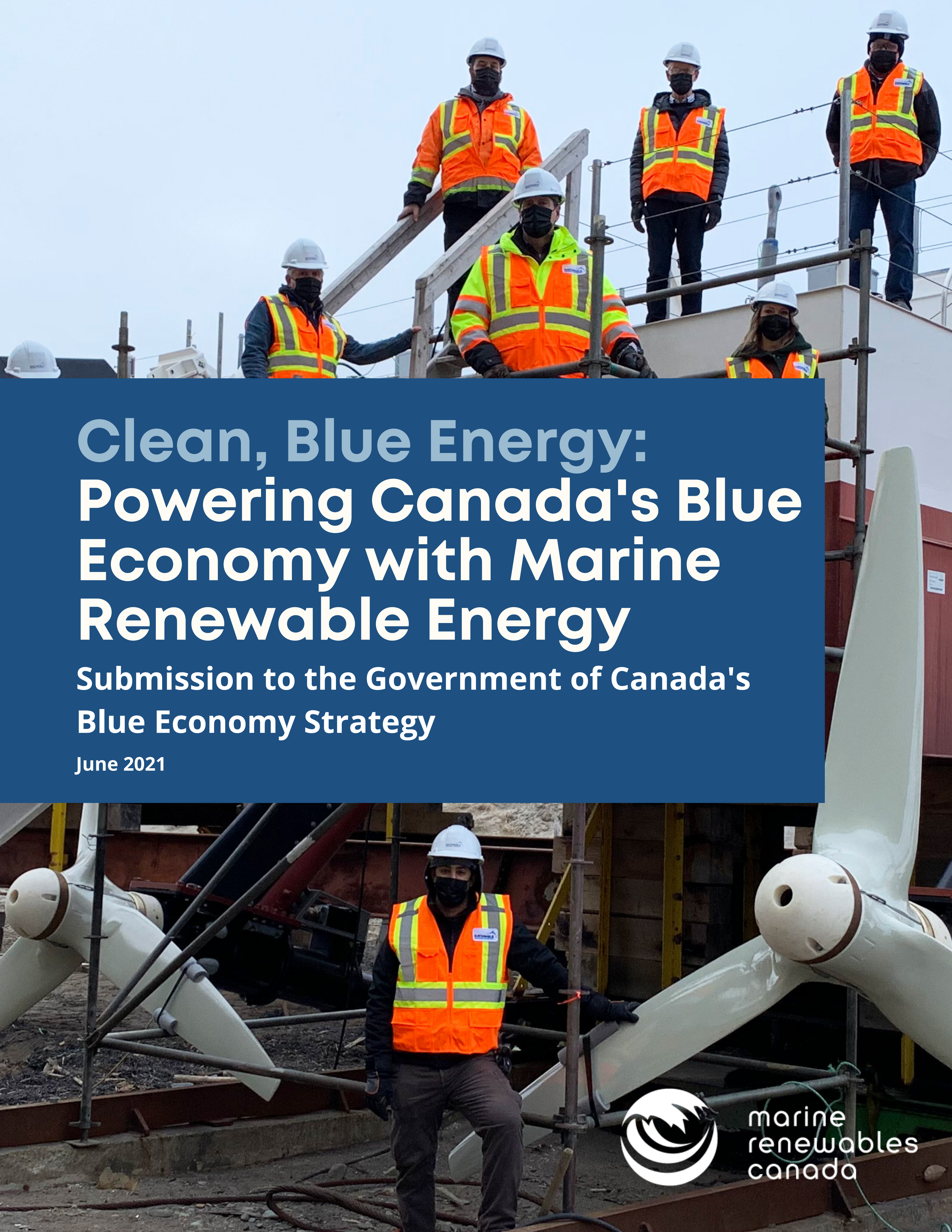

Clean, Blue Energy: Powering Canada's Blue Economy with Marine Renewable Energy

Submission to the Government of Canada's Blue Economy Strategy

June 2021

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TABLE OF CONTENTS

1 Introduction 2

2 Global Context and Market 5

3 Canada’s Marine Renewable Energy Opportunity 10

4 Our Vision 15

5 Key factors for sector growth 18

6 Recommendations 25

References 29

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1 INTRODUCTION

Marine renewable energy (MRE) from tides, waves, rivers, and offshore wind has the potential to drive Canada's Blue Economy Strategy in a way that no other ocean sector can. As the sector advances, Canada generates more clean power, reduces emissions, slows ocean acidification, sea level rise and coastal erosion, revitalizes and grows the ocean industry supply chain, and supports the ocean industries' transition to net zero. MRE technologies have the ability to generate electricity and fuels that can power marine transportation, aquaculture, and offshore oil and gas. Marine renewables are uniquely positioned to help achieve two of Canada's key priorities: building the Blue Economy, and fighting climate change.

Canada's MRE resources are largely untapped, offering enormous potential to deliver on economic recovery and decarbonization agendas. They present a market that has proven to be resilient, with major growth potential. While other markets suffered significant impacts due to the COVID-19 pandemic, global renewable electricity installation hit a record level in 2020. An International Energy Agency (IEA) report indicates that this growth has been fuelled by investors who have an increasing appetite to invest in sectors providing climate change solutions [1]. Strengthening and bolstering MRE in Canada will foster greater resiliency, while encouraging and attracting investment for sustainable growth.

The Government of Canada – and provinces – have committed to achieving net-zero by 2050: this target will require the development of numerous clean energy resources. Recently, the IEA published its roadmap to achieving net zero by 2050 and noted that "reaching net zero by 2050 requires further rapid deployment of available technologies as well as widespread use of technologies that are not on the market yet" [2]. Most MRE technologies are in the pre-commercial stage (with the exception of offshore wind) but can play an important role in Canada's future. As the IEA also noted, "major innovation efforts must occur over this decade in order to bring these new technologies to market in time" [2].

Canada has some of the world's best MRE resources, with tidal energy alone having an estimated potential of 40,000 megawatts (MW): enough clean power to displace over 113 million tonnes of CO2 (equal to removing over 24 million cars off the road).

Adding wave and river, the potential climbs to 340 gigawatts, enough energy to power every home in Canada five times over. The country's offshore wind energy potential is still being mapped, but projected to be larger still.

In addition to the domestic opportunity from developing MRE, there is also the potential for Canada to export to an estimated 1300 GW global market by 2050, valued at more than $1.8 trillion[1][3] [4]. Developing MRE can also help to fulfil the Sustainable Development Goals (SDGs) adopted by the United Nations as global priorities for 2030: SDG7 aims to ensure affordable, reliable, sustainable and modern energy access for everyone, SDG8 promotes sustained, inclusive and sustainable economic growth, SDG9 aims to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation; SDG13 urges action to combat climate change and its impacts, and SDG14 calls for conservation and sustainable use of oceans, seas, and marine resources [5].

