Funding and Financial Supports for Tidal Energy Development in Nova Scotia

Report to the Ocean Energy Research Association

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Executive Summary

If Nova Scotia achieves its goal of 300 MW of installed capacity in the Bay of Fundy, the undertaking will have generated an estimated $1.7 billion in GDP and $1.1 billion in labour income and avoided 9.7 million tonnes of greenhouse gas emissions over the years 2015 to 2040. The cost of energy would be high at first, while the technology is new, and reach parity with a combination of low-carbon and other renewable sources of electricity soon after 2040. By leading in the new global industry, Nova Scotian and Canadian ocean technology companies could participate in a global market worth approximately $4.4 billion per year by 2030.

The nascent tidal energy industry needs government partners while the technology is new and risks deter private-sector investment. To see the industry develop in Nova Scotia, the provincial and federal governments will need to support the industry, more in the early stages and less as the industry learns and becomes competitive with other renewables. The investment over the 25 years (2015-2040) would be an estimated $813 million.

The UK, Scotland particularly, France and Ireland have supported marine renewable energy (offshore wind, tidal and wave energy) and, except for wave energy, they have been developing at pace. Lessons learned from the failures of two wave energy technology developers, as well as setbacks in the tidal energy industry have informed new grant programmes and are directly applicable to tidal energy development support in Canada. Wave Energy Scotland (WES) serves as a model for future grant programmes.

It is important for funding programmes to be flexible, to be able to respond to what is needed in the industry as it progresses. As progress is made, important components, array-enabling technologies, sensors and monitoring technologies, as well as procedures and materials are needed. These are areas where Nova Scotian companies can develop a competitive advantage.

Of the programmes in other jurisdictions, several stand out as effective models and relevant to the Nova Scotia context. They include: Wave Energy Scotland; ADEME; price supports; the UK Green Investment Bank; the EU Fast Track to Innovation Fund; the SEAI Early Commercialization Fund (proposed); and the Offshore Wind Energy Fund.

A system of price support will still be needed to help the industry. France combined infrastructure investment and capital grants with a modest feed-in tariff, attracting developers to their sites. A feed-in tariff is one type of price support, a fungible renewables certificate is another.

An estimated time of 25 years until the cost of energy reaches grid-parity with low-carbon and other renewable sources means long-term support, though diminishing over time, will be needed to draw investment to the region. Beyond capital grants and a price-support mechanism, other supports would fit the later needs of projects, similar to the UK Green Investment Bank loans and other products, and a public-private investment fund. These would take some of the risks from commercial lenders and other private-sector investors. They would help lower the developers' cost of capital and, in turn, the cost of energy. The system of tax incentives, already in place for renewables and fossil fuels in Canada, can also help reduce the net upfront capital cost and cost of energy.

The financial institutions that have played a role in the UK, Ireland and France are the counterparts of Canada's Business Development Corporation, the Export Development Corporation, Nova Scotia Business Inc., the Atlantic Canada Opportunities Agency, and the Sustainable Development Technology Corporation. These are the organizations in Canada best suited to administer funding and financial support for tidal energy and marine renewable energy more broadly. They should be engaged early so as to gain experience with the tidal energy industry. As was done for the Wave Energy Scotland programme, these organizations will need to draw together

advisory panels consisting of people from industry, academia, investment, and insurance, to assess applications, identify technical milestones, and conduct stage-gate reviews of project performance.

Paramount to success are clearly defined and articulated overarching goals of the governments' program of funding and financial supports so developers and investors can gauge the breadth, depth and duration of the governments' commitment and provide a line of sight to when financing can be raised from commercial banks and private-sector investors. The government supports need to be clear, sufficient, stable and predictable so as to reduce uncertainty related to policy, financial, and market risks. As the industry becomes viable on its own, government support can diminish so as to make way for private-sector investment.

Summary

Within the global tidal energy industry, companies are now undertaking activities related to technology demonstration and demonstration of arrays. In Nova Scotia, at FORCE, demonstration arrays are planned by berth-holders. The costs of developing tidal energy are large and private, while the potential benefits are not only private but societal and environmental as well. Accordingly, provincial and federal governments have a role to play while the costs and risks at this stage are a barrier to progress.

In Scotland and France, where full-scale devices are being deployed and small arrays demonstrated, the funding and financial supports are largely a combination of demonstration grants and price supports through feed-in tariffs or renewables credits. The grants are not only for demonstrations of TEC devices but also of array-enabling technologies. While Nova Scotia's feed-tariff has been effective in attracting international developers to FORCE berths, for all but the largest companies, a feed-in tariff alone will likely be insufficient support for getting devices and arrays in the Bay of Fundy. A package of capital grants and price supports are needed, as well as continued investments in infrastructure.

Federal agencies and departments needed as partners are ACOA, SDTC, BDC, EDC, Innovation Science Economic Development Canada, and Natural Resources Canada. In Nova Scotia, the Department of Business and Consumer Services, and Nova Scotia Business Inc. have roles to play. These organizations should be engaged early to gain experience in the tidal energy industry and will need to draw on the knowledge of experts in industry, academia, investment and insurance in the design and oversight of project funding.

Funding and Financial Supports for Tidal Energy Development in Nova Scotia

1.0 Project Introduction and Scope

Nova Scotia's initiative to provide support for the demonstration of in-stream tidal energy conversion technologies in the Bay of Fundy has been effective in attracting companies from around the world. Preparations to demonstrate devices at five berths at the Fundy Ocean Research Centre for Energy (FORCE) are underway in response to government legislation, investment in FORCE, feed-in tariffs, and Sustainable Development Technology Canada grants.

The stages of technology development beyond demonstration are capital intensive and risky and private-sector financing is scarce. For the industry to progress, further government support in the form of direct funding and other financial supports will be needed. The nascent industry has yet to prove environmental and economic sustainability so a staged approach must be taken. What risks government can reduce through financial support, infrastructure investment, and clear policy and regulations will help incubate a sustainable industry and garner the opportunity to build and operate, innovate, sell technologies here and abroad, and reduce greenhouse gas emissions. [1]

To build upon Nova Scotia's progress in tidal energy development and help it gain momentum, this study has been undertaken to identify a suite of relevant government funding and financial support mechanisms, recommend a combination suitable for the Nova Scotia context, and identify the local entities that could administer the funding and financial supports for tidal energy development.

The cost of installed turbines in these early days are approximately $15 million per MW ($m/MW) of nameplate capacity. This estimate is based on the published cost estimates of early projects in the UK and France and the input costs used for the Nova Scotia demonstration feed-in tariff (see Table 1). The cost per MW is expected to decline as more capacity is built through improved technologies, materials, processes, and economies of scale, as shown in MeyGen's Phase 1b estimate of $7.8m/MW.

Table 1. Estimated cost/MW of early devices and arrays, based on published costs

Project	Published Cost Est.	CA $	MW	CA $ m/ MW
MeyGen - Phase 1a	£51 m (Capex)	$87.6 m	6 MW (4x1.5)	$14.45
EDF/OH - Normandie Hydro	€112 m (Capex & Opex)	$163.5 m	14 MW (7x2)	$11.68
Engie/Alstom - Nephtyd	€101 m (Capex & Opex)	$147.5 m	5.6 MW (4x1.4)	$26.33
Sabella - D10	€10 m (Capex & Opex)	$14.6 m	1 MW	$14.60
Synapse/UARB - FIT	$111 m (Capex & Opex)	$111 m	10 MW	$11.10
MeyGen - Phase 1b	£460 (Capex)	$782 m	100 MW	$7.82

Sources: www.atlantisresourcesltd.com; www.ademe.fr; www.sabella.fr; Synapse 2013; Tidal Today 2016.
€1=CA$1.46 £1=CA$1.70 (as of 10 Aug 2016).

Synapse (2013) estimated the levelized cost of energy (LCOE) of in-stream tidal in the Minas Passage to be $465 per MWh. According to the 2015 Value Proposition for Tidal Energy Development (Gardner et al 2015), if the industry reaches Nova Scotia's goal of 300 MW (NS DOE 2012) by 2028, the LCOE will decrease to an estimated $226/MWh by 2040.[2] The LCOE reduction is expected to occur as a result of learning, as the global industry grows and gains experience, and economies of scale. The value proposition report estimates the cost of

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[1] For a primer on tidal energy development in Nova Scotia, refer to the *Community and Business Toolkit for Tidal Energy Development* (2013), MacDougall, S. and Colton, J. (eds), available at: http://tidalenergy.acadiau.ca/community-business-toolkit.html.

[2] This estimate assumes no government funding or financial support. Support provided by government that lowers the developer's capital, operating or financing costs will correspondingly lower its LCOE.

electricity generated from the tides will be competitive with a blend of renewable and low-carbon alternatives (wind, distributed solar and natural gas) soon after 2040. The amount of support needed in the interim - the learning investment - will be approximately $813 million over the 25 years from 2015 to 2040. In that time, however, the total industry expenditure in Nova Scotia will be approximately $2.1 billion, generating $1.7 billion in GDP and labour income of $1.1 billion. Approximately 9.7 million tonnes of greenhouse gas emissions will be avoided by displacing coal in the generation of electricity. There is an estimated 2,500 MW of extractable power in the Minas Passage (Karsten et al 2008),[3] and potential to export electricity to north-eastern USA, if additional electrical infrastructure (transmission lines, interprovincial intertie or subsea cable) is built.[4]

There are many estimates of the potential size of the global tidal energy industry. In 2013, the Danish Hydraulic Institute estimated there to be 50-100 GW of accessible energy globally, with a potential market of €1 billion/year by 2020, €3 billion/year by 2030. Bloomberg New Energy Finance estimates total installations of tidal-stream facilities around the world reaching 148 MW by 2020, while industry trade association, Ocean Energy Europe, estimates 200 MW. In 2013, the International Energy Association estimated installed capacity could reach 23 GW by 2035, while the UK's Carbon Trust projects 55 GW by 2050. Reaching the latter capacity would entail an estimated cumulative expenditure of CA$ 900-1,000 billion. These estimates of growth assume the cost of energy will become competitive with other sources of electricity, at least other renewable sources. Cost reduction is an imperative if the industry is to outlive government support and thrive.

