COMMUNITY AND BUSINESS TOOLKIT FOR TIDAL ENERGY DEVELOPMENT

March 2013

ATEI Publication 2013-01

ACADIA Tidal Energy INSTITUTE

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Community and Business Toolkit for Tidal Energy Development

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Photo Credit: Leigh Melanson

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26 MARCH 2013

To the readers and users of the *Community and Business Toolkit for Tidal Energy Development:*

Increasing concerns over global climate change, caused, in part, by our dependence upon fossil fuels for energy production, has been leading countries around the world to investigate the potential of renewable and sustainable energy sources, especially for electricity production. This is evident in the development of wind farms around the globe, both on land and offshore, and in efforts to develop the vast energy potential of the oceans' waves and currents. Of the marine energy resources, tidal currents have the virtue of being both renewable and eminently predictable.

While the tidal energy industry is still in its infancy, it seems probable that the next few years will see tidal power devices installed at many places around the world, including the Bay of Fundy. Such developments represent both opportunities and challenges for local communities and businesses. The Community and Business Toolkit for Tidal Energy Development is intended to provide a comprehensive resource that would help people in companies and communities to better understand the opportunities for tidal energy development and the social and environmental challenges that it presents.

The Toolkit project was developed by the newly established Acadia Tidal Energy Institute at Acadia University in Nova Scotia. Located near the shores of the Bay of Fundy (one of the world's finest potential locations for tidal power development), Acadia University has been involved in tidal power-related research for decades, particularly through the Acadia Centre for Estuarine Research. With the advent of new ways of obtaining power from tidal currents, and growing understanding of both the potential and challenges of tidal energy conversion, we felt that a guide to the technical, financial, environmental and social issues would be beneficial for both communities and businesses, and would help inform decisions, reduce risks and maximize benefits. The Toolkit was developed in the context of Nova Scotia and the Bay of Fundy, but we believe it will have great benefit for readers and users elsewhere. This document is the product of a multi-disciplinary, collaborative effort by contributors from many institutions and sectors. We see the Toolkit as a living document that can be adapted as new information becomes available and the industry matures. To that end, we welcome any advice and comments that would enable us to enhance its value to communities and businesses that have opportunities to be engaged in meeting future energy needs from tidal energy resources.

Anna Redden, PhD
Director, Acadia Tidal Energy Institute
Acadia University

Photo Credit: Leigh Melanson

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PROJECT CO-LEADS

SHELLEY MACDOUGALL, PhD.

Dr. Shelley MacDougall is a professor of finance in the F.C. Manning School of Business Administration at Acadia. Born and raised in Nova Scotia, she earned a Bachelor of Commerce degree from Saint Mary's University, an MBA from Dalhousie and a Ph. D. from Bradford University, in Bradford, England. She joined the Acadia faculty in 1987.

Dr. MacDougall's area of research is in strategic capital investment and investment in new technology. She has published her research in OMEGA International Journal of Management Science, the Journal of Enterprising Communities: People and Places in the Global Economy, the Journal of Small Business and Entrepreneurship, the Journal of Financial Education, the International Journal of Knowledge, Culture and Change Management, and the Journal of Intellectual Capital. She is a founding member of the Acadia Tidal Energy Institute and is conducting research on the feasibility and sustainability of tidal energy in Nova Scotia.

JOHN COLTON, PhD.

Dr. John Colton is a professor of Sustainability and Community Development Studies in the Environment, Sustainability Studies, Recreation Management and Community Development programs at Acadia university. He received his BA from University of Washington in geography and his Masters' Degree and PhD from the University of Alberta, where he focused on sustainability studies.

Dr. Colton's research interests have included sustainable tourism, aboriginal tourism, agritourism and community sustainability. He has published papers and book chapters in The Journal of Native Studies, The Pacific Tourism Review, Leisure, Municipal World, and Indigenous Peoples and Tourism. He is a scholar practitioner with applied research projects related to municipal sustainability strategies and decision-making with Halifax Regional Municipality, sustainable procurement, aboriginal tourism feasibility studies and interpretation and programming development program. Dr. Colton is also a training associate for The Natural Step, an international sustainability training organization. He is the east coast sustainable tourism expert for National Geographic's' World Legacy program and has served as an expedition leader for several northern Canadian river-based expeditions for National Geographic. He is past co-chair of the Atlantic Aboriginal Health Research Program, Director of the Atlantic Canada Sustainability Initiative, Chair of the Centre for Rural Sustainability, and served on the Nova Scotia Renewable Energy Steering Committee that drafted the Nova Scotia 2015 renewable energy targets. He is a founding member of the Acadia Tidal Energy Institute.

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ALAN HOWELL, MA

Alan is a land-use planner by training and has degrees in planning from Concordia University and the University of Waterloo.

Alan has worked on a variety of projects in Nova Scotia from developing innovative policy to reduce unemployment to needs and feasibility assessments for multi-million dollar facilities. Alan has always been interested in research looking at community economic development in rural and remote communities, in particular resource based communities.

ANNA REDDEN, PhD. DIRECTOR, ACADIA TIDAL ENERGY INSTITUTE

Dr. Anna Redden is a marine ecologist and professor in Biology, with degrees from Acadia University (BScHon, MSc) and Memorial University (PhD). Her postdoctoral work was conducted in Australia, after which she was appointed to a faculty position at Newcastle University in New South Wales, Australia. She returned to Nova Scotia and to Acadia in 2005 to assume the positions of Associate Professor in Biology and Director of the Acadia Centre for Estuarine Research.