Challenges remain. MRE technologies are relatively new, capital intensive, and typically operate in harsh environments; these factors can make it challenging to attract financing. The sector is often evaluated against more mature renewable resources that may not necessarily offer the same benefits, and may have received greater support to achieve cost reductions. Regulatory uncertainty in the sector impedes project development and puts private sector financing at risk.

But the potential for water – the largest resource on the surface of the planet – to play a role in our clean energy future continues to attract activity. Canada has been building a MRE industry for the last decade. About $125 million has been invested by the public sector which has in turn, attracted an estimated $225 million of private sector investment. These investments have created new jobs and business in rural and remote parts of the country. Researchers and academic institutions have contributed to growing the knowledge around environmental, technical, and social questions impacting sector advancement. Technologies have been tested, refined, and progressed closer to commercial viability. Canadian suppliers and researchers have exported expertise gained from early projects to international markets. And overall, Canada is well recognized as a global leader in this sector – even at this early stage when projects are yet to be commercial or a major contributor to the electricity system.

[1] All amounts featured in this document have been converted to Canadian Dollar (CAD) using rates on June 9, 2021.

The Government of Canada's Blue Economy Strategy, by advancing the MRE sector, can not only help meet federal targets for clean energy, climate change, and economic recovery, but also place Canada in a position of global leadership in the Blue Economy. Marine Renewables Canada is excited by the close alignment between the sector's goals and those of the Blue Economy, and is pleased to share information on the benefits of the sector, the opportunities Canada can realize through developing MRE resources, the key factors for sector growth, and the steps that can be taken to support the sector's potential.

For the purposes of this document, the MRE sector comprises tidal (tidal stream), offshore wind, wave, and river current energy. Although river current energy is not an offshore renewable resource, river current employs similar technologies to tidal stream; as such, river current energy has been recognized by national organizations as a MRE resource [6].

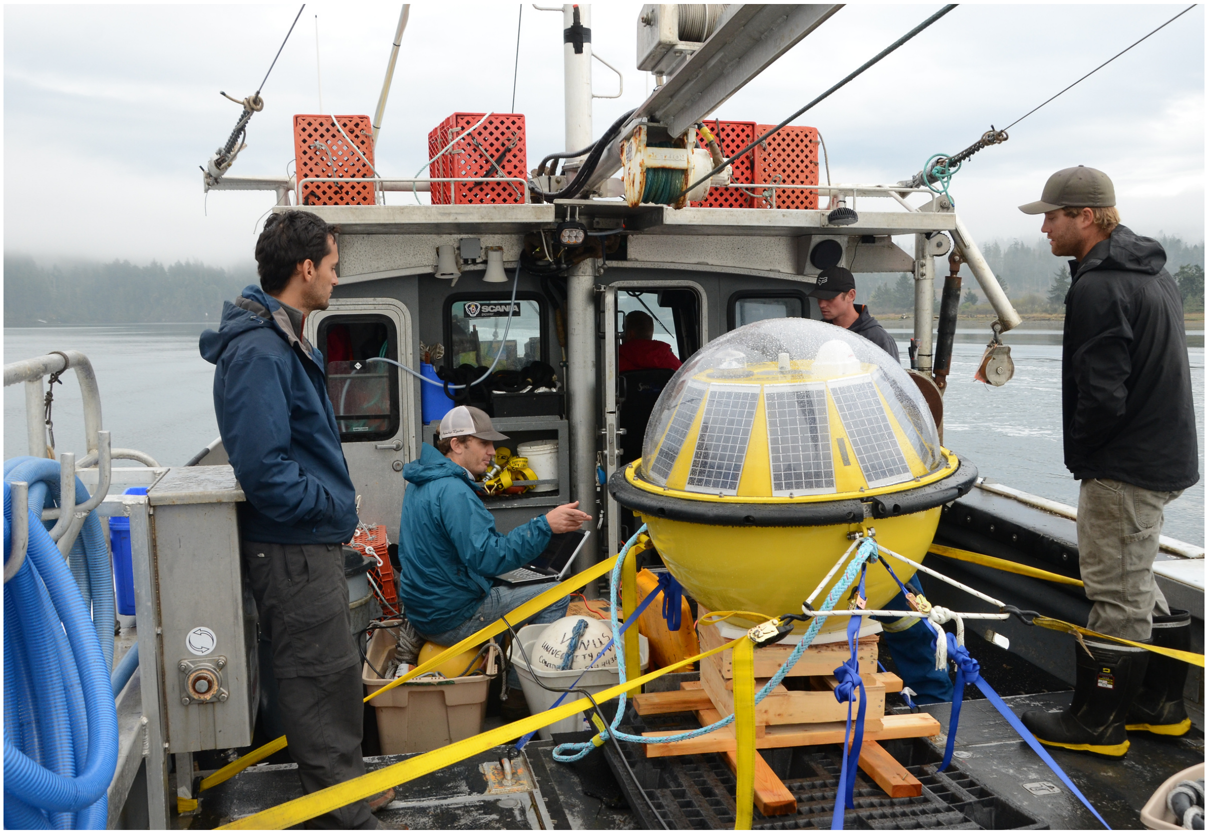


Image: Work underway by researchers at the University of Victoria to support wave energy research in British Columbia.

2 GLOBAL CONTEXT & MARKET

MRE is experiencing increased interest and support around the world. Beyond its contribution to clean energy targets, MRE resources are also being pursued by many countries for the long-term sustainable economic benefits. The IEA's Ocean Energy Systems estimates 300 GW of wave and tidal to be developed by 2050, resulting in 680,000 jobs, $42 billion in investment and carbon savings of 500 million tonnes of CO2. Over the past ten years, Europe alone has invested $440 million in MRE R&D and the European Union recently launched a strategic roadmap with policy and funding measures to achieve 1GW of wave and tidal capacity by 2030 [7]. Most notably, the offshore wind sector has become one of the fastest growing energy markets in the world, estimated to reach 340 GW (valued at $1 trillion) by 2030. Rapid growth of offshore wind has helped achieve major cost reductions and has attracted the interest of oil majors who are transitioning their businesses to comply with net zero mandates from governments around the globe.

Tidal, river current, and wave market

Theoretical estimates for tidal energy show that there could be up to 1,200 terawatt hours (TWh) of electricity potential, while wave resources present up to 29,500 TWh of potential [3]. To put this in perspective, one terawatt hour could power about 83,300 households per year in Canada. Energy from river currents is also substantial, especially in Canada – but worldwide estimates of the resource have yet to be produced.