A number of countries are making progress in tidal energy development. At the forefront are the United Kingdom (particularly, Scotland), France and Canada. While Scotland made many of the early advances, changing government policies have disrupted its progress. The French government introduced well-timed and targeted support for the development of marine renewable energy and is challenging Scotland's lead. With regards to in-stream tidal energy development, Nova Scotia is, arguably, not far behind the leaders, UK and France. The Bay of Fundy's waters are challenging to harness but there is a large area with a fast tidal stream, offering potentially high energy yield and economies of scale, proximity to transmission lines, and to a large export market. These features, bundled with legislation, infrastructure and financial support form a package that will influence whether development in Nova Scotia continues to keep pace or not.

As developers move through the stages, installing demonstration units and demonstration and pre-commercial arrays, government regulations and financial supports need to be clear, sufficient, stable and predictable (Burer and Wustenhagen 2009; Leete et al 2013). Carefully defining and communicating the programme's overarching goals will help provide clarity and a line of sight to the time when private-sector financing can be raised. Examples of program goals are: meet emissions targets, improve energy security, diversify energy supply, support local economic development, diversify rural industry, lower (renewable) energy costs, develop green technology markets, create jobs, and create exportable technologies. Used as a touchstone, the goals also help ensure the elements of the package (regulations, infrastructure investment, financial supports, etc.) are complimentary and internally consistent.

The stages of tidal energy conversion (TEC) development, shown in Figure 1, will be referred to through this report. Globally, the ocean energy industry is having difficulty progressing through the demonstration and pre-commercial stages. There are a number of technologies in development: the energy conversion technologies

[3] Removing 2,500 MW of energy from the water would reduce the tidal height by an estimated 5% reduction (Karsten et al 2008). The near-field and far-field ecological effects of this change are not fully known. Research is ongoing.
[4] The 2015 *Value Proposition for Tidal Energy Development in Nova Scotia, Atlantic Canada and Canada,* estimated the maximum domestic demand for electricity generated from the tides to be 500 MW. Beyond that, to export to the New England states would require additional investment in facilities in the Bay of Fundy for the manufacture, assembly, staging and deployment of tidal devices; grid interconnections to support the export of tidal and other renewable electrical energy to the U.S. market; and a delivered cost of tidal energy that is competitive with alternative energy sources there (Gardner et al 2015 p.24).

themselves, component parts, and array enabling technologies, as well as processes and procedures. In the case of tidal energy conversion devices, only developers with strong balance sheets or large strategic investors are able to finance early deployments and make progress. However, for more than a small number of full-scale devices, balance sheet (corporate) financing becomes insufficient because the large capital requirements of a project can begin to alter the risk profile of the larger company.

Figure 1: Stages of TEC development

Stage	R&D[5]	Part-scale demonstration	Full-scale device demonstration	Demonstration array	Pre-commercial array	Commercial arrays
Activities	Generate idea, IP, develop prototype.	Test prototype in simulated environment, refine prototype.	Demonstrate full-scale prototype (device, reaction system, station keeping) in operational environment; prove technical validity in the field.	Demonstrate array - enabling technologies, demonstrate array; refine technologies, processes, materials.	Build small array in commercial marine area, commercial viability not yet achieved, technology costs still high.	Build large, commercially viable arrays.

Source: Bloomberg New Energy Finance 2010; ORE Catapult 2013.

The following section will provide a jurisdictional review of key marine renewable energy markets (Scotland, France, Ireland) and the funding and financial supports used there. Section 3 will provide an inventory and description of generic funding and financial supports suitable for renewable energy development. Section 4 will recommend a suite of funding and financial supports that could be used for the next phases of tidal energy development in Nova Scotia.[6] Section 5 will identify Canadian organizations capable of delivering a suite of funding and financial supports. Section 6 will present concluding remarks.

2.0 Jurisdictional Review

2.1 Stage of development

There are currently few in-stream tidal energy facilities delivering electricity: SeaGen in Northern Ireland (1.2 MW, commissioned in 2008 by SeaGeneration Ltd, now owned by Atlantis Resources); and Texel Tidal Project (Netherlands, 200 kW, commissioned in 2015 by Tocardo Tidal Energy). In the Pas du Fromveur, Sabella SAS is demonstrating its grid-connected D10 device (0.5 MW), which it installed in 2015. Cardiff-based Delta Stream Ltd. installed its 0.4 MW demonstration device in Ramsey Sound (near Pembrokeshire, Wales) in December, 2015.

Several large-scale[7] projects are under construction and expected to produce electricity within the year. These are full-scale devices being deployed in small arrays to demonstrate the technology in real-life conditions. They are:

- Paimpol-Brehat – EDF and DCNS OpenHydro – demonstration array, two 1-MW devices, installed, to be grid connected in 2016;
- Pentland Firth – MeyGen – four 1.5 MW devices, installation planned for 2016;
- Bay of Fundy – Cape Sharp Tidal - two 2-MW devices, installation planned for 2016.

[5] ORE Catapult activities: Proof of principle, component critical functions, design integration.

[6] Research and development funding will be intentionally omitted from this report. Mechanisms for supporting R&D and their effectiveness are well documented. What is needed next is support to move through demonstration and early arrays, which require large amounts of capital when risks (technology, supply chain, construction, operator, political/regulatory, market, and environmental (MacDougall 2013) are still high. Support for R&D will still be needed for continued improvement of technologies, materials, and processes to bring the cost of energy down but it is not the focus of this study.

[7] Large-scale refers to projects with ≥ 0.5 MW devices.

In Europe, several additional sites have been awarded contracts for near-term construction. France has awarded contracts for pilot arrays by 2018 in the Raz Blanchard, off the tip of Normandy. Electricité de France (EDF) and DCNS OpenHydro plan to install a 7-turbine array, each 2 MW, and Engie and Alstom will deploy 4 turbines of 1.4 MW each in 2017. France is aiming for 3 to 4 projects of 4- to 10-turbine arrays, to be constructed in the Raz Blanchard and Pas du Fromveur.

Other devices are in test centres, such as Scotrenewables' SR2000 floating 2 MW device. It is being installed at EMEC's Fall of Warness, a grid-connected test site, in Orkney, Scotland.

Case study: Private-sector investors in European tidal energy companies

ScotRenewables Tidal Power Limited

-ABB Group (power and automation technologies; Swedish-Swiss publically-traded company)
-Total New Energies (international oil and gas; French publically-traded company)
-Bonheur ASA (offshore drilling, renewable energy, shipping, offshore wind; Norwegian publically-traded company),
-DP Energy (renewable energy project developer; privately owned)
-Harland and Wolff Heavy Industries (shipbuilding and offshore construction, located in Northern Ireland, owned by Norwegian publically-traded company, Fred Olsen Energy, ASA, an international drilling contractor)
-Scotmarine Ltd (owner/operator of a specialized vessel servicing the marine renewables sector; Orkney-based, privately-owned company)

Tidal Power Scotland Limited

-Atlantis Resources (turbine and project developer, publically-traded company)
-Scottish Power Renewables (International electrical utility, owned by Iberdrola, SA)

OpenHydro

-DCNS Group (naval defense and energy company; 62.5% owned by the French State).

2.2 European funding and financial support

Magagna and Uihlein (2015) summarized the funding and financial supports offered to ocean energy in the European Union, as of May 2015. These are shown in Table 2 and updated by the author. They are categorized as "push" or "pull" mechanisms, which are defined as follows (LCICG 2012, Gardner et al 2015):

> **Technology-push** mechanisms are designed to facilitate the development of technology. Research and development grants for prototype development are a primary tool but technology push also includes capital grants for demonstration projects. Technology prizes fit in this category.
>
> **Market-pull** mechanisms create a demand or price for renewable electricity. A government-legislated renewable energy standard or quota, such as Nova Scotia's renewable energy targets (40% by 2020), creates market demand for renewable electricity. Many countries have these. A pricing mechanism that allows for a premium price to be paid, such as a feed-in tariff, or fungible green certificates, creates an adequate price. Together, these provide some confidence in there being a market for the electricity and the price to be received per unit delivered.

