New Brunswick Supply Chain Study

ARC Clean Technology Canada Inc.

Final Report

August 2, 2023

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Study Partners

This study was completed through a collaborative effort between NB Power, Opportunities New Brunswick and ARC Clean Technologies. All parties contributed industry expertise, data and funding towards the study.

Énergie NB Power

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arc
CLEAN TECHNOLOGY

Small reactors. Big opportunities.

The deployment of advanced small modular reactors (SMRs) will generate safe, reliable, and affordable low-carbon electricity and offer the flexibility to adjust to varying energy requirements within New Brunswick's power grid. NB Power is working with ARC Clean Technology (ARC) to progress advanced SMR technology and ensure that SMRs are part of the solution to reach the utilities' target of being net-zero by 2035.

A made-in-New Brunswick small modular reactor

NB Power, in partnership with ARC, has plans to construct and operate one advanced SMR on the site of the existing Point Lepreau Nuclear Generating Station (PLNGS). ARC's SMR is a modular, sodium-cooled fast reactor that will generate at least 100 megawatts of electricity. On June 30, 2023, NB Power achieved a significant project milestone in its submission of an Environmental Impact Assessment Registration and License to Prepare Site Application.

Leveraging the significant analysis done to date, Deloitte worked to determine the path to strengthen and enhance New Brunswick's industrial supply chain to support the deployment of a first-of-a-kind (FOAK) SMR by 2030 and a series of nth-of-a-kind (NOAK) SMRs across the province by 2050.

Any strategy to maximize the economic benefit for New Brunswick must be underpinned by a robust, resilient, and secure supply chain that meets the demanding requirements of the nuclear industry. We prepared a current state assessment of the provincial supply chain based on maturity, commercial readiness, and vendor availability and built a demand curve for both the FOAK and NOAK reactors. The current supplier base was mapped against forecasted demand to identify growth potential and level of required investment.

A procurement target of 80% supplied, manufactured, and built-in-New Brunswick

In 2022, Opportunities New Brunswick (ONB) prepared an inventory of the suppliers, manufacturers, and fabricators currently in the province who self-identified their interest, and capability to supply SMR components and systems. That inventory was supplemented with Canadian and international nuclear industry suppliers given the requirements for specialized and certified SMR componentry. We note that refueling and servicing equipment is out of scope for this study.

Deploying the first-of-a-kind (FOAK) reactor in New Brunswick by 2030

About 20% of critical and non-critical systems can currently be manufactured by New Brunswick vendors. To meet the 80% procurement target of local suppliers, the vendor base for five systems need to be advanced and matured: reactor vessel and internals, electromagnetic pumps, heat exchangers, instrumentation and controls, and condenser. The current road, rail, and port infrastructure in the province will support the FOAK reactor.

One hundred next-of-a-kind (NOAK) SMRs by 2050

In our 2050 scenario, the SMR vendor base has matured and almost 90% of the systems can be sourced within New Brunswick. The steam turbine and plant electrical systems are unlikely to be manufactured in the province but can be sourced from Canadian or U.S. suppliers. Long-lead items or those requiring between 21 and 48 months introduce additional complexity to an already complex procurement mandate. Only 25% of long-lead items can currently be sourced in New Brunswick.

Small reactors. Big opportunities. (continued)

There is a path forward to deploying 100 SMRs by 2050 globally by a New Brunswick-based company, but it will require a coordinated industrial strategy, additional investment, industry mobilization, new partnerships, and new models of collaboration.

New Brunswick has a leadership position at the forefront of this emerging sector. A procurement target of 80% supplied, manufactured, and built-in-New Brunswick has been set to maximize the economic development opportunity for the province. This ambition should be mapped against the realities of project timelines. New Brunswick's leadership on SMRs will accelerate the development and optimization of its own provincial supply chain capacities as well as a pan-Canadian supply chain that enables deployment of SMRs in Ontario, Saskatchewan, and Alberta.

The nuclear industry must mobilize in a focused and coordinated way. The deployment of the FOAK reactor in 2030 is a critical milestone and about 20% of critical and non-critical systems can currently be manufactured by local vendors. The supply chain has a very limited ability to deliver NOAK reactors without significant investment, industry partnerships, a build-out of manufacturing capabilities and focused skills development strategies.

The supply chain is only one element of a coherent commercial ecosystem. Innovation must be assessed in reference to desired commercial objectives. Efforts to advance and mature the supply chain must occur on a parallel path to efforts to streamline permitting and regulations, optimize codes and standards specific to SMRs, ensure transport infrastructure capacity, and test the required business models.

Talent, skills, qualifications, and certifications are critical to the growth of New Brunswick's nuclear industry. A skilled and qualified labour force enables the realization of SMR objectives particularly for NOAK reactors. Other non-nuclear infrastructure and industry projects have the potential to drain the workforce available for SMR manufacture, fabrication, construction, and operation. Currently there is a very limited number of indigenous suppliers in New Brunswick for the nuclear industry so additional efforts will be needed to expand this supplier base.

The barriers to the deployment of SMRs are well-known and well-understood. It is our hope that this study and the methodology offered for the development of New Brunswick's SMR supply chain act as a catalyst to the growth and expansion of the nuclear industry and the realization of New Brunswick's and Canada's 2050 net-zero objectives.

Key Findings

Key Findings	Description
Limited supplier base	The current supplier base may not be sufficient to meet mid-term NOAK (2040) and end-term NOAK (2050) goals as those suppliers who expressed interest in ONB's survey may not have the capabilities or locations to produce ARC-100 units in New Brunswick.
International forging shops	Currently, ARC has identified two forging shops based internationally in Italy and the UK. Further investigation into additional options is required - domestically and internationally - to identify, qualify and develop forging shops to support demand.
Immediate investment required	Immediate investment is necessary to develop and mature the supply chain in New Brunswick to meet FOAK and NOAK reactor goals and demand.
Detailed infrastructure study required	The current infrastructure can handle FOAK and mid-term NOAK (2040) goals. Multiple ports should be considered to meet end-term NOAK (2050) goals and future export objectives, requiring further study.
Environmental, Social and Governance (ESG) criteria and goals need to be defined	Clear definitions are crucial to achieving ESG goals such as net-zero emissions and indigenous procurement. There is a limited number of indigenous suppliers in New Brunswick, so additional and focused efforts will be needed to expand this supplier base.

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1. Study Introduction

Study objective and purpose

In December 2020, ARC Clean Technology (ARC), NB Power, and the Government of New Brunswick signed a Memorandum of Understanding (MOU) for the development, deployment, and commercialization of the ARC-100 SMR. One goal of the MOU is to create economic development opportunities in New Brunswick through the creation of a provincial supply chain to support sales of the ARC-100 in Canada and globally. This analysis fulfills ARC's commitment to prepare a supply chain study.

Identify areas of opportunity

Review the data and results of Opportunities New Brunswick's (ONB's) Self-Assessment survey and identify areas of opportunity for local and non-local companies to support the manufacturing, fabrication, and construction of SMRs in New Brunswick.

Identify transportation hubs

Identification of transportation hubs and supporting infrastructure within New Brunswick (air, road, rail, and seaports) that could support the national and international export of ARC-100 components.

Prepare strategic considerations

Identify strategic considerations to support the development of the supply chain for the first-of-a-kind (FOAK) ARC-100 demonstration unit and potential strategies for nth-of-a-kind (NOAK) ARC-100 units.

Address supply chain gaps

Prepare strategies to address supply chain gaps in New Brunswick.

Identify fabrication facilities

Identify potential fabrication facilities across New Brunswick, both publicly and privately owned, that could fabricate ARC-100 components.

Calculate demand scenarios

Develop a supply chain view to support the various projected demand scenarios for the ARC-100.

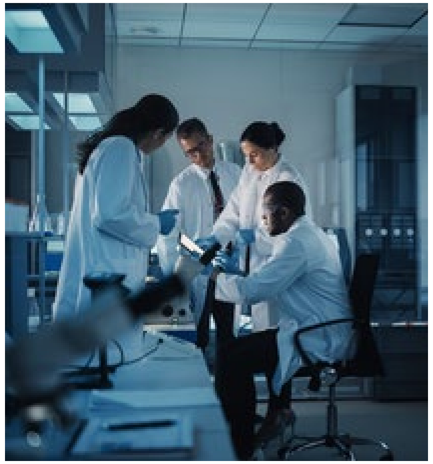
ARC's objectives

ARC is developing the ARC-100, an advanced small modular reactor offering inherently safe, reliable, and economical carbon free power. The ARC-100 has been selected by New Brunswick Power for implementation on their Point Lepreau site with completion targeted for 2030.

COST COMPETITIVE AND FASTER TO MARKET

As a small modular reactor, parts can be factory-assembled into large modules for shipment around the world and installation at an ARC-100 site. The overall construction schedule is 34 months. They are quicker to build than traditional designs with less upfront cost, which makes them accessible to a broader range of customers, including sites with limited water.

By refueling once every 20 years, ARC-100 reduces operational costs and complexity. And since 99% of the fuel is utilized, our design drastically reduces fuel waste and storage expenses.



PROVEN RELIABILITY

ARC leverages proven technology developed by the U.S. government's Argonne National Labs that operated successfully for thirty years. ARC's team, together with world-class technical partners, has refined this underlying technology to create the ARC-100.

SUSTAINABLE

The ARC-100 burns fuel efficiently, and the 20-year refuelling cycle limits the amount of waste and protects the fuel supply from short-term supply constraints and political influences.

In the future, and after the process is approved by regulatory bodies, the ARC-100 will be capable of consuming its own recycled spent fuel. With fuel recycling, this will further limit the amount of waste, and the hazard life of the fuel waste will be 1000 times less than waste from the current reactor fleet.

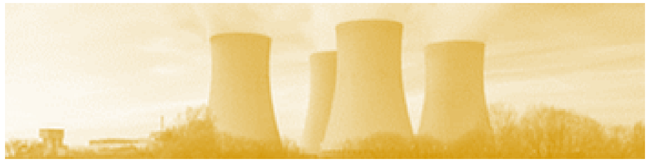
ECONOMICAL

The ARC-100's simple, modular design reduces manufacturing costs while its highly efficient operation with 99% fuel utilization drastically reduces fuel waste and storage expenses.

INHERENTLY SAFE

An advantage of the ARC technology is its natural safety. The ARC-100 uses sodium as a coolant (instead of water, which is used by current-generation nuclear plants) enabling the reactor to operate at lower pressures, given the boiling point of sodium (889.2°C). This ensures more efficiency and enhanced safety compared to current nuclear technology.

In the event of a power interruption, the unit naturally shuts down without operator intervention. This prevents the possibility of overheating, ensuring that the reactor operates safely at all times. Passive systems ensure residual heat is removed from the reactor without the need for back-up power and water supplies.



VERSATILE

The ARC-100 is suitable for a wide range of applications – from clean power for the grid to industrial heat and hydrogen production with true load following capability to partner with renewables.

SCALABLE

Multiple ARC-100 units can be constructed on the same site, increasing generation and decreasing the footprint required for each unit.

LIFE-SAVING MEDICAL ISOTOPE PRODUCTION

As a sodium-cooled fast reactor, the ARC-100 will be capable of high-volume medical isotope production at highly efficient rates.

Because the production of large quantities of radioisotopes for many medical applications benefits from high neutron flux and energy, the ARC-100 offers significant advantages. 20 different medical isotopes have been identified as primary candidates for production.

Project scope and deliverables

The project aims to assess the capability and capacity of New Brunswick's SMR and industrial supply chains for gaps and limitations that could hinder the production of FOAK and NOAK reactors. New Brunswick aims to leverage its **leadership** position in SMRs and stimulate economic growth by ensuring **80%** of components are **locally sourced**, creating a **secure and resilient** supply chain that meets nuclear industry regulations.

METHODOLOGY

Current state assessment

Analysis of the current state through document review, current state assessment, and desktop research. We developed an overview of current state based on supply chain maturity and vendor availability in New Brunswick. A demand curve was built for both the FOAK and NOAK reactors.

Demand and supply mapping

Mapping the current supplier base to support forecasted demand. This assessment is aimed at identifying the growth potential of supply chain to meet future demands, and to determine the level of investment required.

Strategy development

Based on our analysis of the current state, Deloitte has formulated a list of strategic considerations and implementation recommendations to advance the deployment of SMRs in New Brunswick.

DELIVERABLE

Deloitte has prepared a comprehensive study that encompasses the following:

1. **Commercial Readiness Assessment** – provides a holistic view of the current state of the technology development and identified critical gaps and barriers to commercialization.
2. **Demand Modelling** – through scenario analysis, we were able to model the demand of a selection of critical components to identify the required investment timelines and overall potential scale of the SMR industry.
3. **Supply Chain Mapping and Assessment** – Mapping current vendors and fabricators against projected demands. Identify potential suppliers of critical components within and outside New Brunswick, evaluate supply chain gaps and provide areas of development
4. **Strategic Considerations** – Bringing together the commercial readiness assessment, demand scenarios and supply chain assessment, we provide a strategic assessment of the industry and gap closure recommendations.
5. **Next Steps and Call to Action** – based on our findings, we have identified areas for additional study as well as a direct call to action for the industry and government to consider.

OUT OF STUDY SCOPE

- The vendors listed were chosen primarily for their past nuclear experience and proximity to New Brunswick, not their qualifications or manufacturing capabilities.
- Labour force and capability analysis has not been included.
- Vendor analysis of the nuclear fuel supply, refueling & servicing equipment system is out of scope.

Project assumptions

DEMAND

- List of critical long-lead equipment items, their quantity, and design/fabrication/shipment lead times were retrieved from the *Draft Procurement Plan for Long-Lead Equipment* prepared by ARC in June 2023.
- For any UNKNOWN data in the *Draft Procurement Plan for Long-Lead Equipment,* assumptions were discussed with ARC and noted in the slides that follow.

SUPPLY

- List of critical long-lead items was retrieved from the *Draft Procurement Plan for Long-Lead Equipment* prepared by ARC.
- Suppliers identified for the FOAK reactor are based on manufacturing location and their self-identified expertise in the nuclear industry.
- Provincial suppliers for the NOAK reactor are based on expressed interest from ONB's Company Self-Assessment Survey conducted in 2022.

Deloitte's team

We are a global professional services firm that provides a wide range of services, including audit, consulting, tax, and financial advisory services. Our firm has a rich history of over 175 years, and we have a presence in more than 150 countries around the world. At Deloitte, we understand the importance of the nuclear industry and the role it plays in meeting the world's growing energy demands.

Infrastructure and Capital Projects Practice

The Infrastructure and Capital Projects team at Deloitte is a group of professionals who specialize in providing advisory services to clients in the infrastructure and capital project industry. The team works with clients to help them manage their projects from start to finish, including planning, financing, construction, and operations. They also provide expertise in areas such as risk management, project controls, and procurement. The team is made up of individuals with diverse backgrounds, including engineers, construction managers, financial analysts, and project managers, who work together to provide comprehensive solutions to clients.

Supply Chain & Network Operations Practice

The Supply Chain and Network Operations (SCNO) practice is part of the Enterprise Technology & Performance offering portfolio, which sits under Deloitte Consulting. SCNO professionals help businesses manage and optimize supply-chain performance in an era of digital disruption that brings both challenge and opportunity. With a strong presence of 3,000 dedicated Supply Chain professionals and 10,000 global professionals in 40+ countries we are solving the most complex Supply Chain issues and challenges for clients in 150+ countries. We bring in a strong network of global subject matter experts to support our client with best-in-class solutions.

The Team

Karen Hamberg
Deloitte Partner and National Clean Technology Leader
Lead Engagement Partner
Karen is a Partner with Deloitte, leading the Nation Clean Technology practice group. She brings over 25 years of industry experience and is an ecosystem builder with a demonstrated track record of global policy and regulatory influence for the commercialization and deployment of clean transportation technologies.

Tom Stevens
Deloitte Senior Manager
CleanTech Commercialization Lead
Tom is a Senior Manager with Deloitte in the I&CP practice based in Calgary. He has 13 years of experience in process engineering, capital project execution, technology commercialization and strategy implementation.

Delivery Team

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2. Commercial Readiness

Commercial readiness assessment - FOAK (1/2)

Technical, market, policy, and organizational readiness levels for ARC-100 FOAK were reviewed as part of the Deloitte's commercial readiness framework. The overall commercial readiness level is rated as moderate, with stronger readiness levels being observed in policy and organizational capability.