Since 2009, Dr. Redden has been a Director on the Board of the Fundy Ocean Research Center for Energy (FORCE) and serves on committees of the Offshore Energy Research Association of Nova Scotia. She has over 30 years of experience working on a broad range of environmental issues and effects monitoring in coastal waters. This includes environmental studies at North America's only Tidal Power Plant, at Annapolis Royal, during the 1980s, contributions to ecosystem modelling workshops on the consequences of an Upper Bay of Fundy tidal barrage (early 1980s), and recent research with local tidal energy project developers at the FORCE tidal power demonstration facility in the Minas Passage, Bay of Fundy. Anna's research activities with collaborators and students at Acadia involve understanding how marine animals utilise high flow environments. This involves tracking the movements of coastal fishes and lobsters, assessing marine mammal activity patterns and investigations of sediment-animal relationships.

Dr. Redden is the co-founder and co-executive chair of the Fundy Energy Research Network (FERN), established in 2010 to assist the province, FORCE, the emerging tidal energy industry and the research community in working collaboratively to address a range of environmental, engineering and socio-economic needs and challenges.

GRAHAM DABORN, PhD. PROFESSOR EMERITUS

Dr. Daborn is Professor Emeritus at Acadia University. He was a graduate of the University of Alberta and taught Biology at Acadia University from 1973 to 2004. He was the founding Director of the Acadia Centre for Estuarine Research (ACER), which was established in 1985 to focus attention on estuarine environments, such as the Bay of Fundy. A lot of the research has dealt with the effects of human modifications of estuaries and coastal waters, such as the construction of causeways, the dredging of harbours, the addition of nutrients or contaminants, and tidal power.

He is a member of the Board of the Ocean Renewable Energy Group (OREG), and served as a volunteer on the Research Advisory Committee and the Tidal Area Sub-committee for the Offshore Energy Environmental Research Association (OEER).

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Dr. Richard Karsten is an associate professor of Mathematics at Acadia University in Wolfville, Nova Scotia. He has a Bachelor's in Math from the University of Waterloo and a PhD in Applied Mathematics from the University of Alberta. He spent three years as a Postdoctoral Researcher at the Massachusetts Institute of Technology before joining Acadia in 2001.

In recent years, Dr. Karsten and his colleagues at Acadia have been working on examining tidal power in the Bay of Fundy. Their work resulted in the first published assessment of in-stream tidal power in the Minas Passage based on a theoretical estimate of extractable energy and a numerical simulation of in-stream turbines. His current research is focusing on tidal energy site assessment using numerical models and innovative monitoring methods. Dr. Karsten is co-chair of the FERN hydrodynamic and geophysical subcommittee, a member of the IEC standards committee on resource assessment for tidal energy, a steering committee member for the Canadian Marine Renewable Energy Technology Roadmap, and a founding member of the ATEI.

SUE MOLLOY, PhD, MEng, BEng, BSC

Sue Molloy, based in Halifax, Nova Scotia, Canada, is a researcher, adjunct professor and consulting engineer in Ocean engineering and specializes in Marine Renewable Energy, Eco-Ships and sustainable engineering. Sue has a PhD in Naval Architectural and Ocean Engineering working on marine propulsion systems with emphasis on modeling and power prediction. Sue is the chair of the Engineering Committee on Oceanic Resources Marine Renewable Energy specialist panel and a co-chair of the Fundy Energy Research Network engineering sub committee. Currently, Sue is the engineer in residence for Tidal Power research in the faculty of engineering at Dalhousie University and teaches courses on tidal power and turbomachines. Sue is the Science officer for FORCE and is focused on developing the R&D program for the new subsea sensor platform expected to be deployed in 2013. Sue is working on research and consulting projects related to educating communities about investing tidal power, the development of tidal power test facilities, testing methods for tidal turbines, cabling of tidal turbines and the efficiency and environmental effects of power systems.

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James retired from NSPI in August, 2011. He started up an engineering consulting firm, Quadrule Services Inc. James joined Nova Scotia Power following graduation from the Technical University of Nova Scotia, with a bachelor degree in Mechanical Engineering in 1978. He spent the first half of his career involved in the design and construction of the coal plant involved in the transformation to an indigenous, carbon intensive generation source – Nova Scotia coal. The second half of his career at Nova Scotia Power was spent in the optimization and operation of the generation facilities and lately the transformation of Nova Scotia Power Incorporated from the heavy reliance on coal to a balanced portfolio of prime energy sources.

James is on the board of the Carbon Capture and Storage Research Consortium of Nova Scotia (CCSNS) and Fundy Energy Research Network Subcommittee on Socio-Economics.

ELISA OBERMANN, MPA. BA

Elisa Obermann is the Atlantic Director of Marine Renewables Canada (formerly OREG), Canada's marine renewable energy industry association. She joined the organization in January 2012 to support and strengthen collaboration in the Atlantic region. In this role, she works to provide information and education for communities, businesses and individuals and engages government and other sectors to advance the development of a marine renewable energy industry in Canada that can be globally competitive.

Prior to joining Marine Renewables Canada, Elisa worked at Nova Scotia Department of Energy where she focused on renewable energy policy and regulatory development including the province's Renewable Electricity Plan and marine renewable energy policy. She also spent several years in the private sector, specialized in corporate communications and marketing. Elisa holds a Bachelor of Arts in English and a Masters in Public Administration from Dalhousie University.