Table 2: Market push and pull mechanisms for ocean energy (EU) (2015)

Country	Type	Description
United Kingdom	Pull	Renewable Obligation Certificate (ROCs) Scheme. Tidal energy is eligible for 5 ROCS/MWh. Renewable Obligation Certificates (ROCs) buyout price set to £44.77 for 2016-17. The RO scheme will be replaced by a Contract for Difference (CfD) scheme in 2017, with technology bands, allocating a minimum of 100 MW for wave and tidal energy.
	Push	Renewable Energy Investment Fund (REIF) Scotland, £103 m.
		Marine Energy Array Demonstrator (MEAD), £20 m. MEAD aimed at supporting two pre-commercial projects to demonstrate the operation of wave and/or tidal devices in array formation for an extended period of time.
		Energy Technologies Institute (ETI), about £12 m for wave and tidal projects.
		The Crown Estate, £3 m spent for enabling activities in the area of project development processes, committed to invest and manage an additional £5.7 m in enabling actions for Pentland and Orkney. Plans to invest up to £20 m in first array projects.
		Marine Renewables Commercialization Fund (MRCF) Scotland, £18 m and £5 m for enabling technologies.
		Marine Renewables Proving Fund (MRPF), £22.5 m, managed by Carbon Trust. Awarded to six projects.
		Saltire Prize, Scotland, £10 m for first device delivering >100 GWh for two years.
France	Pull	Feed-in tariff for renewable electricity. Currently 15 c EUR/kWh for ocean energy.
	Push	ADEME, €1,125 m (renewable energy and green chemistry). Specific call for ocean energy. Funds projects with 4–6 machines at min. generation of 2,500 MWh per machine for 2 years. Eight projects submitted proposals, selection finalized by end of 2014. Each project to receive up to €30 m and benefit from a feed-in tariff of 17.3 c EUR/kWh.
Ireland	Pull	Feed-in tariff for ocean energy of 26 c EUR/kWh (up to 30 MW) from 2016.
	Push	SEAI Prototype Development Fund, €26 m.
		Ocean energy development budget will be increased by €16.8 m to €26.3 m by 2016, mainly for test centres.
		SEAI Sustainable RD&D programme, €3.5 m.
Portugal	Push	Fundo de Apoio à Inovação (FAI) for renewable energies, €76 m total.
Spain	Pull	Feed-in Tariff suspended for all renewables, replaced in 2014 by a scheme of a fixed annual investment bonus for existing installations.
	Push	EVE, €3 m scientific programme for ocean energy demonstration.
Denmark	Pull	Maximum tariff of 8 c EUR/kWh (sum of market price and bonus) for ocean energy.
	Push	Energinet.dk, €2.4 m for minor renewable energy technologies (e.g. PV, wave, bio-gasification) by ForskVE. In 2015 round, the programme for development and demonstration projects will provide about €13.4 m of funds.
Germany	Pull	Feed-in Tariff, 3.5–12.5 c EUR/kWh for ocean energy, depending on installed capacity.

Source: Magagna and Uihlein 2015 p.90.

There is a third category of support mechanisms, described by LCICG (2013) as **enabling actions**. Enabling actions help remove barriers to development or facilitate progress. They include: developing permitting processes, building publicly-funded testing facilities and demonstration sites, constructing infrastructure, streamlining consenting and permitting processes, and collecting and disseminating data collection (e.g. resource measurement and site characterization) (Gardner et al 2015).

Case Study: Tidal Power Scotland Ltd.

Atlantis Resources partnered with Scottish Enterprise Investment Bank (Scottish Enterprise) to create a holding company called Tidal Power Scotland, Ltd (TPS). This holding company owns the MeyGen project. Atlantis originally owned 85% of the shares of TPS. Scottish Enterprise owns 15%, in exchange for a £103 m investment via its Renewable Energy Investment Fund (REIF). Atlantis is inviting project developers to join, bringing their assets to TPS in exchange for shares and representation on its board. Atlantis' percent ownership of TPS will become proportionately less.

In December 2015, Scottish Power Renewables sold its tidal power business (100 MW at the Ness of Duncansby in the Pentland Firth and a 10 MW project at the Sound of Islay) to Atlantis Resources in exchange for a six percent stake in Tidal Power Scotland Limited, valued at £6.6 m. The project assets include Crown leases and, in the case of the Sound of Islay project, a grid-connection offer and construction consents.

Project	***Capacity***	***Location***
MeyGen	*380 MW*	*Pentland Firth*
Ness of Duncansby	*100 MW*	*Pentland Firth*
Sound of Islay	*10 MW*	*Sound of Islay*

Tidal Power Scotland is a project holding and development company. It is technology-agnostic. Atlantis Resources provides project development services on a contract basis to TPS. Atlantis Resources has also developed a tidal turbine that can be sold to TPS projects (Scottish Energy News 2015).

Table 3 profiles some of the prevalent and/or highly regarded funding mechanisms in Europe. The list is not exhaustive but it highlights the key funding and financial supports used to support tidal and wave energy development. Some of the supports have run their course and details of others are subject to change, especially in the case of the UK, as a result of the recent Brexit referendum.[8]

[8] On 6 June 2016, Ocean Energy Europe announced it "has obtained assurances from the European Commission that all existing contracts to award Commission funds and all financing contracts with the European Investment Bank for companies and organisations in the UK are still valid and binding. Moreover, for as long as the United Kingdom is a member of the European Union, companies and organisations in the UK have the right to apply for funding or financing under new calls or programmes" (http://www.oceanenergy-europe.eu/communication/industry-news/33-oee-publications/468-press-statement-ec-indicates-business-as-usual-in-the-wake-of-brexit).

Table 3: Funding and financial support programmes in other key marine renewable energy markets (Scotland, France, Ireland)

Program	Technology,[9] stage & form of support		Description
ADEME	Pilot arrays, marine energy Grants	Fr	As part of France's "Investing in the Future" program, the government is supporting the installation of pre-commercial marine energy arrays. In 2014, the French Environment and Energy Management Agency (ADEME) called for expressions of interest to develop pilot arrays to demonstrate the viability of tidal and wave energy, in advance of launching commercial projects. They are aiming for 3 to 4 projects of 4-10 turbines in marine energy parks in Raz Blanchard and Pas du Fromveur. There are three components to this program: one to demonstrate full-scale devices at sea, a second for array-enabling component technologies, and a third for pilot arrays. The ADEME funding is a mix of repayable advances, partially refundable aid, and capital grants. The proportion of each depends on the value of the eligible expenses (both capital and operating), the size of the business involved, and whether a research organization is part of the consortium. The funding is administered by France's General Investment Commission.
CfD	Marine energy Price support	UK	The Contract for Difference regime, part of the UK's 2013 Energy Act, gives renewable power developers fifteen-year contracts and sets the price they will receive for each MWh they produce. The CfD is a long-term contract between a renewable power developer and the Low Carbon Contracts Company (LCCC). Under the CfD, payments can flow from the LCCC to the generator, and vice versa. When the market price is below the price set out in the contract (strike price), payments are made by the LCCC to the generator to make up the difference. However, when the market price is above the strike price, the electricity generator pays the LCCC the difference. This reduces the variability of the price the generator receives for electricity for the duration of the contract. In April 2015, a number of contracts were awarded, with the prices set through competitive bidding. The UK government indicated a minimum of 100 MW of capacity under the CfD regime would be set aside for tidal and wave energy generation. The CfD price for tidal stream energy had been £305/MWh (real 2012£) but it is now under review. There is some uncertainty as to whether the £305 or another legislated price will be used or whether the strike price will be subject to a competitive bidding process. It is also uncertain whether tidal and wave will be competing with off-shore wind for the contracts.
Crown Estate Loans	First-array projects, marine energy Loans	UK	In 2013, the Crown Estate announced it would invest up to £32 m in first-array tidal stream and wave projects. To be eligible, projects would need consents, grid connection agreements, and a Crown Estate lease agreement. The Crown Estate provided the MeyGen Phase 1a project with a £10 m loan. The Crown Estate leases areas of the seabed and manages the associated seabed rights. They have leased 40 sites for wave, in-stream tidal, and tidal range projects. They also do research and technical studies to support project development.
ESIF	Sustainable economic development Grants	EU	The European Structural and Investment funds is the European Union's investment fund to support sustainable economic development and job creation. Its budget is €454 billion for 2014-20, and it is administered on a decentralized basis by the EU countries. Through the European Regional Development Fund (ERDF), €13m of ESIF funds were awarded in 2015 to Swedish company, Minesto, for the first phase of its 10 MW Deep Green tidal power project in Holyhead Deep, off the coast of Anglesey, Wales. There is €100 m available in Wales for marine renewable energy from this fund. The Sabella D10 project in the Pas du Fromveur, in France, also received support from the ERDF.

[9] Marine (renewable) energy includes offshore wind, tidal and wave energy. In Canada, it also includes run-of-river kinetic energy. Ocean (renewable) energy includes tidal and wave energy only.