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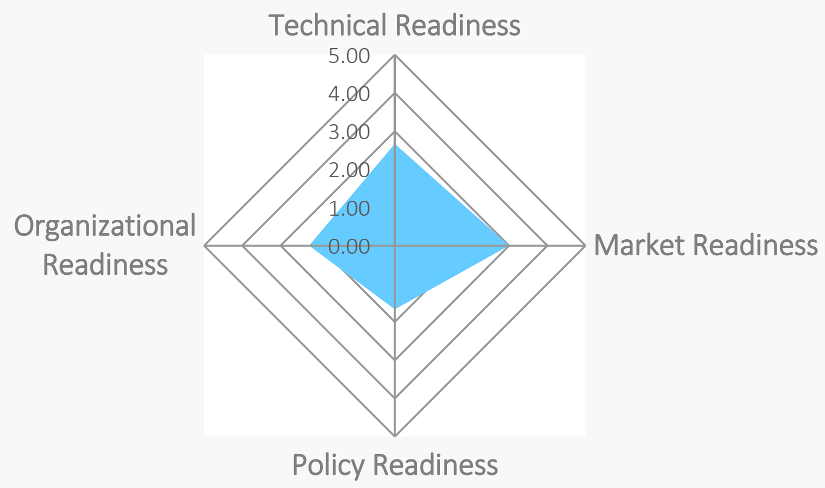
S.S.A.F.
Scaling Solutions Assessment Framework

		ARC-100 FOAK Commercial Readiness	
		Current State	
		Readiness Level (1-5)	Readiness Level Definition
Technical Readiness	Technology Readiness (TRL)	4	Low-emission technology has been successfully prototyped at scale
	Cost-Competitiveness	3	Low-emission technology is cost prohibitive in a market willing to pay a premium
	Abatement Potential	1	Quantifiable, verifiable, material GHG emissions reductions aligned to 2030 and 2050 targets
Market Readiness	Value Chain	4	Some elements reach sufficient maturity by the time the full value chain needs to be deployed
	Infrastructure	2	Infrastructure required to enable deployment and market share is widely established in key markets
	Supply Chain Capability	4	Few and relatively new commercial suppliers of low-emission technology
	Market/Customer Familiarity	2	Majority of customers have familiarity and/or market experience with low-emission technology
Policy Readiness	Policy	1	Policy frameworks prioritize low-emission technology and disadvantage/penalize incumbents
	Regulations (permitting)	2	Regulations and regulators incentivize and facilitate deployment of low-emission technologies
	Codes & Standards (protocols, etc)	2	Codes and standards exist to support deployment of low-emission technology
Organizational Readiness	Partnership Strategy	1	Strategic partnerships enable deployment at industrial scale
	Management Capability	3	Management and technical teams with capabilities to commercialize the technology
	Intellectual Property	1	IP portfolio is strategically managed to monetize assets, IP strategy is business strategy
	Business Models	4	Business model is untested and easy to replicate by competitors
	Overall Commercial Readiness*	3	

Overall Commercial Readiness**



- While the highest level of readiness was observed for policy and organizational requirements, there are opportunities to advance technical and market readiness to address gaps and de-risk investments.
- This assessment was conducted for the FOAK reactor. Actions could be taken across all indicators to strengthen the commercial ecosystem as the industry moves towards NOAK.

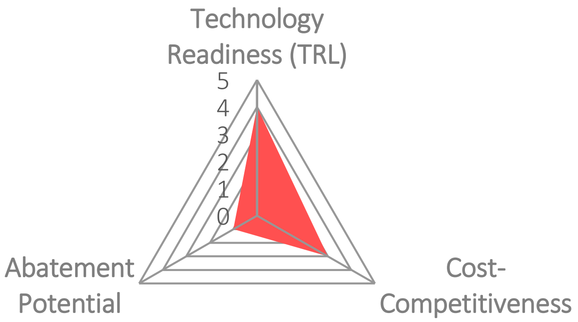
Notes: Lower numbers indicate greater commercial readiness. | Low-emission technology refers to ARC-100 SMR technology.

* Overall Commercial Readiness Level is the round up average of all scores. ** Each pillar's readiness level is the average of all readiness scores within that category.

Commercial readiness assessment - FOAK (2/2)

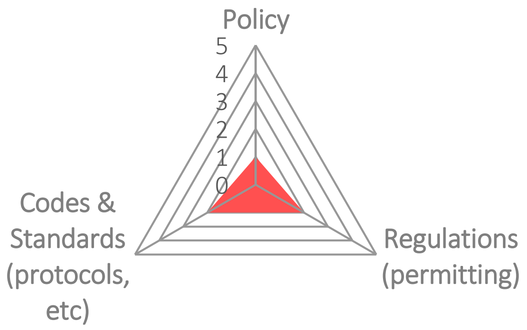
To position NB as a leader in SMR technology, it is essential to advance all four dimensions of readiness ensuring an optimal, integrated commercial ecosystem. While the deployment of an SMR will lead to an improvement across readiness levels, as the industry scales, there is a need to prioritize and potentially incentivize other elements of a coherent commercial ecosystem such as value chain and supply chain capability.

Technical Readiness



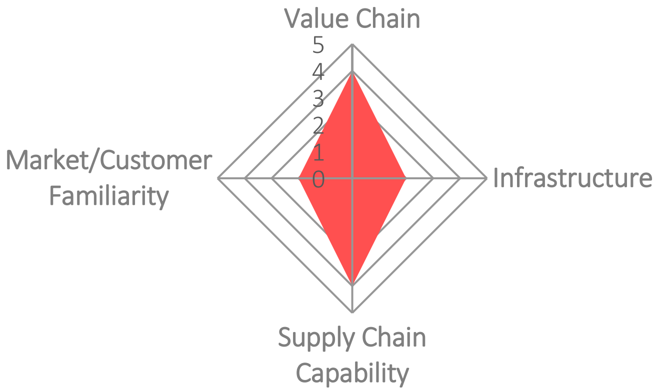
- TRL improves over time (FOAK to NOAK) as the technology becomes commercially available.
- Likewise, cost competitiveness would be improved over time by 2050 if more units are deployed within the region and economies of scale impact are realized. R&D support would also help enhance the score.

Policy Readiness



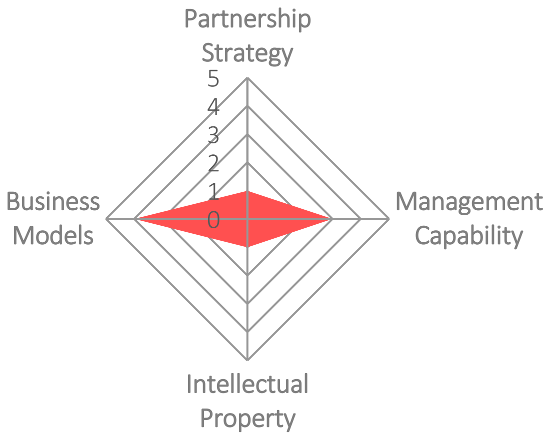
- Policy readiness scored the highest in this assessment due to the robust frameworks already in place within the nuclear industry.
- These robust policies should be adapted for the SMR technology to recognize the significant differences and facilitate deployment, including accelerated timelines for regulatory proceedings.
- The SMR industry benefits from the codes and standards already in place for the nuclear industry and these codes need to be optimized for SMRs.

Market Readiness



- As expected with developing or revitalizing an industry, the value chain and supply chains remain underdeveloped and currently unable to support the deployment of the ARC-100 units.
- Currently, there are a few proponents that support the existing nuclear and heavy industrial market in NB. This study aims to identify methods to develop existing capacity and bring new proponents to the nuclear industry.

Organizational Readiness



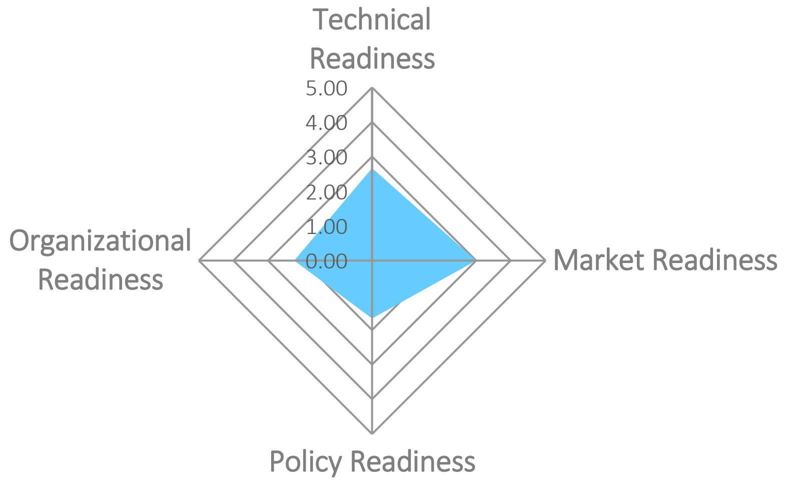
- ARC has developed strong partnerships and robust IP protection.
- Currently the business model is untested. The business model will undergo continuous testing as FOAK and NOAK are deployed.
- The current management team at ARC is well suited to continue to develop the ARC-100 unit. As the unit nears commercialization, the team will need to develop external support capabilities and operational teams.

Notes: Lower numbers indicate greater commercial readiness | Refer to the Appendix A for assumptions and definitions.

Actions and milestones to secure a desired NOAK readiness level (1/2)

To ensure that SMRs can be produced commercially and position New Brunswick as a leader in the low-carbon economy by 2050, several actions should be taken to improve the overall commercial readiness level from a moderate FOAK level to a high NOAK level.

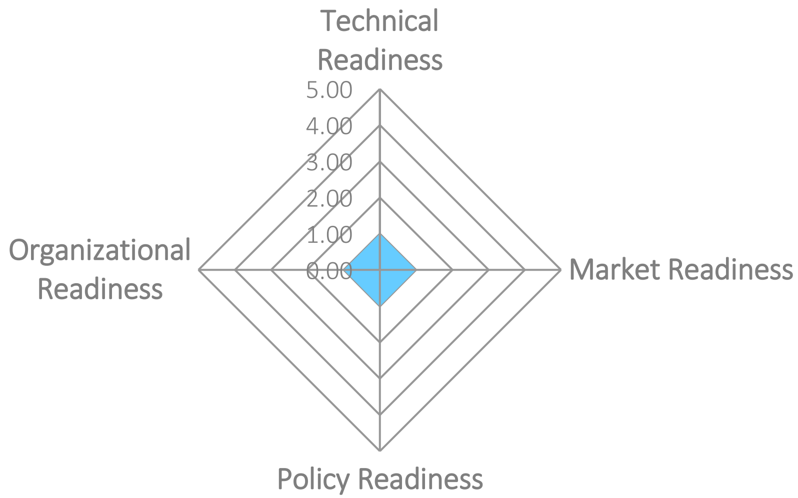
FOAK - 2030



Overall commercial readiness: 3 (moderate)

What is required to get there?

NOAK - 2050



Overall commercial readiness: 1 (high)

Actions that could help improve the readiness level by NOAK:

Build up Business Environment
- Public and Private Strategic Investments
- VC & Angel Investments
- Grass roots collaboration and development through entire process

Secure Political & Regulatory Support
- Incentives & Schemes
- Regulations & Policies
- Legal, Tax, IP Environment
- Develop Codes & Stds

Build Enabling Infrastructure
- Transportation
- Power and Clean Energy Infrastructure

Build Partnerships
- Accelerators & Incubators
- Testing Sites
- Partnerships and collaboration

Create Talent & Capabilities
- STEM support in education
- Nuclear Research Talent
- Workforce with nuclear experience

Streamline An Innovation Ecosystem
- Research and Development
- Regional Adoption
- Nuclear Manufacturing Ecosystem

Actions and milestones to secure a promising NOAK readiness level (2/2)

A more detailed roadmap could be developed by looking at each commercial readiness level pillar and identifying specific tailored actions that could be taken to improve its level in FOAK to that of mid- and long-term NOAK (2040 & 2050).

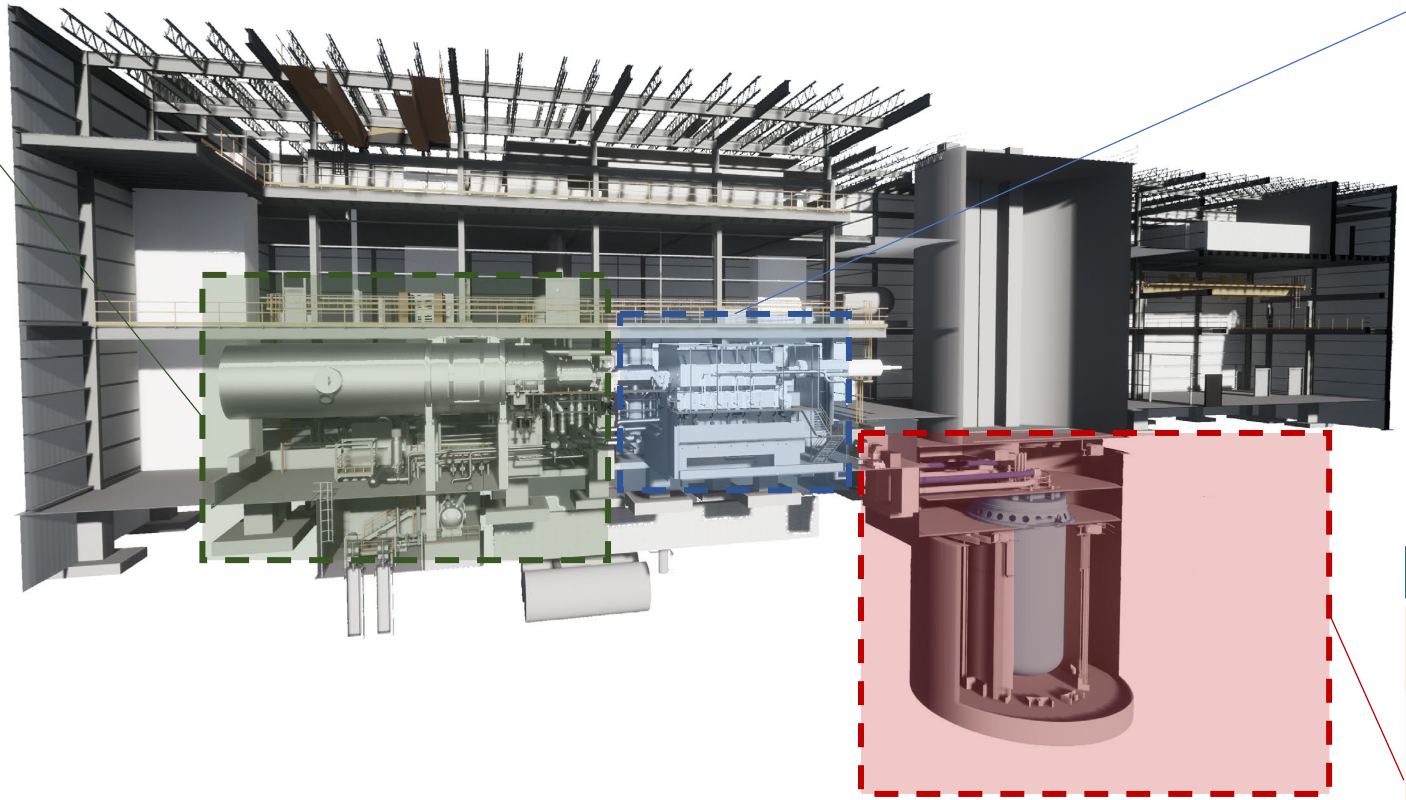
	FOAK - 2030	NOAK - 2040	NOAK - 2050
1 Technical readiness	Partner with leading engineering and technical consultants	Deploy regional hubs and clusters	Ensure a higher process standardization
2 Market readiness	Develop a workload distribution plan between local and national vendors	Enable an infrastructure level that could support this study's forecasted demand	Develop local fabricators and equipment/technology providers partnerships
3 Policy readiness	Streamline permitting and implement policy and regulatory frameworks that are competitive with other jurisdictions.	Help develop safety programs, for workforce and suppliers, and SMR codes/standards	Source locally through Indigenous suppliers and implement ESG related strategic initiatives
4 Organizational Readiness	Create partnership opportunities that incentivize out-of-province companies to train in-province orgs on a commercialization management and technical levels	Secure incentive programs, pathways, and pilot programs that could help test the business models	Develop clear departmental policies, process mapping, and KPI's

3. Demand Model

ARC-100's components, systems, and equipment

An overview of key SMR systems and components.