Tidal, river current, and wave energy technologies are still in the demonstration and pre-commercial stages. Growth of the sector over the last fifteen years has been slower than predicted, but modelling suggests that the rates of growth seen in the offshore wind sector in the last 20 years will be reproduced in the wave and tidal sector between 2030 and 2050 [3]. At the end of 2020, a total capacity of 12.91 MW of tidal and wave energy was operational [8]. IRENA estimates that the sector will continue to grow with a cumulative tidal stream and wave installed capacity of 3 GW over the coming years, and possibly a total of 10 GW by 2030 [8].

The cost of electricity from tidal, river current, and wave energy is still higher than other forms of renewable energy: estimates place the cost of tidal energy between $0.24 kWh and $0.54 kWh and the cost of wave energy between $0.36/kWh and $0.67/kWh [8].

Studies have shown that cost reductions can occur through building volume, economies of scale, turbine size, and industry learning through demonstration [9]. Demonstration projects consisting of multiple devices are critical to getting costs down.

Over 30 countries are working towards facilitating MRE development, and some have significant policies, funding, and supports to spur growth. France, Ireland, Italy, Portugal, Spain, Sweden, United Kingdom (UK), Australia, Canada and the United States (US) have the largest number of projects tested, deployed and planned. To date, government supported R&D and incentives have been necessary to support technology and project development and have also been one of the key motivations for private sector investment. Commercial markets are not yet driving development of tidal, wave, and river current energy because the costs, on a project basis, are still too high. However, the industry is evolving: there have been multiple deployments of single devices worldwide; the focus is now on multiple-device deployments that will build scale, attract private sector investment, and help achieve cost reductions.

Offshore wind market

Offshore wind is growing quickly, with approximately 34 GW deployed at the end of 2020 and is estimated to reach over 234 GW in capacity by 2030 [10] [11]. Once viewed as a less mature renewable energy technology, offshore wind has been proven to be commercially competitive as a result of accelerated deployment. The levelized cost of energy (LCOE) for offshore wind fell 28-49% from 2014-2019 and its anticipated there will be a further 35-41% reduction by 2050 [12].

Given its enormous growth potential, many governments across the globe view offshore wind as a major contributor to post-COVID economic recovery. Denmark, China, Germany and the UK were some of the first countries to engage in offshore wind, and to date about 90% of the global installed offshore capacity is commissioned in the North Sea [13]. Other countries are working quickly to enter the market: France has increased its annual offshore wind tendering target to 1 GW until 2028; Japan has set a target of 45 GW by 2040 and Taiwan, a target of 15GW by 2035 [14]. The United States has targeted 30 GW by 2030 [15].

Offshore wind is also facilitating the energy transition of other energy sectors. For example, Hywind Tampen, an 88 MW floating offshore wind project located in Norway, will provide a clean solution for powering about 35% of the annual demand of five offshore oil and gas platforms. The wind power solution will help reduce the use of gas turbine power for the offshore fields, offsetting 200,000 tonnes of CO_2 emissions per year [16]. Some countries are also using offshore wind to produce green hydrogen, another growing global market.

Global markets for MRE

MRE advancement in Canada not only serves domestic net zero and sustainable economic goals, it provides access and opportunities to a range of growing global markets.

- ***Utility-scale and baseload power***
  MRE can provide reliable, predictable baseload power at a large scale depending on the site location and resource. Studies indicate that tidal energy, in particular, can be advantageous for baseload electricity. With four generation cycles per day tidal energy has proven to limit the use of backup oil generators in regions using diesel fuel [17].

- ***Remote communities, islands and coastal regions***
  Regions at disproportionately higher risk due to climate change, such as small island developing states (SIDS) and least developed countries, are examining domestic renewable resources as a means to relieve power constraints and promote economic growth. Remote communities, islands and coastal regions typically meet their energy needs through exchanges with mainland via submarine cables or their own fossil fuel-based generation facilities.

  These markets tend to coincide with good resource potential for MRE technologies; due to the high costs of incumbent energy technologies (such as diesel), MRE can offer a cost competitive and effective solution. In reference to their community-based river current project in Igiugig, Alaska, village councilors commented: “What we’ve achieved to date is remarkable… with the recent purchase of our battery energy storage system, we are looking at the potential to go diesels off in 2021,” and “The Igiugig community now has the capabilities to deploy and retrieve [the device] with very little help…our growing autonomy and skill set around operation and maintenance of the system make the project much more cost effective for us” [18].

Markets for marine renewable energy
(adapted from the OES and US Department of Energy blue economy reports)

- ***Power at sea (off-grid applications)***
  A growing number of countries have been exploring MRE as an enabler to advance the goals of other blue economy industries. Recent studies led by the United States Department of Energy, Ocean Energy Systems (OES), and International Renewable Energy Agency (IRENA) have found that MRE can provide a cost competitive solution for ocean industries that require access to consistent, reliable, and clean power untethered to land-based power grids [19] [20] [21]. These include traditional ocean sectors such as shipping, offshore oil and gas, fisheries and ports that are increasingly focused on implementing sustainable energy solutions as well as high-growth industries such as aquaculture, ocean observing, marine robotics, biofuels, and seawater mineral extraction. These markets are paying high electricity prices compared to mainstream markets because they mostly use diesel generators and electricity consumption per capita is low which impacts price responsiveness.

- ***Desalination***

  With the global population growing, there is increasing demand for fresh water for industrial, agricultural, power generation, and domestic (human consumption) uses [21]. Seawater desalination is becoming a primary source of potable water for several regions, particularly the Middle East and North Africa [21]. Currently, desalination is supported mostly by fossil fuels and as the need for fresh water in many countries increases, new desalination plants are being developed that increase energy demand and result in additional carbon emissions. MRE can be used to power desalination, leading to the sustainable production of fresh water. For example, wave or tidal powered desalination could be used to directly pressurize seawater without generating electricity for a reverse-osmosis system [19]. This eliminates one of the largest cost drivers for desalination.

- ***Green hydrogen***

  Government interest in green hydrogen as a potential contributor to achieving net zero by 2050 continues to grow. For hydrogen to play a significant role, production needs to increase dramatically in the coming decades. The MRE sector, in particular offshore wind projects with surplus supply, can produce green hydrogen. Current projects include Shell, Equinor and RWE co-operating on a Dutch 10+ GW offshore wind—green hydrogen project, NorthH2; RWE and Shell are collaborating on the 10 GW AquaVentus project in Germany, alongside Vattenfall, Siemens, Vestas, and Canadian owned and based, Northland Power; and Repsol, Vattenfall and TechnipFMC recently signed off on a pilot project in Norway.

  The use of tidal energy for hydrogen production is also being explored. In Scotland, the European Marine Energy Centre (EMEC) has established a hydrogen production plant that produces green hydrogen from excess tidal energy that is then used locally in a variety of fuel, power and heat applications in hydrogen technology projects [22].

