421 operating reactors worldwide and an increasing share reaching 40+ years of operation, the aftermarket for nuclear components is expanding rapidly. Life extension programmes from the standard 40-year licence to 60 or even 80 years require major component replacements: steam generator replacement ($200–400 million per unit), reactor vessel head replacement, and complete I&C modernisation.

The Nuclear Scaling Initiative (NSI) report of March 2026 identified multi-unit order books of 10–30 reactors as necessary to break the “chicken-and-egg” supply chain deadlock, where suppliers will not invest in capacity expansion without firm orders, and utilities cannot place orders without established supply chains.

4. BOTTLENECKS IN EUROPE’S BUILD-OUT AND IMPLICATIONS FOR SWEDEN

4.1. Bottlenecks and consequences for the European build-out

The structural constraints outlined in Chapter 3 translate directly into execution challenges for European nuclear projects. Unlike Asia, Europe lacks a continuous build programme, resulting in limited industrial readiness and repeated FOAK conditions.

Recent projects demonstrate consistent cost overruns and delays:

Hinkley Point C (UK, 2× EPR, 3,260 MWe) was approved in 2016 at £18 billion with Unit 1 targeted for end-2025. The latest estimate stands at £35 billion in 2015 prices (£48.7 billion nominal) nearly triple the original budget, with Unit 1 now expected in 2030. Causes include rebuilding the UK nuclear construction industry after a 20-year gap, difficult ground conditions, Brexit supply chain disruption.

Flamanville 3 (France, 1× EPR, 1,630 MWe) began construction in 2007 at €3.3 billion, targeting 2012 commercial operation. It connected to the grid in December 2024, 12 years late, at a final construction cost of €13.2 billion. Root causes included welding defects requiring 12+ months of rework, carbon segregation in reactor vessel steel, and no dedicated project manager until 2015.

Olkiluoto 3 (Finland, 1× EPR, 1,600 MWe) started construction in 2005 at €3.0–3.2 billion, targeting 2009. It achieved commercial operation in May 2023 (14 years late) at an estimated total cost of €11 billion.

Project	Original Cost	Final Cost	Target Year	Actual Year	Delay
Olkiluoto 3	€3.0 bn	~€11 bn	2009	2023	14 years
Flamanville 3	€3.3 bn	€13.2 bn	2012	2024	12 years
Hinkley Point C	£18 bn	£35–49 bn	2025	2030+	5+ years

Table 6: European FOAK EPR cost and schedule performance

As a result, European nuclear projects face three consistent challenges:

- Extended construction timelines (10–15+ years for FOAK projects)
- High capital costs ($8,000–15,000+/kWe) compared to $2,300–2,500/kWe in China and ~$2,150/kWe in South Korea
- Increased reliance on a limited number of vendors

Bottleneck category	Key constraints	Consequences
Financial & Market	Capital intensity and 10–20 year development cycles; FOAK "first mover disadvantage"; energy-only market failing to reward high-CapEx assets	Risk of project abandonment; continued dependence on state intervention to mobilise private capital
Regulatory Fragmentation	National licensing requires design adaptations per country; Sizewell C consultations began 2012; unit-based licensing fees regardless of prior builds	Each redesign resets projects from NOAK to FOAK status, destroying cost and schedule benefits of standardisation
Gen IV Mettallurgy	Generation IV reactors operate at ~700°C, requiring entirely new materials with no existing commercial production.	Development and qualification of these materials may require up to 15 years of lead time
Supply Chain & Workforce	Critical shortage of RPV-class forging capacity (>1,100 MWe); only 4–7 qualified European suppliers for pumps/valves; ~half of EU nuclear workforce approaching retirement; UK and France each need ~100,000 new professionals	Extended procurement lead times; higher costs; risk of project delays analogous to Flamanville 3 (€23.7 bn final cost) and Olkiluoto 3 (13-year delay)
Fuel Cycle Dependencies	No commercial uranium mines in EU; >40% of EU uranium imports from Russia/Kazakhstan (2024); Russia holds ~40% global enrichment; HALEU commercially unavailable in EU	EU utilities reliant on Russian-linked supply chains; HALEU bottleneck directly constrains SMR/AMR deployment timelines
Geopolitical / Vendor Lock-in	Russian BOO model creates long-term host-country dependency (e.g., Akkuyu, Paks II); proprietary reactor modules tie owners to single vendor for 60–80 years; China and Russia built 48 of 52 reactors started globally since 2017	Loss of energy sovereignty; limited Western alternatives as EDF, Westinghouse, KEPCO risk being contracted to capacity simultaneously by multiple EU nations