Mechanical (nuclear & non-nuclear)
Steam generator*
Steam turbine*
Condenser*
Heat exchangers
Pumps
Valves



Electrical/I&C (nuclear & non-nuclear)
Generator
Diesel generator
Instrumentation & controls*
Transformers
Switchgear

Nuclear components	
Reactor vessel*	In-vessel transfer machine*
Top plate	Control rod drive mechanisms*
Rotatable plug	Intermediate heat exchanger*
Guard vessel*	Electromagnetic pumps*
Reactor internals*	Feed water heater*

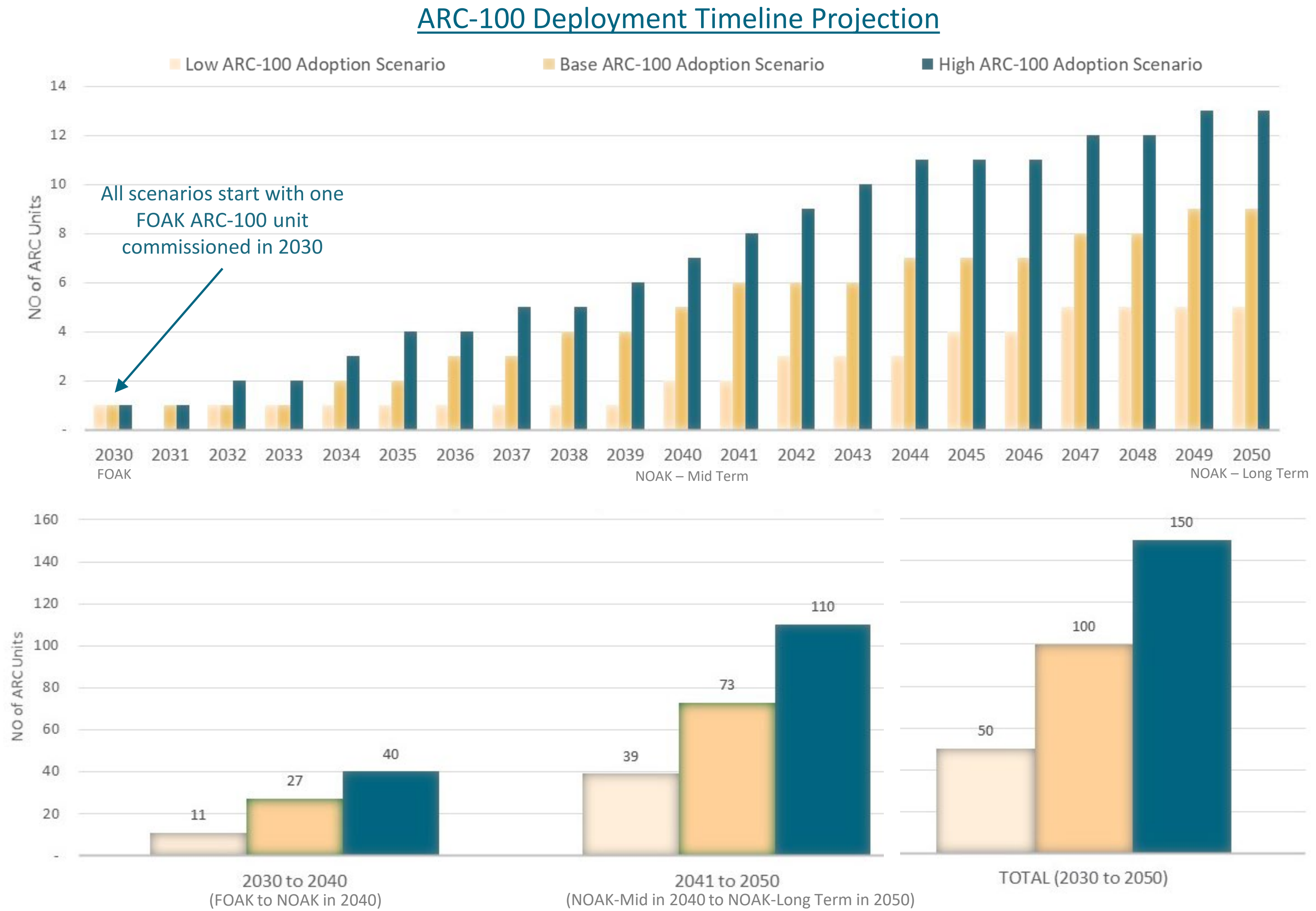
*Long-lead items (21-48 months) identified

Source: ARC Clean Technology Canada Inc., *Procurement Plan for long-lead Equipment*

ARC-100 demand forecast – FOAK, mid-and long-term NOAK

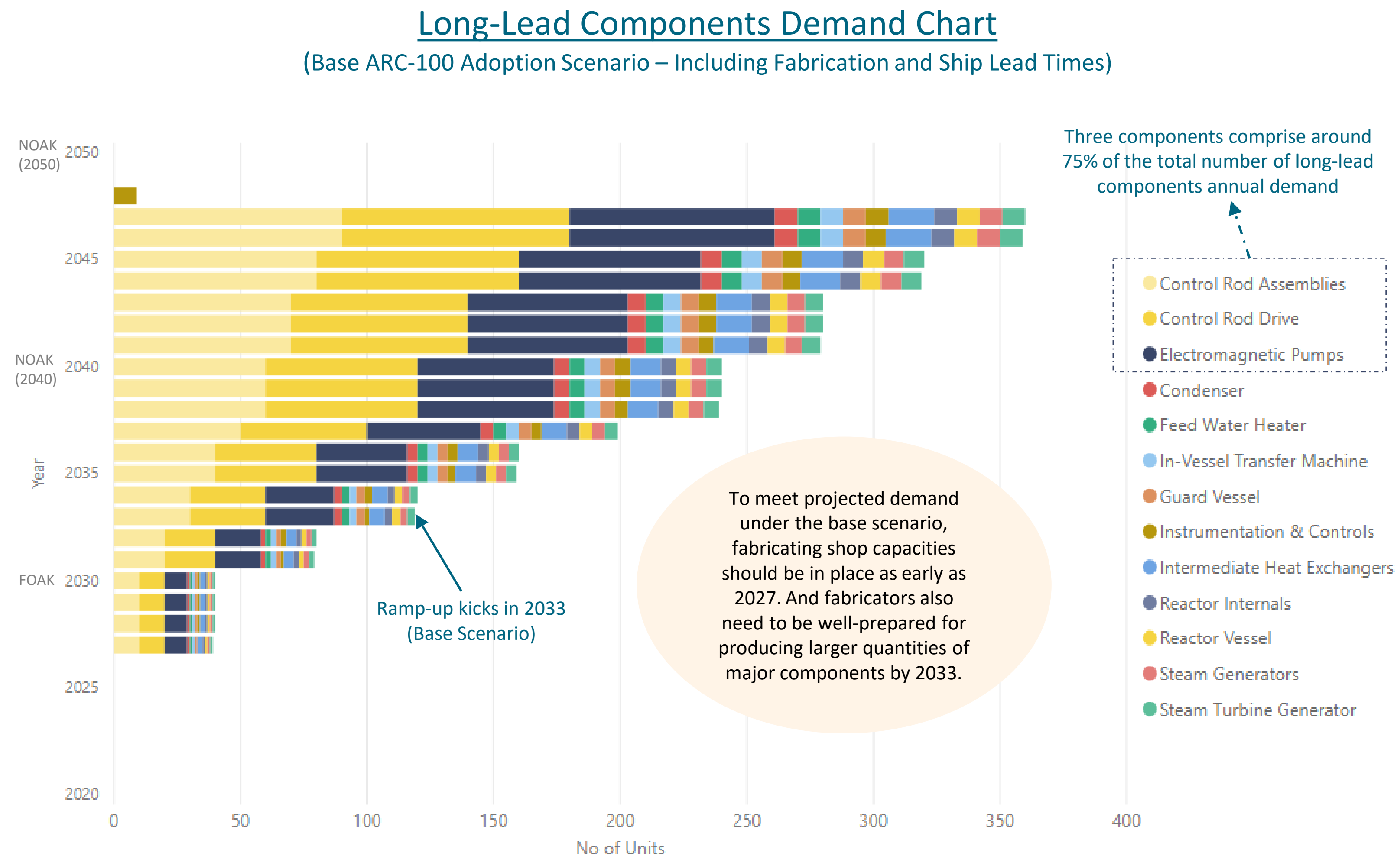
By 2050, New Brunswick could see a deployment of 50 units under the Low adoption scenario, 100 units under the Base adoption scenario, and 150 units under the High adoption scenario.

- The deployment pattern of SMRs and any emerging technology's uptake is characterized by substantial and pervasive uncertainty. As such, we considered three possible scenarios to project the number of ARC-100 units that could be deployed to meet New Brunswick's clean power demand:
  - **Low scenario** (50 units by 2050)
  - **Base scenario** (100 units by 2050)
  - **High scenario** (150 units by 2050)
- These **estimates form the basis** for the fabricator/supplier supply/demand analysis to help quantify the supply chain demand and implications that could emerge as the result of different ARC-100 adoption rates.
- These projections are *possible* scenarios that could be unlocked to help meet New Brunswick's the clean energy targets. While all seem to be relatively ambitious given that no SMR is currently deployed in the province, they could be viewed as the **deployment target required to reach economies of scale and de-risk SMR investments.**
- ARC's vision is to build one hundred ARC-100 units by 2050. While that input forms the basis of our assumed base scenario, the rest of the estimates are **based on Deloitte's internal sources, our market and industry understanding, and public-domain research**. These figures have been verified by the ARC team.



Base scenario: ARC-100 long-lead components procurement demand

To meet the projected demand of 100 units by 2050 under the base scenario, equipment fabrication needs to start as early as 2027. Three major components: control rod assemblies, the control rod drive, and electromagnetic pumps require fabricators to pre-build shop capacity for mass production.



Note: refer to the Appendix A for underlying data details.

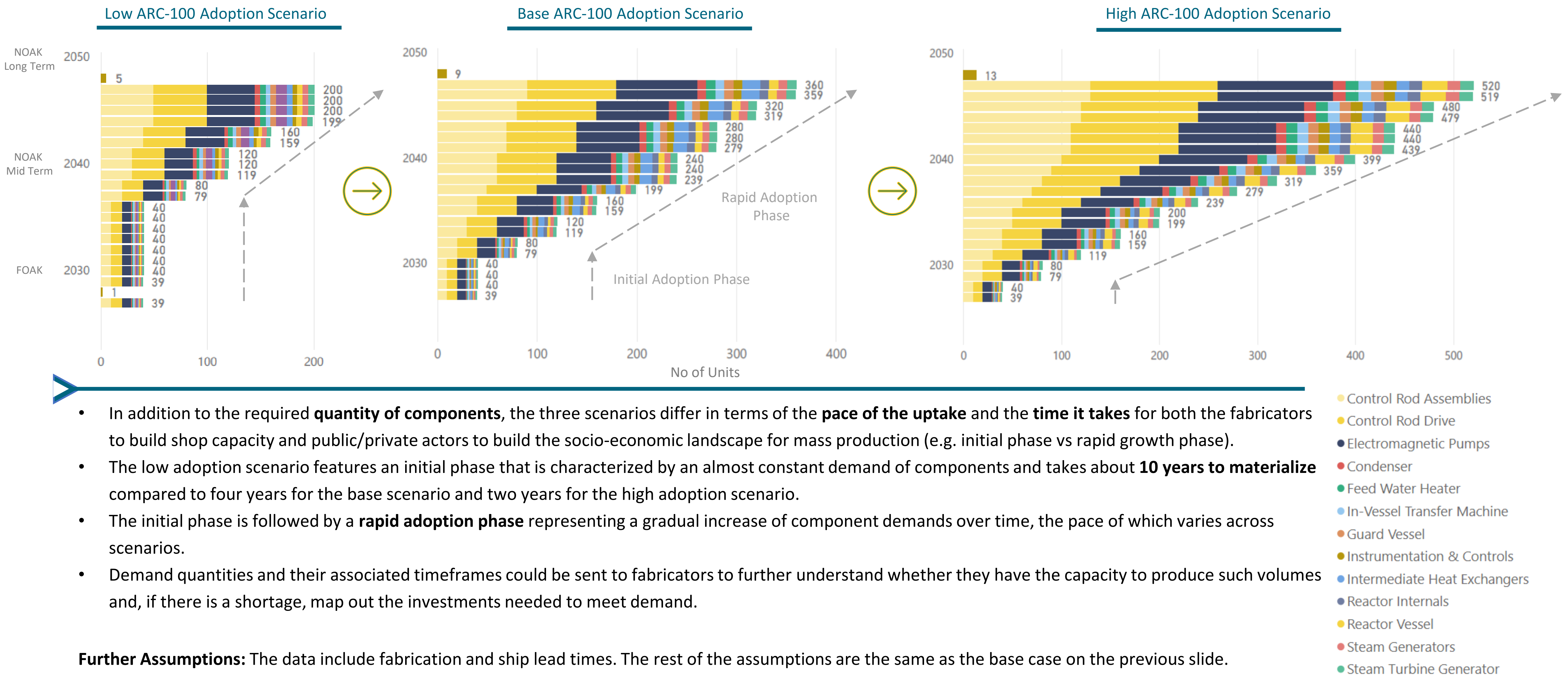
- These estimates reflect **the volume AND the lead times of the demand** that must be met by fabricators/suppliers to achieve the base scenario projected target of deploying 100 ARC-100 units by 2050.
- Three main component groups that must be fabricated will **dominate the demand volume**:
  - Control rod assemblies
  - Control rod drive
  - Electromagnetic pumps

Definitions and assumptions:

- **Ramp-up period:** more than 100 total *component* units.
- Timing includes **fabrication AND shipping time,** without considering any discounting for standardization**.**
- All components could be fabricated in parallel.
- The base scenario's projection assumptions are used in conjunction with the long-lead component data from ARC's procurement plan.
- Lead time months are rounded up to one year.
- Lead times are the average of the ranges highlighted in ARC's procurement plan.
- Refer to Appendix section for additional detailed assumptions.

All scenarios: ARC-100 long-lead components procurement demand

To meet NOAK projected demand of ARC units in 2050, fabricators/suppliers could see a potential peak volume ranging from 200 to 520 long-lead components in 2047. Investments are required to help fabricators build capacity for such a volume.



- In addition to the required **quantity of components**, the three scenarios differ in terms of the **pace of the uptake** and the **time it takes** for both the fabricators to build shop capacity and public/private actors to build the socio-economic landscape for mass production (e.g. initial phase vs rapid growth phase).
- The low adoption scenario features an initial phase that is characterized by an almost constant demand of components and takes about **10 years to materialize** compared to four years for the base scenario and two years for the high adoption scenario.
- The initial phase is followed by a **rapid adoption phase** representing a gradual increase of component demands over time, the pace of which varies across scenarios.
- Demand quantities and their associated timeframes could be sent to fabricators to further understand whether they have the capacity to produce such volumes and, if there is a shortage, map out the investments needed to meet demand.

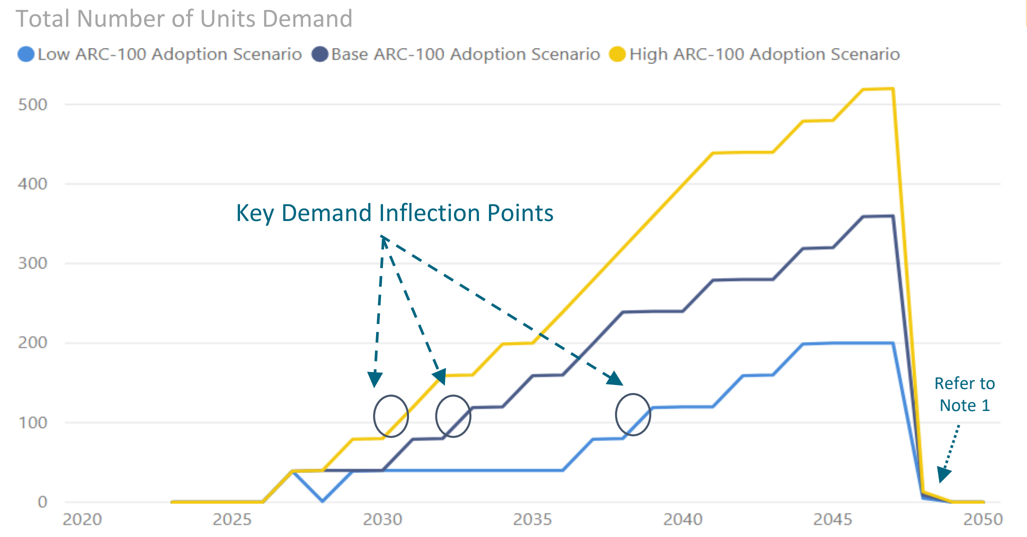
Further Assumptions: The data include fabrication and ship lead times. The rest of the assumptions are the same as the base case on the previous slide.

Note: refer to the Appendix A for underlying data details.

An overview of the required lead times to meet demand

To meet projected demand and support the fabrication and deployment of larger quantities of components, investment capital must be deployed starting in 2024 with the full ecosystem in place by 2039 to meet the base scenario demand requirements.

Ramp-up Kick-in Year Per Scenario

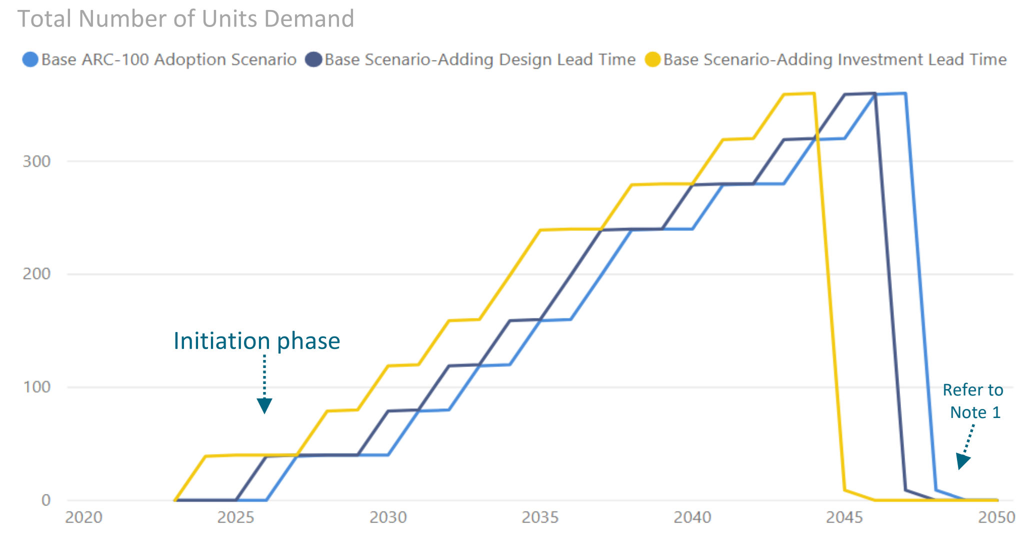


The period between FOAK deployment in 2030 and the ramp-up inflection year is the time that allows suppliers/fabricators to build their fabricating capacity before larger component quantities demand emerge. Before the demand inflection, the government and public/private players should establish a commercial ecosystem that supports a mass deployment of the technology in the province. The ramp-up inflection year varies across different scenarios:

- **Low** ARC-100 Adoption Scenario ramp-up year: **2039**
- **Base** ARC-100 Adoption Scenario ramp-up year: **2033**
- **High** ARC-100 Adoption Scenario ramp-up year: **2031**

The commercial readiness level of the supply chain should be positioned appropriately to support this demand volume. This means the latest year by which the **ecosystem should be in place is 2039**. Refer to commercial readiness section for details of the actions that could be taken.

