The Ocean Renewable Energy Group

Business Opportunities from Marine Renewable Energy Development and Project Life Cycle Needs

Submitted to:

Atlantic Canada Opportunities Agency
Agence de promotion économique du Canada atlantique

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EXECUTIVE SUMMARY

This document is intended to provoke a broader engagement in discussions about the potential for jobs and careers, and the business and economic role that can result as marine renewable energy resources are developed in Atlantic Canada for the benefit of generations to come. It attempts to break the “chicken-and-egg” issue by outlining some of the needed supplies, services and skills using terms that recognize their existing deployment in other industries. It also attempts to emphasize that in the next 1-3 years, it is likely that three phases of tidal energy development that are anticipated to grow towards an industrial-scale development will be planned. Activities during these early stages of industry development will lay a foundation for careers and business activity that will sustain beyond current generations, and early-adopters can have a place in a new worldwide industry.

Marine renewable energy development is a perfect example of the new economic and environmental opportunities for Canada’s “future-economy”. The recently released *Marine Renewable Energy Technology Roadmap* builds on the industrial approach to the development of technologies and expertise that has been taken in Canada to establish a vision and development pathway for achieving a generating capacity, installed by Canadian industry, of 75 MW by 2016, 250 MW by 2020, and 2,000 MW by 2030—resulting in $2 billion annual economic value. As the industry advances, the supply chain will be a key factor in ensuring Canadian industry leadership.

Marine renewable energy development in Atlantic Canada has the potential to catalyze industrial development with activities underway at the Fundy Ocean Research Center for Energy (FORCE), community tidal energy projects, and potential industrial-scale developments. With foundational research initiatives, and existing skills and expertise in marine and offshore industries development including oil and gas, ocean technology, shipbuilding, aquaculture, etc., the region is well poised to build a supply chain that can be globally competitive, providing expertise and solutions around the world.

The Opportunity

An extensive team of services and supply providers will be required to support each project throughout its lifespan. An array of skills, supplies and services are needed at each project stage including marine scientists and engineers, mechanical and electrical technicians, vessels, sensory instruments, divers, steel fabrication, manufacturing and supporting expertise such as insurance, legal, transportation, and financial services. There are many project requirements aside from turbine/generator delivery that are likely present in existing regional capacity and can be built upon by transferring skills from other sectors to establish a new industrial supply chain.

Furthermore, marine renewable energy can be realized as a niche industry for Atlantic Canada. As marine renewable energy is currently an emerging industry, there are no mature supply chains anywhere in the world. This presents an opportunity for Atlantic Canada to become an early adopter and innovator—leading the way for the rest of the world and exporting skills and expertise to a world market.

Engaging Atlantic Canada/Nova Scotia Business Sectors

Atlantic Canada has ample marine and offshore-energy businesses and organizations that could transfer skills across the developing marine renewable energy sector—resulting in new business opportunities and establishment of a new supply chain. Key sectors that should be engaged in marine renewable energy development over the long term to service future industry development stages include Ocean Technology, Research and Academic Institutions, Marine Structure Fabrication and Marine Transportation, Port Facilities, and Professional Services. Engaging these sectors early is imperative to ensure that Atlantic Canadian companies are well positioned to seize supply chain opportunities locally and internationally.

Establishing the supply chain

The tentative first steps in marine renewable energy industry development with deployment of prototype projects have been too small to attract experience, skills, services and technology, but the engagement of recognizable suppliers (Alstom, Andritz, Lockheed Martin. Rolls Royce, Siemens, Voith etc.), interest by companies like Emera and alignment of government policies are all contributing to a growing awareness that there are real career, business and economic opportunities that will emerge.

As Nova Scotia moves ahead with an industrial development strategy and marine renewable energy legislation, there will be an opportunity to grow the mechanisms to actively recruit the supply, service and skills the sector needs, and in doing so demonstrate economic benefits.

Early strategic action is required to ensure that relevant business sectors and potential supply chain companies are aware of the opportunities well in advance.

Further steps to accelerate supply chain development and realize the opportunity of a new industry and associated economic opportunities include:

- Disseminate this document as a stimulus to encourage engagement by businesses outside the marine renewable energy sector.
- Develop web based communications to amplify opportunities messaging.
- Establish an active communications program with other industry sectors (associations, clusters etc.).
- Design a supplier development mechanism for “licensees” for incorporation in Nova Scotia’s forthcoming marine renewable energy legislation.
- Prepare a collaborative mechanism to ensure that the bid procurement processes developed by the Maritimes Energy Association is used by all marine renewable energy development initiatives.
- Develop a list of all businesses and organizations that could support marine renewable energy development in Atlantic Canada.

- Conduct a supply chain gap analysis to determine current capabilities, capacity, and transferrable skills in correspondence with the key project development requirements identified.
- Expand on project development inputs and activities analysis to gain an understanding of requirements for future industrial development stages in Nova Scotia. This could include predicted expenditure, number of devices, human resource requirements, and supporting infrastructure.
- Conduct an assessment of formal education, courses, and training available at Atlantic Canada's universities and colleges that could support marine renewable energy development.

Identifying supply chain opportunities for an individual project is only a starting point to realizing the potential of a supply chain that has the capability and capacity to support a 300 MW commercial development and beyond. To grow Atlantic Canada's maritime tradition with addition of a new industry, continued supporting initiatives are required to ensure that relevant business sectors and potential supply chain companies are aware of these opportunities and what they could mean for their businesses, the region, and Canada. These sectors' expertise and experience must be mobilized if Atlantic Canada/Nova Scotia is going to establish a marine renewable energy industry.

1.0 INTRODUCTION

Marine renewable energy development presents a new economic and environmental opportunity for Canada. Nova Scotia, in particular has an incredible tidal energy opportunity with the Bay of Fundy pushing over 160 billion tonnes of water on the incoming tide. It has an estimated energy potential of as much as 60,000 MW of energy, of which approximately 2,500 MW[1] is now estimated to be capable of safe extraction. Aside from the perpetual supply of clean, renewable energy, development of this resource will grow new careers and sustainable economic activity.

The immature domestic and global marine renewable energy supply chains are reflective of the current stage of the industry. Marine renewable energy deployments (wave and tidal) have consisted primarily of one-off prototype devices to date, have been experimental in nature, and therefore a supply chain capable of providing tens or hundreds of devices per year for commercial deployment has yet to be established. While this gap is a challenge to early projects, it should also be recognized as a global window of opportunity for the early adopters of Atlantic Canada. The lack of a defined value chain and truly industrial approaches creates a “ground-floor” opportunity for Atlantic Canada to set the pace and provide expertise and services that could be exported around the world.