Table 7: European nuclear build-out bottlenecks – constraints and consequences

Financial and market bottlenecks

The capital intensity and long development timelines of nuclear projects, often 10–20 years, make them difficult to finance in liberalised European energy markets without state intervention. FOAK projects suffer from a ‘first mover disadvantage’ where high initial costs and uncertain returns dissuade private investment. For innovative technologies such as SMRs and AMRs, there is a critical funding gap “the valley of death” between research and development and commercial deployment. Current European market designs that prioritise low-marginal-cost generators fail to provide stable long-term revenue signals for high-capital-expenditure assets like nuclear. Effective risk-sharing mechanisms such as the Regulated Asset Base (RAB) or Contracts for Difference (CfD) can potentially reduce financing costs by up to 50%: a change in the interest rate from 4% to 12% can influence total investment cost by as much as 35%.

Regulatory and licensing fragmentation

Nuclear licensing remains a national responsibility, leading to a fragmented regulatory landscape across EU Member States. Each country typically requires design adaptations to meet specific national safety codes, effectively moving projects from efficient NOAK status back to high-risk FOAK status. Lead times for obtaining required authorisations can extend many years, the Sizewell C project in the UK, for example, began consultations in 2012. In some markets, licensing costs are assessed on a unit-by-unit basis regardless of how many identical units have been built previously, further inflating costs. Initiatives such as the IAEA's Nuclear Harmonisation and Standardisation Initiative (NHSI) aim to reduce these barriers, but progress has been slow.

Supply chain and workforce constraints

Decades of limited new construction have left Europe with an eroded base of industrial competence, a thin pool of qualified suppliers, and a workforce profile skewed toward retirement. Building on the component-level constraints set out in Chapter 3, the practical consequence for Europe is longer procurement lead times, higher contingency costs, and intensified competition for specialised labour across simultaneously launching programmes.

The UK and France each estimate they will need around 100,000 additional nuclear professionals over the coming decades At the same time, suppliers remain hesitant to expand capacity without firm long-term commitments, while utilities are reluctant to commit without visible execution capacity. This feedback loop increases the risk of delay, cost escalation, and uneven project sequencing across Europe.

Geopolitical and vendor lock-in risks

The European build-out faces a risk of loss of technological and energy sovereignty if it fails to maintain a domestic industrial programme. China controls most of the world's production of structural graphite, essential for reactors using TRISO fuels. Gas-cooled reactors rely on helium, which is already under tight supply constraints. The Build-Own-Operate model used by Rosatom creates long-term strategic dependencies where host countries rely on a foreign vendor for financing, construction, and operation. The proprietary nature of integrated reactor modules means that plant owners are often dependent on a single vendor for the entire 60–80-year lifecycle, with no viable alternative technology or delivery team available if the EPC consortium is terminated during construction.

4.2. Expected impact on timelines and costs for Sweden's new-build projects

Sweden's nuclear ambitions are substantial. The government targets at least 2 large reactor equivalents by 2035 (~2,500 MW) and approximately 10 by 2045 (~10,000 MW), backed by a financial framework of up to SEK 220 billion (~€20 billion) including state-backed loans and two-way contracts for difference. Vattenfall shortlisted GE Vernova's BWRX-300 (5 units × 300 MWe = 1,500 MWe) and Rolls-Royce SMR (3 units × 470 MWe = 1,410 MWe) for deployment at Ringhals.