Adding the impact of design and investment lead times



Adding the lead times for design and investment to the base scenario data suggests that in order to meet the FOAK and NOAK demands:

- **Investments** should be deployed by 2024 and then raised accordingly to meet the mid-term NOAK demand,
- Design work should start by 2026, and
- Fabrication should be initiated by 2027.

Further investigation could be done to determine the required facility additions and/or modifications, the associated investment, and the lead time required for implementation to meet the mid- and long-term NOAK demands.

Assumptions:

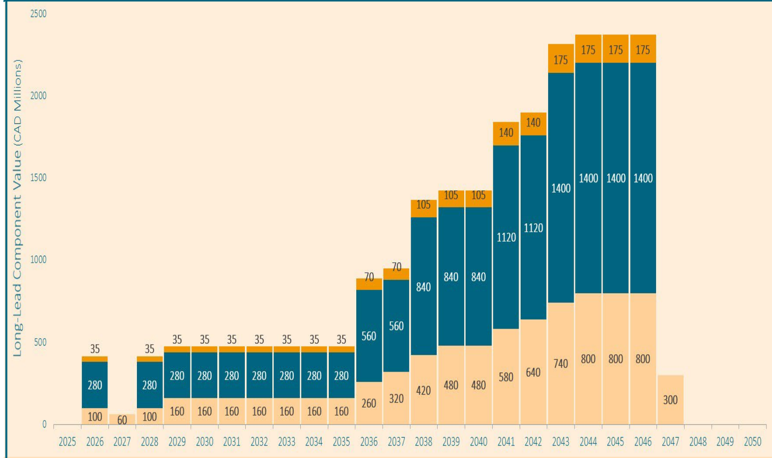
- A two-year lead time requirement for investment prior to design.
- Design lead times are taken from procurement data and vary per component.

Note 1: The model projects into the year 2050. The components' demand declines post-2047 due to the inclusion of varying lead times per component.

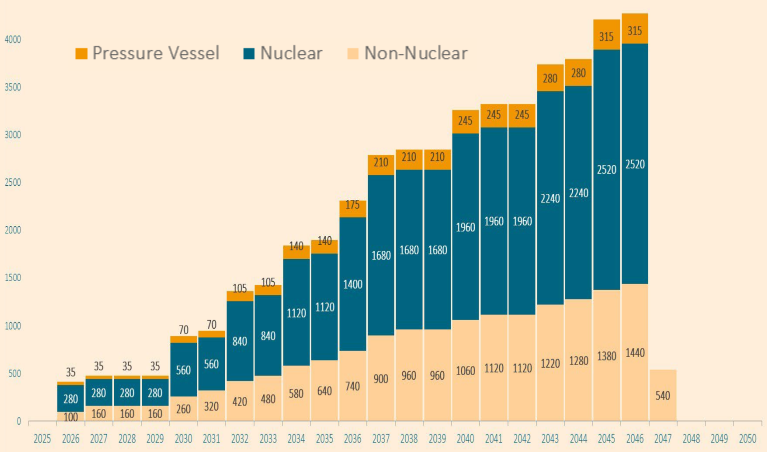
Size of the SMR fabrication opportunity

The deployment of SMRs will unlock value for nuclear component manufacturers and non-nuclear and pressure vessel manufacturers. If the total project cost is assumed to be $1B CDN, it is estimated that the total annual value for manufacturing only long-lead components in New Brunswick could reach ~$2.3B in the low adoption scenario, $4.2B in the base scenario, and $6.2B in the high scenario representing ~7%, 13%, and 19% of provincial GDP (2022) respectively by 2050*.

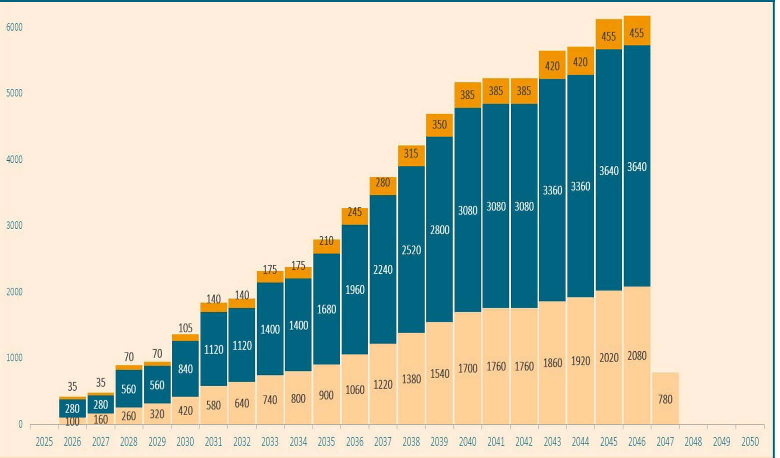
Low ARC-100 adoption scenario



Base ARC-100 adoption scenario



High ARC-100 adoption scenario



- The intended purpose of these figures is to provide a quantitative assessment of the economic opportunity in building a supply chain ecosystem in New Brunswick, as it solely pertains to suppliers and manufacturers meeting the projected demand.
  - ➢ ***FOAK 2030:*** If the projected deployment is achieved and the total cost of a project is assumed to be $1B, under the most conservative low-adoption scenario, nuclear grade suppliers in New Brunswick could unlock and capture a potential annual value of $280M, non-nuclear suppliers an annual value of $160M, and pressure vessel suppliers an annual value of $35M – a potential total annual value of $475 million in 2030. This translates to a potential total cumulative value of $1.8B, $2.7B, and $4B, across the three scenarios, for FOAK. These estimates are for long-lead components only, as manufacturing and the ultimate total value would be more, including the rest of the system components. GDP contributions are not significant for FOAK deployment.*
  - ➢ ***Mid-Term NOAK (2040):*** Across the three scenarios, there is potential to add a total annual value of $1.4B, $3.3B, and $5.2B representing 4%, 10%, and 15% of provincial GDP (2022)* by 2040.
  - ➢ ***Long-Term NOAK (2050):*** Total annual value could potentially increase to $2.3B, $4.2B, and $6.2B representing 7%, 13%, and 19% of provincial GDP (2022)* across the three assumed scenarios by 2050.

Assumptions:

- A sample total project cost of $1B CDN is assumed. A relative share of long-lead component costs to total project costs (~48% of the total project cost) is used as an input. The figures include variable lead times per long-lead component. Refer to the Appendix for additional detailed assumptions.

* 1- The total project cost assumed here ($1B) is used as an illustrative example and is intended solely for information purposes. This cost is NOT indicative of an ARC-100 project. Project cost improvement has also not been considered.
2- Refer to supply section slides for the defining criteria of nuclear, non-nuclear, and pressure vessel manufacturers/components.
3- The figures expressed here only cover long-lead components and do NOT include all SMR components. The additional value that will be unlocked as a result of manufacturing the remaining components has not yet been quantified.
4- GDP Source: Statista.com

4. Supply chain review

4.1 Supplier Overview

Vendor categorization

Five categories of vendors or suppliers are required to support FOAK and NOAK deployment.

EPC/EPCM

An EPC will fully integrate and build out the ARC-100 unit including the nuclear island and the balance of the plant.

FABRICATOR

Fabricators will assemble parts and components of each individual system(s) for the nuclear island and the balance of the plant. They are classified as Level 1 (nuclear), Level 2 (pressure vessel), or Level 3 (non-nuclear/general).

FORGING SHOP

Forging shops will use their material expertise and component manufacturing capabilities to produce raw materials for the reactor vessel, steam generators, and other critical parts.

OEM - SKIDS

The original equipment manufacturer of the components close to the reactor as well as mechanical, electrical, and nuclear OEMs who provide complete systems for SMRs.

OEM - PARTS

The original equipment manufacturers who supply mechanical, electrical, and nuclear parts to construct SMR systems and components near the reactor.

Potential ARC-100 vendors and partners

Potential vendors and partners are available within New Brunswick and outside of the province for both the FOAK and NOAK reactors. Vendor selection criteria has been developed to pre-qualify partners based on reputation, experience, and ability to meet requirements.

WITHIN NEW BRUNSWICK

EPC/EPCM
- Stantec

(Stantec is an EPCM only with limited capabilities in the Atlantic provinces)

FABRICATORS
- B&W (Babcock & Wilcox)
- CFM
- Lorneville
- KGC
- bird
- Sunny Corner Enterprises Inc
- SMS Industrial Fabrication
- Bourque Industrial Ltd
- DBM
- rpc Science & Engineering
- cahill
- OSCO construction group
- Multi Radiator Services Ltd.
- Applus+

OEM - SKIDS
- bird
- Brunswick Industrial Supplies Ltd.
- Pumps & Compressors Ltd.
- rpc Science & Engineering
- Atlantic Controls (Emerson Impact Partner)
- C-Therm Technologies
- levitt safety
- Power Precision
- Sure Grip
- Maritime Hydraulic
- Aboriginal Precision Products
- Monquart Enterprises Ltd.

OEM - PARTS
- Swagelok
- Aluma Safway
- Contro Valve
- Brunswick Industrial Supplies Ltd.
- Glow Group Inc.
- Atlantic Controls (Emerson Impact Partner)
- Pinacle
- omnitech
- Armour Valve
- Clow Canada

SERVICE PROVIDER
- Malta
- Terrane Geoscience Inc.
- Nocturne
- MacDonald Applicators
- Kognitiv Spark
- BIDS Alert
- CBCL
- PLC Fire Safety Engineering
- Sivret
- IDOM
- Calian

OUTSIDE NEW BRUNSWICK

EPC/EPCM
- SNC-Lavalin
- Worley
- Fluor
- AECOM
- Hatch
- L3Harris
- Aecon
- Fox Nuclear Services
- United
- WSP

FORGING SHOPS**
- Somers
- Forgiatura Morandini
- Patriot Forge Co.
- Sheffield Forgemasters
- CanForge

FABRICATORS
- PCL
- Rigid Welding
- Marks Brothers
- Tech Fab
- Metso
- R-V Industries Inc.
- Black&McDonald
- Holtec International
- framatome
- Kennedy Tank and Manufacturing Co., Inc.
- Curtiss-Wright
- AT&F

OEM - SKIDS
- Alithya
- BWXT
- GE
- rotork
- Westinghouse
- Doosan
- Shell Global
- Škoda JS
- CMI
- Novacast
- Mitsubishi Power
- altex Computers & Electronics
- Salher Water Solutions Worldwide
- L&T Heavy Engineering
- Toshiba
- Siemens
- PTI Transformers
- Schneider Electric
- Delta Star Inc.
- Thielmann The Container Company
- Ultra

OEM - PARTS
- CPUS Canadian Power Utility Services Ltd.
- Fike
- Thomas Scientific
- Melt
- Emerson
- Nelta
- Graybar Canada
- Nuclead
- JSW M&E
- Continental Disc Corporation
- Westburne
- Tubacex
- Alleima
- Nippon Steel
- Heavy Pumps
- Toyo Pumps
- ABB
- Atlas
- GeoSIG
- Sandvik
- Centravis

SERVICE PROVIDER
- Deep Trekker
- North American Helium
- Thomas Thor associates
- Bucephalus Consulting
- urenco
- Imagine 4D
- Wild Matriarch

* Vendor selection criteria can be found in the Appendix B

** Details on forging shops are available in the Appendix B

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; Deloitte Research

Disclaimer:
The list of potential vendors and partners referenced is illustrative only and not exhaustive. The inclusion or exclusion of a specific company or organization does not represent an endorsement by ARC or its partners.

4.2 Vendor Demand Mapping

Vendor availability – FOAK reactor systems

Vendor availability (full, partial, and none) for critical and non-critical reactor systems based on interest expressed in ONB's Self-Assessment Survey conducted in 2022.

Critical systems*	In New Brunswick	Outside New Brunswick – in Canada	Outside Canada
Reactor vessel	◐	◐	●
Primary heat transport system	◐	●	●
Intermediate heat transport system	◐	●	●
Steam generator system	◐	○	●
Primary & secondary control rod system	○	○	●
Reactor vessel auxiliary cooling	●	●	●
Direct reactor vessel auxiliary cooling	◐	●	●
Steam turbine system	○	○	●
In-vessel transfer machine	○	●	●
Gaseous waste – cover gas	◐	●	●
Intermediate sodium processing	◐	●	●
Primary sodium processing	◐	◐	●
Liquid metal systems heating & insulating	●	●	●
Condensate & feedwater	◐	●	●
Non-critical systems	**In New Brunswick**	**Outside New Brunswick – in Canada**	**Outside Canada**
Instrumentation & control system	○	◐	●
Security systems and programs	◐	●	●
Plant electrical systems	●	●	●
Non-sodium and sodium fire protection	●	●	●

○ No vendor availability
◐ Partial vendor availability
● Full vendor availability

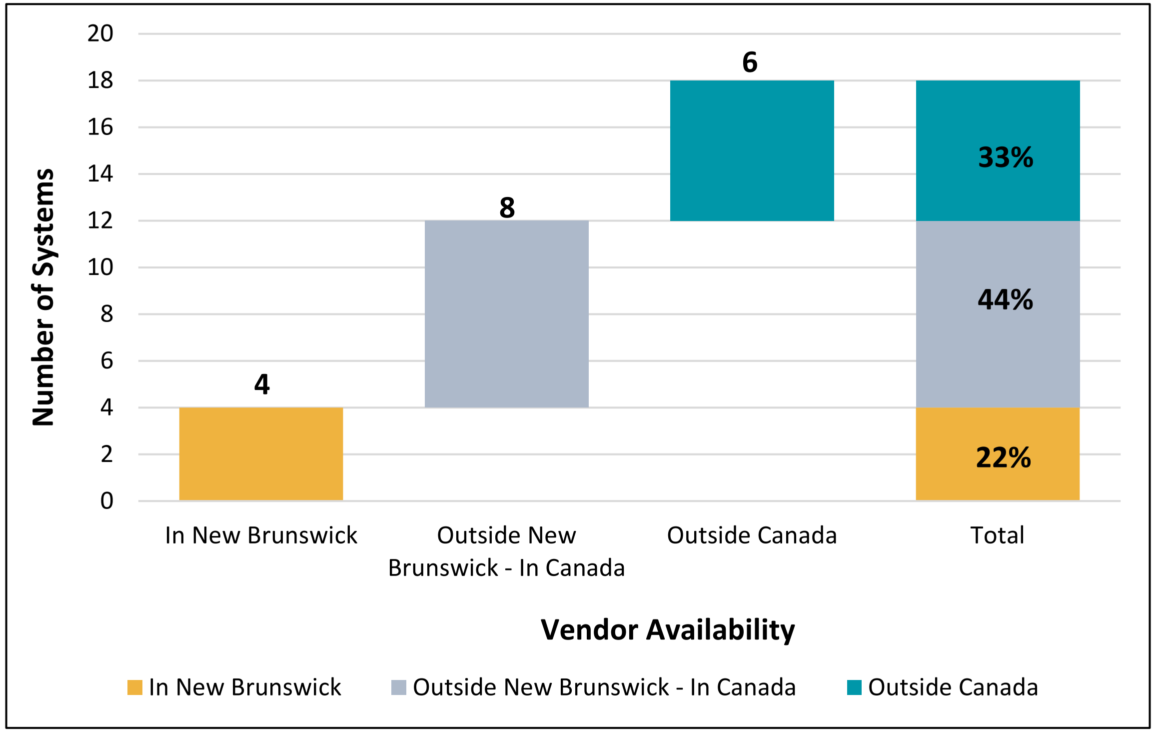
Note: Vendors in New Brunswick chosen for nuclear experience and location rather than credentials and manufacturing capacity. Local fabricators partner with EPCs for assembly and testing of the SMR.

* The refueling & servicing equipment system is out of scope

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; ONB, Current & Future Mapping Excel; Deloitte Research

Vendor availability – FOAK reactor systems (continued)

The SMR vendor base in New Brunswick needs to be advanced and matured. Currently 4 out of 18 systems can be sourced within the province while the remaining systems can be sourced from outside New Brunswick, either within Canada and/or internationally.



Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; ONB, Current & Future Mapping Excel; Deloitte Research

COMMENTS

To meet the 80% procurement target of local New Brunswick suppliers, the vendor base of the following systems need to be advanced and matured.

- Reactor vessel and internals
- Electromagnetic pumps
- Heat exchangers
- Instrumentation & controls
- Condenser

Potential New Brunswick vendors for the FOAK reactor include **Lorneville Mechanical, Sunny Corner Enterprise, and Power Precision** who could supply components for four reactor systems.

Vendor availability – NOAK reactor systems

Vendor availability (full, partial, and none) for critical and non-critical reactor systems based on interest expressed in ONB's Self-Assessment Survey.