Program	Technology,[9] stage & form of support		Description
ETI	Low-carbon technology Public-private investment fund	UK	The Energies Technology Institute is a public-private partnership between energy and engineering companies and the government. ETI makes commercial investments in low-carbon technologies and enabling infrastructure.
FORESEA	Ocean energy to TRL 5+ Funding to access test centres	EU	The Funding Ocean Renewable Energy through Strategic European Action initiative, announced in July 2016, is €11 m, funded by the European Regional Development Fund. The programme will offer a series of "funding and business development support packages" to fund ocean energy technology testing and demonstration of TRL 5+ technologies in ocean energy test facilities at EMEC (Scotland), SmartBay (Ireland), SEM-REV (France), or the Tidal Testing Centre (Netherlands) (Ocean Energy Europe 2016).
FTI	Innovation TRL 6-9 Grants	EU	The European Union's Fast Track to Innovation Pilot fund is administered by Horizon 2020, the funding mechanism for Europe 2020's *Innovation Union* research and innovation programme. Horizon 2020 is a €77 billion research and innovation funding program for the period 2014-2020. In 2017, €8.5 b will be released by Horizon 2020. Funding is allocated through competitive calls. The FTI is designed to provide funding to consortia of 3-5 organizations that are predominantly private, for-profit businesses, to support an innovation at approximately TRL 6, up to TRL 9, so to be ready for market launch. Funded activities include: • Advanced and specific R&D; • Standard setting and advanced performance testing/piloting/demonstration; • Validation of solutions in real working conditions/certification; • Business model validation (European Commission 2014). Projects must be close to market - within 36 months of market launch - and have strong business cases. FTI funds up to 70% and between €1-3m. Applications are evaluated by panel of 4 independent experts with commercial and financial expertise. FTI funding for two full-scale tidal energy testing and demonstration tidal energy projects at EMEC was announced in June 2016: Torcado's InToTidal project, and Magallenes' Ocean 2G project (Hydroworld 2016).
Marine Farm Accelerator	Technologies, methods for arrays, marine energy Grants	UK	Marine Farm Accelerator, led by UK Offshore Renewable Energy Catapult and the Carbon Trust is modelled after the Carbon Trust's Offshore Wind Accelerator. It is designed to develop the technologies needed to reduce the cost and risk of early arrays, in particular, electrical systems, yield optimization, installation methods, insurance, O&M, site characterization, electrical architecture, subsea electrical connection systems, uncertainty in yield in resource modelling, and tidal foundations.
MEAD	Pre-commercial arrays, ocean energy	UK	The UK Department of Energy and Climate Change (DECC), in 2012, announced the £20 m Marine Energy Array Demonstrator fund to support two pre-commercial arrays of three or more wave or tidal energy devices, generating at least 10 GWh per year (approx. 5 MW capacity)**.** The devices had to be demonstrated at full-scale in real sea conditions. Conditions were that project planning had to already be underway, the project site had to be fully within UK waters, leases and consents

Program	Technology,[9] stage & form of support		Description
	Grants		were to be close at hand, and the funds spent by 2014. MEAD was designed as a capital grant to support two projects to demonstrate an array for a minimum of 2 years. MEAD grants were offered to two projects: MeyGen in Scotland and SeaGeneration Ltd. (Siemens/Marine Current Turbines), in Anglesey, Wales. The latter project's funds were withdrawn when deadlines were not met. MeyGen's Phase 1a is under construction. The grant covered eligible capital costs, subject to the EU's State Aid framework. Funds were to be spent between 2013 and 2015 (Wave Hub 2015).
MRCF	Demonstration arrays, ocean energy Grants	UK	The Marine Renewable Commercialization Fund (£18 m) was a Scottish Government fund administered by the Carbon Trust. The MRCF was designed to provide capital support for demonstration arrays of commercial-scale wave and tidal devices in Scottish waters. It was intended for devices that had already been demonstrated at full scale. The fund was announced in 2012 with funds to be distributed by March 2016. There were three rounds: 1) Demonstration array commercialization support (no funds were ultimately awarded); 2) Wave First Array Support Programme - £13 m for device development and proving and site development; and 3) Array Technology Innovation Program- £5 m to support R&D activity on enabling technology innovations for early arrays that will apply to commercial arrays. The Round 2 funds, awarded to Aquamarine Power Ltd (Oyster) and Pelamis Wave Power, were unsuccessful. The lessons learned were applied in the development of the Wave Energy Scotland fund. https://www.carbontrust.com/client-services/technology/innovation/marine-renewables-commercialisation-fund/#arraytechinnovation
MRPF	Full-scale prototype demonstration, ocean energy Grants	UK	Marine Renewable Proving Fund was £22.5 m, administered by Carbon Trust, on behalf of DECC. It provided grant funding and technical support for demonstration of full-scale wave and tidal prototypes. The funds were awarded to Aquamarine Power, Atlantis Resources, Hammerfest Strom, MCT, Pelamis Wave Power and Voith Hydro Ocean, with intended electricity generation in 2012.
NER 300	Renewable energy Public-private investment fund	EU	The New Entrants Reserve is a public-private investment fund developed by the European Commission and managed by the European Investment Bank. It leverages private investment and co-investment of other EU countries' governments. It is a demonstration programme supporting carbon capture and storage and renewable energy technologies to "boost deployment of innovative, low-carbon technologies. The EU funds the NER 300 with proceeds from the sale of 300 million carbon emission allowances. The funds were distributed to projects through two calls for proposals. http://ec.europa.eu/clima/policies/lowcarbon/ner300/index_en.htm.
Offshore Wind Fund	Offshore wind Public-private fund, comer-cial terms.	UK	The Offshore Wind Fund is operated by the UK Green Investment Bank Financial Services Limited. The fund offers "good, risk-adjusted returns" (http://www.greeninvestmentbank.com/funds/offshore-wind-fund/). Investors include UK pension funds and life insurance companies as well as international institutional investors and wealth funds. This public-private fund invests in operating offshore wind farms in the UK.
REIF	Renewable energy projects,	Sc	Renewable Energy Investment Fund provides long-term investment support for renewable energy projects in the test or commercialization stage. It is focused on the deployment and operation of commercial-scale arrays and innovative array-enabling technology. The fund provides loans, guarantees and equity investments on commercial terms. Funding is intended to

Program	Technology,[9] stage & form of support		Description
	commercial-scale arrays Loans, guarantees equity, on commercial terms		reduce the costs or risks of delivering energy from a renewable source and accelerate Scotland's transition to a low-carbon economy. The REIF was a three-year fund, to be distributed by March 2015, and electricity to be generated before 2017, to help meet Scotland's 2020 renewable energy goals. Each deal was unique, typically consisting of loans, loan guarantees and equity finance with co-investment partners. It was administered by Scottish Enterprise, Highland and Islands Enterprise, and the Scottish Investment Bank (all are part of Scottish Enterprise). The conditions were that the project have a demonstrable funding gap, it should demonstrate additionality, the funds would leverage investment of the private sector or unlock grant funding. "Significant leverage is anticipated from a range of sources, including commercial funds and other public sector mechanisms" (http://www.wavehub.co.uk/latest-news/marine-energy-array-demonstrat£or-mead-capital-grant-scheme).
ROCs	Renewable energy technologies Fungible renewable energy credits	UK	In the UK, licensed retail electricity suppliers are required to source an increasing proportion of electricity from renewable sources each year. Accredited producers of renewable energy receive Renewables Obligation Certificates (ROCs) for every MWh of renewable electricity they generate (in-stream tidal and wave energy receives 5 ROCs per MWh, offshore wind receives 1.9 ROCs). The ROCs are purchased from the generator by the retail supplier. The ROC system not only creates demand for the renewable energy, it provides a revenue stream for the generator in addition to the wholesale price for the electricity. The retail electricity supplier submits its ROCs to indicate it has met its renewables obligation. If the supplier does not meet its obligation, it must pay a penalty into a fund. The fund is then redistributed to suppliers who did meet their obligation, thus creating an incentive to do so. The buyout price of a ROC has been set at £44.77/MWh for 2016/17. New tidal energy installations commissioned by March 2017 will be able to receive ROCs for their electricity for 20 years. The ROC system is being phased out and replaced with the Contract for Difference (CfD) system by 2017.
SIF	Commercial wind projects Public-private investment fund	Ir	Managed by Ireland's National Treasury Management Agency, the Strategic Investment Fund has €8 b. Its mandate is to generate commercial returns for the state and make a social impact. It has as invested in commercial wind projects and co-invested in the Malin Biotech Investment Fund, which MRIA (2016) cited as a good model for future marine energy funding.
UK Green Investment Bank	Green projects Financing on commercial terms	UK	The UK Green Investment Bank was created in 2012 and is 100% owned by the UK Government and capitalized with public funds. They provide financing to green projects on commercial terms. Their priority areas are offshore wind, onshore renewables, waste and bioenergy, and energy efficiency. They are required to earn a minimum return on investment of 3.5% p.a. In March 2016, the UK Government initiated the privatization of the Green Investment Bank, which will involve sale of the existing shares owned by the UK Government.

Program	Technology,[9] stage & form of support		Description
			Australia, Japan, Malaysia, Switzerland, United Kingdom have green investment banks or similar institutions, as do California, Connecticut, Hawaii, New Jersey, New York and Rhode Island. Montgomery County in Maryland, USA, has a similar institution, as does the city of Masdar, UAE (OECD 2015).
Wave Energy Scotland	Wave energy Grants	Sc	A number of developers give positive reviews of Wave Energy Scotland (WES), a new Scottish program for funding wave energy technology development. It is administered by Highlands and Islands Enterprise, the Scottish Government's economic development agency, and is 100% funded by Scottish Government and supported by Carbon Trust marine energy experts. WES funds only projects or collaborations that have realistic prospects of commercially viability. The program stipulates that testing and demonstration are to be done in Scotland, research findings are to be broadly disseminated, and IP must be made available to others, on market terms. WES has formed an advisory group, consisting of representatives from industry, academia, investment and insurance, mandated to assess applications and conduct stage-gate reviews of performance and as a condition for further funding. The stage-gate review uses agreed-to technical milestones that introduce engineering rigour, objectivity and cost management (Scottish Government 2015 p. 3). There have been three competitive calls for applications. Applications are assessed on their technical and commercial merit, impact on cost reduction, and performance. The first call was for power take-off system ideas that can result in a significant reduction in capital or performance costs over current designs. There were 16 winning contracts awarded in July 2015 (total £7m). The second call was for new wave energy technology designs or significant modifications to previous designs. Eight projects received a total of £2.25m in August 2015. A third call is presently underway for structural materials and manufacturing processes. There will be one more call and the best devices will be eligible for subsequent rounds of funding to progress through further development. The program provides a long-term funding visibility for technically and commercially sound projects. WES aims to take at least two devices through to small-scale prototype testing at EMEC (Scottish Government 2015).