This document is intended to support a discussion of the potential opportunities presented by marine renewable energy to engage businesses in Atlantic Canada by first focusing on Nova Scotia’s tidal energy activities and existing business sector. It provides a high-level description of inputs (supplies, skills, and services) required to develop an individual marine renewable energy project—with specific focus on in-stream tidal energy. This is intended to provide an understanding of requirements that are going to emerge on the path to an industrial development stage.

Although there is no mature marine renewable energy supply chain in Nova Scotia, the province is well suited to engage in marine energy development and build a productive and successful supply chain given its long marine industry tradition—with significant experience in the fishing, shipbuilding, and offshore oil and gas industries. Nova Scotia also has the highest concentration of ocean technology companies in North America, with more than 200 companies. These companies have developed specialized expertise in marine environments all over the world and could service the marine renewable energy industry.

Nova Scotia is expected to generate a growing demand for supplies, services and expertise in the next decade as tidal energy development is expected to pass through three phases: 1.) FORCE & COMFIT projects; 2.) 64 MW of arrays at FORCE; 3.) 300 MW commercial-scale development.

[1] Karsten, et al., 2008.

2.0 A TIDAL ENERGY PROJECT – Project Life Cycle Requirements

An in-stream tidal energy project will progress through a number of stages requiring an array of inputs—technical as well as supporting and enabling services. Service and supply provider requirements may differ from project to project. Device design, number of devices, and site location are some of the factors that may dictate requirements. Following is a general description of each project stage, sub-stages, associated activities, and corresponding services and supplies required. Some activities and supplies/services required could be addressed by the project developer depending on in-house capability and capacity.

Gathering of data and analysis to inform this section is limited by the fact that all project deployments to date have been experimental in nature and there are few examples of service and supply delivery at each project stage. The following project life cycle inputs description is a compilation of data and analysis from case studies and reports focused on future industry projections, and is not representative of any one particular existing or past project. *(NOTE: The identified project activities and inputs may not be exhaustive.)*

2.1 Site Screening and Project Feasibility

The first stage of project development includes various preliminary activities to identify potential sites and determine project feasibility at those sites. After a potential development area has been identified a site resource assessment is completed consisting of three stages. The pre-feasibility and full-feasibility studies consider the resource identified in the site screening in more detail and should result in a detailed economic model with all constraints in the area identified and assessed. If a technology is selected beforehand, then potential technical, physical, and environmental constraints influencing the site identification are assessed in relation to the technology's performance characteristics.

Activities:

- Desktop screening exercise based on available data to identify sites.
- Early stage resource assessment
- Constraints analysis including preliminary identification of First Nations interests, conservation areas, archaeological sites, infrastructure and other marine environment users such as fishing, commercial transportation, recreational transportation, defence, etc.
- Identification of high-level site-related health and safety hazards for future assessment and to inform design of Safety Plan
- Identification of a suitable grid connection point and determination of availability
- Logistics analysis – identification of suitable harbours, associated services, and infrastructure
- Identification of marine renewable energy technology that will best fit the project objectives and identified sites

Potential service and supply requirements:

- Desktop modeling tools and analysis expertise
- Research support
- Technical and engineering expertise

2.2 Planning

During the planning stage, project developers engage in the environmental and technical studies and activities to help inform project design and provide details necessary for determining applicable regulatory requirements.

Environmental scoping and surveys

Environmental surveys are used to assess whether a project could have an impact on a species that live in, use, or frequent the marine environment, both in the sea and air. Surveys address benthic species, fish, marine mammals, birds, and onshore species.

Activities:

- Planning for multiple surveys
- Operation of vessels for use and management of survey equipment
- Aerial surveying where coverage of larger area is required
- Collection and evaluation of data to provide information on project development issues

Potential service and supply requirements:

- Vessel and operator (range of vessels can be used including local fishing crane, 30m long vessels and specialist physical surveying vessels for environmental surveying)
- Surveying, trawling, and imaging equipment
- Aircraft (helicopter) and operator for aerial survey
- Wildlife observation and data collection by marine biologist, ecologist, environmental scientist, and/or local knowledge from fisherman, etc. (should have knowledge of local species)
- Technical/research consultancy for analysis and interpretation of survey data

Physical Surveys

Coastal process surveys and seabed surveys are used to examine the subsea environment and potential impact of tidal energy projects, particularly on sedimentation and erosion. Existing bathymetry and seabed geomorphology (geophysical and geotechnical conditions) are investigated to further refine the location and extent of the deployment area, assess the fixing and mooring requirements and outline a corridor for the cable route. The geomorphology of the seabed can also provide an indication of the likely benthic habitats in the area.

Onshore geotechnical conditions should also be assessed in order to identify technical requirements for onshore works and cable installation. These use a mix of desktop studies and on-site investigations.

Activities:

- Planning for multiple surveys
- Operation of vessels for installation and management of survey equipment
- Collection and evaluation of data to provide information on project development issues

Potential service and supply requirements:

- Specialized vessel and operator

- Technical/research consultancy with knowledge of sediment transfer and geotechnical engineering

Meteorological and resource assessment/monitoring

Measurement of meteorological and metocean conditions are necessary to enable detailed model of resource characteristics (wave heights, wave periods, tidal speeds and direction of both waves and tides). Data collected is used alongside historical and modeled outputs to inform project design. The final resource assessment stage is completed once technology is chosen and serves to determine the exact location of each device.

Activities:

- Planning for the deployment of instruments
- Operation of vessels for installation and management of subsea deployment of acoustic profilers (ADCP)
- Deployment and collection of ADCP measurements
- Collection and analysis of weather patterns in the area
- Collection and evaluation of acoustic data to provide information on project development issues

Potential service and supply requirements:

- Meteorological instruments and packaged instruments
- Dynamic positioning vessel and operator
- Remotely operated vehicles (ROV) and diver
- Technical and research consultancy services to interpret and advise on modeling data (data analysis and resource modeling, site conditions and device suitability analysis)—metocean

Electrical Connection

The availability of a suitable grid connection with sufficient capacity for the proposed project is integral for moving forward with the project. After identifying suitable grid connection points, a developer must begin discussions with the operator of the electrical grid.