However, neither SMR design has been built anywhere in Europe, and only the BWRX-300 is under construction globally (Darlington, Canada, targeting 2029). This exposes Sweden to FOAK risk despite the designs' promise of simplification. The GEM tracker records Sweden with just 1 pipeline unit (1.5 GW announced), reflecting the early stage of the programme. Business Sweden's foundational report found that Sweden has limited capabilities in the primary circuit and development phases, with full dependency on international Tier 0 OEMs for reactor design and core technology.

Timeline and cost implications

The heavy forging deficit and thin supply chains documented in Chapter 2 translate directly into FOAK cost and schedule risk for any Swedish build programme. Neither the BWRX-300 nor the Rolls-Royce SMR has been built in Europe, and the BWRX-300 is only now commencing construction in Canada (targeting first power by late 2029). Sweden’s 2035 target for first SMR operations should therefore be seen as aspirational; a more realistic planning horizon for first power is the late 2030s.

Initial SMR demonstrators are expected to carry overnight capital expenditures between US$15,000 and US$20,000/kWe. However, the SMR paradigm outlined in Chapter 2 provides a path to cost reduction: smaller components accessible to a wider European forge base, passive safety systems reducing valve and pump count, and factory assembly reducing site labour risk. Costs could fall by 20–40% for industrialised FOAK units and a further 30–50% for NOAK units through modularisation, co-siting, and serial production effects, targeting US$5,000–7,000/kWe over time.

To remain competitive in the Swedish energy system, SMRs must achieve an LCOE of approximately €52/MWh. Sweden's impact modelling suggests this is reachable under a fleet deployment scenario but not for single-unit projects. If Vattelfall select the BWRX-300, regulatory harmonisation with Finland could be a key lever. Leveraging Finland’s recent Olkiluoto 3 experience and STUK’s regulatory familiarity with LWR technology could streamline licensing, pool workforce resources, and de-risk the FOAK phase materially. Under a Rolls-Royce SMR selection, the harmonisation case is narrower but shared LWR regulatory experience between SSM and STUK would still offer licensing benefits.

European megaproject competition and nuclear labour risk

Europe is currently executing a large volume of non-nuclear construction investment across infrastructure, energy, and industrial sectors. A review of major projects above €1 billion identifies 42 projects, of which 28 are already under construction. The peak mobilisation window, when demand for skilled labour, materials and grid connections converges, falls between 2026 and 2032, precisely the period in which any new Swedish nuclear programme would need to mobilise.

The most relevant competing clusters are the pan-European rail and HSR programme including (Ostlänken, HS2 and Rail Baltica), large-scale energy grid expansion in Sweden, Germany and Poland, and the AI-driven hyperscale data centre build-out concentrated in northern Sweden.

The core implication is sequencing. A nuclear programme reaching first concrete before 2028 faces a materially less congested contractor market than one delayed to 2030 or later. Early framework agreements with civil, tunnelling and HV electrical contractors will be essential to secure capacity ahead of the peak competition window. Site location will also influence exposure: locations outside the northern Sweden cluster face lower local labour market pressure, although grid connection remains a constraint across all sites.

4.3. Supplier opportunities by value chain segment

The bottlenecks facing Europe's build-out are also opportunities for well-positioned Swedish industrial companies. Business Sweden's *Powering the Future* (November 2025) identified more than 170 Swedish companies with nuclear new-build relevance across the six-segment value chain. Sweden holds world-class capabilities in Switchyard and strong capabilities in Balance of Plant and Construction.

Two export opportunities are directly tied to the supply bottlenecks documented in this report. In the Switchyard segment, global demand for Generator Step-Up (GSU) transformers has risen ~274% since 2019, with lead times now stretching to 3–4 years, a live constraint that Sweden's world-class transformer and switchgear capabilities are positioned to address across the UK, Polish, and Czech build programmes. In the Balance of Plant, the thin

European supply chain for nuclear-grade pumps and valves represents the most accessible qualification pathway for Swedish industrial companies seeking to enter the nuclear market.