3.0 Funding and Financial Support Mechanisms

In very broad strokes, government funding and financial support mechanisms can be generally categorized as investment incentives or operating incentives. Each comes with advantages and disadvantages, from the various perspectives of government, developers and investors. They are described below (Bloomberg New Energy Finance 2010; Kalamova et al 2011; Wohlgemugh and Madlener 2000):

> **Investment incentives** include: capital grants; low-interest loans or loan guarantees; government venture capital or government-sponsored venture capital funds; accelerated amortization; investment tax credits and tax (sales, excise, property) rebates; interest rate subsidies; and import duty exemptions. These incentives effectively reduce the net outlay of cash by the proponent or cost of capital and improve the project's net present value (NPV). Investment incentives can help get a project underway so operating hours can be accumulated.
>
> Capital grants have been used in Scotland, France and Ireland to support development of ocean energy technologies. Relatively straightforward to administer, they are paid either from the tax base, subsidies on electricity consumption, or with carbon revenues. Capital grants carry with them a moral hazard, such as developers overstating costs. Also, being a new technology, business failures and stranded assets are possible so there should be due diligence.
>
> Tax-based incentives, such as investment tax credits and accelerated depreciation for tax purposes, can be effective but tend to be useful to only profitable companies and investors. This may be good for bringing in companies with strong balance sheets or high-wealth investors (although sometimes for little more than the tax write-off itself) but may be of little advantage to small and start-up companies, at least for many years. In Canada, the use of flow-through shares can help smaller companies since eligible project development expenses can be renounced to shareholders as tax deductions. Tax-based incentives can be more politically expedient but they are less transparent than capital grants and can be quite complicated, making them susceptible to abuse.
>
> **Operating incentives** include feed-in tariffs, either legislatively set or determined by competitive auction, production tax credits, and tradable renewable energy certificates. They are performance-based - direct cash subsidies based on units of electricity produced. These effectively subsidize the generation of energy from a renewable source until it can become price-competitive with other sources at the margin. Integral to success of these operating incentives are reliable power purchase agreements and access to the transmission grid once the electricity is available.
>
> Operating incentives make it easier for smaller businesses to enter the industry since economies of scale are not as critical to early success. Feed-in tariffs are relatively simple and effective, though not necessarily efficient since developers are not competing with one another to be the low-cost supplier. An auction, such as with the contract for difference policy in the UK, adds an element of competition but then tends to advantage more established (lower cost) technologies. Setting technology bands can help in this regard. This is an instance when the goals of the government's support matter: if the goal is to support the development of new technologies or diversify the electricity supply, an auction-based price support may not be the right mechanism to achieve it.

From the perspective of developers and their investors, political risk is a larger problem with operating incentives than investment incentives. Investment incentives are provided up-front or in early stages. Operating incentives, promised for when the electricity is delivered, can be lost over time through policy changes or government budget cutbacks.

Case Study: MeyGen's Phase 1a Funding

MeyGen's Phase 1a demonstration project is £51 million for 6 MW. Their funding is:

- *£10 million Marine Energy Array Demonstrator (MEAD) grant,*
- *£10 million loan from the Crown Estate,*
- *£17.2 million in equity from Scottish Enterprise,*
- *£3.3 million from Highlands and Islands Enterprise, and*
- *£10 million investment by Atlantis Resources.*

Renewable Obligation Credits are expected to contribute approximately 70 – 80% of the revenue for Phase 1A. Subsequent phases will be subject to the Contract for Difference (CfD) (http://atlantisresourcesltd.com/projects/meygen-scotland.html).

Table 4 describes the generic funding and financial support mechanisms that have been used to support new renewable energy technologies and renewable energy generation. The table outlines the features of each mechanism, pros and cons, and examples in Nova Scotia and elsewhere.

Table 4: Inventory and description of funding and financial support mechanisms

Classification	Policy examples	Features, pros and cons	In NS & Canada	Examples from elsewhere
Energy market regulations	Feed-in tariff (administrative-ly-set)	Features: - Paid per kWh delivered - Requires legislation to enable - Easier for small-scale developments and small companies since economies of scale are less relevant - Impact depends on how high the tariff is - Reliable off-take agreement and access to grid are essential Pros: - Reduces market risk related to price to be paid for electricity - Reduces incentive to inflate initial project costs that could occur with capital grants Cons: - Developers must trust incentive will continue to be available - Difficult to forecast the quantitative effect <u>Administratively set:</u> - Limited incentive to decrease costs since IPPs are not competing to be a low-cost provider <u>Set by Auction:</u> - Favours technologies that are further developed but technology bands can be allocated - Encourages some cost-competitiveness		France 17.3c€ Ireland 26 c€ Denmark 8 c€ maximum Germany 3.5-12.5 c€
	Feed-in tariff (set by auction)			UK – FIT CfD
Green Pricing		Features: - Voluntary - Consumers select supplier or pay a premium to support the production of renewable energy Pros: - Creates a market niche Cons: - The niche may be quite small and insufficient to realize economies of scale	Bullfrog Power	
Trade restrictions	Renewable energy standard (quota)	Pros: - Creates demand for renewable energy - Reduces market risk regarding demand for the electricity Cons:	NS 40% by 2020 (Clean Energy Act)	Many

Classification	Policy examples	Features, pros and cons	In NS & Canada	Examples from elsewhere
		- Used alone, tend to favour the most established RE technologies (e.g. hydro, onshore wind)		
	Tradable renewable energy certificate	Features: - Renewable energy sold to a utility at market wholesale price - Certificates can be sold to the utility for its renewables quota or to carbon emitters as offsets Pros: - Creates two revenue streams, one for electricity, another for renewable certificates.		UK ROCs, New England RGGI Renewable Energy Credits (RECs)
Direct financial transfer	Capital grant	Features: - Amount can be based on either installed capacity or capital cost - Can be paid for from tax base, surcharges on utility bills, carbon revenues - Technology-push mechanism, compliments market-pull FITs and RECs. - Support can be targeted/tailored to the specific needs and stage of the industry - Disbursements can be spread over several years, contingent upon meeting performance or design objectives - Can be designed as convertible to loans or equity if commercial success is achieved - Funds need to be efficiently allocated Pros: - Reduces developer's capital outlay - Supports early-stage and facilitates commercialization - Reduces need for performance guarantees - Reduces financial risk Cons: - Can be abused - project costs can be artificially inflated - Does not incentivize efficient, output-based production - Can be administratively complex for applicants - Requires dedicated budget for government - May create disincentive for unsubsidized firms - May encourage overinvestment by a firm - Projects may not be truly additional - Agency issues may arise due to divergent goals of government, company, and managers	SDTC $5m to Atlantis Resources in 2011; $6.5 m to OpenHydro in 2013	ADEME, MEAD, MRCF, MRPF
	Low-interest loan	Features: - Can be issued through government-owned bank or with subsidies to commercial banks Pros:		Crown Estate £10 m loan to MeyGen.

Classification	Policy examples	Features, pros and cons	In NS & Canada	Examples from elsewhere
		- Assists new entrants and smaller developers - Helps lower the cost of capital - Useful to assist funding initial pilot projects - Can help commercialize projects by developers without proven track record or immature technology Cons: - Company needs free cash flows to service the debt		UK Green Investment Bank (low-interest loan)
	Loan guarantee	Features: - Fixed proportion of loan guaranteed, developer's bank debt repaid by government debt if project fails - Resaleable asset generally needed as security Pros: - Reduces investor risk - Government's credit rating reduces company's interest rate, term and debt service conditions Cons: - Represents a contingent liability for government	Muskrat Falls hydroelectric project, $6.3-billion federal loan guarantee[10]	
	Government-run venture capital funds	Features: <u>Government-funded:</u> - Pooled strategic fund - Government provides portion of capital and mandate, managed by private sector entity - Can be structured so government shoulders more than proportional share of risk or enables private equity investors to exit in a shorter period. <u>Government-run:</u> - Difficult to attract investing talent and maintain investment discipline Pros: - Helps young, pre-revenue companies progress through pre-commercial, product development stages		Carbon Trust Investments, ITI Energy Scotland
	Government-funded venture capital funds			Austrailia's REEF equity fund Danish Investment Fund
Preferential tax treatment	Accelerated depreciation	Features: - Investment tax credits can be linked to installed production capacity or capital cost	CCA asset classes 43.1 & 43.2	

[10] The Government of Canada provided a $6.3-billion loan guarantee to the Muskrat Falls hydroelectric project. It enabled the Government of Newfoundland and Labrador to secure financing in the markets. The loan guarantee allows the debt to be booked at Canada's AAA credit rating. The interest savings must be used to reduce electricity rates. The debt is capped at $6.3-billion and will not cover cost overruns (CBC 2012). The full agreement is available at http://muskratfalls.nalcorenergy.com/wp-content/uploads/2013/05/Terms-and-Conditions-of-the-Federal-Loan-Guarantee.pdf.