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Lisa has over 10 years of interdisciplinary experience in the fields of environmental and policy research and analysis, impact assessment, and conservation planning. She has worked as a researcher and project coordinator for both government and non-governmental (non-profit) organizations in Nova Scotia and Ontario in areas such as fish and aquatic habitat management, wetland and watershed management, species at risk recovery planning, and ocean renewable energy. Lisa has lead and served on a number of research projects and advisory committees on ocean renewable energy development in Canada, particularly in relation to understanding and mitigating the potential environmental risks. Since 2010, Lisa has been the Coordinator of the Fundy Energy Research Network, where she collaborates with academics, government and industry to foster research and information exchange with the aim of advancing understanding of the environmental, engineering and socioeconomic aspects of in-stream tidal energy in the Bay of Fundy.

MELISSA BEATTIE , BSc.

Melissa Beattie graduated from Acadia University in 2012 with a Bachelor of Science and a double major in Mathematics and Statistics with Business. She studied the risk and mitigation of risk in tidal energy with the Acadia Tidal Energy Institute. She presently works with WBLI Chartered Accountants in Truro, Nova Scotia.

BRIAN VANBLARCOM, PhD.

Brian earned his PhD at Clemson University in South Carolina, USA. His research interests include economic impact assessment and economic issues related to the tourism, and recreation. Recent publications include: Cost Benefit Analysis of a World Heritage Designation in Nova Scotia, with Dr. Cevat Kayahan, Review of Economic Analysis, accepted for publication, forthcoming; Comparing the Costs and Health Benefits of a Proposed Rail Trail, with by John Janmaat, Special issue of the Journal of Policy Research on Tourism, Leisure and Events: Advancing Healthy Communities through Tourism, Leisure and Events. January, 2103.

Photo Credit: Greg Trowse

ACKNOWLEDGMENTS

ACKNOWLEDGMENTS

We would like to acknowledge the following people for their contribution to the development of the Community and Business Toolkit for Tidal Energy Development. Thank you all for your time, expertise and feedback throughout the process.

Michelle Adams .... Assistant Professor, School of Resource and Environmental Studies, Dalhousie University
Don Aldous .... Don Aldous Consulting Limited
Eric Christmas .... Mi'kmaq Energy Advisor, Mi'kmaq Rights Initiative
Natasha Furey .... Student, Acadia University
Iona Green .... Lecturer, Acadia University
Wayne Groszko .... Instructor, Dalhousie University & Project Manager, Community Energy Co-op (N.B.)
Ralph Heighton .... Nova Scotia Department of Fisheries and Aquaculture, Regional Coastal Resource Coordinator, Northumberland Region
Kristy Herron-Bishop..... Digby Board of Trade
Paul Hopper .... Development Field Officer, Cumberland Regional Economic Development Authority
Leanna McDonald .... Administrative Assistant, Acadia Centre for Estuarine Research
Dana Morin .... Director of Business Development, Fundy Tidal Inc.
Peter Nichols .... Nova Scotia Power Incorporated
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We would like to expressly acknowledge **Dr. Anna Redden, Director of the Acadia Tidal Energy Institute,** for her tireless support of the project.

The Community and Business Toolkit for Tidal Energy Development is the work of many people – experts and community members alike. We wish to thank them all.

Dr. Shelley MacDougall, Co-Project Lead and Toolkit Editor
Dr. John Colton, Co-Project Lead and Toolkit Editor
Alan Howell, Toolkit Project Coordinator

We would like to acknowledge the financial support received from government, industry and research partners.

MAJOR FUNDING PARTNERS

THE ATLANTIC CANADA OPPORTUNITIES AGENCY works to create opportunities for economic growth in Atlantic Canada by helping businesses become more competitive, innovative and productive, by working with diverse communities to develop and diversify local economies, and by championing the strengths of Atlantic Canada. Together, with Atlantic Canadians, we are building a stronger economy.

http://www.acoa-apeca.gc.ca/eng/Agency/OurRole/Pages/Home.aspx

OERA is a not-for-profit association dedicated to leading energy research initiatives, enabling the sustainable development of Nova Scotia energy resources through strategic partnerships with academia, government and industry for the benefit of all. OERA is an amalgamation of OEER Association (Environmental Energy Research) and OETR Association (Technical Energy Research), which were formed in 2006 with funding from the Nova Scotia Department of Energy. OERA's members are Acadia University, St. Francis Xavier University, Cape Breton University, Saint Mary's University, Dalhousie University and the Nova Scotia Department of Energy.

http://www.offshoreenergyresearch.ca

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http://www.gov.ns.ca/econ/overview/

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http://www.aecom.com/About

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http://www.snl.com/irweblinkx/corporateprofile.aspx?iid=4072693

COMMUNITY AND RESEARCH PARTNERS

FORCE

Fundy Ocean Research Center for Energy

FORCE is Canada's leading test center for in-stream tidal energy technology. FORCE works with developers, regulators, and researchers to study the potential for tidal turbines to operate within the Bay of Fundy environment. FORCE provides a shared observation facility, submarine cables, grid connection, and environmental monitoring at its pre-approved test site. FORCE receives funding support from the Government of Canada, the Province of Nova Scotia, EnCana Corporation, and participating developers.

http://fundyforce.ca/about/

CUMBERLAND ENERGY OFFICE

The Cumberland Energy Office is a partnership between Cumberland RDA, the Municipality of the County of Cumberland, the Town of Springhill, and the Town of Parrsboro.