Activities:

- Discussion with System Operator of the electrical grid
- Identification of technical and contractual agreements for connection and associated costs

Potential service and supply requirements:

- Technical and electrical expertise
- Legal expertise

2.3 Project design and development

Public and stakeholder consultation

Developers will engage with the local community throughout the life of the project. Extensive consultation with stakeholders, especially those more likely to be affected by the project, is typically undertaken during the preparation of an Environmental Assessment (EA).

Activities:

- Design of a consultation strategy and plan.
- Identification of potential stakeholders
- Ongoing and formal engagement with First Nations
- Production of materials for public consumption that provide project details and future development plans.
- Arrangements for public event/meetings.
- Collection of stakeholder input and analysis to inform project design, preparation of permit/approval applications, and EA.

Potential service and supply requirements:

- Consultant with knowledge of key local stakeholders and their relevant interests in a project may be required.
- Public relations expertise
- Meeting/conference space (local community centre or hotel)
- Consultants with existing EA expertise

Mi'kmaq Ecological Knowledge Study (MEKS)

There are sites in Nova Scotia that have particular cultural significance for the Mi'kmaq of Nova Scotia, who may utilize them to support traditional or current practices for food, social, or ceremonial purposes. A MEKS should be conducted to identify areas of historical and current use in the project area and helps ensure that traditional knowledge informs project design and development.

Activities:

- Determine MEKS scope in consideration of project requirements and proposed site

Potential service and supply requirements:

- MEKS services[2]

Environmental Assessment (EA)

Although EAs have basic requirements and common elements, they should be project and site specific. They are informed by scoping and surveying conducted during the feasibility stage of project development. The EA considers the impacts of the project through the installation, operation, and

[2] There are currently two MEKS firms in Nova Scotia-- The Confederacy of Mainland Mi'kmaq and Membertou Geomatics Consultants.

decommissioning phases. Parameters assessed include: coastal and sedimentary processes, marine ecology (including benthic ecology, marine mammals, cetaceans), fish resources and commercial fisheries, marine navigation, cultural heritage and archaeology, ornithology, terrestrial ecology, landscape and visual impact, road traffic and access, tourism and recreation, water/sediment/soil quality, noise and air quality, and socio-economics.

Activities:

- Surveys and specialist investigations to provide a description of current environmental features (baselines).
- Data gathering according to criteria defined by the previous surveying and scoping.
- Modeling and specialist studies to predict potential environmental impacts and evaluation, identification mitigation measures, identification of uncertainties, assessment of cumulative effects, and identification of monitoring requirements/plans.
- Input from stakeholders/consultees from continued dialogue on scope of surveys and studies, likely impacts, and mitigation measures.
- Design of potential monitoring program

Potential service and supply requirements:

- Consultants with existing EA and related specialist experience

Other legal, permitting and approval requirements

Project developers will need to prepare applications and documentation for all legal and permitting requirements including: land lease, power purchase agreement, regulatory approvals, financial agreements, insurance, etc.

Activities:

- Preparation of land lease document, permits/approvals applications
- Preparation of application for negotiation of electrical grid connection conditions including modeling of device and array power quality output (if applicable)
- Design of Safety Plan (addressing operational and occupational health and safety issues)
- Determination of financing options and building of a financial team
- Clarification of required insurance during the construction and operating phases covered by plant suppliers, construction and installation contractors

Potential service and supply requirements:

- Detailed experience in the permitting and approval of projects within the marine environment
- Power project interconnection studies
- Legal expertise
- Consulting services (health & safety expertise)

Project design

The project design is developed and refined in parallel to the EA. Findings from the environmental surveys and studies should feed back into the design and technical specification. This process should also set the basis for the preparation of suitable procurement and contract strategies. Technical specifications and drawings will assist in the drafting of the contract documents.

Activities:

- Evaluation of design options and outline of selected design using the following preset criteria: functionality, flexibility, operability, costs, proven performance, safety issues, environmental and socio-economic impacts, ease of installation, project risks, reliability, maintainability, and survivability.
- Techno-economic analysis to determine the expected costs and revenues arising from the project to facilitate eventual financial investment decisions.

Potential service and supply requirements:

- Engineering consultants to provide final input on technology and project design.
- Marine architect to provide logistical support during final design stage.

Development of a procurement strategy

A strategy for the procurement of services and materials to serve project lifecycle needs will be developed. Strategies are designed to select suppliers that provide value for money over the expected life of the project while ensuring supplier competence, and quality of service. Design of a strategy typically takes the following factors into consideration:

Activities:

- Analysis of current market status and projected market trends
- Research and consideration of rules and procedures for procurement applicable to project development
- Analysis of risk between parties involved and development of management techniques for uncertainty
- Development of procurement process timescales and integration with overall project program

Potential service and supply requirements:

- In-house/project developer
- Consultant may be required depending project developers procurement and contract management experience.

2.4 Project Fabrication

Detailed Design

A detailed design of the project will commence once a project receives the necessary approval from regulatory authorities and the predicted technical and commercial performance of the project remains feasible and in line with project objectives. Technical studies will be undertaken to refine project design.

Activities:

- Assessment and detailed design of electrical equipment and cables (subsea and onshore)
- Detailed design of Supervisory Control and Data Acquisition (SCADA) System, communications, and control equipment
- Detailed design of onshore facilities and auxiliary equipment
- Development of generation profiles and quality of generation based on selected technology to inform grid connection studies
- Grid connection feasibility study and integration with network
- Specification of safety features, navigational marking, and lighting
- Detailed review of the selected technology
- Marine logistics studies to optimize installation methods, vessel and port requirements
- Failure Modes, Effects, and Criticality Analysis (FMECA) to ensure the integrity and survivability of the project infrastructure and to optimize its reliability, availability, and maintainability.
- Review and refinement of cost estimates and program
- Update of the design risk register.
- Preparation of a Quality Plan

Potential service and supply requirements:

- In-house/project developer
- Marine architect to provide logistical support and inform on marine safety and standards requirements
- Consultant with understanding of subsea electrical equipment
- Health and safety culture consultant to inform OHS processes
- Consultant with experience in construction planning and methods suitable for short access windows due to tidal flow.
- Knowledge in site-specific conditions in and around the project.
- Technical knowledge in marine renewable energy or parallel sectors including pressurized vessels, marine equipment and aquaculture.

Main structural components

The development of most components needed for the core generating technology will be developed and/or used by the original equipment manufacturer (OEM) and would likely be outside of the local supply chain in Atlantic Canada unless there are developers or manufacturers active in the region. Depending on the rate and scale of development, there may be potential to attract the assembly or some manufacturing. Servicing and maintenance of these components is more likely to be done locally.