3 CANADA'S MARINE RENEWABLE ENERGY OPPORTUNITY

The MRE sector strengthens Canada's pursuit of a strong blue economy, spurs the decarbonization of traditional industries, and accelerates action on climate change. Canada's support for MRE development offers the following benefits:

- ***Contributes to sustainability and net zero goals of other ocean industries***
  Canada's traditional ocean industries such as marine transport and offshore oil and gas are developing net zero strategies that incorporate the integration of clean technologies. MRE can provide clean solutions. For example, offshore wind for clean electrification of offshore oil and gas platforms in Newfoundland and Labrador is being assessed with support from the Emissions Reduction Fund. Industry is also working to understand the potential for using offshore wind to produce green hydrogen that could be used for marine transport.

- ***Contributes to economic recovery and development***
  The development of MRE can help revive businesses that have experienced impacts of the COVID-19 pandemic and downturns in traditional ocean industries. For example, Nova Scotia and Newfoundland and Labrador have many businesses with decades of experience from servicing offshore oil and gas operations. They are looking for opportunities to transfer their skills and expertise. Tidal energy development in Canada has already engaged over 500 different suppliers. Growth of the sector and the possible introduction of offshore wind development in Canada presents long-term opportunities for job creation, innovation, and export.

- ***Supports goals for increased electrification***
  Canada will need to generate upwards of three to five times the amount of clean electricity currently being generated in order to meet net zero by 2050 targets [30]. MRE is more energy dense, more predictable, and more reliable than other renewable energy resources. It supports the integration and uptake of more intermittent resources like onshore wind and solar, and cuts down

the need to build new grid infrastructure and battery/smart grid storage.

- ***Provides a clean electricity resource for remote, coastal and Indigenous community resiliency and self-sufficiency***
  Canada has 270 remote communities. Over 60 per cent of these are Indigenous and over 200 of the communities have their own fossil fuel plants, using diesel or fuel oil [23]. While many of these communities have access to different renewable energy resources, MRE may present the more optimal technology in some cases where wind and solar are not as plentiful or reliable. Over 100+ remote communities in Canada have access to a marine renewable energy or waterpower resources.

  With many Indigenous communities reliant on diesel, MRE presents both a clean energy solution and an opportunity for skills and expertise development. Supporting MRE planning in Indigenous communities can result in greater capacity and knowledge to develop community energy plans and assess the opportunities and risks of development. Growing the knowledge base about MRE within Indigenous communities will also assist with communities making decisions on how they may get involved or partner in projects.

  A focused effort on developing remote community MRE projects can also lead to the development of innovative systems and technologies that can be exported to international remote and island regions.

- ***Creates a new opportunity to diversify and adapt the offshore and marine supply chain***
  As a new sector, MRE requires a skilled workforce. Canada's experienced supply chain in traditional marine and offshore industries give Canada a natural advantage in the sector. Canadian suppliers that have historically worked in offshore oil and gas, defence, and other ocean sectors are already finding opportunities in the domestic and international MRE sector. For example, over 300 local suppliers have supported tidal energy projects in the Bay of Fundy. A growing number of Marine Renewable's Canada's members are engaged in international tidal and offshore wind development including Atlantic Towing, AXYS Technologies, BMT, DSA Ocean, Dominion

Diving, Growler Energy, Horizon Maritime, LOGISTEC, London Offshore Consultants, MacArtney, Northland Power, Ocean Sonics, Pangeo Subsea, Scanmudring, Seaforth Geosurveys, and Stantec.

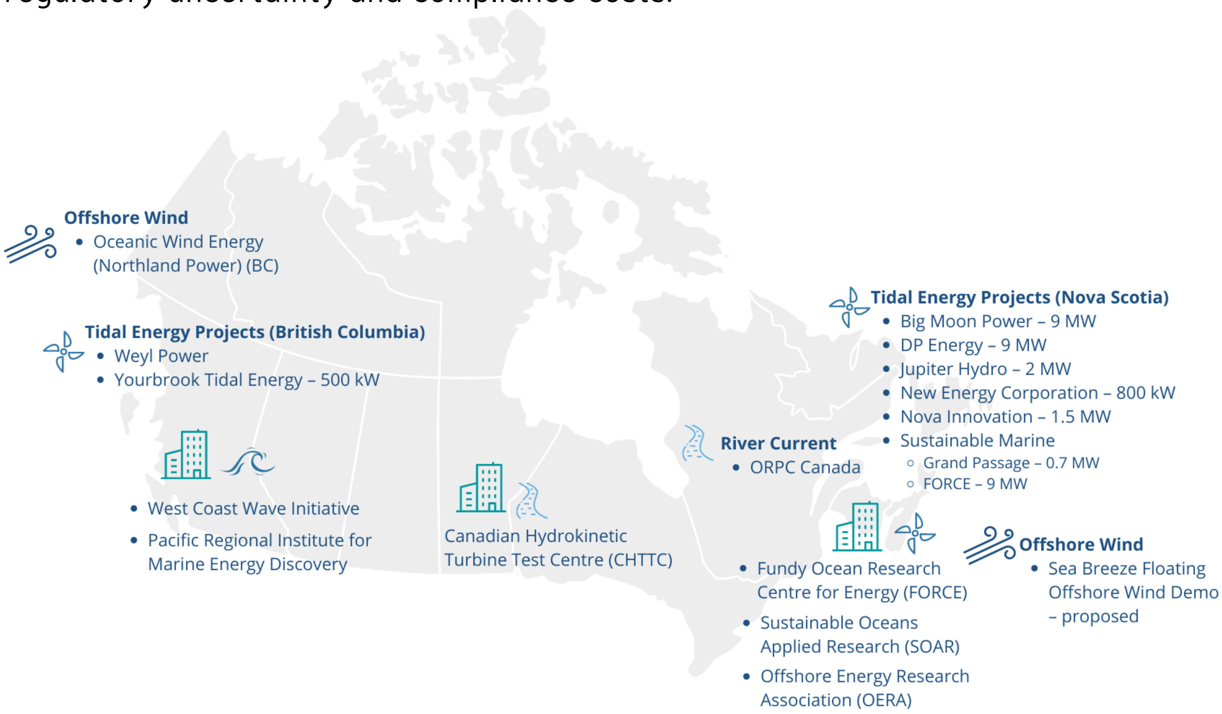
US offshore wind development has also spurred opportunities in Canada for suppliers and infrastructure. For example, in Spring 2020, Dominion Energy and Ørsted delivered turbine components and monopiles to Woodside (Port of Halifax) in Dartmouth, Nova Scotia before they were loaded on the installation vessel, Vole au Vent, for the 12 MW Coastal Virginia Offshore Wind (CVOW) pilot project. This work arose from limitations due to the US Jones Act which requires that any transport of goods between US ports to be done on US built, crewed and flagged ships. Currently, there are no US offshore wind installation vessels, which creates an opportunity for Canadian ports in close proximity.