http://www.cumberlandrda.ca/energy/

Municipality of Digby

The Municipality of Digby is actively pursuing opportunities to develop a tidal industry in the Bay of Fundy. Digby was recognized as the "Port of Choice" as part of the Department of Energy, Marine Renewable Energy Infrastructure Assessment. Digby understands the importance of taking a cautious approach to developing this industry and is working with manufacturers and developers in an effort to identify long term supply chain needs. Officials from Digby also believe that the long term socio-economic potential of this industry must have the right balance between ensuring that environmental concerns are not compromised at the sake of industry growth and that, as this industry matures, all efforts are made to ensure its sustainability.

http://www.digbydistrict.ca/renewable-energy.html

Fundy Tidal Inc. (FTI) was established in 2006 to take advantage of local interest in opportunities to generate renewable energy from the tidal currents of the Digby Gut, Grand and Petit Passages located in Digby County, which borders the Bay of Fundy. FTI's mission is to serve as a vehicle for community led in-stream tidal energy projects throughout Nova Scotia and to establish Digby County as a focal point for marine renewable energy industry development and R&D activities. Fundy Tidal has received 5 small-scale tidal Community Feed-In Tariff (COMFIT) agreement, totalling 3.55MW and seeks to complete these projects by 2017.

http://www.fundytidal.com/index.php?option=com_content&view=section&id=5&Itemid=35

Design and layout by Revsof Productions. www.revsof.com

EXECUTIVE SUMMARY

MODULE 1 - OVERVIEW OF TIDAL ENERGY

Author: Dr. Graham Daborn

Tidal power is an old technology. The tidal movements of the oceans represent huge amounts of predictable, renewable energy derived from the gravitational effects of the Moon and the Sun, and have been used by human beings for centuries. Tidal mills, which convert the power of moving water into mechanical energy for grinding grain or sawing wood, existed in Roman times in Europe, and were widespread in eastern North America until the end of the 19th century. Since the beginning of the 20th century, however, interest has been in the generation of electricity from the tides, especially in the Bay of Fundy (Nova Scotia). This module provides a brief introduction to tidal power, its potential in Canada, the alternative approaches by which it can be captured, and the principal environmental and socio-economic issues involved.

Canada has tidal energy opportunities on all three coasts: the Atlantic, Pacific and Arctic. The greatest potential is in the Bay of Fundy, not only because it has the world's highest tides (up to 16m), but also because the region's electricity demand is currently being met primarily by fossil fuels. Tidal energy is renewable, and has the advantage, unlike wind, of being predictable, because the tides are predictable and well known; however, the power output varies over time because of slack water periods, variations in tidal range, and daily changes in the times of high and low tide. For one hundred years, there have been plans for generating electricity from the Fundy tides. Most of the schemes considered building barrages (dams) across the entrances to bays or between islands, storing the tidal waters at high tide, and then allowing the stored water to exit through turbines that would rotate to produce electricity. Conversion of the *potential energy* of the stored water is similar to that in hydroelectric power stations, with which Canada has a great deal of experience.

Research over many decades has shown that barrages have significant implications for water flows, regional ecology, and other coastal resources such as fishing and transportation. The Annapolis Tidal Generating Station, opened in 1985, has demonstrated that the more severe environmental effects are associated with the dam, rather than the turbines used to generate the power, although the latter may pose important risks to fish and mammal populations in the area. As a result, present approaches to tidal power development are based mainly upon electricity generators that are driven by the force of flowing water, rather than by the water stored behind a dam or barrage. These so-called *tidal in-stream energy converters* (TISECs) are analogous to windmills, in that they take the *kinetic* energy from flowing water, without requiring a barrage. Consequently, many of the negative effects of barrages can be avoided, although there remain concerns, particularly with regard to fish and marine mammals. There are numerous designs for TISECs currently being developed around the world, some of which are of commercial scale, able to generate 1 to 2 MW of power. A test site, the Fundy Ocean Research Centre for Energy (FORCE), is being established at the entrance to Minas Basin, Bay of Fundy, to test commercial-scale TISECs.

In 2008, Nova Scotia conducted a Strategic Environmental Assessment of tidal power development in the Bay of Fundy, the outcome of which was a commitment to a systematic, cautious programme of evaluation of tidal power potential in Nova Scotia. As the FORCE test facility is being completed, a broad programme of research and monitoring is under way to assess the environmental and socio-economic implications of large scale electricity generation from the Fundy tides. Principal environmental concerns include: the potential effects on fish, bird, mammal and other aquatic life associated with turbines, electrical cables, construction activities, etc.; the effects on sediment distribution and movement; and the overall effects on tides of removing some of the energy from the water. Socio-economic concerns include: the effects on other resource uses, such as fisheries, mining and transportation; the developmental opportunities for local communities, e.g. through job creation, tourism, etc.; and financial feasibility. These implications are examined in this toolkit.

MODULE 2 - MEASURING AND ASSESSING THE TIDAL RESOURCE

Author: Dr. Richard Karsten

With the world record tides of the Bay of Fundy, Nova Scotia has one of the world's best tidal power resources. Accurately measuring the size of this resource and assessing the portion of the resource that could be exploited is an important step in developing a tidal power industry.

HOW LARGE IS THE NOVA SCOTIA TIDAL RESOURCE?

The combined extractable power from the largest tidal flows in Nova Scotia is nearly 7500 MW. The vast majority of this power is located in Minas Channel (7200 MW). The passages of the Digby Neck region have another 230 MW, while Cape Breton has 5-10 MW.

HOW MUCH OF THE TIDAL RESOURCE CAN BE CONVERTED INTO ELECTRICITY?