Classification	Policy examples	Features, pros and cons	In NS & Canada	Examples from elsewhere
	Expensing project development expenditures	- Requires high level of equity participation for full benefit - Projects would require profits for tax credits to be usable - Accelerated depreciation lowers tax rates in early years, can be carried back or forward to profitable years Pros: - Effective - Easily implemented and extended - Effectively lowers capital cost, improves project NPV - Entices profitable companies or high-income individuals to enter - Politically expedient Cons: - Can be inefficient if investor's goal is to maximize tax shelter, rather than develop renewable energy - Tax credits are less transparent than direct investment subsidy - Small project developers may not have sufficient pre-tax income to benefit. - Complex due to distortions inherent in modifying the tax system - Tax credits alter the company's optimal capital structure toward more (& more expensive) equity (Wohlgemugh and Madlener 2000)		
	Investment tax credit			
	Production tax credit			
	Tax reductions (sales, energy, excise, value-added)			
	Flow-through shares	Features: - Eligible expenses can be renounced to shareholders (individual or corporate), Pros: - Makes some of the above-noted tax breaks valuable to a new company.	Canadian Renewable Conservation Expenses (CRCE)	
Insurance	Provide insurance to projects	Features: - Underwrites specific risks - Can be phased out as risks become known through learning Pros: - Reduces uncertainty of unknown or unquantifiable risks - Lowers cost of capital		
	Provide reinsurance to commercial insurers			
	Commercial insurers create pool for RE	Features: -Insurance industry can be incented to create a pool for insurance -Government can provide reinsurance		
Services provided by government	Public investment in infrastructure, site preparation	Pros: Reduces upfront development time and costs Reduces uncertainty	FORCE, grid connection, undersea cable, site characterization,	EMEC, Raz Blanchard Marine Park, SmartBay Ireland, France's

Classification	Policy examples	Features, pros and cons	In NS & Canada	Examples from elsewhere
	Streamlined regulations and permitting processes		SEA, EA, Value Proposition	port expansion in Cherbourg
	Pre-approved sites, permitting done			
Other supports	Interest rate subsidy	Pros: - Lowers cost of capital		
	Carbon pricing	Features: - Carbon revenues can be redirected to support renewable energy Pros: - Helps to level playing field with carbon-emitting sources of electricity	Quebec, Ontario, British Columbia, Alberta	New England, California, Chile, South Africa.

Sources: Bloomberg New Energy Finance 2010; Kalamova et al 2011; Wohlgemugh and Madlener 2000.

3.1 Project/industry development phases and supports

Figure 2 builds on Figure 1, adding the sources of financing typical at each stage and applicable government supports. It also shows where the Nova Scotia phases of industry development fit within them. The Nova Scotia phases of project/industry development are identified as:

> Phase I - Demonstration at FORCE, five contracts plus ComFIT projects, totaling 25 MW;
> Phase II - 26 MW to 50MW pilot array(s); and
> Phase III - >50 MW commercial development to 300 MW (NS Renewable Energy Strategy goal) and beyond (500 MW for domestic use, additional for export).

Figure 2: Stages of TEC development, typical sources of financing, government supports

Stage	R&D[11]	Part-scale demonstration	Full-scale device demonstration	Demonstration array	Pre-commercial array	Commercial arrays
Activities	Generate idea, IP, develop prototype.	Test prototype in simulated environment, refine prototype.	Demonstrate full-scale prototype (device, reaction system, station keeping) in operational environment; prove technical validity in the field.	Demonstrate array -enabling technologies, demonstrate array; refine technologies, processes, materials.	Build small array in commercial marine area, commercial viability not yet achieved, technology costs still high.	Build large, commercially viable arrays.
Sources of private-sector financing	Balance sheet finance, angel investment, corporate venture capital		Balance sheet finance, corporate venture capital “Technology valley of death”			Bank finance, project finance, public markets, mergers, acquisitions
Nova Scotia phase				Phase I Demonstration at FORCE 25 MW	Phase II Pilot arrays 26-50 MW	Phase III Commercial development 51-300 MW
Government support mechanisms			Renewables quota, price-support (diminishing $/kWh)			
	R&D grants, government and university research, technology prizes.		Demonstration grants, array-enabling technology grants, array-demonstration grants, infrastructure investment, development bank financing.		Capital grants, public-private investment fund, tax incentives, domestic and export development bank financing.	

Sources: Bloomberg 2010; Ghosh & Nada 2010; Kalamova et al 2011; MacDougall 2013; ORE Catapult 2014.

3.2 Analysis within the Nova Scotia/Canada context

The fast, deep waters of the Minas Passage present more technical challenges for developers than other locations where tidal energy conversion is being demonstrated. It is a difficult training ground for first demonstrations of technologies and procedures. The features of the Minas Passage resource make it attractive to developers long-term, though, because of the potential for reaching economies of scale and export markets, as well as the brand value of meeting the “Fundy Standard.” Support for tidal energy development needs to be tailored to the Nova Scotia situation in order to offer a resource and policy “package” that will draw viable companies that are ready to work in these waters.

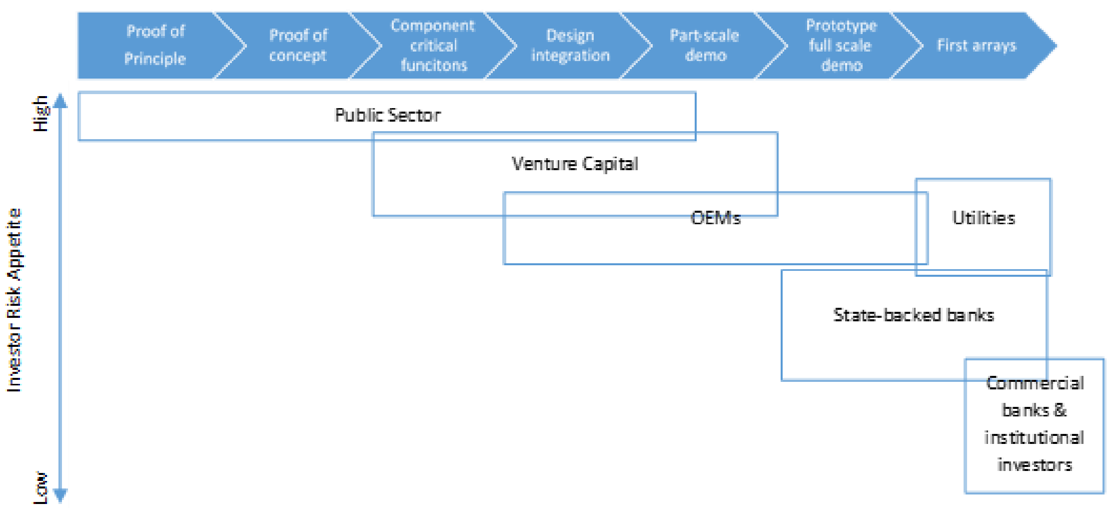
At approximately $15 million per MW of nameplate capacity, the cost of demonstrating energy conversion technologies at FORCE and building pilot arrays is prohibitive for many companies. Though the industry seems to be converging on a horizontal axis, the timing and likelihood of convergence on a particular TEC and station-

[11] ORE Catapult activities: Proof of principle, component critical functions, design integration.

keeping design is uncertain. Accordingly, government funding and financial supports for several stages and several designs, competitively awarded on technical merit and commercial viability, will be important in Nova Scotia. Funding and financial support for the component technologies and supporting systems that enable and monitor tidal energy arrays will also be important, such as the UK's Marine Farm Accelerator programme and French ADEME's (second) call for applications for support of array-enabling component technologies. As the industry in Nova Scotia develops, so too must the support mechanisms, transitioning to development bank financing and public-private investment funds, such as the UK Green Bank's Offshore Wind Energy Fund, until the tidal energy farms can raise commercial bank debt and private-sector equity unaided.

ORE Catapult (2014) describes the stages at which investor types typically provide capital, as shown in Figure 3. The leaders in the tidal energy industry are late in the "prototype full-scale demonstration" stage and are edging into first arrays. In France, the successful bidders on the ADEME calls for pilot-arrays in the Raz Blanchard marine park were French utility and OEM combinations. Similarly, in Nova Scotia, Cape Sharp Tidal is a joint venture between DCNS-owned OpenHydro and Emera. By contrast, Minas Tidal, DP Energy, Atlantis Resources, and Blackrock Tidal Power (Schottel GmB), are somewhat less well-capitalized. If diversification in Canada is to occur, government funding and financial supports will be needed to supplement or replace the balance sheet financing otherwise provided by large strategic investors.

Figure 3: Investor type by risk appetite and technology readiness



Source: ORE Catapult 2014

In Phase II, some form of capital grant will be needed, on a competitive basis, for pilot arrays in the Bay of Fundy, while there is a demonstrable funding gap. Government funding and financial supports should be additional – where funding is not otherwise available. Once private sector financing can be raised, the government funding and financial supports should be scaled back and eventually discontinued so as to not crowd out private-sector investment.

There will still be a need for market-pull mechanisms. Project developers must have confidence there will be sufficient demand for the electricity, access to markets, and price-support until the industry can reach grid-parity. A feed-in tariff or fungible renewables certificates will still be needed, as will power purchase agreements and access to the transmission system. If combined with capital grants, the price support can be less and phased out over time.

Tax incentives and accelerated depreciation are effective solutions for companies that have profits on which they pay taxes (present, past or foreseeable future). The flow-through share mechanism can help in this regard but is not as effective for a young or small company as an upfront infusion to begin a project.