A foundation for growth – Canada's MRE sector

Canada is already well positioned to continue building and growing its MRE sector. As a result of public sector support and investment in foundational R&D and infrastructure, the level of technology and project development has increased in Canada. This is particularly true of Nova Scotia, where the provincial government has championed tidal energy, establishing the Fundy Ocean Research Centre for Energy (FORCE) with support from the Government of Canada, feed-in tariffs (FITs), a demonstration permitting program, R&D support, and legislation designed specifically to guide the sector from prototype demonstration to commercialization: the Marine Renewable Energy Act.

Nova Scotia has successfully attracted over $200 million in international investment, engaged researchers and suppliers, created new business opportunities and jobs in rural communities, and catalyzed the development of a long-term, homegrown clean electricity industry. Currently, approximately 30 MW of renewable electricity is permitted and under development. At FORCE, DP Energy will be developing its Uisce Tapa project, a 9 MW project awarded $29.7 million by the Government of Canada under its Emerging Renewable Power Program (ERPP). More recently, Sustainable Marine was awarded $28.5 million through the ERPP to deliver up to 9MW at the FORCE site using its PLAT-I floating in-stream tidal energy technology and BigMoon Power was successful in winning a bid to occupy FORCE's vacant berth. In addition to these larger projects, there a number of smaller developments underway in other areas of the Bay of Fundy, with Nova Innovation, Jupiter Hydro, and New Energy Corporation all having received permits.

Over the last decade, a tremendous effort has gone towards building the body of knowledge on tidal energy in Canada. The sector has benefited from a strong network of research expertise from post-secondary institutions, research and innovation organizations, and the enabling activities provided through FORCE. At this early stage, with few deployments, there has already been significant work done to understand potential environmental effects, technical issues, and broader socio-economic impacts. FORCE has been steadily gathering data integral to environmental monitoring and most recently has been leading the Risk Assessment Program (with support from the Government of Canada), a project designed to create a detailed, credible assessment tool to gauge the probability that fish will encounter a tidal device. This project will help to support greater regulatory clarity around tidal energy project development. Related to potential environmental risks, the Offshore Energy Research Association (OERA) has been leading the Pathway Program, a collaborative environmental effects monitoring research program aimed at reducing regulatory uncertainty and compliance costs.



Current Activity in Canada's Marine Renewable Energy Sector

Other regions of Canada are also making progress in the sector – many with a focus on providing clean electricity to remote communities and off-grid applications. Smaller, community-scale tidal energy projects have been demonstrated in British Columbia, along with corresponding research on technical and environmental aspects. To date, over 30 investigative permit applications for tidal energy have been made in British Columbia, but few projects are under development – largely due to the lack of policy and funding supports [24].

Wave energy development has been supported on the west coast through enabling R&D led by the University of Victoria (UVic). Through UVic's work, there is now enough detailed information on the height, frequency and direction of its coastal waves to start developing and testing energy converters in the ocean.

UVic has also expanded its efforts to support and reduce risks for remote, coastal, and Indigenous community projects by establishing the Pacific Regional Institute for Marine Energy Discovery (PRIMED).

Canada is also home to the Canadian Hydrokinetic Turbine Test Centre (CHTTC), a test centre for river current (hydrokinetic) energy turbines. CHTTC has carried out numerous deployments with MRE device developers, assisting in future commercialization of river current energy technologies, particularly for use in remote communities.

While not yet developed in Canada, offshore wind also holds huge untapped potential. Canadian-owned and based energy developers are already participating in the global offshore wind market, gaining experience and insight that can benefit future offshore wind development in Canada. For example, Northland Power is developing three offshore wind farms internationally: 1) Deutsche Bucht, a 252 MW project in the North Sea, Germany 2) Gemini, a 600 MW project in the North Sea, Netherlands and 3) Nordsee One, a 332 MW project in the North Sea, Germany. Northland Power recently acquired rights to develop, build and operate NaiKun Wind, a 400 MW offshore wind project in Hecate Strait, between Haida Gwaii and mainland British Columbia.

To date, over 3.6 GW of offshore wind energy projects have been proposed in Canada. The lack of a path to market has been a barrier, but as demand for clean electricity increases through greater electrification, offshore wind energy could play an important role.

4 OUR VISION

To support Blue Economy and climate change goals, the potential of MRE should be fully explored, understood, and supported.

Vision: Marine renewable energy providing a clean energy solution for increased electrification and action on climate change, while contributing to a resilient and sustainable Blue Economy for Canada.

With the right supports and measures in place, Canada can grow a sustainable MRE sector that contributes to many objectives of building a Blue Economy. The following vision illustrates what could be accomplished by 2030 and by 2050 (to reach net zero goals).

- **Canada is respected as a world leader in tidal energy with expertise in both large- and small-scale projects**

  By 2030:
  - Nova Scotia's currently permitted projects have been installed and are successfully generating approximately 30 MW of installed capacity, contributing to cost reductions,
  - New projects are in the pipeline at FORCE, slated to occupy the full 64 MW of subsea cable capacity,
  - Additional small and community-scale sites in Nova Scotia and British Columbia are licensed, operational or slated for activity,
  - Indigenous groups, suppliers, and rural communities have increasing opportunities for participation and ownership in the growing tidal energy sector,
  - Potential environmental impacts are well understood as a result of more device deployments and continued data collection and monitoring, and
  - Canada has established the expertise, technology, and skilled workforce to support both national and international markets.

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By 2050:

- The sector has successfully demonstrated the benefits of predictable, clean electricity, providing baseload power and cost savings to the electricity system,
- 2 GW of tidal energy projects are operating or in development,
- Projects can reach installed capacity on the time-scales needed to meet any potential electricity export opportunities, and
- Tidal energy is to Canada what wind has been to Denmark: a homegrown opportunity, creating thousands of jobs, and realized by building an early competitive advantage.

- **MRE powers remote communities and other blue economy markets**

By 2030:

- 15-20 remote communities are using and demonstrating MRE technologies as a solution to displace diesel,
- Canada completes resource assessments and atlases for MRE potential in remote communities; this accessible database attracts new communities into the sector,
- Other ocean industries (e.g. offshore oil and gas, aquaculture) are partnering and demonstrating MRE technologies to meet needs for clean power and reduced emissions, and
- Government programs facilitate the use of MRE in Indigenous, coastal, and remote communities through eligibility requirements and resource assessment.

By 2050:

- 50+ remote communities are powered by MRE,
- MRE is a common part of the options for Indigenous, remote, and coastal, community electricity resources,
- Aquaculture sites and other ocean industries are powered by MRE to achieve net zero emissions, and
- Canadian MRE technologies and innovation are exported to the global market for off-grid coastal, remote and island clean electricity needs.