Critical systems*	In New Brunswick[1]	Outside New Brunswick – in Canada[2]	Outside Canada[2]
Reactor vessel	●	◐	●
Primary heat transport system	●	◐	●
Intermediate heat transport system	●	◐	●
Steam generator system	●	◐	●
Primary & secondary control rod system	●	○	●
Reactor vessel auxiliary cooling	●	●	●
Direct reactor vessel auxiliary cooling	●	●	●
Steam turbine system	○	○	●
In-vessel transfer machine	●	●	●
Gaseous waste – cover gas	●	●	●
Intermediate sodium processing	●	●	●
Primary sodium processing	●	◐	●
Liquid metal systems heating & insulating	●	●	●
Condensate & feedwater	●	●	●
Non-Critical Systems	**In New Brunswick**	**Outside New Brunswick – in Canada**	**Outside Canada**
Instrumentation & control systems	●	◐	●
Security systems and programs	●	○	●
Plant electrical systems	○	●	●
Non-sodium and sodium fire protection	●	●	●

○ No vendor availability
◐ Partial vendor availability
● Full vendor availability

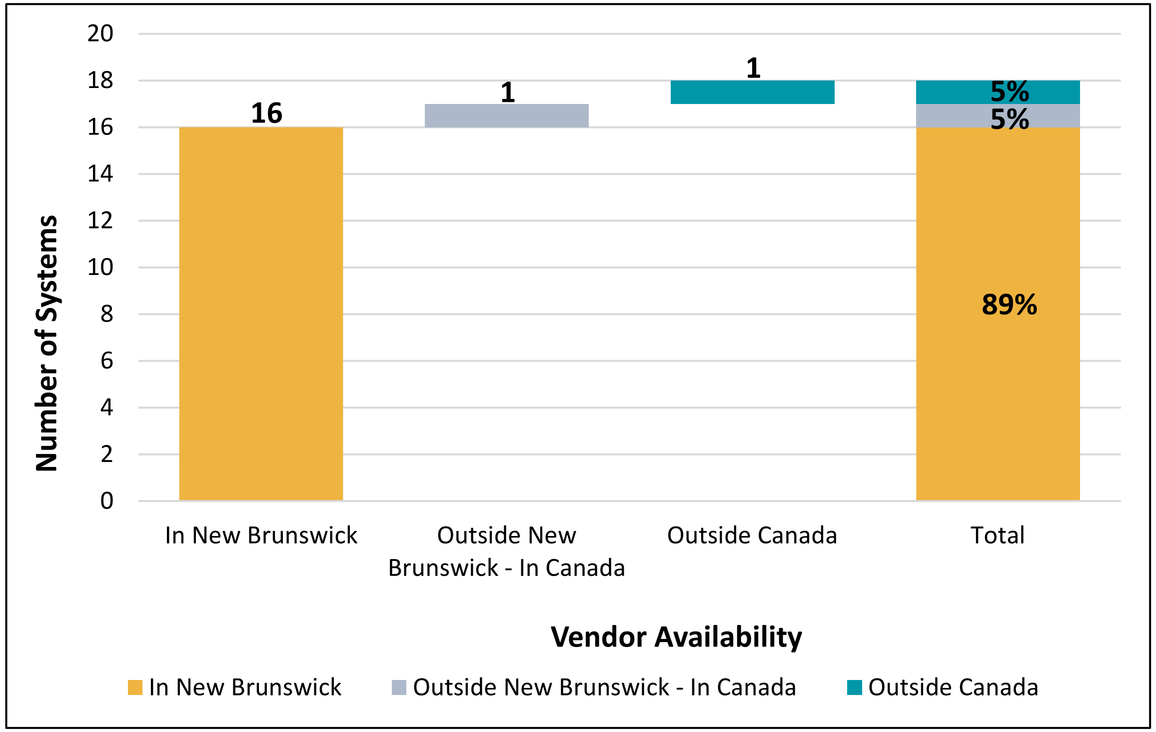
Note: Vendors in New Brunswick chosen for nuclear experience and location rather than credentials and manufacturing capacity. Local fabricators partner with EPCs for assembly and testing of the SMR.

***** The refueling & servicing equipment system is out of scope.

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; ONB, Current & Future Mapping Excel; Deloitte Research

Vendor availability – NOAK reactor systems (continued)

The SMR vendor base in New Brunswick has matured. It is estimated that 16 out of 18 systems could be sourced within New Brunswick while the two remaining systems can be sourced from outside the province, either within Canada and/or internationally.



Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; ONB, Current & Future Mapping Excel; Deloitte Research

COMMENTS

Based on interest expressed by New Brunswick suppliers for the NOAK reactor, the **steam turbine and plant electrical systems are unlikely to be manufactured** in the province.

The **steam turbine is a complex system** that requires heavy engineering capabilities and precision manufacturing and only a small number of vendors supply this system globally. Purchasing the steam turbine from vendors such as General Electric in the United States may be a more feasible option.

Plant electrical is a non-critical system yet developing electrical component manufacturing in New Brunswick would likely require significant investments. Relocating these suppliers to New Brunswick is not a primary need, especially when multiple vendors are available in Canada.

Vendor availability of long-lead items

Vendor availability (full, partial, and none) for critical long-lead reactor components that require between 21 to 48 months of lead time.

Type		Component or System	In New Brunswick	Outside New Brunswick – In Canada	Global
Component	Nuclear	Reactor vessel	◐	●	●
Component	Nuclear	Guard vessel	●	○	●
Component	Nuclear	Reactor internals	○	◐	●
Component	Nuclear/ Non-nuclear	Electromagnetic pumps	○	●	●
System	Nuclear	Steam generators	◐	○	●
Component	Non-nuclear	Instrumentation & controls	○	●	●
System	Nuclear	Control rod system	○	○	●
Component	Nuclear	Intermediate heat exchangers	●	●	●
System	Nuclear	In-vessel transfer machine	○	○	●
Component	Nuclear	Condenser	○	●	●
Component	Nuclear	Feed water heater	●	●	●
System	Nuclear	Steam turbine generator	○	○	●

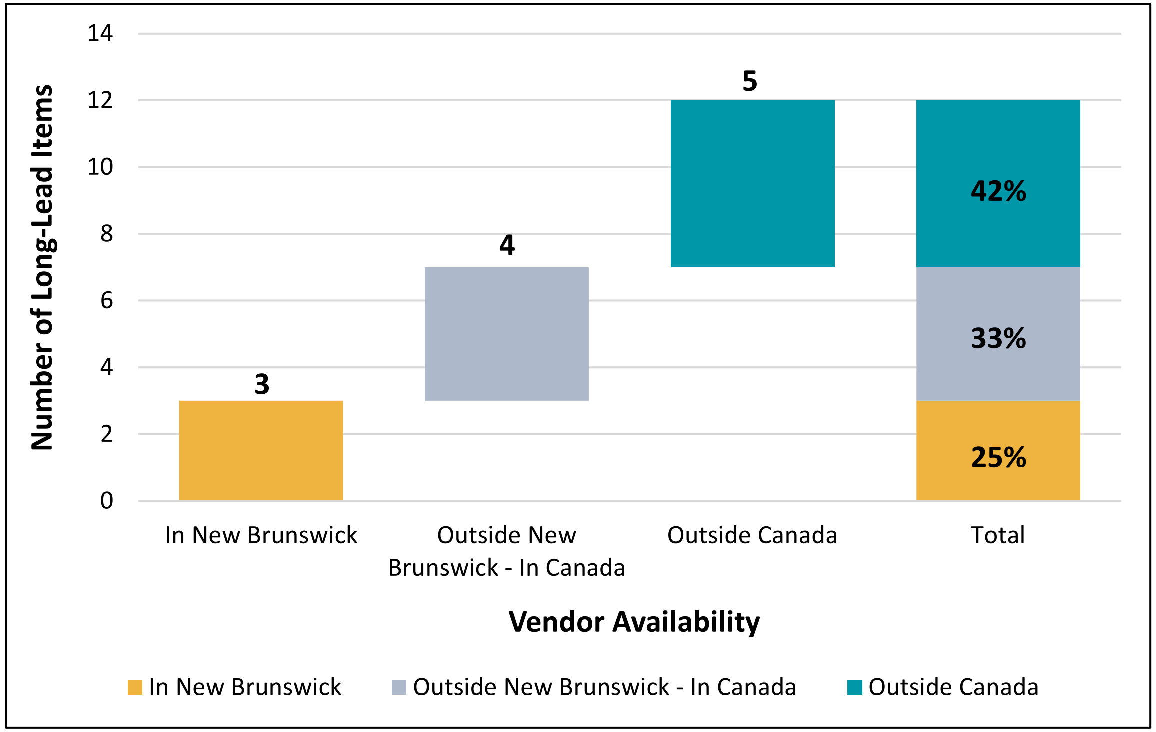
Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; ONB, Current & Future Mapping Excel; Deloitte Research

○ No vendor availability ◐ Partial vendor availability ● Full vendor availability

Note: Vendors in New Brunswick chosen for nuclear experience and location rather than credentials and manufacturing capacity. Local fabricators partner with EPCs for assembly and testing of the SMR.

Vendor availability of long-lead items

The vendor base in New Brunswick needs to be advanced and matured. Currently 3 out of 12 long-lead items can be sourced within the province while the remaining systems can be sourced from outside New Brunswick, either within Canada and/or internationally.



Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; ONB, Current & Future Mapping Excel; Deloitte Research

COMMENTS

To meet the 80% procurement target of local New Brunswick suppliers, the vendor base of the following long-lead items need to be matured.

- Reactor vessel and internals
- Electromagnetic pumps
- Intermediate heat exchangers
- Instrumentation & controls
- Condenser

Currently potential New Brunswick vendors for the FOAK reactor include **Lorneville Mechanical, Sunny Corner Enterprise, and Power Precision** who could supply components for four reactor systems.

How are long-lead items linked to demand?

We have identified the component manufacturing production time for those with the shortest and longest lead-time and calculated the number of suppliers required to meet the demand for 99 reactors by 2050. This calculation does not account for the vendor's fabrication capacity and may vary once design requirements are shared with suppliers and a more accurate fabrication time is identified.

FOAK production time with base case – linear manufacturing process

Component	Quantity per project	Queue/design time (months)	Fabrication time (months)	Time to ship (months)	Total time FOAK (months)
Steam turbine generator	1	12	21	3	36
Reactor vessel	1	6-12	24	4	34-40

NOAK production time (99 reactors) in the matured case with a parallel manufacturing process - certain production process will run in parallel to cut the overall production time. There will be a higher process standardization achieved after the FOAK deployment.

Sample calculations:

STEAM TURBINE GENERATOR

NOAK parallel production time with discounted fabrication, shipping, and design time with one supplier:

- Design time = 0 months
- Fabrication time = 10.5 months (50% fabrication time)
- Ship time = 3 months

13.5 months x 99 reactors = 1336.5 months = 111.37 years (based on discounted fabrication and shipping time)

If production time for 99 reactors is 25 years, four suppliers will be required.

- 111.37 years/25 years = 4.45 or 5 suppliers

REACTOR VESSEL

NOAK parallel production time with discounted fabrication, shipping, and design time with one supplier:

- Design time = 0 months
- Fabrication time = 12 months (50% fabrication time)
- Ship Time = 1 month

13 months x 99 reactors = 1287 months = 107.25 years (based on discounted fabrication and shipping time)

If production time for 99 reactors is 25 years, five suppliers will be required.

- 107.25 years/25 years = 4.46 or 5 suppliers

Assumptions:

- **Design time** = the component is only to be designed once
- **Ship time** is one month assuming majority of components will be shipped locally with exception to the control rod unit and steam turbine

Case Selection

We'll assess the base case for mid-term NOAK and the matured case for end-term NOAK. Between FOAK and mid-term NOAK, discounted fabrication time will be considered as higher process optimization and standardization are expected to be achieved due to improved load distribution among vendors.

Note: The number of suppliers to meet demand can either indicate the need for many different suppliers or have the vendor(s) increase production capacity.

Source: ARC Clean Technology Canada Inc., *Procurement Plan for long-lead Equipment*; Client Discussions, Deloitte research

Vendor mapping against mid-term – NOAK demand

There is no immediate need for vendor development based on the demand for 27 reactors for mid-term NOAK by 2040.

Component	Quantity per project	Fabrication time- NOAK (months)		Time to ship (months)	Suppliers required		Number of potential suppliers in NB	Number of suppliers outside of NB	Development phase
		Base case	Matured case		Base case	Matured case			
Electromagnetic pumps	9	18	9	1	3	2	1	2	● (green)
Intermediate heat exchangers	2	24	12	1	4	2	1	4	● (green)
Steam generators	1	17	9	1	3	2	4	4	● (green)
Control rod drive*	10	24	12	3	4	3	2	0	● (orange)
Control rod assemblies*	10	23	12	3	4	3	2	0	● (orange)
In-vessel transfer machine	1	23	12	1	4	2	3	1	● (green)
Instrumentation & controls	UNKNOWN	UNKNOWN	UNKNOWN	1	UNKNOWN	UNKNOWN	2	2	● (grey)
Steam turbine generator*	1	21	11	3	4	2	0	0	● (orange)
Reactor vessel	1	24	12	1	4	2	1	3	● (green)
Guard vessel	1	20	10	1	3	2	2	2	● (green)
Reactor internals	1	35	18	1	5	3	4	2	● (green)
Condenser	1	24	12	1	4	2	2	2	● (green)
Feed water heater	1	24	12	1	4	2	1	2	● (blue)

The suppliers have been selected based solely on their expressed interest, without consideration of their nuclear credentials, experience, or capabilities. The mapping is focused on a total demand of 27 reactors in the base case. We anticipate that process standardization will be achieved after the FOAK implementation.

● (orange) Weak supplier base ● (blue) Intermediate supplier base ● (green) Strong supplier base ● (grey) Insufficient data

Note: Cells highlighted in yellow are revised fabrication times received from the client not the *Procurement Plan for long-lead Equipment*

***** These systems will be supplied by international vendors as moving these vendors locally to New Brunswick is capital-intensive.

Source: ARC Clean Technology Canada Inc., *Procurement Plan for long-lead Equipment*; Client discussions

Vendor mapping against end-term NOAK demand

There is an immediate need for vendor development for certain components based on the demand for 73 reactors for end-term NOAK by 2050.

Component	Quantity per project	Fabrication time- NOAK (months)		Time to ship (months)	Suppliers required		Number of potential suppliers in NB	Number of suppliers outside of NB	Development phase
		Base case	Matured case		Base case	Matured case			
Electromagnetic pumps	9	18	9	1	7	4	1	2	Intermediate supplier base
Intermediate heat exchangers	2	24	12	1	9	5	1	4	Strong supplier base
Steam generators	1	17	9	1	6	4	4	4	Strong supplier base
Control rod drive*	10	24	12	3	9	5	2	0	Weak supplier base
Control rod assemblies*	10	23	12	3	9	5	2	0	Weak supplier base
In-vessel transfer machine	1	23	12	1	8	5	3	1	Intermediate supplier base
Instrumentation & controls	UNKNOWN	UNKNOWN	UNKNOWN	1	UNKNOWN	UNKNOWN	2	2	Insufficient data
Steam turbine generator*	1	21	11	3	8	5	0	0	Weak supplier base
Reactor vessel	1	24	12	1	9	5	1	3	Intermediate supplier base
Guard vessel	1	20	10	1	7	4	2	2	Strong supplier base
Reactor internals	1	35	18	1	12	7	4	2	Weak supplier base
Condenser	1	24	12	1	9	5	2	2	Intermediate supplier base
Feed water heater	1	24	12	1	9	5	1	2	Intermediate supplier base

The suppliers have been selected based solely on their expressed interest, without consideration of their nuclear credentials, experience, or capabilities. The mapping is focused on a total demand of 73 reactors, based on matured case. We anticipate that process standardization will be achieved after the FOAK implementation.