4.0 Recommended suite of mechanisms for the next phases of development

Of the programmes in other jurisdictions, several stand out as effective models and relevant to the Nova Scotia context. They include: Wave Energy Scotland; ADEME; price supports; the UK Green Investment Bank; EU Fast Track to Innovation Fund, SEAI Early Commercialization Fund (proposed); and the Offshore Wind Energy Fund.

Scotland has provided the most support for tidal and wave energy development, especially in combination with the support of the UK government and the EU. The funding and financial supports have had considerable effect. Developers from many countries formed consortia to take their expertise and designs to Scottish waters. The failure of wave energy device developers Pelamis Wave Power and Aquamarine Power (Oyster) stand as lessons for government, private industry and investors alike. Subsequent analysis determined the funding did not fit the stage of the technology and the timelines for getting devices in the water were too short. Tidal energy had its setbacks as well. There was an early entry of utilities, largely in response to the 5 ROC support mechanism, but they later exited when it became evident the development time and cost would be much higher than expected. Despite Marine Current Turbine's Strangford Lough success, plans to develop other sites were supported and then abandoned with the entry and subsequent divestment by Siemens. These departures left the industry with few strategic investors.

Wave Energy Scotland. Scotland learned from the experience of the Marine Renewable Commercialization Fund (MRCF) and the failure of wave energy device developers, Aquamarine Power and Pelamis Wave Power.[12] The lessons were not lost, rather, they were applied in the development of Wave Energy Scotland (WES), a new program for funding wave energy technology development. Though wave energy conversion is at an earlier stage of development than tidal energy conversion, there are elements of WES that are directly applicable to the stage tidal is in.

WES has an industry-development focus rather than a company-development focus and takes a public-procurement commercial approach. This is a model on which future government programs can be built. Important features include (Scottish Government 2015):

- Administered by the Scottish Government's economic development agency, Highlands and Islands Enterprise;
- 100% funded by the Scottish Government, removing the need for industry matching funds;
- Supported by Carbon Trust marine energy experts;
- Funds are awarded after competitive calls for applications;
- An advisory group of people from industry, academia, investment and insurance, has been formed and mandated to assess applications;
- Applications are assessed on their technical *and* commercial merit, impact on cost reduction, and performance;
- WES funds only projects or collaborations that have realistic prospects of commercially viability;
- Testing and demonstrations must be done in Scotland;
- Research findings are to be broadly disseminated, though IP remains with the proponent;
- The IP must be made available to others (e.g. via licensing) on market terms;
- Funding is awarded through a sequence of competitive calls for applications. Ready technologies are eligible for subsequent rounds of funding to progress through further development:

[12] The £18 m Scottish government fund, administered by the Carbon Trust, was designed to provide capital support for demonstration arrays of commercial-scale wave and tidal devices in Scottish waters.

    - The first call was for power take-off system ideas that could result in a significant improvement in capital costs or performance over current designs.
    - The second call was for new wave energy technology designs or significant modifications to previous designs.
    - The third call, presently underway, is for structural materials and manufacturing processes for construction. There will be one more call.
- The advisory group conducts stage-gate reviews of performance as a condition for further funding;
- The stage-gate review uses agreed-to technical milestones that introduce engineering rigour, objectivity and cost management.
- The WES program's stated goal is to take at least two devices through to small-scale prototype testing at EMEC. This goal is providing long-term funding visibility for technically- and commercially-sound projects.

The technical and commercial focus of the WES process and the follow-through with later stages of competitive funding for projects demonstrating success are important elements for a grant program. Drawing on Scotland's experience, the design of grants for marine renewable energy development in Canada should include these elements.

ADEME. France's ADEME funding reflects an understanding of the multiple technological developments that need to occur concurrently. There are three components to the ADEME programme: one to demonstrate full-scale devices at sea, a second for array-enabling component technologies, and a third for pilot array projects. The Raz Blanchard developments will be pilot arrays, rather than demonstration arrays, with space to build out in the future.

France is also supporting marine renewable energy development through infrastructure investment. In 2013, three levels of government agreed to fund a €160 m construction of a 350 m quay in Brest, capable of offloading offshore wind turbines, tidal turbines, thermal energy conversion units and wave energy devices (SeeNews 2013). Also, the Normandy Port Authority plans to expand its port at Cherbourg by 35 hectares at a cost of €60 million to facilitate marine energy projects. Cherbourg is located near the Raz Blanchard (Renewable Energy Focus 2013). These enabling investments in infrastructure are drawing device developers/OEMs DCNS OpenHydro and Alstom to set up manufacturing facilities there. OpenHydro recently announced a contract to supply a 2 MW device to Japan that will be constructed at their new facility in France (Tidal Energy Today 2016).

Case Study: ADEME and France's Investing in the Future Programme

As part of France's "Investing in the Future" program, the government is supporting the installation of pre-commercial tidal energy arrays, and the expansion of the port of Cherbourg. The port has a development plan to expand with 40 hectares for infrastructure devoted to marine renewable energy. DCNS has a MOA to build facilities there with the goal of producing 100 turbines per year there.

In 2014, the French Environment and Energy Management Agency (ADEME) announced a call for expressions of interest to develop pilot arrays to demonstrate the viability of the tidal industry in advance of launching commercial projects. The goal is for 3 to 4 projects of 4-10 turbines in Raz Blanchard and Fromveur. In September 2014, ADEME called for expressions of interest on 2 pilot tidal farms in the Raz Blanchard. In late 2014, Alstom and French utility, Engie, as well as DCNS (OpenHydro) and French utility, EDF, were awarded the contracts. Both projects are planned for grid-connection in 2018.

Engie's "Nephtyd" project is a 5.5 MW, 20-year tidal energy array of Alstom turbines, with construction to begin in 2017. The array will consist of four 1.4 MW "Oceade 18" turbines in the Raz Blanchard. The cost of the *project was disclosed to be €101 M, capital investment and operating costs for 20 years (ademe.fr 2014). The contract with ADEME includes a capital grant and repayable advances of €51 M. The projects will also receive a feed-in tariff of €173 per MWh for 20 years (ademe.fr 2015).*

DCNS OpenHydro and EDF will build its "Normandie Hydro" project, an array of seven 2 MW turbines for 20-year operation in the Raz Blanchard. The cost of the project was announced to be €112 M, (CAPEX and OPEX), with ADEME providing a capital grant and repayable advances of €52 M. The projects will also receive a feed-in tariff of €173 per MWh for 20 years. For DCNS OpenHydro and EDF, the Normandie Hydro project will follow their Paimpol-Brehat tidal array demonstration in Northern Brittany. This array will consist of two 1 MW tidal turbines, connected by an underwater converter, developed and demonstrated by General Electric. The first turbine was installed in early 2016.

Like France, Scotland and the UK have funded various elements and stages: the MRPF (demonstration of full-scale prototypes, MEAD (array demonstrator), REIF (deployment of commercial-scale devices and array-enabling technology), Marine Farm Accelerator (supporting technologies needed to reduce cost and risk of early arrays), MRCF (demonstration arrays of commercial-scale devices). There is debate over whether a funding program should focus on developing individual energy conversion devices or on solving specific technology issues and developing sub-systems and components. Arguments can be made for each and MIRA (2016) recommends funding programmes be flexible and responsive to the needs of the industry and target what needs to be supported through the stages, from individual units to multiple-unit arrays.

FIT/renewables certificates/production incentive. The price support of green or renewable energy certificates (e.g. UK ROCs) or feed-in tariffs are essential to the development of the industry in an environment where there are tax incentives for fossil fuel industries and no price on carbon. Price supports must be carefully designed and the design should depend on the goals of the programme. The ROC program in the UK was successful and could be tailored for particular technologies (e.g. 5 ROCs for tidal and wave, 2 ROCS for offshore wind, 0.9 ROCS for onshore wind). Differentiating between technologies in this way facilitates the development of multiple sources of renewable energy and technological expertise. The ROC system in the UK is now closed to new entrants and is being replaced by a FIT and a contract for difference. In the new program, contracts are awarded on the basis of competitive bids. Though there are technology bands (100 MW reserved for tidal and wave, with a guaranteed price),[13] the system tends to favour their lowest-cost marine renewable technology, offshore wind. This is consistent with the current UK government's goals of meeting its GHG commitments but minimizing electricity costs within those constraints.

France's support for marine renewable energy is a combination of a feed-in tariff and capital grants, along with other enabling mechanisms, such as infrastructure development. The feed-in tariff offered is less than elsewhere, at 17.3 cEUR/kwh. France's program has met with success to date as it addresses the potentially show-stopping capital cost and risks with capital grants, allowing devices to be built, enabling technologies and pilot arrays to be developed and demonstrated, and operating hours to be logged.

Nova Scotia's feed-in tariffs have been effective in attracting developers from around the world, though it is uncertain how effective it will be in reaching the programme goals of 25 MW of installed capacity. Another form of price support used in Canada is the Wind Power Production Incentive (WPPI). It was offered from 2002-2007 by Natural Resources Canada to support the development of wind power projects. The price incentive was $0.01 per kWh of new wind power delivered. The programme goal was to see 1,000 MW of new installed capacity

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[13] In the first round, there was 100 MW reserved for wave and tidal, with a guaranteed strike price of £ 305/MWh. No power producers applied. A second round is due to be announced shortly and it is uncertain whether the terms will be similar.

built. The agreements were for 10 years, the last of which will expire in 2017. The program funded 22 projects, totaling 925 MW.