- **Canada is an emerging market for offshore wind**

  By 2030:
  - Regional Environmental Assessments have been conducted by the federal government to inform offshore wind development,
  - Studies, assessments, and research to support offshore wind development have been completed and industry has access to data to inform development planning,
  - A regulatory framework is established for the leasing of offshore wind sites and all other aspects of development,
  - Canadian ports have been assessed to support domestic and international offshore wind development and necessary upgrades will be supported in conjunction with industry growth and opportunity trajectory,
  - A commercial pathway and framework to enable large-scale offshore wind development is established that can support a range of market opportunities – domestic electricity, electricity export, and hydrogen export, and
  - 2 GW of offshore wind planned and in the pipeline.

  By 2050:
  - 10 GW of offshore wind developed and in the pipeline,
  - Offshore wind is providing clean electricity for the domestic market and is available for export to the US (if an option),
  - Offshore wind is providing net-zero solutions for offshore oil and gas platforms and their operations,
  - Green hydrogen production from offshore wind is a burgeoning new market, creating export opportunities to international markets, and
  - Existing offshore oil and gas (and other ocean industry) expertise and supply chains are working to support Canada's growing offshore wind industry.

5 KEY FACTORS FOR SECTOR GROWTH

As MRE technologies progress, there are challenges that must be faced and barriers that must be overcome.

- ***Cost reduction and innovation***
  MRE projects are often sited in harsh, high-flow environments where deployment and operating costs are high. These costs are challenging to offset during this early stage: technology designs and development approaches are still evolving. The UK's Offshore Renewable Energy Catapult illustrated that tidal and wave energy can experience a similar cost reduction curve as offshore wind, through increased deployment as suppliers and developers overcome early design and operational challenges as well as incremental innovation and continuous learning. It is projected that cost reductions can be achieved over a relatively modest volume of deployment. For example, modelling for tidal energy has shown LCOE of $260 per MWh by 100 MW installed, $225 per MWh by 200 MW, and $155 by 1 GW [9]. An LCOE of approximately $0.11/kWh is expected to be reached between 2022 and the early 2030s, while the costs for wave would lag five years behind, reaching $0.26/kWh by 2025 and $0.20/kWh by 2030 [8].

  While MRE costs will come down, the sector requires sustained and coordinated innovation and commercialization efforts by industry and government. The demonstration of multiple devices in arrays is critical to driving costs down – government can enable and facilitate success by aligning funding support and regulatory pathways that are associated with the stage of technology and project development and potential risks.

- ***Environmental impact***
  MRE devices hold the potential for lower potential ecological impacts than conventional technologies. In particular, kinetic energy devices – such as tidal stream, river current, wave energy devices – reduce or avoid many of the known impacts of potential energy devices like hydro dams because they: 1) do not force marine life and migrating fish to pass through them, and 2) have smaller effects on water flow and sedimentation (which can lead to problems with erosion and land drainage).

Most of the sector, with the exception of offshore wind, is at a pre-commercial stage, with few long-term deployments to collect data on potential environmental effects. While research to date is positive, it is not extensive: uncertainty remains. This is largely an industry-wide challenge that continues to be assessed by researchers, regulators, and industry. In particular the 2016 State of the Science Report indicates [25]:

> “Most of the perceived risk to animals from MRE devices is due to uncertainty about the interactions because of the lack of definitive data, and continue to present challenges to permitting/consenting of commercial-scale development” [25].

The most recent report, published in 2020, summarizes the potential environmental impacts and knowledge from experience to date. Potential impacts include [26]:

- Collision risk: “Tidal and river energy devices may pose a risk of collision to marine mammals, fish, and diving seabirds. To date, there have been no observations of a marine mammal or seabird colliding with a turbine, and the limited number of interactions of fish in close proximity to a turbine have not resulted in obvious harm to the fish.[However] it is difficult to determine how well marine mammals, fish, and seabirds may be able to sense, react to, and avoid an operating turbine” [26].

- Underwater noise and disturbance: “Evidence suggests that underwater noise emitted from operational MRE devices is unlikely to significantly alter behavior or cause physical harm to marine animals” [26].

- Changes to habitats: “Overall, changes in habitat caused by MRE devices and arrays are likely to pose a low risk to animals and habitats if projects are sited to avoid rare or fragile habitats” [26].

- Effects of electrical cables: “The evidence base to date suggests that the ecological impacts of EMFs emitted from power cables from single MRE devices or small arrays are likely to be limited, and marine animals living in the vicinity of MRE devices and export cables are not likely to be harmed by emitted EMFs” [26].

Assessing impacts can be challenging when working in high-flow environments. Turbidity, current speed, and sedimentation can make it difficult to conduct research, collect data, and monitor effects as some sensing technologies may be available, but not originally designed to work in high-flow environments like the Bay of Fundy.

Central to retiring outstanding questions around environmental effects will be monitoring and data gathering – and these can only happen in tandem with the deployment and demonstration of devices. While there are unknowns and potential risks at this stage, those concerns must also be weighed against other environmental risks such as climate change which is already known to have impacts on ocean biodiversity. The development of MRE technologies poses a solution to climate change. Through collaboration and adaptive management, government and industry can ensure that these clean technologies play a role in ocean health that in turn, supports the sustainability and growth of other ocean industries.

- ***Leadership and a coordinated strategy***

  As an emerging clean technology and ocean technology sector, MRE has been governed and supported through multiple departments at federal and provincial levels. While the support provided to date has been integral to the success and achievements of the sector, there have been challenges created for industry due to programs and regulatory requirements not aligning to achieve the same end goal: a commercially viable industry. This challenge can be addressed through a departmental champion for the sector that leads and develops a cohesive sector development strategy and coordinates closely with other relevant departments. This would help ensure that any roadblocks and challenges are identified proactively.