Weak supplier base | Intermediate supplier base | Strong supplier base | Insufficient data

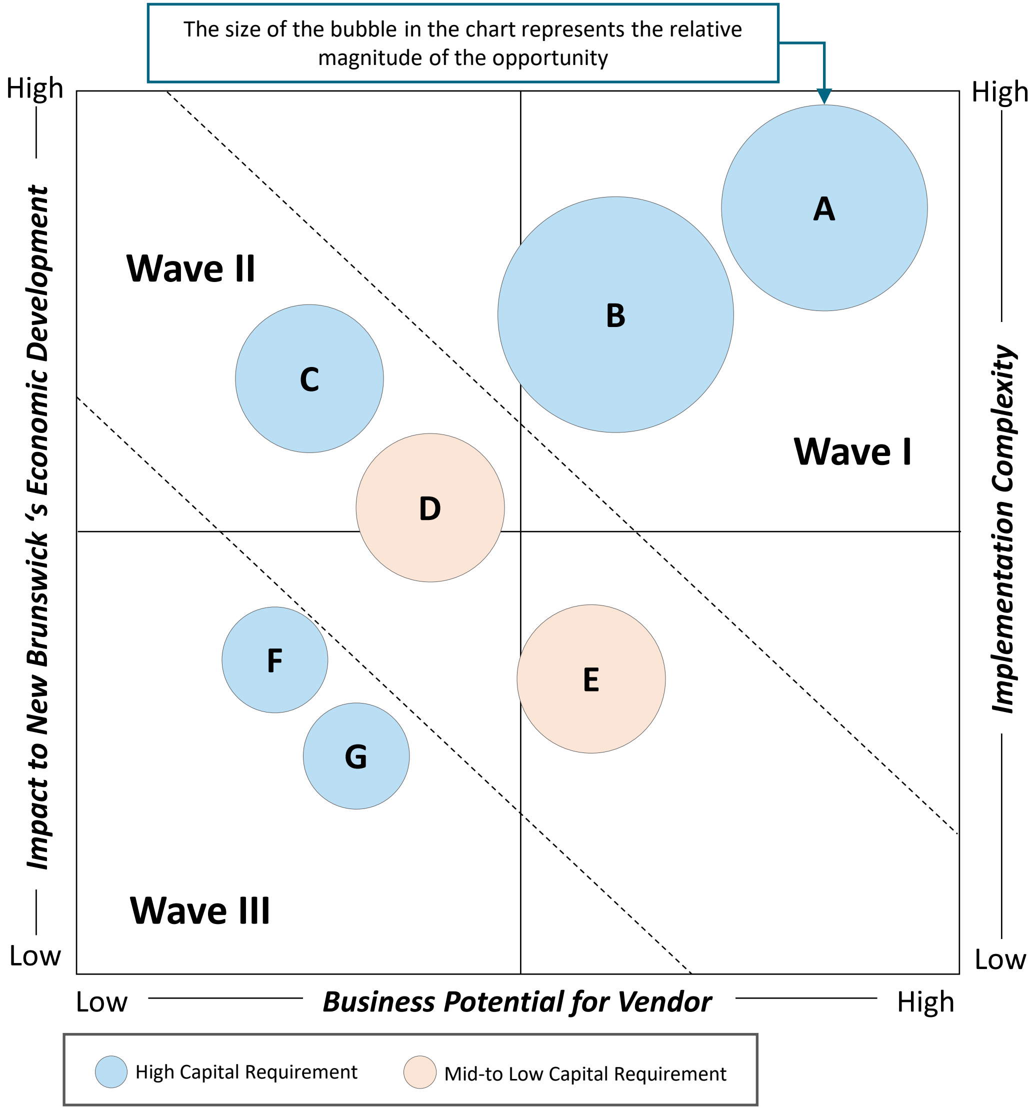
Note: Cells highlighted in yellow are revised fabrication times received from the client not the *Procurement Plan for long-lead Equipment*

* These systems will be supplied by international vendors as moving these vendors locally to New Brunswick is capital-intensive.

Source: ARC Clean Technology Canada Inc., *Procurement Plan for long-lead Equipment*; Client Discussions

Vendor development prioritization matrix

There is an opportunity to enhance the production of SMR long-lead items in New Brunswick via the relocation of key OEMs to New Brunswick and using local forging companies to support the manufacturing of the reactor vessel and top plate.



WAVES OF OPPORTUNITY*

WAVE I *(5 – 10 years)*

Enhance local manufacturing

A. Potential movement of key OEMs to New Brunswick to support multiple skid development (condenser, heat exchanger)
B. Local forging companies to support reactor vessel, vessel, and top plate

WAVE II *(5 – 10 years)*

Enhance component availability locally in New Brunswick

C. Local OEM to support critical parts such as pumps
D. Local OEM parts suppliers to support small parts manufacturing such as tubing, fittings etc.
E. Development of instrumentation and controls

WAVE III *(15 – 20 years)*

Strategic considerations

F. Complete OEM system development for the control rod assembly
G. Complete OEM system development for the steam turbine

* These waves can be carried out simultaneously or sequentially, depending on the availability of funds, criticality, and complexity of implementation.

Source: Deloitte Research

4.3 Fabricator Demand Mapping

Fabricator level classification criteria

Nuclear facility component manufacturers must obtain the ASME N stamp to comply with ASME BPVC Section III. This code sets standards for the design, fabrication, and quality assurance of nuclear components, ensuring safety and regulatory compliance. None of the identified New Brunswick based fabricators currently comply.

Fabricator class	Safety related quality assurance programs	ASME N-Stamps for manufacturing various nuclear components	Nuclear experience	Machinery/equipment (test equipment e.g., x-ray)	Workforce skills (welding qualification)
Level 1 – Nuclear	✓	✓	✓	✓	✓
Level 2 – Pressure vessel	✓		✓	✓	
Level 3 – Non-nuclear/general				✓	

Level 1

Nuclear

Fabricators certified with an N stamp and/or CSA Standard N285.0 (nuclear)

Level 2

Pressure vessel

Fabricators certified to manufacture components of a pressure vessel

Level 3

Non-nuclear / general

Fabricators with no nuclear certifications and/or welding certifications

Note: For more details on fabricator accreditation, please refer to Appendix B

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; Deloitte Research

Fabricator demand

Should process optimization not be realized over time, between two and five fabricators will need to be developed to meet 2050 demand.

FABRICATOR DEMAND – REACTOR VESSEL

Fabricators are mainly known to work on the reactor vessel

Component	Quantity per project	Fabrication time- NOAK (months)		Time to ship (months)	Suppliers required (Mid-Term 2040)		Suppliers required (End-Term 2050)	
		Base case	Matured case		Base case	Matured case	Base case	Matured case
Reactor vessel	1	24	12	1	4	2	7	4

With only 2 nuclear fabricators currently in New Brunswick…

BASE CASE

No process optimization made

2 Fabricators need to be developed by **2040**

5 Fabricators need to be developed by **2050**

MATURED CASE

Process optimization obtained over time

0 Fabricators need to be developed by **2040**

4 Fabricators need to be developed by **2050**

Assumptions:
The production demand will be fulfilled evenly by all fabricators without knowing their future fabrication capacity and capability. Workload can change if supplier fabrication capacity is different.

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; Deloitte Research

HOW THE DEMAND WAS CALCULATED

NOAK parallel production time with discounted fabrication, shipping, and design time with one supplier:

- Design time = 0 months
- Fabrication time = 12 months (50% fabrication time)
- Ship time = 1 month

13 months x 99 reactors = 1287 months = 107.25 years (based on discounted fabrication and shipping time)

If production time for 99 reactors is 25 years, five suppliers will be needed in the supply base.

- 107.25 years/25 years = 4.46 or 5 suppliers

Case Selection
The demand for mid-term NOAK is mapped using the base case for mid-term NOAK and the matured case for end-term NOAK. To support demand, two additional fabricators will be required by 2040 and two further by 2050.

Fabricator development prioritization matrix

Immediate priority is the movement of Level 3 fabricators to Level 2 and Level 2 fabricators to Level 1 by mid-term NOAK (2040) and end-term NOAK (2050) to meet future SMR fabrication demands.

	FOAK (2030)	NOAK (2040)	NOAK (2050)
L1	SUNNYCORNER; B&W BABCOCK & WILCOX	bird	LORNEVILLE
L2	bird	Applus; LORNEVILLE; cahill	OSCO construction group; BOURQUE INDUSTRIAL LTD
L3	cahill; Applus	OSCO construction group; BOURQUE INDUSTRIAL LTD	

Source: Deloitte Research

Disclaimer:
The list of potential vendors and partners referenced is illustrative only and not exhaustive. The inclusion or exclusion of a specific company or organization does not represent an endorsement by ARC, Deloitte or its partners.

DEVELOPMENT PLAN

A total of five vendors will be matured from Level 3 and Level 2 fabricators to Level 1 fabricators.

WAVE I *(2030-2040)*

- Two fabricators will mature from Level 3 to Level 2. Potential fabricators under consideration based on current qualifications and need:
  - G.J Cahill & Company
  - RTD Quality Services Inc. (Applus)

WAVE II *(2040 - 2050)*

- One fabricator will mature from Level 2 to Level 1. The potential fabricator under consideration based on current qualifications and need:
  - Bird Construction
- Two fabricators will mature from Level 3 to Level 2. Potential fabricators under consideration based on current qualifications and need:
  - Ocean Steel Construction Ltd.
  - Bourque Industrial Ltd

Additional supporting fabricators: One fabricator will be available in Level 1, and two will be available in Level 2 to support the expected demand.

The selection of fabricators for maturing through levels was based solely on vendor interest expressed in ONB's Self-Assessment Survey. It's important to note that vendors have not been audited on their manufacturing capacity, willingness to invest, or any other related factors.

4.4 Transportation Model

Transportation model

The dynamic transportation model showcases the availability of road, rail, and ports from critical FOAK and NOAK reactor vendors to ARC's facilities.

FOAK REACTOR

Location considered for ARC facilities

McAllister Industrial Park, Saint John

Vendors

BWXT Canada
Sunny Corner Enterprises
Lorneville Mechanical
QC Pumps & Compressors
Pinacle Stainless Steel
Rotork
Forgiatura Morandini
Sheffield Forgemasters
Framatome
GE

Ports considered

Saint John Port
Port of Belldune
Port of La Pallice (France)

NOAK REACTOR

Location considered for ARC facilities

McAllister Industrial Park, Saint John

Industrial parks in New Brunswick

Grand View Industrial Park
McAllister Industrial Park
Spruce Lake Industrial Park
Spruce Lake Barge
New Brunswick North Industrial Park

Vendors

Bird Construction
Sunny Corner Enterprises
Maritime Hydraulic
Patriot Forge
Black and McDonald
Bourque Industrial Inc
Framatome
Canada Forgings

Ports considered

Saint John Port
Port of Halifax
Strait of Canso Superport
Port of Sydney (NS)
Port of La Pallice (France)
Port of Belldune

14 Major road routes in New Brunswick connecting to critical vendors, ports, and industrial areas.

03 Major rail roads in New Brunswick connecting to critical vendors, ports, and industrial areas and to Quebec and Ontario.

PORT SELECTION CRITERIA

- Deepwater port
- Breakbulk ports
- Proximity to ARC facilities
- Efficient transport connections
- Operation size

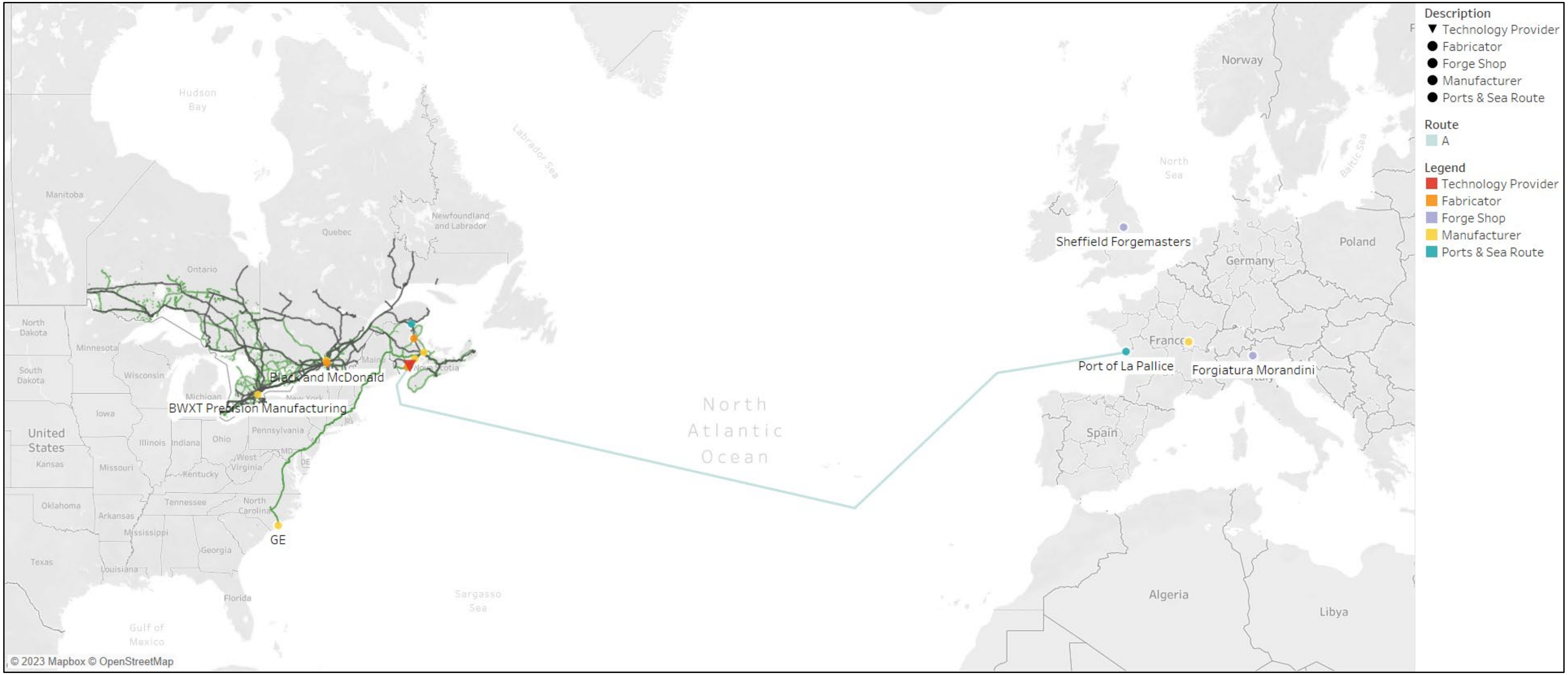
RISK MITIGATION:

Port congestion – Secondary ports in Nova Scotia were considered to meet future demands.

Inadequate infrastructure – Several options available for road routes with seamless connections from ports, railroads, and vendors to ARC facilities.

Transportation model – FOAK

Global vendors to supply forgings, turbines, and control rod units will be required to support the FOAK reactor.



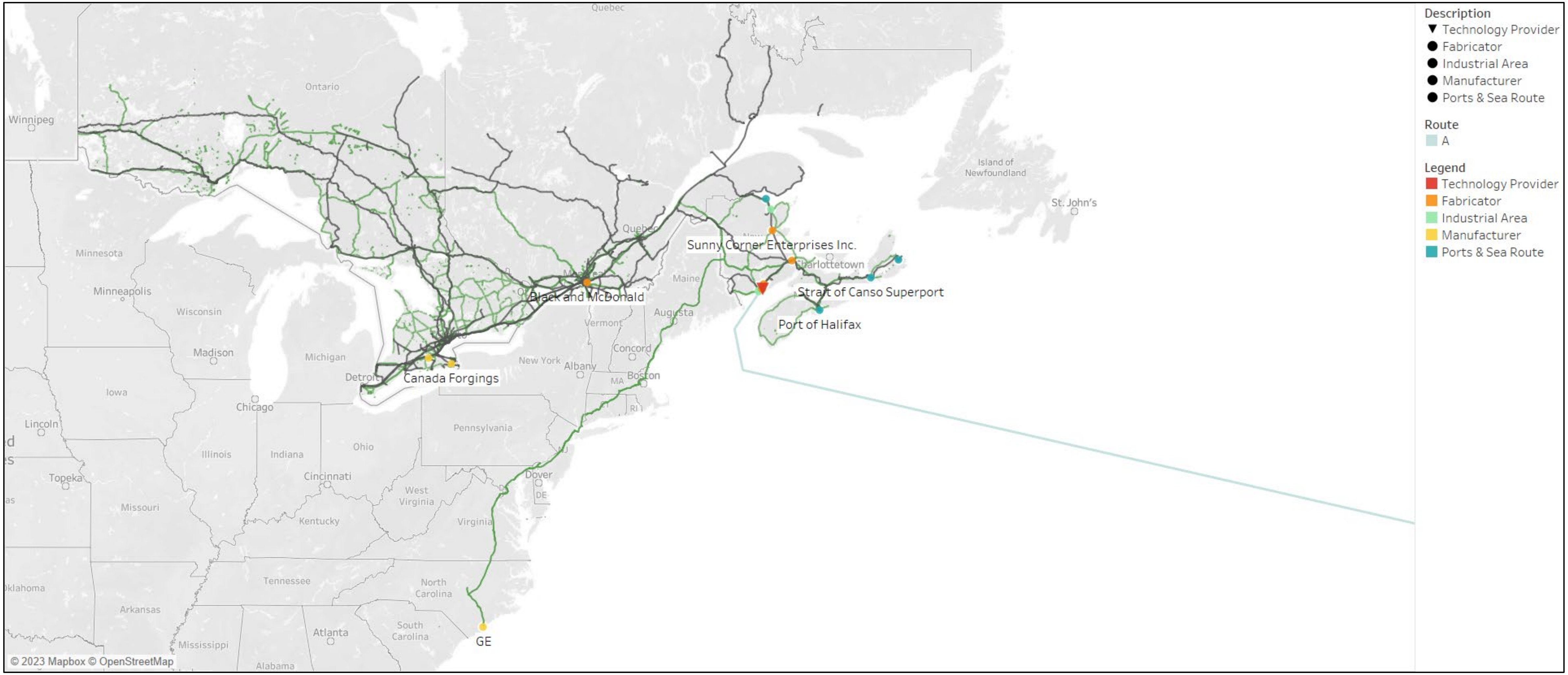
Note: The sea route from France to Canada is for *illustrative purposes only*

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; Deloitte Research

The transportation model was built in Tableau. In order to fully experience the map, please **download the Tableau Reader** – a free tool – from the link: https://www.tableau.com/products/reader/download

Transportation Model – NOAK

With a focus on provincial vendor development, the majority of the NOAK supplier base will be within Canada except for the steam turbine.



Note: The sea route shown to Canada is for *illustrative purposes only*

Source: ONB, SMR Supply Chain Development (SDC) – Company Profile Catalogue; Deloitte Research

The transportation model was built in Tableau. In order to fully experience the map, please **download the Tableau Reader** – a free tool – from the link: https://www.tableau.com/products/reader/download

5. Strategic Considerations

Strategic considerations overview

Opportunities exist to address immediate gaps in the SMR supply chain.