Hydrodynamic system

The hydrodynamic system is composed of the blades or hydrofoils and moves directly under the influence of forces applied by water.

Activities:

- Precision fabrication of blades and hydrofoils
- Moulding and finishing of composite materials
- Casting of metal structures used in providing buoyancy
- Assembly of components with fasteners, welding or other means
- Design and production of pressure vessels for marine environment
- Provision of coatings and treatments to control corrosion and marine growth
- Workshop testing and verification

Potential service and supply requirements:

- Steel fabrication

Reaction System

The reaction system keeps the device in position and provides static reference point for oscillating devices (mooring arrangement, gravity base, foundation or foundation fixed to sea bed via piles).

Activities:

- Design of dynamic structure in the marine environment under frequent waves.
- Procurement, fabrication and handling of large scale steel and concrete structure of up to over 1000 tonnes
- Design, manufacturing, and installation of wire ropes, chains and anchors

Potential service and supply requirements:

- Steel fabrication
- Concrete supplier
- Expertise in corrosion and marine growth prevention
- Local knowledge of marine conditions

Power Take-Off System

The power take-off system converts the motions of a device’s hydrodynamic system into electrical energy. This can be done in two ways – 1) with hydraulic actuators or a linear electrical generator or 2) constraining movement with speed-up gearboxes or direct drive electric generators.

Activities:

- Production of gearboxes, bearings and power transmission components.

Potential service and supply requirements:

- Electrical and hydraulic knowledge in marine environment
- Subsea connectors from device to inter-array cabling with voltage rating of 11kV and above.

Control System

The control system provides both supervisory and closed-loop control. It also includes auxiliary systems.

Activities:

- Design and production for high reliability applications.

Potential service and supply requirements:

- Specialist sensors and data collection systems related to the marine environment to indicate pressure, movement, electrical characteristics or environmental conditions.
- Experience in design and use of SCADA systems
- Hydraulic actuators, valves, or other equipment.
- Bearings and actuation components for use in yawing or pitching

Subsea Cabling and Connectors

An electrical collector system is needed to connect individual devices to a common device interconnection point. There are two types of cables that are necessary for the operation of an in-stream tidal energy project. Array cables are required to connect strings of devices (if the project consists of an array) to an offshore substation and higher voltage cables are necessary to connect the substation to the onshore grid connection point. There is already very high demand for these types of cables from other industries and if manufacturing capacity does not increase, bottlenecks will likely occur.

Activities:

- Advise on selection of cable
- Specify protection requirements

Potential service and supply requirements:

- Large-scale and high precision cabling extrusion and assembly equipment
- Expertise in the production of insulation for cables to provide thermal and electrical protection
- Cable armouring products to protect against extreme forces and ensure life of the conductor
- Electrical design knowledge
- Mechanical engineer

Electrical Equipment

Transformers, switchgear, and other electrical equipment are likely to be based on conventional electrical power engineering products, but adapted to meet the needs of specific applications.

Potential service and supply requirements:

- Knowledge and understanding of design requirements of distributed generation and impacts of wave and tidal supply characteristics.
- Offshore electrical solutions manufacturing experience.

Foundations, anchoring systems, and moorings

In-stream tidal devices are anchored to the seabed. There are different types of systems for anchoring depending on device design. The following is a generalization of activities and supplies required to design and produce a foundation and anchoring system.

Activities:

- Production of large scale concrete structure
- Fabrication of steel frame structure weighing up to over 500 tonnes
- Assembly of various components

Potential service and supply requirements:

- Steel fabrication: subsea base and inspection of subsea base during fabrication
- Expertise in the design of dynamic structures for the marine environment
- Corrosion and marine growth prevention products
- Concrete supplier: ballasting subsea base
- Cranes: lifting of various components into place for assembly and lifting assembly into barge for testing and deployment.
- Marine Architect to evaluate subsea base design

Other project stage service and supply requirements:

- Insurance: protection of owner from accidental damage to the components during fabrication and assembly
- Transportation of component parts to site for final assembly

2.4 Construction, Installation, and Commissioning

The construction, installation and commissioning stage commences once all permits and approvals have been received and the device and other components are complete and ready for final assembly. This includes onshore assembly, offshore installation activities, and on-site commissioning. A range of vessels are typically required including specialist, modified, standard and jack-up vessels. A number of suppliers are required to manage and deliver the safe, timely installation of expensive and relatively delicate technology in tough environmental conditions.

This stage presents an array of opportunities for local suppliers and smaller companies as they have the advantage of local knowledge, understanding of the site conditions, and access to local labour.

Procurement and assembly logistics

Activities:

- Identification of permitting requirements
- Movement of materials procured from other jurisdictions

Potential service and supply requirements:

- Marine consultant
- Customs broker for importing materials and guidance in obtaining proper permits for temporary use of barge

Port facilities and services

Developers will likely aim to carry out as much activity as possible prior to departing from port to minimize time spent working offshore and associated costs. Dockside facilities with appropriate depth, craneage and storage are required for each project.

Activities:

- Marine logistics
- Mechanical and electrical fit-out

Potential service and supply requirements:

- Heavy lift capacity of up to 1000 tonnes
- Large lay-down and storage areas to enable assembly of components and rapid deployment of devices for larger scale developments
- Suitable space for final assembly adjacent to quayside
- Dry and potentially wet commissioning of electrical parts
- Sufficient draft and beam to facilitate movement of vessels and devices at a range of tides.

Barge requirements

Supply vessels such as jack-up barges and crane barges will be required for lifting heavy loads.

Activities:

- Inspection of barge and associated equipment for compliance with regulations.
- Towing of barge through test program prior to deployment activities.