The exact proportion of the tidal resource that can or should be converted into electricity is an open question that depends on the efficiency of the turbine technology and acceptability of the environmental impacts of extracting the tidal power. Estimates are based on today's technology and on limiting the impact of power extraction to small reductions in the flow (5-10%). These estimates suggest the Nova Scotia tidal passages can support turbine arrays with an installed capacity of nearly 1500 MW. Once again, the vast majority of this capacity (1400 MW) would be located in Minas Channel. Currently, Nova Scotia has a generation capacity of about 2500 MW. So, tidal power could play a significant role in Nova Scotia's energy future.

HOW DOES THE TIDAL RESOURCE VARY ACROSS NOVA SCOTIA?

The tidal resource is not the same for all tidal passages. Tidal passages that connect tidal basins to the Bay of Fundy, like Minas Channel and Digby Neck, have a large extractable power. But, extracting power from these passages will have a direct impact on the tides in the tidal basin. Other passages that lie between two large bodies of water, like Petit Passage and Grand Passage, may have a smaller extractable power but a greater portion of this power can be exploited with little impact on the surrounding tides.

The speed of the tidal currents in each passage also affects how the power will be generated. Petit Passage and Digby Gut appear to be similar passages, but the speed of the currents in Petit Passage is almost twice that in Digby Gut. This means the same turbine will produce roughly eight times more power if placed in Petit Passage than if it was placed in Digby Gut. It will also experience four times as strong forces. Clearly, these passages require different technologies to efficiently exploit the resource.

The resource and deployment sites in each passage must be assessed individually to determine the technology to be used and the power that should be produced.

HOW ARE POTENTIAL TURBINE ARRAY SITES ASSESSED?

There are many aspects to determining a suitable site for an array of tidal turbines. In terms of the characteristics of the tidal flow, sites are assessed using a combination of observations of the tidal currents (using acoustic profilers) and numerical simulations. These assessment techniques can produce an accurate prediction of how the tidal currents will vary over years and decades. However, it is still difficult to predict high frequency, turbulent variations of the flow that will have important affects on power production.

Determining how large an array could be deployed at a given site is difficult. Turbine arrays can have odd cumulative effects; that is, 100 turbines may not generate 100 times the power of one turbine. An array of turbines can be more efficient than individual turbines if they increase the blockage ratio – the portion of the channel they occupy. An array can also decrease the efficiency if the turbines lie in each other's wake. The impact turbines have on the environment generally increases as the number of turbines increases; that is, 100 turbines have more than 100 times the impact of a single turbine. Once again, an assessment of how large an array can be deployed at each site is required.

MODULE 3 - TIDAL POWER EXTRACTION DEVICES

Authors: Dr. Sue Molloy and James Taylor, P.Eng.

TIDAL ENERGY CONVERTERS

The overall theme in tidal energy convertors (TEC) is that designs are changing constantly but that the fundamental science of operation does not. There is currently no single TEC model that can be applied to all tidal resource settings. However, there are two primary categories of tidal turbines, horizontal axis and vertical axis.

- Horizontal Axis: When a turbine has a horizontal axis, the axis of rotation is designed to be parallel or slightly off-parallel to the flow of the water. These types of turbines tend to resemble underwater windmills.

    o Cross flow: Cross flow turbines are a variant of horizontal axis. This model of turbine has the axis of rotation across the flow of water, parallel to the water surface. These turbines can resemble push-style lawnmowers.

    o Open centre: Open centre turbines are a variant of horizontal axis. These types of turbines are shaftless and have the blades connected to an outer rotating rim to allow current flow through a large centre hole.

- Vertical Axis: Vertical axis turbines have an axis of rotation that is perpendicular to the flow of water. This means the axle around which the blades rotate is vertical at 90° to the water flow direction. These devices can resemble egg beaters.

Turbines rotate in tidal currents of typically 2m/s - 4m/s (metres/sec) (4-8 knots). This rotational energy turns an axle that creates electrical energy through a generator. That electrical energy is then used to provide power for a specific use/user or is added to the central power grid. The high current speeds of the Bay of Fundy (more than 5m/s) offer developers both a unique opportunity and a formidable challenge.

Tidal turbines can be moored in a variety of ways. Turbines can be floated on the surface of the water, usually on a floating platform or set of pontoons, with the blades of the turbine underwater. Vertical axis turbines typically use this style of mooring to take advantage of the highest-speed currents approximately 1m below the surface. Typically, in a floating structure, there will be some form of cable mooring to keep the turbine in relatively the same place. Some turbines can be anchored to a permanent structure like a pier and extended out into the water. Currently, most horizontal axis designs are being deployed on the sea bottom. They are connected to a pile that is driven into the ocean floor or connected to a concrete surface that has been installed on the sea floor, known as a gravity base.

In Nova Scotia, each model of tidal turbine has, or is expected be, tested. In 2009, the first turbine, an open center model developed by Open Hydro, was installed and removed from the Bay of Fundy.

A general attitude in the tidal industry right now is that turbine designs need to be kept simple. Fewer parts in the design mean less maintenance will be required over the life of a turbine and a simple design enhances the ability of the device to work in the marine environment.

Some questions currently facing designers include:

- What is the marine environment like at the installation site?
- How will the turbine be installed?
- How accessible will the turbine be for maintenance?
- How long will the turbine last before maintenance is required?
- What kind of maintenance can be expected?
- How much time will there be to access the turbine at slack tide?
- Should the turbine be installed on the sea floor or floated at the surface?
- How will the geological marine environment affect the turbine and vice versa?