In the Secondary Circuit, Sweden has an established domestic manufacturing base for industrial turbines in the relevant power range. In the Primary Circuit, Sweden has no domestic OEM with design authority; contribution is limited to niche manufacturing such as precision steam generator tubing and thermal hydraulic modelling, with the full nuclear island sourced from international Tier 0 partners.

5. GEOPOLITICAL AND SECURITY-OF-SUPPLY RISKS

The supply chain bottlenecks described in Chapter 3 do not exist in a vacuum, they are the industrial expression of deeper geopolitical vulnerabilities. Europe’s heavy forging deficit, its thin nuclear-grade component supplier base, and its near-complete dependency on international Tier 0 OEMs are not merely commercial challenges: they reflect deeper geopolitical dependencies. This chapter maps those dependencies and assesses their security-of-supply implications.

5.1. Strategic dependencies on non-EU countries

Europe's civil nuclear programme rests on a supply chain architecture shaped during the Cold War and largely unreformed since. Across all critical input categories (heavy forgings, fuel cycle services, digital I&C, and specialist maintenance) European operators depend on non-EU suppliers. In heavy components, Japan Steel Works, Doosan Enerbility, and China's state forges together account for most of the RPV-class manufacturing capacity outside Europe. In digital I&C, Rosatom and a small number of US and French vendors hold near-complete market coverage. The pattern across all of these categories is the same: decades of underinvestment in European sovereign capability have created dependencies that are now both commercially constraining and strategically exposed, as the seller’s market in RPVs already demonstrates.

East Asian dominance of heavy component supply

As established in Chapter 3, the most critical manufacturing dependency in European nuclear is the concentration of heavy forging capacity in East Asia. Japan Steel Works, Doosan Enerbility (South Korea), and China’s domestic forges dominate the global supply of RPV-class components. The risk is not only commercial: rising domestic demand in Asia may reduce export availability just as Europe’s build-out accelerates.

The ‘chicken-and-egg’ deadlock described in Chapter 2 makes this dependency self-reinforcing: without firm long-term orderbooks, European forges will not invest in rebuilding capacity, and without domestic forging capacity, European projects will remain dependent on Asian supply. The UK’s Sheffield Forgemasters investment, including a 13,000-tonne press expected to become operational later this decade, is a step toward rebuilding this base, but a single facility cannot substitute for the decades of lost capacity across the continent. Breaking the cycle requires coordinated, programmatic demand signals from multiple European governments simultaneously.

Vendor concentration and the seller’s market risk

Of the 52 reactors that began construction worldwide since 2017, 25 are of Chinese design and 23 are of Russian design, leaving only four using Western or Korean designs. For Western-aligned countries, Europe effectively has only three major Large Scale Reactor suppliers (EDF, Westinghouse, and KEPCO) alongside a nascent SMR vendor landscape. As multiple EU nations simultaneously launch new-build programmes (the UK, Poland, the Netherlands, Czechia, Finland, and Sweden) all within the same decade, these vendors risk being contracted to capacity. For Sweden as a relatively late mover in the European pipeline, this creates a time-sensitive risk: delay in making technology decisions and engaging OEMs could result in unfavourable contract terms, reduced supplier attention, and loss of influence over localisation decisions. The competing programmes are already locking in vendor commitments. The Czech Republic signed a CZK 407 billion EPC contract with KHNP in June 2025, Sizewell C reached Final Investment Decision in July 2025, and Poland is targeting first concrete in 2028. Tier 0 OEMs freeze supplier lists, allocate senior engineering capacity, and reserve long-lead forging slots at these milestones. Every additional month of Swedish indecision narrows the engineering bandwidth, contractual leverage, and localisation influence once projects move into execution.