Potential service and supply requirements:

- Marine consultant for review and inspection
- Customs broker to provide guidance in obtaining proper permits for temporary use of barge

Deployment and installation of device

Activities:

- Preparation of device at port and float-out and install devices using general purpose vessels where possible
- Marine logistics planning
- Towing of barge and tidal assembly into place for deployment (and recovery)
- Monitoring movement of marine life (lobster, fish, mammals, birds) during deployment for indication of change from normal behavior.
- Explore fish monitoring technologies at the turbine site (2-D and 3-D sonar) and follow fish patterns.
- Identification of acoustic signatures
- Passive monitoring of acoustic noise from marine mammals to determine any effect or risk.
- View turbine in operation using side scan SONAR and camera on tether
- Monitoring and analysis of anticipated wind and sea state during expected deployment/recovery window

Potential service and supply requirements:

- Marine consultant for review and inspection and knowledge of local conditions and constraints
- Electrical Engineer
- Mechanical Engineer
- System Engineers
- Power Engineers
- Certified welders (CWB Class 47.1)
- Journeyman machinists
- Customs broker to provide guidance in obtaining proper permits for temporary use of barge
- Tugboat and operator
- Fishing boats for transporting additional personnel and emergency response
- Health and Safety/Emergency Response preparedness
- Personal protective and safety equipment
- Radios for communication between all parties involved in deployment
- Environmental consultant/researcher – biologist, ecologist, marine biologist—for observation and monitoring of marine life, environment,
- Technical/engineering consultant
- Diving services
- Instrumentation for communication with the assembly during deployment and recording of forces experienced on the assembly and other data to further understand environmental conditions and optimize design.
- Specialist tooling and ROVs

- Marker buoys and navigational lighting

Installation of foundations and moorings

In-stream tidal devices are anchored to the seabed. The method by which it is anchored depends on device design (pin-piled, concrete gravity, multipoint mooring).

Activities:

- Offshore installation and assembly of various components

Potential service and supply requirements:

- Cranes: lifting of various components into place for assembly and lifting assembly into barge for testing and deployment.
- Diving services: assistance with removal of subsea base ballast fit pipes
- Supply and operations of specialist tooling and ROVs during installation activities
- Support vessels and personnel to provide construction and monitoring support
- Specialist vessels able to carry out complex installation procedures.
- Drilling and piling operations

Installation of offshore electrical systems (including cable installation)

Activities:

- Grid connection upgrades
- Procurement of cabling/electrical contractors and storage/testing of cables
- Procurement of bespoke winches and drums for cable
- Draw-through and installation of several kilometers of subsea cabling to avoid geohazards
- Cable protection and securing using rock dumping (and potentially ROVs for pinning and active positioning around seabed features)
- Directionally drilled pipelines from shore out to the location of devices
- Installation and connection of the offshore substation and array cabling between devices (if applicable)

Potential service and supply requirements:

- Installation of power conditioning equipment—converters, generators, etc.
- Underwater substation pod—procurement of transformers, switchgear
- Cabling/electrical contractors: LV Dynamic cable and MV Static Cable (with fibre optics)—procurement, storage and testing
- Subsea cable armouring/burial vessels and skills
- Bespoke winches and drums for cable
- Cable laying vessel
- Special drilling equipment (carbon steel pipeline, fabricated-coated-assembled-welded)
- Drilling contractor with geotechnical knowledge
- ROV (optional)

Onshore structures

Projects will likely include an onshore substation and control building. This could also be built to house some essential operations and maintenance staff. Given the remote location of some of these projects, it is also possible that a road may need to be built to provide for site accessibility.

Activities:

- Construction of building
- Preparation of applications for any planning permits or approvals required by regulatory authorities

Potential service and supply requirements:

- Building contractor
- Subcontractors (electrical, concrete supplier, window, telecommunications, metal works, plumbing)

Other project stage service and supply requirements:

- Insurance: protection of owner from accidental damage to the components during deployment
- Project certification

2.5 Operation and Maintenance

The project development process will be designed to ensure cost-effective and safe operation throughout the life of the project. Maintenance will be scheduled to enable efficient performance and mitigate environmental impact. This stage will likely require technical support from the installation contractor, equipment supplier, and technology developer at early stages of operation. Some technical developers are anticipating significant service interventions every five years and expect major overhaul of equipment replacement every 25 years. Since properly chosen marine renewable energy sites are expected to remain in perpetuity, ongoing support of them can be a sustainable business opportunity and source of career employment.

When possible, developers will likely want to carry out operations and maintenance tasks local to each project using port facilities to reduce logistics costs and response times. If port facilities were shared between projects and able to accept complete devices for repair or refurbishment, then the scale of activity could attract a supporting supply chain with a clustering effect.

Operations

Activities:

- Review, monitoring, auditing and management of environmental performance to ensure compliance with permit/approval conditions
- Provision of information on environmental impact to stakeholders and regulatory authorities
- Monitoring performance
- Inspection of operations and activities
- Planning and management of maintenance activities

- Administrative activities related to customer, regulatory, and legal requirements

Potential service and supply requirements:

- Dedicated operations staff and control centre
- Marine engineer (class 4 or higher) for offshore and onshore maintenance work
- Power Engineer (Class 1 and Class 4)
- Computing systems
- Navigation systems and data
- GIS services
- Subcontractor support services
- Vessels for ongoing environmental monitoring activities and inspection
- Ecologists and marine biologists
- Diving services
- Mechanical technicians
- Electrical technicians
- Health & Safety/Emergency Response

Maintenance

Activities:

- Planned maintenance including retrievals using tugs and workboats
- Management of unplanned maintenance

Potential service and supply requirements:

- Port facility
- Dedicated maintenance staff and control centre
- Support vessels including tug boats and workboats
- Portside lifting capability to lift the device to shore if needed (crane)
- Local workshop facilities to allow for strip-down, refurbishment, re-assembly and testing of devices.
- Mechanical technicians
- Electrical technicians
- Marine engineer (class 4 or higher) for offshore and onshore maintenance work
- Storage for replacement parts/PTO systems
- Welding and machining
- Health & Safety/Emergency Response

Recovery and Decommissioning

Decommissioning and re-commissioning activities and inputs are expected to be part of the long-term O&M process. Therefore, this project stage was determined to be out of scope for this analysis and document.

3.0 THE SUPPLY CHAIN OPPORTUNITY

As the marine renewable energy sector is not as well developed as some other energy industries, it presents opportunities and challenges for an emerging supply chain. Specifically for tidal energy development, the opportunities in the near-term are for the advancement of both small scale (defined as less than 0.5MW nameplate capacity) and large scale in-stream tidal devices. In the mid-term, demand for in-stream tidal as well as offshore wind components and service is projected to increase.

Eventually industrial approaches to support project development will be needed and there are presently gaps in capability and capacity regionally as well as internationally. Some of the current gaps in Canada that have been identified are device manufacturing, engineering construction, foundations/anchoring[3] and in Nova Scotia availability of appropriate infrastructure in a deep water port with close proximity to the resource as well as the need for adaptive methods to service and/or deploy devices from shallow or dry ports have been have been identified as gaps to be addressed to enable future development[4].