As projects progress, these questions get asked over and over again, and each new marine environment requires a new set of answers. At present, turbines need to be customized for an environment as there are no "one size fits all" turbines at the moment. Some solutions to these types of questions have been successful in one location and found to be completely inappropriate in others. For example, the Bay of Fundy has approximately 20 minutes of slack tide and very high current speeds, which makes drilling to install concrete piles unattractive. However, piles have been used successfully to support many turbines in the ocean around the European Marine Energy Centre Test Centre in the Orkney Islands in Scotland, where the currents are somewhat slower.

MODULE 4 – THE REGULATORY REGIME FOR TIDAL ENERGY

Author: Elisa Obermann

Tidal energy is a public resource, and like many natural resources, tidal energy is governed by several pieces of legislation, regulations, and overarching policies. Laws and policies are designed to ensure that the development of this resource is carried out in the best interest of the public and the environment. As the marine ecosystem supports multiple users and uses, legislation strives to provide suitable licensing processes, environmental protection, worker/public safety, resource conservation, recognition of other users, community benefits, and economic benefits.

POLICY AND PROGRAMS FOR TIDAL ENERGY

The development of tidal energy in Nova Scotia has been supported through enabling policies, strategies, plans, programs, and regulatory development. Several provincial policies, programs, and legislation addressing tidal energy development have been established in recent years, with many of them informing the current regulatory requirements and processes for tidal energy, including:

- **Strategic Environmental Assessment (SEA):** SEAs are an important planning tool and provide an assessment of the social, economic, and environmental effects and factors associated with potential development of renewable energy sources. A SEA was completed for the Bay of Fundy in 2007-2008 and the Cape Breton region in 2012-2013. An update to the Bay of Fundy SEA will be completed in 2013.

- **Renewable Electricity Plan:** The Government of Nova Scotia's Renewable Electricity Plan, established in April 2010, sets out a detailed path for achieving the target of 25% renewable electricity supply by 2015 and establishes an ambitious goal for 2020 to have 40% of Nova Scotia's electricity supply (sales) produced from renewable resources. The 2020 goal is now legislated in Nova Scotia's Electricity Act. It also includes direction to establish a feed-in tariff (FIT) for tidal energy.

- **Renewable Electricity Regulations:** The Renewable Electricity Regulations established under Nova Scotia's Electricity Act in October 2010 provide a legal basis for many of the actions put forward in the Renewable Electricity Plan. The regulations outline many of the legal criteria and requirements for the Community Based Feed-In Tariff (COMFIT) program as well as establish a One Window Process to review COMFIT applications and details on the developmental tidal FIT.

- **Enhanced Net-Metering Program:** Net-metering is a utility-led program by Nova Scotia Power that allows a consumer to meet their annual electricity needs with a low impact renewable electricity generation facility of up to 1 MW capacity. Tidal energy is considered a low impact renewable resource that qualifies for this program.

- **Community-Based Feed-In Tariff (COMFIT):** The COMFIT is a program designed to support smaller-scale renewable energy projects developed and owned by communities. Tidal energy is supported through the COMFIT program and is eligible to receive an established price per kilowatt hour (kWh).

- **Developmental Tidal Array Feed-In Tariff (FIT):** A FIT specific to large-scale devices and tidal arrays is being developed by the Nova Scotia Utility and Review Board. It will cover projects connected at the transmission level using devices greater than 0.5 MW.

- **Marine Renewable Energy Legislation:** Unlike other resources, legislation specific to tidal energy does not exist. The Bay of Fundy SEA recommended that legislation for marine renewable energy be developed. The Government of Nova Scotia has been working to develop new legislation that would provide clear, predictable, and efficient processes to support the sustainable advancement of the sector.

- **Marine Renewable Energy Strategy:** In May 2012, the Government of Nova Scotia released its Marine Renewable Energy Strategy. It includes enabling mechanisms and activities to help advance tidal energy in Nova Scotia, including a feed-in tariff scheme coupled with a licensing process that will be established in legislation to provide a pathway for projects to proceed from the testing stage to demonstration and, finally, to commercial development.

• **Statement of Best Practices:** The Government of Nova Scotia is currently developing a statement of best practices that embeds standard requirements and practices for risk assessment as well as options for precautionary and adaptive environmental assessment, licensing and management, site assessment and environmental monitoring requirements, modeling and monitoring energy production, deployment of devices, stakeholder consultation and engagement, and transparency in environmental data collection and dissemination.

RELEVANT LEGISLATION, REGULATION, AND THE PERMITTING PROCESS

There are multiple federal, provincial, and potentially, municipal authorities involved in the regulation of tidal energy. Nova Scotia's current regulatory framework and policies reflect the varied and complex public interests associated with tidal energy. These public interests include: multiple uses of the marine environment; potential conflicts among these uses; granting rights to produce energy from a shared, public resource (oceans); and the sale and distribution of electricity through a regulated, integrated utility (Nova Scotia Power Inc.).

PROVINCIAL LEGISLATION	FEDERAL LEGISLATION
• Nova Scotia Environment Act	• Fisheries Act
• Environmental Goals and Sustainable Prosperity Act	• Canadian Environmental Assessment Act
• Fisheries and Coastal Resources Act	• Species at Risk Act
• Endangered Species Act	• Migratory Birds Convention Act
• Energy Resources Conservation Act	• Navigable Waters Protection Act
• Crown Lands Act	• National Energy Board Act
• Beaches Act	• Oceans Act
• Special Places Protection Act	• Canada Environmental Protection Act
• Electricity Act	• Shipping Act
• Public Utilities Act	• Canada Labour Code
• Social Legislation	
• Assessment Act	
• Municipal Government Act	

THE FUTURE OF TIDAL ENERGY REGULATION

Nova Scotia's Marine Renewable Energy Strategy includes a plan to establish a licensing process in legislation for tidal energy projects. The licensing process will include two licensing streams—one for technology development and the other for commercial power development. This system will focus on a staged, progressive, and adaptive approach to development and deployment of in-stream tidal devices.