The proprietary nature of integrated reactor modules deepens this risk into a lifecycle dependency. Once a Tier 0 OEM is selected, the owner is effectively tied to that vendor for the entire 60–80-year life of the plant for core system components, maintenance services, and spare parts If an EPC consortium is terminated mid-construction, there is often no viable alternative technology or delivery team capable of completing the project, a risk illustrated by the difficulty of switching vendors on a partially built plant. This vendor lock-in is particularly acute for SMR designs, where the proprietary nature of integrated factory-built modules leaves owners with few alternatives.

China and Russia as strategic competitors

Rosatom and China’s state-owned nuclear entities (CNNC, CGN) actively compete for global nuclear market share through mechanisms that Western vendors cannot easily replicate: state-subsidised financing, Build-Own-Operate (BOO) contracts that absorb all project risk for the host country, and integrated packages that bundle reactor technology, construction, fuel supply, and long-term operation in a single arrangement. The BOO model, used at Türkiye’s Akkuyu plant (Rosatom), creates structural host-country dependency for the lifetime of the plant. Hungary’s Paks II, financed through Russian sovereign debt, illustrates the financial dimension of this dependency. As African and Central Asian countries consider nuclear power, they face a clear trade-off: Western technology delivered on commercial terms with more complex financing, versus Russian or Chinese offerings backed by the state and packaged on simpler terms. The geopolitical implications of this dynamic extend well beyond energy security.

5.2. Fuel Cycle Dependencies

While the manufacturing and technology dependencies above represent the most structurally deep vulnerabilities, fuel supply security remains a significant near-term concern, particularly for the EU’s existing fleet and for countries selecting SMR designs that require advanced fuel forms.

Uranium and enrichment

The EU has no commercial uranium mines in operation, forcing total reliance on imports. Kazakhstan, Canada, and Australia account for approximately 70% of global supply; in 2024, more than 40% of EU uranium imports still originated from Russia and Kazakhstan. Russia holds approximately 40% of global uranium enrichment capacity, and despite domestic enrichment capacity in France, Germany, and the Netherlands, EU utilities have historically imported roughly 30% of their enriched uranium from Russia. The EU’s 20th sanctions package (February 2026) explicitly sanctioned Rosatom and TVEL, banning new contracts subject to a transitional period, and EU dependence on Russian enrichment dropped from 38% in 2023 to 23% in 2024. Western enrichment capacity is expanding with Urenco adding 2.5 million SWU with a record €21.3 billion order book, Orano expanding Georges Besse II, but the gap will not close before 2030.

For Sweden specifically, the Swedish Parliament's repeal of the uranium mining ban in November 2025 (effective January 2026) is strategically significant: Sweden holds an estimated 27% of Europe's known uranium reserves, including the Häggån deposit. Westinghouse's fuel fabrication facility at Västerås is already part of the Western VVER fuel diversification supply chain, delivering alternative fuel assemblies to countries seeking to reduce Russian dependency. These assets position Sweden as a potential critical node in Europe's fuel supply security.

HALEU and next-generation fuel

Russia is currently the only viable commercial supplier of High-Assay Low-Enriched Uranium (HALEU), enriched between 5% and 19.75% and required by many advanced SMR and AMR designs. HALEU is not manufactured commercially in the EU, and the process has been inactive for over a decade. The UK's allocation of £300 million for Urenco's Capenhurst HALEU facility is the most concrete European response, though first production is not expected until the early 2030s. This constrains deployment timelines for designs requiring HALEU. Sweden's two shortlisted designs have different exposures: the BWRX-300 uses conventional LEU, substantially reducing this risk for Sweden's near-term programme; the Rolls-Royce SMR is also a conventional LWR design. However, any future diversification toward advanced AMR designs would reintroduce this dependency.

Zirconium and cladding materials

Zirconium alloys are the irreplaceable structural material for nuclear fuel rod cladding, accounting for over 95% of nuclear-grade alloy use across all commercial LWR designs with no viable substitute. The supply chain faces structural pressure from both ends.