While closing these gaps will be challenging in some cases, they also create opportunities for Nova Scotia and the region as solutions will be in demand for future marine renewable energy technology projects locally and worldwide. As evidenced by the list of inputs and activities described (compiled list in Appendix A), it is likely that many services and supplies needed to support a marine renewable energy project are available in Nova Scotia and/or the Atlantic Provinces. Many of the technologies, components, and techniques under development in the marine renewable energy sector may already exist in related sectors such as offshore oil and gas, electrical utilities, naval, fisheries, salvage operations, and aerospace.

Services and supplies that are currently unavailable or that do not have the operating capacity necessary to support future large-scale commercial development are areas where new business opportunities could develop. Solution-providers that emerge from Atlantic Canada and Nova Scotia's early participation in this sector would lead to strong export opportunities. Additionally, due to its strategic geographical location, Nova Scotia is well positioned to meet future demands elsewhere in North America and internationally.

[3] NRCan, 2011.
[4] Maritime Tidal Energy Corporation, 2011.

4.0 ENGAGING BUSINESS SECTORS

Growth of a marine renewable energy industry in Nova Scotia will be dependent on having access to the right businesses, skills, and expertise to support project and industry development. Nova Scotia and the Atlantic region have a unique opportunity to capture the benefits of this new sector through the entire supply chain—from research and development through to engineering, manufacturing, installation, operation and maintenance. This would build on the Nova Scotia's maritime tradition of the fisheries, shipbuilding, offshore oil and gas, and aquaculture. If Canada and Nova Scotia continue to take a lead in marine renewable energy development, a large part of that supply chain could be based in Canada, resulting in an attractive environment for domestic or inward investment in manufacturing facilities.

Businesses and organizations with a track record in working in the marine environment, perhaps gained from industries such as offshore oil and gas, ocean technology, fishing, or marine aggregates extraction may be well suited to undertake this work. An already embedded workforce to transfer skills across this developing sector and the ability to build on the supply chain and infrastructure will be essential to for advancing the sector and establishing a new industry.

Engagement of the following business sectors to participate in marine renewable energy development will grow the supply chain and support future industry success.

Offshore Petroleum

Canada has internationally recognized expertise in extraction equipment, drilling technologies and maintenance systems for the offshore oil and gas industry—expertise that has already been engaged in some aspect of early marine renewable energy prototyping and will be critical to leverage as the sector moves forward. Aligning oil and gas technical skills and resources with the costs and requirements of marine renewable energy projects will support the installation, operation and maintenance of devices.

Ocean Technology

Ocean technology is a growing sector in Nova Scotia generating $5 billion in revenue and employing 14% of the province's workforce. The sector is a mix of primarily small and medium-sized enterprises with a few large multi-national corporations.[5] Local companies have been pioneers in underwater acoustics and imaging, marine communications, navigation, ocean monitoring, a wide variety of enhanced engineering and environmental services, and the production of innovative equipment to operate in harsh marine environments. Many ocean technology firms also have a breadth of experience in the offshore oil and gas industry, having provided much of the engineering, seismic survey, modeling, forecasting, production and processing underwater intervention support during the Sable Offshore Energy project and Deep Panuke Project.

The marine renewable energy sector has been identified as an emerging market for ocean technology. Key sub-sectors existing in Nova Scotia's ocean technology sector that could become involved with marine renewable energy development include:

- Acoustics, sensors, and instrumentation

[5] Government of Nova Scotia,2011.

- Data, information, and communications systems
- Marine geomatics
- Unmanned surface and underwater vehicles
- Naval architecture

In close proximity, Newfoundland and Labrador also has more than 50 knowledge-intensive enterprises that develop innovative ocean technology products and services for niche markets in Canada, the United States, Central and South America, Europe, and Asia. A key element of Newfoundland's ocean technology sector is a multi-stakeholder cluster initiative—OceansAdvance—joining companies, institutions, and government agencies to facilitate world-class capability.

Research and Academic Institutions

Marine renewable energy project development will require access to R&D facilities, skilled workers, and research expertise in a number of disciplines. Nova Scotia is well suited to address these needs, with 450 PhDs in ocean-related disciplines and the world's highest concentration of researchers in the sector. The province is home to 11 universities and a community college system, all of which have marine, science, engineering, marine geomatics, geological oceanographic studies, or technology programs, courses, and potential research activities that have and/or will likely contribute to support marine renewable energy development.

Research and academic institutions in Nova Scotia include (list not exhaustive):

- Bedford institute of Oceanography
- Geological Survey of Canada
- National Research Council
- Defence Research Development Canada
- Offshore Energy Research Association (formerly OEER/OETR Associations)
- Fundy Ocean Research Center for Energy (FORCE)
- Halifax Marine Research Institute
- Acadia University (Centre of Estuarine Research, Acadia Tidal Institute, Fundy Energy Research Network)
- Dalhousie University
- Saint Mary's University
- St. Francis Xavier
- Cape Breton University
- Nova Scotia Community College

Academic institutions could serve to support future training and skills marine renewable energy development by establishing programs and courses that cater to the needs of the sector. They also may have research facilities, resources, and expertise that could be applied to future project development.

Strategic research initiatives among key organizations are integral for answering key research questions and gathering data to support project development. Increasingly important is collaboration among researchers in Nova Scotia, regionally, and internationally to share knowledge on successes, failures, and best practices. Collaborative activities and projects among local research institutions and industry could serve to accelerate marine renewable energy industry development through applied research projects, business incubation, and university placements.

Marine Structure Fabrication and Marine Transportation

Nova Scotia and the Atlantic region have expertise in marine structure fabrication for the shipbuilding and offshore oil and gas sectors. This is a growing sector evidenced by the addition of new players such as Korean company Daewoo Shipbuilding and Marine Engineering and the recently announced $33-billion federal shipbuilding contract to Irving Shipbuilding. Many of the companies and skilled workers involved in this sector are also well suited to play a role in marine renewable energy development. Opportunities include potential manufacturing of some system components, flotation equipment, mooring expertise, marine towing and navigation, and supply and maintenance.

Port Facilities

Nova Scotia has port facilities and associated infrastructure available to support deployment, operations, maintenance, and recovery activities for marine renewable energy projects. Ports and nearby businesses will have opportunities to support emerging industry needs including the housing of large vessels to assembly of device structures.