Observations	Strategic Consideration	Impact
Limited production capacity for nuclear components at vendor facilities	Expand current production capacity	Expanding production capacities can help meet the build-out demand for NOAK reactor and can potentially lower the cost of production. Expansion can also lead to job creation in the industry and can invite the potential for future business investments.
Limited availability of vendors in New Brunswick	Relocate strategic vendors / Encourage partnerships between national and provincial players to build provincial capacities over time	Relocation can diversify the local supplier base but also increase competition amongst them. This can lead to more innovation in the industry. Improvements would need to be made to existing infrastructure to accommodate new facilities, benefiting the entire area.
Insufficient development of the nuclear industry ecosystem	Build potential partnerships between existing vendors	Building partnerships can foster collaborative efforts, innovation and potential cost savings.
Limited awareness of infrastructure capacity	Review existing infrastructure to support FOAK goals	Reviewing infrastructure can provide insights into potential bottlenecks, enhance efficiency, assess scalability for the future and ensure compliance with regulatory requirements
Inadequate skilled workers in New Brunswick for SMRs, partially as a result of competing infrastructure projects limiting workers availability	Upskill workforce and vendors	Upskilling the workforce and vendors improves productivity, adaptation to technological advancements, service quality, and reduces skills gaps.
Constrained capacity to manufacturer complex technical systems	Source globally	Sourcing globally can allow more access to critical resources and can help with supply chain resilience via diversification. On the other hand, sourcing globally can come with challenges surrounding regulations, security, laws, and environmental impact

Source: Deloitte Research

Strategic considerations overview (continued)

Opportunities exist to address immediate gaps in the SMR supply chain.

Observations	Strategic Consideration	Impact
Cost competitiveness of early-stage units could slow technology adoption	Improve total installed cost on early NOAK unit	Optimization of the technology deployment all the way through the value chain will improve cost competitiveness. This can only occur if the entire value chain can work together and share risk. End use customers will not adopt the technology as easily until the price is lower, but the suppliers of the components can't lower the price until there is economies of scale. Building trust and distributing risk, including through supportive governing policy, is the only way to solve the challenge.
Slow regulatory framework timelines	Adoption of SMR specific regulatory timelines	Accelerating the regulatory processes to facilitate accelerated deployment timelines will support the technology adoption, industry growth and overall cost competitiveness. Long regulatory timelines increase overall project and financial risk for the various stakeholders.
Nuclear specific codes and standards are built for the legacy reactors	Adoption of SMR specific codes and standards	Current nuclear codes and standards should be evaluated for SMR specific risk and reducing the number of components within the nuclear island. This will decrease overall unit cost as well as open up more industry participants.
Limited awareness globally of made in Canada SMR technology	Actively advocate for Canadian made SMR technology exports globally	With consideration to maintaining regulatory compliance, national security and IP protection, making Canadian made SMR technology available globally will not only support global decarbonization efforts but also assist in building the critical mass required to effectively scale the SMR industry locally. This will greatly assist with demand certainty leading to an overall risk reduction to the industry and therefore reducing costs for Canadians.

Source: Deloitte Research

A framework to evaluate strategic recommendations

Decisions may be informed by four criteria: capital investment, regulatory requirements, ease of implementation, and impact to economic development of New Brunswick

Expand current production capacity

- Assess the ability to expand equipment, technology, and work force (e.g., use this study's demand model to run surveys)
- Ensure expansion timelines do not compromise quality and that quality control standards are met
- Review the need for additional hiring, training, and reorganization to support expansion (surveys could be conducted)

Capital investment *High* – *Low*
Regulatory requirements *High* – *Low*
Ease of implementation *High* – *Low*
Impact to New Brunswick economic development *High* – *Low*

Potential candidates:

- Fabricators and vendors with strong nuclear credentials and experience

Relocate strategic vendors

- Highlight advantages to relocation such as access to key markets, infrastructure, skilled labour development, available resources, funding/incentives, and tax benefits
- Demonstrate opportunities for collaboration within the industry
- Ensure the development of local skilled labour pool and talent availability
- Be aware of provincial legal and regulatory requirements and assist with compliance

Capital investment *High* – *Low*
Regulatory requirements *High* – *Low*
Ease of implementation *High* – *Low*
Impact to New Brunswick economic development *High* – *Low*

Potential candidates:

- OEM suppliers with capabilities to supply multiple parts and complete systems

Build partnerships between existing vendors

- Evaluate vendor compatibility by their capabilities, strengths, track records, and reputation, and support partnerships based on the levels identified in this study:
  - E.g., Level 3 fabricators can be leveraged for primary welding and Level 2 or 1 for final welding and pressure testing. Match in-province and national fabricators based on expertise.
- Develop SMR supplier and labour strategy for indigenous owned businesses

Capital investment *High* – *Low*
Regulatory requirements *High* – *Low*
Ease of implementation *High* – *Low*
Impact to New Brunswick economic development *High* – *Low*

Potential candidates:

- Pair OEM suppliers with a L2 fabricator to make non-critical components locally
- Match L2 and L3 vendors with L1 fabricators for additional machining capacity

Source: Deloitte Research

A framework to evaluate strategic recommendations (continued)

Decisions may be informed by four criteria: capital investment, regulatory requirements, ease of implementation, and impact to economic development of New Brunswick

Source globally

- Ensure compliance of safety standards, regulatory requirements, and quality assurance processes. Identify export/import barriers and develop plans to address them.
- Ensure security of nuclear supply chain from disruptions by diversifying supplier base and avoiding reliance on one geographical region
- Ensure appropriate safeguards are in place to protect intellectual property rights of technology
- Ensure adherence to sustainable practices and environmental considerations

Capital investment	High — Low
Regulatory requirements	High — Low
Ease of implementation	High — Low
Impact to New Brunswick economic development	High — Low

Potential candidates:

- General Electric USA
- Framatome France
- Curtiss-Wright

Upskill workforce and vendors

- Identify skills and qualifications, needed to work with nuclear technologies, and national expertise to help train the in-province workforce over time
- Ensure upskilling programs address regulatory compliance and safety protocols
- Address knowledge transfer planning from a retiring workforce to a younger one
- Collaborate with industry stakeholders, educational institutions, and research organizations

Capital investment	High — Low
Regulatory requirements	High — Low
Ease of implementation	High — Low
Impact to New Brunswick economic development	High — Low

Potential partners:

- Workforce Warriors
- Canadian Building Trades Union
- University of New Brunswick (UNB)
- University Network of Excellence in Nuclear Engineering (UNENE)

Review current infrastructure to support FOAK

- **Roads** – Evaluate capacity of primary and secondary roads to handle material movement of heavy equipment from rail stops and ports to the ARC facility.
- **Rail** – Ensure rail connections from ports that lead to the ARC facility
- **Ports** – Primary port will be the Saint John Port (deep water). If imports/exports increase, Port of Halifax and Port of Sydney can be considered as secondary ports.

Capital investment	High — Low
Regulatory requirements	High — Low
Ease of implementation	High — Low
Impact to New Brunswick economic development	High — Low

Potential candidates:

- Port of Sydney (NS), Port of La Pallice (France) and Port of Belldune
- Rail operators including CN and CP

Source: Deloitte Research

A framework to evaluate strategic recommendations (continued)

Decisions may be informed by four criteria: capital investment, regulatory requirements, ease of implementation, and impact to economic development of New Brunswick

Improve cost competitiveness

- Development of collaborative value chains within the SMR industry.
- Distribution of risk as well as assigning risk to those who are capable of effecting change is crucial to the success.
- Continued investment, including in R&D, through the value chain.
- Government policy that reduces risk, increases certainty and is developed in conjunction with the SMR industry.

Capital investment	*High* — *Low*
Regulatory requirements	*High* — *Low*
Ease of implementation	*High* — *Low*
Impact to New Brunswick economic development	*High* — *Low*

Potential candidates:

- Governments of New Brunswick, Ontario, Alberta, and Saskatchewan
- Federal government
- Industry associations

Adopt SMR specific regulatory framework and codes/standards

- Identify key risk differences between conventional nuclear and SMRs based on technical differences, deployment scenarios, security and environmental considerations.
- Continued collaboration with International Nuclear Regulators Association (INRA) on reactor design assessments and licensing through bi-lateral and multi-lateral arrangements.

Capital investment	*High* — *Low*
Regulatory requirements	*High* — *Low*
Ease of implementation	*High* — *Low*
Impact to New Brunswick economic development	*High* — *Low*

Potential partners:

- Governments of New Brunswick, Ontario, Alberta, and Saskatchewan
- Canadian Nuclear Safety Commission (CNSC)
- International Nuclear Regulators Association (INRA)

Support global export of Canadian SMR technology

- Develop export strategy with Canadian SMR technology providers.
- Evaluate global markets to determine most likely markets for adoption of SMRs and those without local technology developers.
- Continued collaboration with INRA to support standardization, IP protection, and security.

Capital investment	*High* — *Low*
Regulatory requirements	*High* — *Low*
Ease of implementation	*High* — *Low*
Impact to New Brunswick economic development	*High* — *Low*

Potential candidates:

- Governments of New Brunswick, Ontario, Alberta, and Saskatchewan and Federal Government
- International Nuclear Regulators Association (INRA)

Source: Deloitte Research

A complex project faces complex challenges

It is important to consider the potential challenges when implementing risk mitigation recommendations.

Front End Planning

- **Poor planning, integration management** leading to cost and schedule overrun
- **Limited qualified supplier base** that can meet strict regulations and standards
- **Inadequate stakeholder requirement analysis** affecting the entire project and operations value chain
- **Significant capital investments** and long operational lifecycles

Compliance

- **Project strategy** developed **in isolation of regulatory requirements**
- **Maintaining strict quality assurance** standards and regulations
- **Lack of adherence** to environmental limitations and regulations
- **Robust safety program** implementation and compliance

Upskilling Resources

- **Development of workforce skills** requires significant investments in certifications
- **Skills Transfer** from experienced personnel leaving the workforce are not thought out well or imposed and managed effectively affecting operational requirement
- **Workforce training programs not developed** to support rapid demand
- **Knowledge gap** when adopting to **rapidly evolving** technology in the industry

Nuclear Industry Challenges

- **Uncertainty of demand** due to economic conditions, political and regulatory factors etc.
- **Slow development in industry** because of licensing processes regulatory changes, and public perception
- **Long-lead times in prototype development** making it difficult to meet technology advancements

Integrated Project Management

- **Inadequate interface management** between internal stakeholders (e.g. engineering, procurement and owners) and external stakeholders (e.g. suppliers, investors, government)
- **Inadequate risk management** for managing interdependencies between various stakeholders

Agile Supply Chain

- **Inadequate understanding of nuclear** component sourcing from partners and risk associated in the value chain
- **Limited access to subcontractors and partners** and lack of communication between value-chain
- Greater risk of **foreign competition** to take over production needs
- Advance investments in technology and infrastructure due to **long payback periods**

Operational Readiness

- **Lack of integrated planning for OR** in terms of access to raw materials, systems, processes, and technology
- **Lack of proper certifications and qualifications** in place for vendors
- **Limited capital** available for production
- **Limitations in production facilities to meet demands** – high costs associated with production facility expansion
- **Low retention of workforce** due to changing skill requirements and strict regulatory environment

Source: Deloitte Research, Deloitte SME's and Deloitte's past experience

Risk mitigation plan

Key risks and associated mitigation strategies.

Risk	Description	Likelihood of ocurrence	Impact	Mitigation
Limited qualified supplier base	The nuclear industry has a relatively limited supplier base compared to other industries, as suppliers undergo strict evaluations to obtain and maintain proper accreditation	Medium	High	It is essential to establish and maintain relationships with dependable suppliers. Partnering with critical and strategic suppliers can improve security of supply and access to continuous improvement and innovation.
Limited workforce availability and high turnover	Lack of qualified workforce due to knowledge and skills gaps, operational risks and cost overruns	High	High	Working with various groups (government entities, professional organizations and educational institutions) to address workforce challenges, invest in training, and promote nuclear-related education programs.
Uncertainty of demand	Uncertainties may arise from economic factors, changes in politics and regulations, technological advancements, and public perception.	High	Medium	Proper planning and forecasting are crucial for analyzing factors that may affect the demand for nuclear power. Accurate forecasting informs decisions about expansion, new projects, and resource allocation.
Unable to obtain Government of New Brunswick's support for proposed investments	High capital investments required for construction, operations, maintenance and compliance	Medium	Medium	Use a comprehensive approach integrating planning, risk evaluation, collaboration, and proactive project management and work with experts and regulatory entities.
Delays in the vendor selection process	With an extended evaluation phase and contract negotiation with potential vendors can lead to delays in production start times and meeting investment timelines	Low	Medium	Define business requirements, pre-qualify vendors, request proposals from qualifying vendors and track their progress.
Obtaining new site development approvals	New site development is subject to approvals for construction, conducting mandatory safety checks, and undergoing external audits from authorities such as the government of New Brunswick, the Impact Assessment Agency of Canada, and surrounding communities.	Low	High	Research local regulations, consult with planning experts, assess environmental impact, and gain community support before creating a comprehensive development proposal that outlines the benefits for the community and the economy.

Supply chain maturity pathway

Supply chain maturity is obtained by optimizing different operational and strategic functions at an organizational level.

	Strategy	Stakeholder management	Organisation alignment	People & capability	Digital & analytics	Strategic sourcing	Supplier management
World-Class	Mission integrated with corporate strategy – supported by robust metrics	Balanced strategies including stakeholder needs	Hybrid, centralized organization – strategic focus, accountability aligned	Deep market and customer requirement insights	Fact-based support for robust strategies	Strategies balance cost, quality, risk, and business support	Leverage suppliers to create competitive advantage
Advanced							
Basic	Mission aligned with corporate at highest levels	Non-standard goals and approaches to suppliers	Several alternate methods & process	Customer service provider – little strategic insight	Some data support, but often manual	Strong, standardized processes – cost reduction	Manage suppliers – focus on cost only
Developing							
Non-Existing	Undefined or misaligned mission	Purchasing transaction support only for customers	Many alternate methods & inferior process	Pure, transactional support	No historic or market data – ad hoc tactics	Transaction only, purchase when needed	No contracts or supplier evaluation, transactional buying

Realizing value in the short-term needs to consider the maturity of the current organization

6. Next steps

Next steps and call to action

FURTHER STUDY

1. Survey vendors to gauge their current and expected manufacturing capabilities and capacities to support the potential demand quantity and timeframe data provided in this study. The surveys should also zero-in on manufacturing capacities for Control Rods Drive and Assemblies components as they represent a major portion of the demand volume and are a strategic consideration due to limited domestic production capacities.
2. If there is a gap in vendor manufacturing capacity, a likely scenario, survey vendors on the amount of capital required to expand the capacity to meet the demand.
3. Survey local infrastructure (roads, rails, industrial parks) players on their capacity to support the transportation of the identified demand quantity in this study.

CALL TO ACTION

1. De-risk capital investment through innovative models utilizing private and public funding
2. Conduct a jurisdictional scan and review the applicability of various investment incentives and tax credits schemes, including Canada's investment tax credit (ITC) and the production tax credit (PTC) in the U.S. for SMRs.
3. Establish an independent SMR hub/taskforce in NB to accelerate the transition
4. Engage and work with different project sponsors and stakeholders to develop an integrated investment blueprint/roadmap
5. Form strategic partnerships with key vendors to understand expansion needs
6. A 2–5-year workforce development program needs to be implemented before the ramp-up period beginning in 2033 based on operational complexity for vendor, fabricator, and technology provider. The program should address upskilling and acquiring nuclear skills needed to support NOAK requirements.
7. Implement a local integrated management office to oversee and support all strategic initiatives (could be a part of the hub/taskforce)

7. Appendix

Appendix A

Additional Demand and Cost Models Assumptions

Demand Model

- Only Long-Lead Components, from ARC Clean Technology's "Procurement Plan for Long-Lead Equipment ARC-100 Projects (Document no: CANB00-A60-PIR-100609-RA)" report, have been included in the model. Table 1 of the report has been leveraged to assume components quantities in addition to design, fabrication, and ship times.
  - For the "unknown" table cells, the following assumptions have been made:
    - Steam Gens and Instrumentation and Controls lead times were UNK. Assumed 2 years for SG and 1 year for Instrumentation and Controls.
    - Instrumentation and Controls quantity was UNK. Assumed 1 package per project.
    - Queue/Design Time for Reactor Internals was UNK. Assumed 12 months.
- No discounting for standardization was factored in.
- It was assumed that all components could be fabricated in parallel.
- Lead time months are rounded up to one year.
- Lead times are the average of the ranges listed in ARC's procurement plan report.

Cost Model

- Costs are calculated for long-lead components only.
- A relative share of long-lead components costs are used. The relative share figures have been collected through desktop research, internal Deloitte resources, and insight provided by ARC.
- The cost calculations reflect fabrication costs and do not include the costs of delivering to site.
- Fuel Handling Machine category is not included in the demand model; However, it is added to the list of components for the cost calculation purposes to make the cost model more comprehensive. Lead times and quantities for it were assumed to be the same as those of Feed Water Heater category.

Commercial Readiness Framework: Technical Readiness

A technology's in-use performance and maturity, its cost-competitiveness in markets that are unwilling to pay a premium, and the degree to which it delivers quantifiable, verifiable, and material GHG-emissions reductions are the measures of its technical readiness.