On raw materials, analysts project a global shortage of zircon concentrate as major Australian mines face depletion cliffs, while global zircon sand supply is expected to decline by around 11% through 2025–2030 even as nuclear demand grows. At the processed end, three manufacturers (Orano/Cezus, ATI, and Westinghouse) control over 75% of Western production capacity, with long-term utility contracts dominating supply and limiting new entrants, and ATI is already reporting record order backlogs. China serves only its domestic programme; Russia remains embedded in parts of the European processing chain.

Sweden has no domestic capability across the full zirconium chain and is import-dependent for the 60–80 year plant life of either design.

5.3. Long-term availability of spare parts and maintenance capacity

The manufacturing dependency that creates FOAK construction risk also creates long-term operational risk. The same erosion of European heavy manufacturing and specialist component supply that complicates new build also weakens long-term maintenance resilience over the 60–80-year life of a plant. In practice, security of supply is not only a build-phase issue but a decades-long lifecycle challenge.

VVER-operating EU Member States (Bulgaria, Czechia, Finland, Hungary, Slovakia) remain particularly exposed, still relying on Russian-designed spare parts, maintenance protocols, and modernisation services despite political pressure to reduce these dependencies. European utilities are increasingly seeking alternative suppliers and establishing European intellectual property for VVER components, but this is a multi-year process. Approximately half of the EU's current nuclear workforce is approaching retirement age, creating a knowledge loss risk that parallels the manufacturing capacity loss.

Advanced predictive maintenance technologies (digital twins, AI-powered analytics, remote sensors) can extend asset life by 33–60% while reducing maintenance expenditures by 35–60%, offering a partial offset to the physical capacity constraint. SMRs, designed for easier component replacement and greater use of off-the-shelf industrial-grade equipment for non-safety applications, offer a structurally better long-term maintenance profile than the large reactors they complement.

SKB’s commencement of construction on a deep geological spent fuel repository at Forsmark in January 2025 making Sweden only the second country after Finland to licence such a facility, giving Sweden a further strategic differentiator. End-of-lifecycle waste management has become a prerequisite for new-build programmes across Europe, and Sweden’s demonstrable solution to this challenge strengthens both its domestic programme credibility and its position as a potential regional hub for spent fuel management expertise.

6. CONCLUSIONS

The global nuclear build-out is accelerating at a pace not seen since the 1970s, but benefits are unevenly distributed. Europe faces a structural disadvantage rooted, not in policy ambition, but in limited manufacturing capability.

SMR deployment carries FOAK risk, but offers a scalable industrial opportunity for Sweden

SMR deployment carries genuine FOAK risk, but the underlying industrial model is more accessible for Sweden. Neither finalist design has yet been built in Europe, and a realistic planning horizon for Sweden's first SMR extends into the late 2030s.

The 7–10 GW Nordic-Baltic pipeline meets the volume thresholds identified by Tier 0 SMR vendors for manufacturing localisation, provided regional ordering is coordinated and programme commitments are made promptly. Localisation becomes viable only at scale, typically above 4–7 GW for module manufacturing and above 7 GW for full industrial localisation.

At 7–10 GW, the Nordic-Baltic corridor sits precisely at the threshold where the most transformative localisation outcomes become achievable, potentially including heavy forging capacity. This reinforces the case for coordinated, programmatic demand signals across Sweden, Finland, Estonia, and Norway, rather than country-by-country procurement.

Sweden's supply chain opportunity is immediate, targeted, and time-sensitive

Business Sweden's Powering the Future report identified more than 170 Swedish companies relevant to nuclear new build, with world-class capabilities in switchyards and strong positions in balance of plant and construction, precisely where European bottlenecks are driving export demand.

The global shortage of GSU transformers, where demand has increased by 274% since 2019 and lead times have reached 3–4 years, represents a clear near-term opportunity. Similarly, constrained European supply chains for nuclear-grade pumps and valves create entry points for companies willing to pursue qualification.

Beyond these areas, the secondary circuit and turbine island represent additional opportunities. Globally, only a limited number of OEMs produce nuclear-grade steam turbines, constraining capacity as build-out accelerates and opening space for capable suppliers to position into the value chain.