Infrastructure requirements vary according to the type and size of technology used and life cycle stage. The *Marine Renewable Energy Infrastructure Assessment* conducted by the Maritime Tidal Energy Corporation identified that multiple ports in Nova Scotia could support aspects of project development given the broad requirements of developers at this early stage. The Assessment concluded that current infrastructure was sufficient in these early stages, but major infrastructure would be required to support the tidal energy industry beyond the capacity of 64 MW at FORCE.

Ports within the region that have been used or have been identified[6] as having future potential include and their respective assets include:

Assets/Details	**Port**
Proximity to the Bay of Fundy (within 150 km of the Minas Passage site)	Digby, Parrsboro, Hantsport, Saint John, NB
Large-deep water shipping facilities, heavy lift capacity, manufacturing and access to service providers	Halifax Regional Municipality
Deep ports with heavy lift capacity	Shelburne and Mulgrave/Strait of Canso
Small-scale tidal support	Meteghan, Saulnierville, Weymouth, Freeport, Westport, Tiverton, East Sandy Cove

[6] Maritime Tidal Energy Corporation, 2011.

Professional and Supporting Services

Support services will also be required by marine renewable energy projects including: legal, financial, logistics and management support, consultants (environmental, engineering, technical), planning, transportation, construction (onshore) and communications. These services are readily available in Nova Scotia and the region, but there may not be an awareness of opportunities related to the emerging marine renewable energy sector. At this early stage, there may not be an abundant amount of business for these businesses, but as the industry advances, it is likely that many new opportunities could also emerge. For example, the creation of innovative businesses such as a turn-key management service providing planning and implementation of the installation process could be attractive to project developers.

5.0 REALIZING THE OPPORTUNITY

Development of a strong and productive supply chain presents one of the most significant economic opportunities to be realized from establishing a marine renewable energy industry. Given the existing skills and expertise and potential for leveraging skills and experience from other sectors, Nova Scotia and Canada's marine renewable energy sector has the potential to become highly competitive in the global marketplace.

The inputs and activities of marine renewable energy project development identified and business sectors that could become engaged are only a starting point to realizing the supply chain development opportunity. Initiatives must continue to ensure that Atlantic Canadian companies are well positioned to seize the supply chain opportunities. Early strategic action is required to ensure that relevant business sectors and potential supply chain companies are aware of the opportunities well in advance.

Further steps to accelerate supply chain development and realize the opportunity of a new industry and associated economic opportunities include:

- Disseminate this document as a stimulus to encourage engagement by business' outside the marine renewable energy sector
- Develop web based communications to amplify opportunities messaging
- Establish an active communications program with other industry sectors (associations, clusters etc.)
- Design a supplier development mechanism for "licensees" for incorporation in Nova Scotia's forthcoming marine renewable energy legislation
- Prepare a collaborative mechanism to ensure that the bid procurement processes developed by the Maritimes Energy Association is used by all marine renewable energy development initiatives.
- Develop a list of all businesses and organizations that could support marine renewable energy development in Atlantic Canada.
- Conduct a supply chain gap analysis to determine current capabilities, capacity, and transferrable skills in correspondence with the key project development requirements identified.
- Expand on project development inputs and activities analysis to gain an understanding of requirements for future industrial development stages in Nova Scotia. This could include predicted expenditure, number of devices, human resource requirements, and supporting infrastructure.
- Conduct an assessment of formal education, courses, and training available at Atlantic Canada's universities and colleges that could support marine renewable energy development.

6.0 NOTES AND REFERENCES

Data to inform project supply chain requirements at each stage was gathered from the following documents:

- BVG Associates. (2011). Wave and tidal energy in the Pentland Firth and Orkney waters: How the projects could be built. The Crown Estate.
- Government of Nova Scotia. (2011). Nova Scotia Tidal Symposium Supply Chain Presentations. July 2011. Retrieved from: www.nsrenewables.ca
- Maritime Tidal Energy Corporation. (2011). Marine Renewable Energy Infrastructure Assessment. p. 27-32.
- Natural Resources Canada. (2011). The Marine Renewable Energy Sector Early Stage Supply Chain.
- The European Marine Energy Centre Ltd. (EMEC). (2009). Guidelines for Project Development in the Marine Energy Industry.

OTHER REFERENCES CONSULTED

Government of Nova Scotia. (2011). Defined by the Sea: Nova Scotia's Oceans Technology Sector Present and Future.

Karsten, Richard H., McMillan, J.M., Lickley M.J. and Haynes, R.,(2008). "Assessment of tidal current Energy in the Minas Passage, Bay of Fundy," *Proceedings of the Institution of Mechanical Engineers*, 222, Part A: Power and Energy,293-507.

Appendix A - IN-STREAM TIDAL ENERGY PROJECT – Project Life Cycle Requirements Summary

	ACTIVITIES	SUPPLY OR SERVICE REQUIRED
Site Screening & Project Feasibility	• Desktop screening exercise based on available data to identify sites. • Early stage resource assessment • Constraints analysis • Identification of high-level site-related health and safety hazards • Identification of a suitable grid connection point and availability • Logistics analysis – identification of suitable harbours, associated services • Technology identification	• Desktop modeling tools and analysis expertise • Research support • Technical and engineering expertise
Planning	Environmental scoping and surveys (Surveys address benthic species, fish, marine mammals, birds, and onshore species.)	• Vessel and operator (range of vessels can be used including local fishing crane, 30m long vessels and specialist physical surveying vessels for environmental surveying) • Surveying, trawling, and imaging equipment • Aircraft (helicopter) and operator for aerial survey • Wildlife observation and data collection by marine biologist, ecologist, environmental scientist, and/or local knowledge from fisherman, etc. (should have knowledge of local species) • Technical/research consultancy for analysis and interpretation of survey data
	Physical surveys (Coastal process surveys and seabed surveys)	• Specialized vessel and operator • Technical/research consultancy with knowledge of sediment transfer and geotechnical engineering
	Meteorological and resources assessment/monitoring	• Meteorological instruments and packaged instruments • Dynamic positioning vessel and operator • Remotely operated vehicles (ROV) and diver • Technical and research consultancy services to interpret and advise on modeling data (data analysis and resource modeling, site conditions and device suitability analysis)—metocean