	Technology readiness	Cost-competitiveness	Abatement potential
5	The low-emission technology is available within a highly competitive commercial environment	The low-emission technology is lower-cost than an incumbent in a market unwilling to pay a premium	Quantifiable, verifiable, material GHG emissions reductions are aligned to 2030 and 2050 targets
4	The technology is commercially available in key markets	The technology is cost-competitive with an incumbent in a market unwilling to pay a premium	Quantifiable, verifiable, material GHG emissions reductions are not aligned with either 2030 or 2050 targets
3	The technology has been successfully demonstrated in commercial operating environment	The technology is cost-prohibitive in a market willing to pay a premium	Estimated, unverfiied GHG emissions reductions are not aligned with 2030 or 2050 targets
2	The technology has been successfully prototyped at scale	The technology is cost-prohibitive and the market is unwilling to pay a premium	GHG emissions reductions are not estimated or projected
1	The technology is at the concept or early prototype stage	The technology is cost-prohibitive at any/all TRLs	The technology does not deliver GHG emissions reductions
Additional notes on the study approach used to rank a specific category	-	For the purpose of this study, this category was ranked for FOAK in comparison with other SMR technologies. If more SMR units are deployed during the transition period from FOAK to NOAK, the cost is expected to decrease gradually.	Reductions might be completed in the form of offsetting GHG emissions. The quantification depends on the nature of the future projects.

Commercial Readiness Framework: Market Readiness

This refers to the external commercial ecosystem and the structures required to support the deployment and use of technologies.

	Value chain	Infrastructure	Supply chain capability	Market/customer familiarity
5	All elements reach maturity by the time the full value chain needs to be deployed	The infrastructure required to enable deployment and market share is ubiquitious and accessible	Low-emission technology is available within a highly competitive commercial market	Low-emission technology is a product of choice
4	Key elements reach commercial maturity by the time the full value chain needs to be deployed	The infrastructure required to enable deployment and market share is widely established in key markets	Competition is increasing to supply low-emission technology in a commercial market	The majority of customers have familiarity and/or market experience with low-emission technology
3	Key elements reach sufficient commercial maturity by the time the full value chain needs to be deployed	The infrastructure required to enable deployment and market share is partially established	Experienced, specialized providers of low-emission technology are available and market competition is emerging	Early adopters have familiarity and/or market experience with low-emission technology
2	Some elements reach sufficient maturity by the time the full value chain needs to be deployed	The infrastructure required to enable deployment and market share is emerging	Few and relatively new commercial suppliers of low-emission technology exist	Innovators have some familiarity and/or market experience with low-emission technology
1	No element of the value chain is mature enough	The infrastructure required to enable deployment needs to be developed entirely	No commercial suppliers of low-emission technology exist	There is no market awareness of the low-emission technology
Additional notes on the study approach used to rank a specific category	A. It occurs gradually. B. The ranking is tied into the Infrastructure category.	The ranking is linked with Infrastructure and Value Chain categories.	-	Market experience played a decisive role in ranking this category.

Commercial Readiness Framework: Policy Readiness

Public and private sector policies facilitate the ability of an organization to adopt a new technology and foster the creation of niche or commercial-scale markets.

	Policy	Regulations	Codes and standards
5	Policy frameworks prioritize low-emission technology and disadvantage/penalize incumbents	Regulations and regulators create a market where the low-emission technologies must be deployed	Codes and standards are designed and adopted to promote the use of low-emission technologies
4	Policy frameworks incentivize the deployment of low-emission technology	Regulations and regulators incentivize and facilitate the deployment of low-emission technologies	Codes and standards exist to support the deployment of low-emission technologies
3	Policy frameworks are technology-neutral, outcomes-driven, and forward-looking	Regulations and regulators are technology-neutral and permit experimentation with low-emission technologies	A limited number of codes and standards exist to support deployment of low-emission technologies
2	Policy frameworks support incumbent technologies but do not disadvantage/ penalize low-emission technologies	Regulations and regulators support incumbent technologies but do not disadvantage/penalize low-emission technologies	No codes and standards exist to support the deployment of low-emission technologies
1	Policy frameworks support incumbent technologies and disadvantage/penalize low-emission technologies	Regulations and regulators limit experimentation and the adoption of low-emission technologies	Existing codes and standards prohibit the deployment of low-emission technologies
Additional notes on the study approach used to rank a specific category	-	-	Codes and standards are not a gap currently. However, they need to be optimized and updated to further address the specific characteristics of SMRs in the future.

Commercial Readiness Framework: Organizational Readiness

Ultimately, the cleantech company itself must be able to allocate resources, capabilities, and competencies in environments of technological and regulatory uncertainty through responsive business models that can address the constant adaptation to market challenges.

	Partnership strategy	Management capability	Intellectual property	Business models
5	Strategic partnerships enable deployment at industrial scale	Demonstrated management ability and experience with deployment at an industrial scale	IP portfolio is strategically managed to monetize assets, IP strategy is business strategy	Tested business model enables deployment at scale and cannot be replicated
4	Commercial partners lend credibility and legitimacy to new market entrants	Demonstrated management ability and experience with product commercialization	IP strategy optimizes the approach to intangible assets and is flexible to the stage of the innovation cycle	Sustainable business model that is responsive to market demands and cannot be replicated
3	Commercial partners validate market need	Management and technical teams with capabilities to commercialize the technology	IP strategy is centred on acquisition of legal rights, IP defence, and alignment with business strategy	Business model is adaptable to product innovation cycle and difficult to replicate
2	Partners are identified but the partner acquisition strategy is undefined	Inexperienced management and technical teams with no track record of commercialization	Intellectual property has not been protected	Business model is untested and easy to replicate by competitors
1	Technology solutions are developed with no tie to industry or partner needs	Inexperienced technical team focused primarily on techology development	Intellectual property has not been created/understood/identified	Business model is undefined
Additional notes on the study approach used to rank a specific category	A. A. Ranked level 1 in this study as it ties into the Business Models category. B. Readiness level depends on the partnership group considered; e.g., development partners in the value chain side only or development partners in the market.	This study considered SMRs only. However, this category depends on whether the commercialization of other technologies is included in the definition.	-	This is linked with Partnership Strategy category.

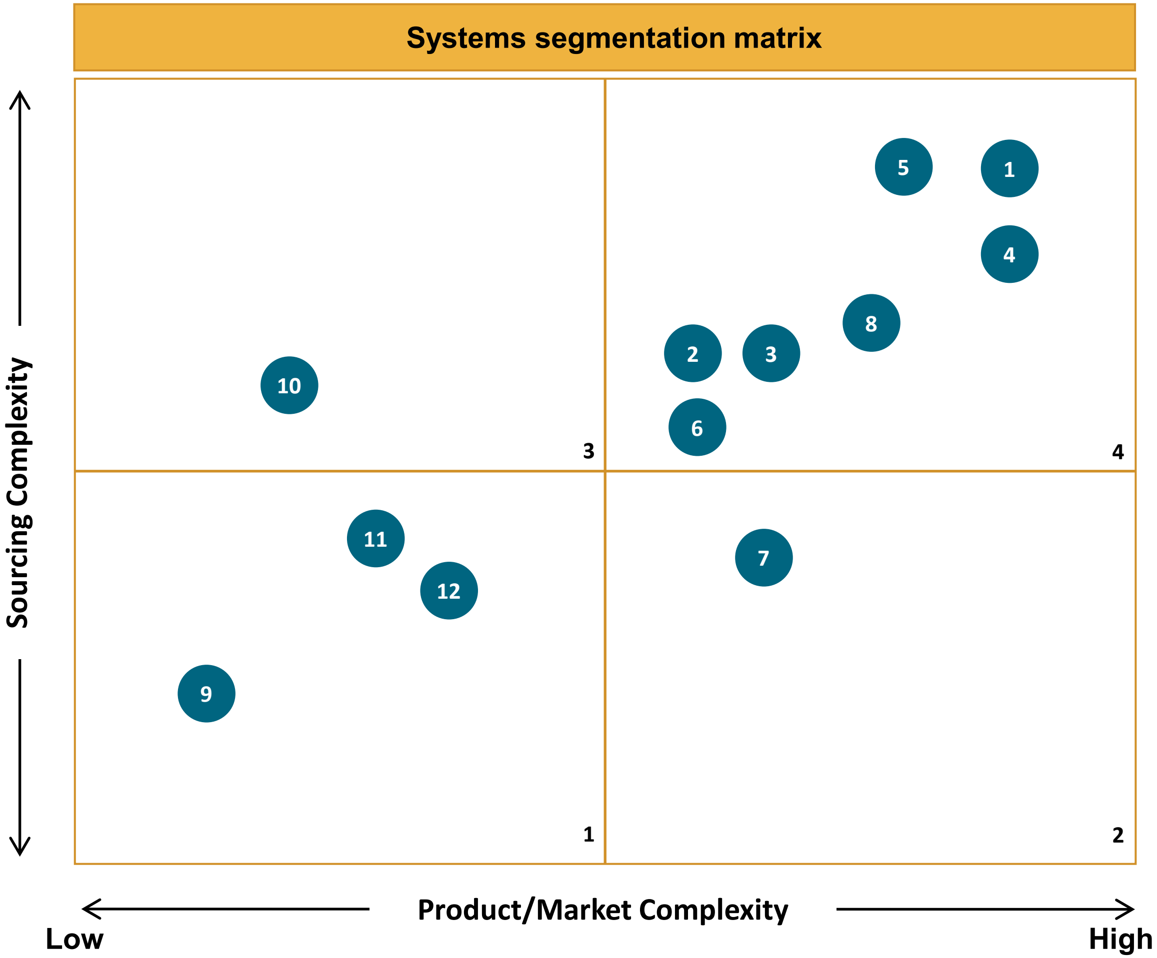
Appendix B

Sourcing complexity of critical systems

Systems' procurement will be driven by product complexity, manufacturing complexity, and market drivers. Systems in Quadrant 4 will require support from EPC to source versus systems in Quadrant 1 that can be handled by ARC independently.

- Requires detailed engineering and QA review
- Suppliers have previous experience

- Market have standardized product configurations
- Easy to stock and execute bulk purchase



Low
- Many suppliers
- Limited, constrained knowledge
- Common technology
- No regulation

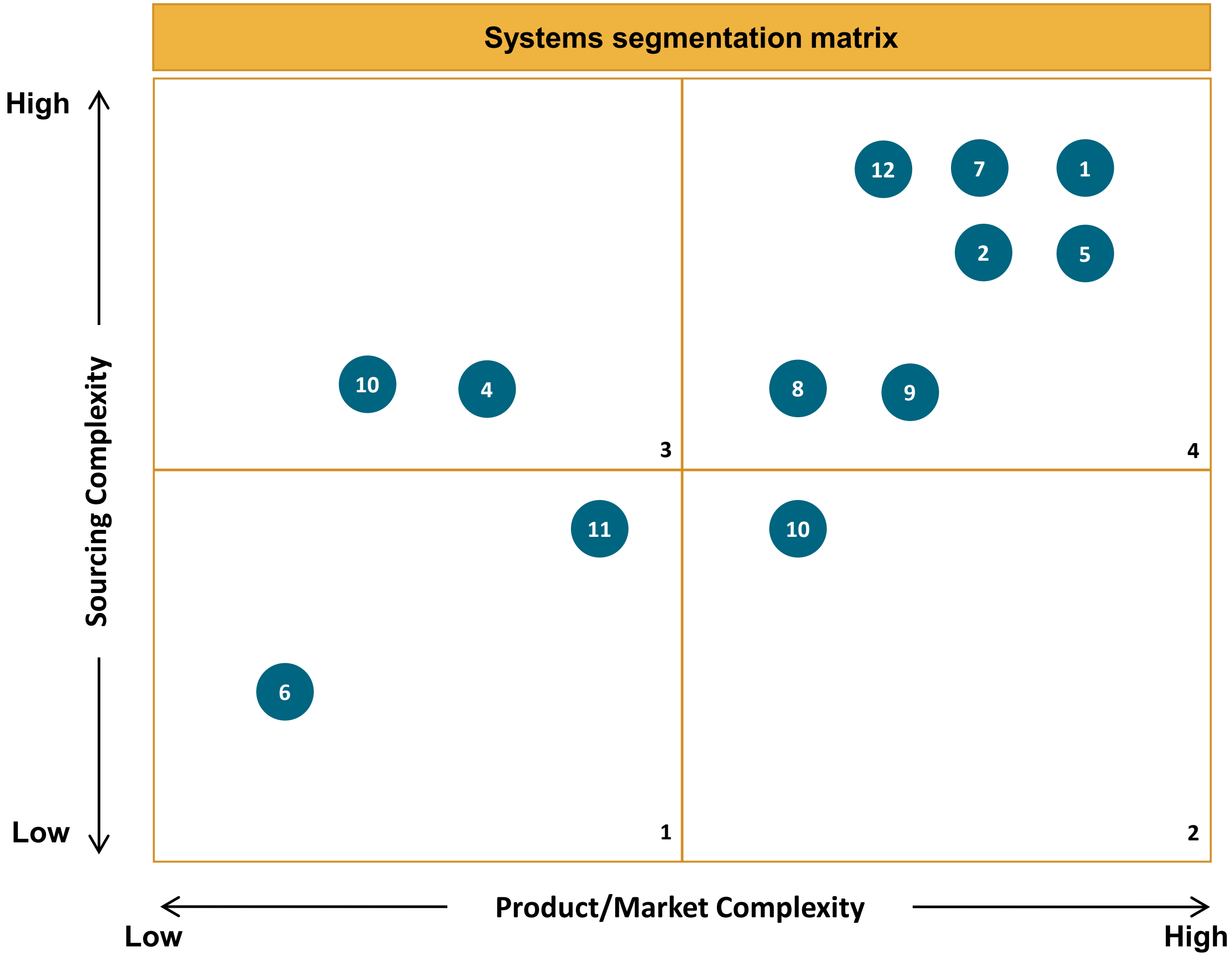
High
- Few suppliers
- Proprietary knowledge
- Innovative technology
- Highly regulated

	Systems	Estimated lead time
1	Reactor vessel	50-64 months
2	Primary heat transport system	42-51 months
3	Intermediate heat transport system	42-51 months
4	Steam generator system	UNKNOWN
5	Primary & secondary control rod system	39-48 months
6	Reactor vessel auxiliary cooling	UNKNOWN
7	Direct reactor vessel auxiliary cooling	37-50 months
8	Steam turbine system	36 months
9	Instrumentation & control system	UNKNOWN
10	Security systems and programs	UNKNOWN
11	Plant electrical systems	UNKNOWN
12	Non-sodium and sodium fire protection	UNKNOWN

Sourcing complexity of long-lead items

Systems' procurement will be driven by product complexity, manufacturing complexity, and market drivers. Systems in Quadrant 4 will require support from EPC to source versus systems in Quadrant 1 that can be handled by ARC independently

- Requires detailed engineering and QA review
- Suppliers have previous experience



- Market have standardized product configurations
- Easy to stock and execute bulk purchase

Low:
- Many suppliers
- Limited, constrained knowledge
- Common technology
- No regulation

High:
- Few suppliers
- Proprietary knowledge
- Innovative technology
- Highly regulated

	Systems	Estimated Lead Time
1	Reactor vessel	50-64 months
2	Guard vessel	33-49 months
3	Reactor internals	UNKNOWN
4	Electromagnetic pumps	42-51 months
5	Steam generator system	UNKNOWN
6	Instrumentation & controls	UNKNOWN
7	Control rod system	39-48 months
8	Intermediate heat exchangers	37-50 months
9	In-vessel transfer machine	42-27 months
10	Condenser	33-45 months
11	Feed water heater	33-45 months
12	Steam turbine generator	36 months

An illustrative example of vendor selection criteria

The following is an example of a high-level vendor selection criteria* considered for the nuclear industry. A detailed study will be required when selecting and vetting potential vendors. The cut-off score is 80 points out of 100 points and can be used for preliminary vendor selection – a detailed audit will be required in order to qualify as a vendor.

Illustrative

Selection Criteria	Description	Points
Previous Nuclear Experience	Evaluate vendors based on their past project experience, positive reputation, customer recommendations, and established track record.	30
Technical Competence	Evaluate the vendor's technical expertise and competence in designing, manufacturing, and installing nuclear equipment or systems.	20
Qualifications and Certifications	Ensure that the vendor understands nuclear safety regulations and has a good track record of acquiring accreditation to meet these requirements.	15
Skilled Labour Availability	Evaluate workforce utilization rates, retention programs and workforce capacity and capabilities (example welding) . Also, examine the vendor's training and development programs for the workforce.	10
Export Experience	Ensure the vendor's track record of adhering to legal, regulatory, and security protocols for exporting is in good standing	10
Financial Stability	Consider the vendor's financial stability and ability to complete the project within the agreed-upon budget. Evaluate their financial standing and history.	5
Environmental, Social and Governance Considerations	Evaluate the vendor's commitment to ESG considerations. Consider third-party certifications or assessments that can provide independent verification of credentials.	5
Safety Records	Look at the vendor's safety reports and documentation to review safety incidents, accidents, or near-misses and evaluate how they were handled and resolved.	5

The vendor selection process is complex and lengthy, ensuring that vendors meet all necessary safety, regulatory, technical competence, location, reliability, and partnership requirements. This process can effectively mitigate risks, optimizes costs, and increase the likelihood of successful project execution.

***** The criteria shown are for illustrative purposes only and will change based on the equipment and skid.

Source: Deloitte Research