MODULE 5 – ENVIRONMENTAL RISK ASSESSMENT

Authors: Lisa Isaacman and Graham Daborn (Executive Summary written with assistance from Monica Reed.)

Understanding the potential environmental implications of Tidal Energy Convertors (TEC) development is crucial for the technology's success in providing clean, renewable energy. With little evidence on the environmental effects of TEC development, careful assessment and mitigation of environmental risk is required. Independent scientific experts have collaborated to produce "A Framework for Environmental Risk Assessment and Decision-Making for Tidal Energy Development in Canada," which was prepared for the Department of Fisheries and Oceans and the Nova Scotia Department of Energy. This framework provides guidance for project planners and reviewers in the assessment and mitigation of environmental risks for TEC development proposals and projects. Module 5 highlights the Framework's key considerations and procedures and is intended to inform project planners and reviewers, as well as the general public.

Ecological components, including wildlife, physical habitats (sediment, water, vegetation, geology) and ecosystem processes (e.g., biophysical dynamics, food-web interactions), are often referred to as *receptors* because they receive the pressures induced by development. When examining the potential implications of TEC development, the pressures, known as stressors, are assessed to evaluate their potential impact on the receptors. The table below lists the predicted stressors and the potential environmental effects associated with each stressor. **Please note**: the listed effects have only the potential to occur, and thus require evaluation; the list is not a forecast of what *will* happen.

Predicted Stressors and Potential Environmental Effects

STRESSOR	POTENTIAL ENVIRONMENTAL EFFECTS
Changes in Current Energy	Change in water movement characteristics and patterns in close proximity to TEC device, altering local sediment dynamics (scour, sediment deposition, and transport). Alteration of regional and/or coastal/shoreline habitat due to alteration of sediment dynamics (alteration of substrates, erosion, transport, and deposition pattern) and tidal patterns (timing, height, mixing patterns, velocity).
Presence of Physical Infrastructure	Loss or modification of benthic or pelagic habitat structure and complexity due to scour and presence of device base and submarine cables. Attraction, avoidance, or exclusion of species from habitat areas leading to changes in biological community structure and function.
Physical Interactions with Infrastructure	Physical contact with device or stress induced by pressure flux or turbulence causing injury or death of marine organisms. Altered movement and migration patterns due to avoidance.
Noise, Vibrations, and Light Emitted from Devices	Increased stress, physical or physiological damage to auditory systems, or behavioural changes (e.g. habitat avoidance/attraction, change in movement patterns, decreased mate and prey detection).
Emitted Electromagnetic Fields	Increased stress, physical or physiological damage, and behavioural changes (avoidance/attraction, communication, movement, and migration patterns).
Release of Contaminants	Chemical pollution from paints, antifoulants, and lubricants affecting water chemistry and marine organism health.
System-scale Effects	Impacts on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function, particularly when migratory species are affected.

It is important to recognize the great amount of scientific uncertainty associated with TEC developments. The listed environmental impacts have been recognized as potential effects that require pre-deployment assessment, with monitoring continuing throughout the device's operational phase and beyond device decommissioning.

The probability and magnitude of the potential effects are difficult to gauge for a number of reasons. Every environment is unique and complex. Additive or *cumulative effects* caused by the combination of past, present, or future human activities should be anticipated, but are difficult to predict. Changes to critical ecosystem processes may appear small and incremental, but may change, intensify, or only become detectable over a period of time. Acting in concert with other activities, a seemingly minor disturbance may well result in a major impact on a critical aspect of the environment or other established resource use. Developments, particularly commercial-scale arrays, will need to be reassessed at regular intervals to address these elements of uncertainty.

In addition to the environmental complexities, the potential effects are difficult to predict because in-stream tidal energy generation is still in the early stages of research and development. Numerous TEC technologies have been developed, but few full-scale devices have been tested for prolonged periods of time. To date, environmental monitoring has largely focused on the *near-field* (in the immediate vicinity of the turbine) impacts of a single device. Monitoring studies have been limited by the duration and scope of the test projects, as well as by the lack of available monitoring technologies and techniques suitable for high-energy marine environments. New methodologies for data collection and environmental monitoring techniques are being developed alongside the emerging industry, and thus, have not yet been verified as effective and accurate. Because the aforementioned factors combine to create a substantial degree of scientific uncertainty, environmental monitoring results from one project should not be used to predict the potential environmental effects of TEC developments elsewhere. Additionally, the outcomes of one project should not be used to make inferences about another project because environmental effects are likely to be technology-, scale-, and site-specific.

Due to the uncertain environmental risks, a set of principles for the objective review of proposed TEC projects is presented to facilitate environmentally responsible advancement of this developing industry. These principles include:

1. adequate consideration of ecosystem-scale and cumulative effects;
2. a precautionary and adaptive management approach;
3. the need for appropriate and early initiation of baseline studies;
4. the need for risk evaluation criteria and indicators that are relevant, flexible, and can be consistently applied to projects of any type, size, or location;
5. consideration of other human uses of the ecosystem; and
6. early and on-going First Nations engagement.

See Module 5 for further information pertaining to these principles.