UK Green Investment Bank. A green investment bank is a public entity with a mandate to finance innovation in environmental and renewable energy technologies. It can be funded by, for instance, carbon revenues, surcharges on utility bills, government funding, gas taxes, or a public bond offering. An alternative to a green investment bank is to 'green" an existing national development bank by adding (or expanding) green investment to its mandate. This is less expensive and avoids what might be otherwise considered a duplication of services. However, there may be conflicting mandates for the national development bank if it is also funding innovation in fossil fuel-related technologies. A dedicated green investment bank can be focused and able to respond innovatively with the changing needs in the marketplace (OECD 2015).

A green investment bank can provide financing when none is available to business startups and green technology because the risks are too high for private sector financing. The goal of a green investment bank is to reduce investment risk so as to mobilize private-sector funds. This can be done with subordinated loans, bundling of small investments, securitization, creating and co-funding green funds (e.g. UK Green Bank's Offshore Wind Energy Fund), loan loss reserves, insurance and credit guarantees (OECD 2015). The financing approaches vary but a study done on the International Development Financial Club found of the new commitments of $98 b in green financing in 2014, 44% were in the form of concessional loans (low interest rates and/or long grace periods, 51% were non-concessional loans (market terms), 3% were grants, 1% were other financial instruments such as equity and guarantees, and 1% were unspecified loans (IDFC 2015).

EU Fast Track to Innovation. The European Union's Fast Track to Innovation (FTI) pilot fund is focused on commercial viability and provides important support for later-stage development. The projects supported by FTI must be at TRL 6, within 36 months of market launch, and have a strong business case. The applications are evaluated by independent experts with commercial and financial expertise. Funded activities include: advanced and specific R&D; standard setting and advanced performance testing/piloting/demonstration; validation of solutions in real working conditions/certification; and business model validation (European Commission 2014).

SEAI Early-commercial Fund (proposed). Ireland's Marine Renewable Industry Association released a discussion paper (MRIA 2016) on how to fund the development of the ocean energy industry there.[14] In their discussion paper, the MRIA recommends two funding programmes to follow on from the existing Sustainable Energy Authority of Ireland (SEAI) Prototype Development Fund, which supports the development of ocean technologies through to TRL 3.[15] The MRIA recommends the SEAI follow with a pre-commercial fund for TRL 3+ to approximately TRL 6 and subsequently, an Early-Commercial Fund to finance the early commercial deployment projects at TRL7+. Combined, these would give developers a line of sight to when they can attract private-sector investment. The MRIA outlines a programme that follows the Wave Energy Scotland model. They recommend three agencies, Enterprise Ireland, IDS, and the Irish National Treasury Management Agency's Strategic Investment Fund (SIF), help design and operate the fund. This would bring in needed expertise and give these agencies early experience in the ocean energy industry.

Offshore Wind Energy Fund. Offshore wind energy is much further along than tidal energy, due largely to the experience with onshore wind and the ability of the devices to work above the seawater. To support the development of offshore wind farms, the UK Green Investment Bank's Offshore Wind Energy Fund is considered effective. It is operated by the bank's wholly-owned subsidiary, UK Green Investment Bank Financial Services Limited, and it includes public and private funds. Investors include UK pension funds and life insurance companies, as well as international institutional investors. The fund offers "good, risk-adjusted returns" from a

[14] Ireland has mostly wave energy resources, rather than tidal.

[15] The Prototype Development Fund provides grants for developing devices or sub-systems with grants for up to 70% of costs.

portfolio of operating offshore wind energy projects. It provides a liquid market for the owners of wind farms and lowering the cost of capital (http://www.greeninvestmentbank.com/funds/offshore-wind-fund/).

A fund dedicated to tidal energy would not be practical per se, being a relatively immature industry, even in Phase III, and having limited investment opportunities. However, a fund with a broader mandate that includes tidal energy, such as ocean energy (wave and tidal), marine energy (offshore wind, wave, tidal, river current), or ocean technology more broadly, could allow for diversification. A federal government-funded, private sector-managed investment fund or programme for ocean technology broadly, or marine energy technologies specifically, will be needed to leverage private-sector investment in the early commercial stages and to sustain leading-edge technology development.

5.0 Canadian organizations to play a role

The suite of funding and financial support mechanisms for tidal energy, or more broadly, marine renewable energy, will need to involve a number of government agencies and crown corporations. Examples from other jurisdictions show a strong preference for programmes that are government-funded but private sector-managed. Organizations administering or providing government funding include:

- UK - Crown Estate, Green Investment Bank, Energy Technologies Institute (ETI);
- Scotland – Scottish Enterprise, Highlands and Islands Enterprise, Scottish Investment Bank;
- Ireland - Ireland National Treasury Management Agency, Enterprise Ireland;
- EU - European Investment Bank.

These organizations have been funded by their respective governments and given specific mandates related to renewable energy.

Enterprise Scotland, Highlands and Islands Enterprise, Enterprise Ireland are economic development agencies, somewhat like Nova Scotia Business Inc. The UK Green Investment Bank, Scottish Investment Bank and European Investment Bank are national development banks that resemble the Business Development Bank of Canada (BDC) and Export Development Canada (EDC). At the federal level, adding a renewable energy investment mandate to BDC is less expensive than establishing a new green investment bank, though a stand-alone green investment bank or subsidiary can be more focused, free of conflicting mandates, and be more innovative and responsive to market needs.

Sustainable Development Technology Canada (SDTC), which has already provided capital grants to two tidal energy developers at FORCE, is a suitable agency to implement a program of grants. The Atlantic Canada Opportunities Agency (ACOA) has a role at the regional level and can support the development of infrastructure, enabling technologies, supply chain innovation, and capacity-building through grants and concessional loans.

As Highlands and Islands Enterprise does for the Wave Energy Scotland programme, these Canadian organizations will need to draw together advisory panels consisting of people from industry, academia, investment, and insurance, to assess applications, identify technical milestones, and conduct stage-gate reviews of the projects' performance (Scottish Government 2015). The Canadian organizations should be engaged early so as to give them experience in the tidal energy industry.

6.0 Summary

Several tidal energy technology companies have been demonstrating full-scale devices and have been building demonstration or pilot arrays in the UK and France in the last year. In Nova Scotia, at FORCE, demonstration arrays are planned by the berth-holders. However, there have been many delays and setbacks, as well as several changes in the ownership of berths. These are symptomatic of the many challenges developers encounter, which we typically summarize as the "risks" inherent in tidal energy development: technology, supply chain, construction, operator, political/regulatory, market, and environmental (MacDougall 2013). The costs are high and beyond the financial capacity of many of the companies.

The costs and risks of developing tidal energy are large and private, while many of the potential benefits are societal and environmental. For this reason, provincial and federal governments have a role to play while the costs and risks are a barrier to progress. In Scotland and France, where full-scale devices are being deployed and small arrays demonstrated, the funding and financial supports are mostly a combination of demonstration grants, price supports through feed-in tariffs or renewables credits, and infrastructure investment. The grants are not only for demonstrations of TEC devices but also of array-enabling technologies. While Nova Scotia's feed-tariff has been effective in attracting international developers to FORCE berths, for all but the largest companies, a feed-in tariff alone will likely be insufficient support for getting devices and arrays in the Bay of Fundy. A package of capital grants and price supports are needed, as well as continued investment in infrastructure.[16]

Later, as commercial sites are identified in Nova Scotia and permits are awarded, the industry will move to pre-commercial arrays. The funding and financial supports should then include concessional loans and later, loans on commercial terms, by an organization like the BDC. Tax incentives, accelerated depreciation for tax purposes, and flow-through shares, already in place in Canada, will also provide important support. As the industry moves toward commercial arrays, a public-private investment fund will leverage private-sector investment to help draw the large amounts of capital that will be needed to build arrays of sufficient size that economies of scale will help bring the cost of energy to grid-parity. These later funding and financial supports need to be developed and announced early, during the demonstration stage, so developers can see what lies ahead and momentum is not lost after the demonstration units have been deployed.

Of the funding programmes in other jurisdictions, particular attention should be given to: Wave Energy Scotland; ADEME; the UK Green Investment Bank; the EU Fast Track to Innovation Fund, the SEAI Early Commercialization Fund (proposed); and the Offshore Wind Energy Fund, as effective models. In particular, many of the features of the new Wave Energy Scotland funding program would apply to a tidal energy development funding programme in Nova Scotia, if adapted for the stage tidal energy conversion is in.

Federal agencies and departments needed as partners are ACOA, SDTC, BDC, EDC, Innovation Science Economic Development Canada, and Natural Resources Canada. In Nova Scotia, the Department of Business and Consumer Services, and Nova Scotia Business Inc. have roles to play. These organizations should be engaged early to gain experience in the tidal energy industry and will need to draw on the knowledge of experts in industry, academia, investment and insurance in the design and oversight of project funding.

Paramount to success are clearly defined and articulated goals of the governments' programme of funding and financial supports so developers and investors can gauge the breadth, depth and duration of the governments' commitment and provide a line of sight to when financing can be raised from commercial banks and private-sector investors. The government programme needs to be clear, sufficient, stable and predictable so as to reduce uncertainty related to policy, financial, and market risks. As the industry becomes viable on its own, government support can diminish so as to make way for private-sector investment.

[16] Local infrastructure needs are to be identified in the *Marine Renewable Energy Infrastructure Assessment for the Bay of Fundy,* a study commissioned in 2016 by the Ocean Energy Research Association.

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