- ***Regulatory predictability and a path to commercial viability***

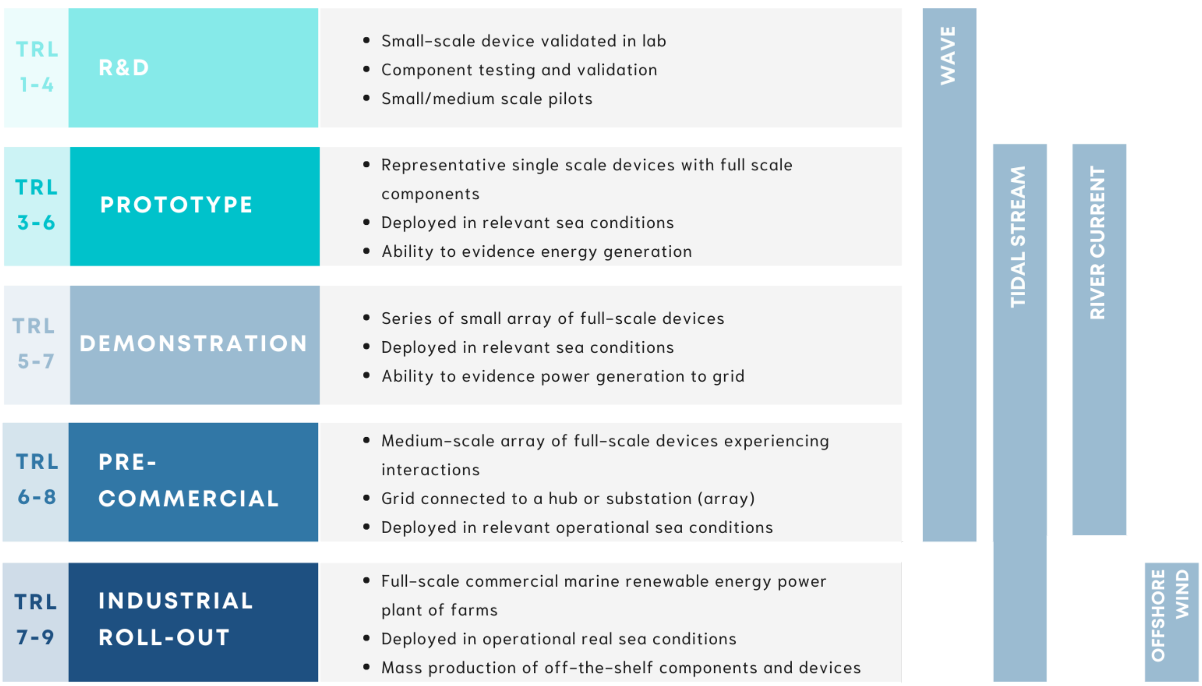
  A clear and predictable regulatory and policy framework is needed to support MRE development and growth. A roadmap detailing regulatory processes and requirements, along with written guidance for how to meet conditions of the permitting processes will help ensure that developers have adequate information to plan projects and provide investors with details on timelines and development milestones needed to access financing. Challenges with regulatory and permitting processes are a major risk for the industry as they can threaten investment and impact contracts and suppliers engaged in the project. Currently, Canada lacks a clear regulatory framework and guidance for the MRE sector. While the federal government has been working towards establishing regulations under the Canadian Energy Regulator Act for offshore wind development, it remains unclear what the processes will be for gaining access to a site and how multi-jurisdictional issues between federal and provincial governments will be managed. For tidal developers, they do not understand how determinations on the need for authorizations under the Fisheries Act are made; the industry has not seen nor understood the framework regulators use for decision-making and assessing risk. A predictable pathway and guidance on how projects can proceed from one phase of development to next (i.e., incremental device deployment) is missing.

Establishing clear, predictable regulatory frameworks and policies for MRE will help ensure that the sector can advance and that technologies and projects can scale-up to commercial viability. A proactive and collaborative approach amongst relevant government departments to further develop regulations, policies, and guidance will help address current permitting bottlenecks and facilitate project development. As frameworks and processes are developed, they should be appropriately-scaled to recognize the difference between technology demonstration and industrial-scale commercial build-outs.

- ***Integration with current uses and users***
  MRE projects co-exist with traditional and existing ocean communities and activities. Increases in installed capacity may be perceived as a threat or potential impact to other users and uses of the marine space such as fishing, oil and gas, recreational activities, aquaculture, navigation, and ecotourism. Early engagement, relationship-building, and ongoing communication are integral to understanding and addressing concerns of Indigenous communities, other stakeholders, and the public. Processes and actions to ensure proper engagement in legislation, policies, guidance, and/or industry best practices will serve to support sustainable growth of the sector.

- ***Funding and financing***
  MRE development's high upfront costs can make it difficult to attract private sector financing. The sector requires support to help with financing challenges, including investment in research, development and demonstration [8].

Like other clean technologies, a variety of mechanisms tailored to technology and project stage can support MRE financing. During R&D, early testing and demonstration phases, support is often acquired through capital support schemes such as grants or through special tools such as stage-gate metrics [8]. The phase between demonstration and first commercial deployment (also known as the valley of death) is critical for innovations and start-ups. At later stages of development, government can play a key role in helping developers attract private sector investment by providing support. For example, in Canada, the combination of a grant from the federal government and revenue stream support from Nova Scotia helped to de-risk projects from a financial perspective and helped attract private sector investment. Continued support, along with the right signals and measures, is necessary to grow the sector in Canada.



Innovation continuum for marine renewable energy
(adapted from the Ocean Energy Systems [31])

Several countries have established dedicated funding programs to support MRE growth. For example, the US Water Power Technologies Office spearheads several MRE funding programs and the UK's Offshore Renewable Energy Catapult, Energy Technologies Institute, and Carbon Trust have all managed specific funding programs for the sector [27].

Canada has yet to allocate resources towards a targeted MRE funding initiative or program; consequently, MRE R&D and MRE projects are assessed with metrics from more mature renewable energy technologies. Often eligibility requirements are not fully sensitive to the unique characteristics and development stage of the sector. Targeted funding specific to MRE would help to address key technology and innovation challenges more quickly, and accelerate development.

- ***Data for decision-making***

  Research and data are needed to inform industry and government decisions around MRE development. Resource assessment, seabed geology, wind and water conditions, electricity interconnection points, environmental baseline conditions, traditional uses, and many more factors are considered when siting and permitting MRE projects. Canada has supported some data collection around tidal, wave, and river current energy development, but regional and resource gaps remain – particularly for offshore wind.

  Government can play an important role in building the foundation of knowledge and data available for MRE development by:
  - funding initiatives for resource assessment and other types of data collection, and
  - hosting databases to make information publicly available

  The US Bureau of Ocean Energy Management (BOEM), for example, has established a public portal of offshore wind data: “California Offshore Wind Energy Gateway,” which provides numerous maps and data sets. Canada could establish a similar tool for MRE from coast to coast [28].

- ***Infrastructure***

  Infrastructure is fundamental to MRE development, including grid infrastructure, marine facilities and ports, and test centres. Support from government, including investment and coordinated strategies to enhance and build infrastructure, can spur investment and project activity.

Access to the grid: In some coastal and rural regions, electricity transmission infrastructure may not be adequate. Developing MRE resources may require upgrades to the grid, cabling, and smart grid infrastructure as well as investments in energy storage. While different areas of Canada also have grid challenges, some of the best tidal sites like the Bay of Fundy benefit from their close proximity to the existing transmission system. Building new grid connections or upgrades can be challenging from a regulatory and investment perspective.

Marine facilities and ports: Marine and port infrastructure for device deployments, operations, and maintenance in many prime MRE locations may not have all of the assets or capabilities required as the sector advances. There have been some analyses of ports in Atlantic Canada for both tidal and offshore wind, but long-range planning for the sector may optimize any future investment in infrastructure and ensure that Canada is prepared for growth.