However, Tier 0 OEMs lock in supplier lists early in project development. Sweden's window to embed companies in international supply chains is narrowing as programmes in the UK, Poland, and Czechia progress. Component manufacturers are already making siting and sourcing decisions, placing the critical window for influence in 2026–2028.

Sweden's geopolitical position is stronger than it appears, if action is coordinated

Sweden holds 27% of Europe's uranium reserves following the lifting of the mining ban, operates the Westinghouse fuel fabrication facility in Västerås, part of the Western VVER diversification chain, and leads Europe in geological spent fuel disposal through SKB's Forsmark project.

This existing operational base provides institutional knowledge that pure newcomer countries lack. In addition, Sweden’s strengths in precision tube manufacturing, advanced steel, and its broader engineering ecosystem represent tangible assets in Europe’s effort to rebuild industrial capacity and reduce dependence on Russia and East Asia.

However, these advantages will only be fully realised through a coordinated, programme-based strategy, not through isolated responses to individual project opportunities.

The window to build capability is external, and closing quickly

Supplier positions are being secured internationally years before Swedish projects reach construction, meaning Swedish companies cannot rely solely on the domestic programme to build capability.

Participation in ongoing international projects, particularly in North America and Europe, is essential to gain execution experience, secure nuclear qualification, and embed within vendor ecosystems. Companies that engage early will be positioned to capture repeat roles as global programmes scale and will enter the Swedish build-out with an established track record.

Appendix 1.1

Pipeline data filtered to Construction, Pre-construction, and Announced projects with a dated start year between 2028 and 2040. Credibility weights applied by status (Construction 90%, Pre-construction 65%, Announced 25%). Three RPV scenarios modelled by applying progressively stricter eligibility filters.

Reactor Pressure Vessels – Europe, 2028–2040

Scenario definitions (LSR only)

Scenario	Pipeline included	Start year filter	Total LSR units
Conservative	Construction units + pre-construction with start year ≤2033	2028–2033	**23 units**
Central	Construction + all pre-construction + announced ≤2035	2028–2035	**43 units**
Ambitious	All pipeline units with a dated start year	2028–2040	**56 units**

Annual LSR unit start-ups by scenario

Scenario	28	29	30	31	32	33	34	35	36	37	38	39	40	Total
Conservative	2	2	2	3	4	3	2	2	1	1	1	–	–	**23**
Central	**2**	**2**	**2**	**3**	**4**	**3**	**3**	**3**	**3**	**4**	**4**	**5**	**5**	**43**
Ambitious	2	2	2	3	4	3	3	4	5	6	6	7	9	**56**
EU supply cap	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**26**

** EU supply cap = Framatome Creusot Forge (~2 RPV sets/yr). Sheffield Forgemasters (UK) adds limited additional capacity later this decade.*

Key finding: Under the Central scenario, Europe requires 43 LSR RPV sets over 2028–2040 against a domestic supply ceiling of ~26 sets (Framatome at ~2/year). The structural shortfall of 15–17 sets must be sourced from Asia (structurally necessary) confirming the strategic dependency identified in the main report and quantifying it for the first time.

SMR RPV requirements (additional, Central scenario)

SMR RPV requirements are tracked separately as they involve smaller forgings accessible to a wider supplier base (Doosan, Atommash, and potentially European heavy industry). The European SMR pipeline yields an estimated 10 units with a dated start year between 2025 and 2040 in the central scenario. These do not add to the LSR forge constraint but require separate supplier qualification, as no European manufacturer currently produces them at commercial scale.

Limitations:

- Credibility weights: Credibility weights (90%/65%/25%) are indicative; actual project attrition may vary by country and regulatory environment.
- RPV count per unit: One RPV per LSR unit is assumed. Some designs (e.g. EPR-1200) require two primary circuit loops and may require different forgings.
- Framatome capacity: Framatome supply cap of ~2 sets/year is approximate; actual throughput depends on order sequencing and quality yield.

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