	ACTIVITIES	SUPPLY OR SERVICE REQUIRED
	Electrical connection	• Technical and electrical expertise • Legal expertise
Project Design & Development	Public and stakeholder consultation	• Consultant with knowledge of key local stakeholders and their relevant interests in a project may be required. • Public relations expertise • Meeting/conference space (local community centre or hotel) • Consultants with existing EA and related specialist experience
	Mi'kmaq Ecological Knowledge Study (MEKS)	• MEKS consulting services
	Environmental Assessment (EA) *(data and results to inform the EA are gathered during earlier stages)*	• Consultants with existing EA and related specialist experience
	Other legal, permitting and approval requirements	• Detailed experience in the permitting and approval of projects within the marine environment—could require environmental consultant or in-house expertise from the project developer • Power project interconnection studies • Legal expertise • Consulting services (health & safety expertise)
	Project design	• Engineering consultants to provide final input on technology and project design. • Marine architect to provide logistical support during final design stage.
	Development of a procurement strategy	• Consultant may be required depending project developers procurement and contract management experience.
Project Fabrication	Detailed Design	• Marine architect to provide logistical support and inform on marine safety and standards requirements • Consultant with understanding of subsea electrical equipment • Health and safety culture consultant to inform OHS processes • Consultant with experience in construction planning and methods suitable for short access windows due to tidal flow. • Knowledge in site-specific conditions in and around the project. • Technical knowledge in marine renewable energy or parallel sectors including pressurized vessels, marine equipment and aquaculture.

	ACTIVITIES	SUPPLY OR SERVICE REQUIRED
	Main structural components	• Steel fabrication • Concrete supplier • Expertise in corrosion and marine growth prevention • Local knowledge of marine conditions • Electrical and hydraulic knowledge in marine environment • Subsea connectors from device to inter-array cabling with voltage rating of 11kV and above. • Specialist sensors and data collection systems related to the marine environment to indicate pressure, movement, electrical characteristics or environmental conditions. • Experience in design and use of SCADA systems • Hydraulic actuators, valves, or other equipment. • Bearings and actuation components for use in yawing or pitching
	Subsea cabling and connectors	• Large-scale and high precision cabling extrusion and assembly equipment • Expertise in the production of insulation for cables to provide thermal and electrical protection • Cable armouring products to protect against extreme forces and ensure life of the conductor • Electrical design knowledge • Mechanical engineer
	Electrical equipment	• Knowledge and understanding of design requirements of distributed generation and impacts of wave and tidal supply characteristics. • Offshore electrical solutions manufacturing experience.
	Foundations, anchoring systems, and moorings	• Steel fabrication: subsea base and inspection of subsea base during fabrication • Expertise in the design of dynamic structures for the marine environment • Corrosion and marine growth prevention products • Concrete supplier: ballasting subsea base • Cranes: lifting of various components into place for assembly and lifting assembly into barge for testing and deployment. • Marine Architect to evaluate subsea base design
	Other requirements	• Insurance: protection of owner from accidental damage to the components during fabrication and assembly • Transportation of component parts to site for final assembly
Constr uction,	Procurement and assembly logistics	• Marine consultant • Customs broker for importing materials and guidance in obtaining proper permits for temporary use of barge

	ACTIVITIES	SUPPLY OR SERVICE REQUIRED
	Port facilities and services	• Heavy lift capacity of up to 1000 tonnes • Large lay-down and storage areas to enable assembly of components and rapid deployment of devices for larger scale developments • Suitable space for final assembly adjacent to quayside • Dry and potentially wet commissioning of electrical parts • Sufficient draft and beam to facilitate movement of vessels and devices at a range of tides.
	Barge requirements	• Marine consultant for review and inspection • Customs broker to provide guidance in obtaining proper permits for temporary use of barge
	Deployment and installation of device	• Marine consultant for review and inspection and knowledge of local conditions and constraints • Electrical Engineer • Mechanical Engineer • System Engineers • Power Engineers • Certified welders (CWB Class 47.1) • Journeyman machinists • Customs broker to provide guidance in obtaining proper permits for temporary use of barge • Tugboat and operator • Fishing boats for transporting additional personnel and emergency response • Health and Safety/Emergency Response preparedness • Personal protective and safety equipment • Radios for communication between all parties involved in deployment • Environmental consultant/researcher – biologist, ecologist, marine biologist—for observation and monitoring of marine life, environment, • Technical/engineering consultant • Diving services • Instrumentation for communication with the assembly during deployment and recording of forces experienced on the assembly and other data to further understand environmental conditions and optimize design. • Specialist tooling and ROVs • Marker buoys and navigational lighting

	ACTIVITIES	SUPPLY OR SERVICE REQUIRED
	Installation of foundations and moorings	• Cranes: lifting of various components into place for assembly and lifting assembly into barge for testing and deployment. • Diving services: assistance with removal of subsea base ballast fit pipes • Supply and operations of specialist tooling and ROVs during installation activities • Support vessels and personnel to provide construction and monitoring support • Specialist vessels able to carry out complex installation procedures. • Drilling and piling operations
	Installation of offshore electrical systems (including cable installation)	• Installation of power conditioning equipment—converters, generators, etc. • Underwater substation pod—procurement of transformers, switchgear • Cabling/electrical contractors: LV Dynamic cable and MV Static Cable (with fibre optics)—procurement, storage and testing • Subsea cable armouring/burial vessels and skills • Bespoke winches and drums for cable • Cable laying vessel • Special drilling equipment (carbon steel pipeline, fabricated-coated-assembled-welded) • Drilling contractor with geotechnical knowledge • ROV (optional)
	Onshore structures	• Building contractor • Subcontractors (electrical, concrete supplier, window, telecommunications, metal works, plumbing)
	Other requirements	• Insurance: protection of owner from accidental damage to the components during deployment • Project certification

	ACTIVITIES	SUPPLY OR SERVICE REQUIRED
Operations & Maintenance	Operations	• Dedicated operations staff and control centre • Marine engineer (class 4 or higher) for offshore and onshore maintenance work • Power Engineer (Class 1 and Class 4) • Computing systems • Navigation systems and data • GIS services • Subcontractor support services • Vessels for ongoing environmental monitoring activities and inspection • Ecologists and marine biologists • Diving services • Mechanical technicians • Electrical technicians • Health & Safety/Emergency Response
	Maintenance	• Port facility • Dedicated maintenance staff and control centre • Support vessels including tug boats and workboats • Portside lifting capability to lift the device to shore if needed (crane) • Local workshop facilities to allow for strip-down, refurbishment, re-assembly and testing of devices. • Mechanical technicians • Electrical technicians • Marine engineer (class 4 or higher) for offshore and onshore maintenance work • Storage for replacement parts/PTO systems • Welding and machining • Health & Safety/Emergency Response