Test centres: Test and demonstration centres like FORCE and CHTTC have played a critical role in facilitating technology and project development. Centres act as industry and technology incubators and can provide or assist with: site approvals and permitting, assistance with supporting technologies and methods, grid connection, targeted technical and environmental research, baseline studies and environmental monitoring, and stakeholder engagement. Demonstration centres will continue to play a role in developing the sector, particularly for tidal, wave, and river current energy, as industry works to advance towards commercialization.

Sustainable Marine's floating tidal energy platform, PLAT-I 6.40 launched from A.F. Theriault & Son Ltd. in Meteghan, Nova Scotia before future deployment at FORCE.

6 RECOMMENDATIONS

Canada can build its MRE sector and ensure that it plays a role in the Blue Economy by implementing a range of actions and measures that support the key factors for sector growth discussed in the previous section.

Marine Renewables Canada and its membership believe that the Government of Canada's Blue Economy Strategy aligns closely with the goals of the MRE sector; together, they can sustainably harness Canada's ocean growth potential. Canada can support MRE's potentially game-changing role in the Blue Economy by taking the following strategic actions:

#1 Establish a champion department within the federal government tasked with building the sector from an economic development perspective.

Actions:

- Focus on building the sector through an economic development lens, and coordinate all other required aspects (i.e., regulatory, funding and finance) with other necessary departments,
- Work with industry to assess progress on the 2011 Canadian MRE Technology Roadmap and establish a renewed sector action plan,
- Make a clear signal that Canada is committed to the development of MRE,
- Proactively support and enable the sector through mechanisms such as one-window processes, guidance, and advisory services, and
- Ensure funding and regulatory frameworks align with the innovation continuum of MRE technologies (as with all new clean technologies).

#2 Provide support to help reduce development and permitting risks for MRE projects.

Actions:

- Establish a regulatory pathway/roadmap task force with representation from relevant departments and in collaboration with industry,
- Support the establishment of a collaborative environmental research program (including government and industry) that identifies environmental permitting risks and supports research and data needs,

- Review the current regulatory framework for MRE and explore options for flexibility that enable investment and innovation,
- Equip the Department of Fisheries and Oceans Canada's (DFO) with dedicated staff/resources focused on MRE strategy and policy (in addition to the current focus on administration and enforcement of the Fisheries Act) that considers its economic benefits/Blue Economy potential, and
- Support and collaborate with industry on proactive and meaningful Indigenous and stakeholder engagement activities.

#3 Establish targeted financing and funding mechanisms for MRE R&D, technology demonstration, and project development.

Actions:

- Ensure funding criteria is sensitive to MRE technologies being clean technology, typically with high capital costs,
- Establish a funding program or stream that is specific to MRE and aimed at research and innovation that can accelerate cost reductions,
- Ensure that MRE is an eligible technology in government programs targeting emission reductions in the energy sector, renewable energy, ocean tech, etc., and that requirements for capacity/scale are appropriate for the stage of development,
- Contribute advice on the financing needs of the MRE sector to the UN Sustainable Blue Finance Initiative,
- Amend Income Tax Regulations for Canadian Renewable and Conservation Expenses (CRCE) to allow for flow-through shares to investors for test and demonstration MRE technologies,
- Enable Export Development Canada (EDC), Business Development Bank of Canada (BDC) and/or the Canada Infrastructure Bank to establish more accessible financing options for MRE projects and related electricity infrastructure, and
- Work with international development banks to support and match Canadian MRE technologies and expertise to clean electricity needs of developing regions.

#4 Foster and facilitate remote community and off-grid MRE opportunities by establishing tools and process for industry and communities.

Actions:

- Provide support for Indigenous, coastal, and remote communities to engage in community energy planning and MRE technology assessment,
- Enhance and extend initiatives underway by Natural Resources Canada to map remote MRE resources (including river current) to establish a robust resource assessment and list of high-potential sites, and
- Establish specific funding support for pilot off-grid projects that encompass the use of MRE for clean power applications (ex. aquaculture, desalination, marine observation, offshore oil and gas).

#5 Support Canadian engagement in domestic and international offshore wind energy development.

Actions:

- Provide support to assess domestic development potential for offshore wind and establish enabling conditions (e.g. data collection, data accessibility, regulatory framework),
- Establish a roadmap for offshore wind development that includes timelines for energy generation to send a clear signal that Canada is open to offshore wind development (in partnership with provinces),
- Implement a program for identifying and obtaining international opportunities for Canadian suppliers, including training, gathering market intelligence, fostering business relationships and developing market access strategies (in partnership with suppliers and Marine Renewables Canada),
- Provide support for Canadian infrastructure (e.g. ports) and suppliers to engage in international offshore wind energy projects, and
- Support further assessment of the synergies between offshore wind, tidal and wave energy sectors in terms of infrastructure, marine operations, and electricity system integration.

#6 Grow Canada’s MRE sector by fostering international collaboration

Actions:

- Continue to support Natural Resources Canada’s engagement in IRENA’s Collaborative Framework on the Ocean Energy/Offshore Renewables and the IEA’s Ocean Energy Systems,
- Support Marine Renewables Canada’s efforts to engage Canadian supply chain in international MRE projects,
- Stay informed about international industry best practices that can benefit Canadian sector development, and
- Continue to support the Canadian sub-committee for the International Electrotechnical Commission’s (IEC) TC114 international standards development for MRE.

Tides, waves, rivers, and offshore wind generate clean power, reduce emissions, slow ocean acidification, sea level rise and coastal erosion, boost the ocean industry supply chain, and support the ocean sector’s transition to net zero. MRE has the potential to drive Canada’s Blue Economy strategy in a way that no other ocean sector can.

Image: Roll Group’s Bigroll Beaufort vessel, Jan De Nul’s Vole au Vent Installation vessel, and Atlantic Towing’s harbour tugs involved in the delivery of offshore wind components to Woodside/Port of Halifax, Nova Scotia for the Coastal Virginia Offshore Wind project.

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ABOUT US

Marine Renewables Canada is the country's tidal, offshore wind, wave and river current energy association. We represent over 90 businesses and organizations including technology and project developers, utilities, researchers, and the energy and marine supply chain. Our focus is on ensuring Canada's largely untapped marine renewable energy resources contribute to clean electricity production, action on climate change, and building a sustainable blue economy.

Since 2004, the organization has worked to identify and foster collaborative opportunities, provide information and education, and represent the best interests of the sector to advance the development of a marine renewable energy industry in Canada that can be globally competitive.

More at www.marinerenewables.ca

Front cover photo

Sustainable Marine's floating tidal energy platform, PLAT-I 6.40 at A.F. Theriault & Son Ltd. in Meteghan, Nova Scotia in January 2021 before it's launch into Grand Passage. They are working to deliver the world's first floating tidal energy array at the Fundy Ocean Research Center for Energy (FORCE) in Minas Passage.

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