Module 5 presents a series of steps (framework), best practices, and criteria/indicators to guide project planners and reviewers in assessing the environmental risks of a proposed project and planning for the appropriate adaptive mitigation and monitoring of the identified risks. The table below describes the steps.

Framework to Reduce Risk

STEPS	EXPLANATION
1. Define the scope of the review.	Clearly delineate the scope of the project and review. This includes identifying the activities and ecosystem components to be reviewed, defining the spatial and time scale of the project, and the review, integrating ecosystem-scale and cumulative effects and recognizing the potential for staged developments.
2. Evaluate the project site characteristics.	Assess the interrelationship between the scale of the development and the site characteristics. TEC developments may be found in three different site types: through the narrow entrance of a coastal basin, through multiple passages between landforms, or in certain coastal areas offshore. The characteristics of the site, as well as the presence of a species or habitat of high conservation concern, will influence the implications of the TEC development.
3. Evaluate the environmental risk of the project proposal based on a set of standard defined criteria and indicators.	Evaluate risk based on multiple qualitative and numerical science-based evaluation criteria and indicators, which are adjustable to particular project designs and sites. Criteria in the categorization of risk levels of TEC development include: 1. Extent of Habitat Alteration Due to the Presence of Physical Infrastructure; 2. Effect on Water Movement and Sediment Dynamics; 3. Timing of Short Term Projects; 4. Physical Obstacle to Marine Organisms; 5. Noise, Vibrations, and Turbulence Effects on Marine Organisms Due to Turbine Operation; and 6. Effects of Other Signals Emitted by Project Infrastructure. To determine the risk level, risk indicators within each of these criteria will need to be evaluated based on the probability, detectability, spatial extent, significance, duration, and reversibility of the forecasted effect.
4. Identify risks of interference with other human uses of the ecosystem.	Determine the risk level for interference with other human uses of the marine and coastal ecosystem (e.g. fisheries, recreation). While many activities will be able to coexist with TEC developments, some may be displaced or disrupted. Marine spatial planning, socioeconomic impact assessment, and/or consultations with stakeholders can assist in evaluating the risks and planning mitigation measures.
5. Categorize the overall risk of the proposed project and make a management decision.	With the risk level of each of the criterion established and weighted equally, assess the overall risk level of the entire project. Each risk level (low, moderate, high, extremely high) couples with a management decision on the project's appropriateness to proceed as proposed.
6. Propose supplementary mitigation measures to reduce the overall risk of the project, when applicable.	Mitigation measures can be used to downgrade the overall risk of the project, potentially avoiding rejection, delays, and/or added costs associated with the need for a more in-depth review, baseline studies, and monitoring program. Mitigation measures may involve site relocation, change in the timing of project activities, adjustments to the size or configuration of the development, or use of mitigation devices such as erosion protection, or fish/marine mammal deterrents.
7.) Prepare the environmental monitoring and follow-up activities, and an adaptive management program for an approved project.	Design a long-term adaptive environmental monitoring and management program for an approved project, including monitoring requirements, timelines, and/or conditions for re-assessment, and an adaptive management response plan. These follow-up activities are key to reducing scientific uncertainty and allow improved decisions to be made in the future. Monitoring confirms the predictions of the environmental assessment, exposing the effectiveness of the mitigation measures and identifying lower than anticipated and/or unanticipated changes that necessitate adaptive management measures. An adaptive response plan can ensure appropriate and timely actions are taken to mitigate the cause of unanticipated effects.

See Module 5 for further information pertaining to these steps.

MODULE 6 - STAKEHOLDER AND COMMUNITY ENGAGEMENT

Author: Dr. John Colton

Effective community and stakeholder engagement is critical in the development of tidal energy. There is no better strategy for mitigating the risks associated with developing a tidal energy project than to develop a stakeholder engagement process that is inclusive of all stakeholders. Stakeholder and community engagement is particularly relevant to tidal energy development as there is likely to be a wide range of stakeholders affected. Experience shows that participatory processes facilitate consensus and conflict management, build local pride, and create confidence, trust, and greater cooperation.

Once stakeholders have been identified, it is important to work to understand their concerns. Stakeholders form opinions on renewable energy developments based on their perception of the environmental, socio-economic, and emotional impacts the proposed development has on them and their community. When considering the potential for tidal energy development in an area, it is important to also identify any First Nation communities in the region. Keep in mind that these communities do not have to be necessarily close to the proposed tidal energy site to be considered an important stakeholder. Treaty rights can extend across hundreds and, in some cases, thousands of square kilometers, including both terrestrial and marine ecosystems. The Crown or government has the legal authority to consult with First Nation communities, but it is incumbent on tidal energy developers to play a role as well.

Methods for stakeholder engagement vary and are numerous. Planning ahead and choosing the right community and stakeholder tool is important, as some methods are better suited for specific points in the development process. The *Spectrum of Community Engagement* provides an outline of engagement goals and the methods associated with each goal. Understanding the right mix of methods and their use will provide better opportunities for communicating information and learning the perspectives of community and business stakeholders. More importantly, basing the community and stakeholder engagement process on principles of transparency and respect will foster the collaborative spirit necessary to engage in a discussion on a tidal energy project.

MODULE 7 - FINANCIAL EVALUATION AND THE COST OF ENERGY

Author: Dr. Shelley MacDougall

The electricity generated from tidal energy will be expensive at first, but the cost is expected to decline over time as experience, efficiency, technology improvements, and economies of scale are gained. The goal is for tidal energy to be competitive with other forms of renewable energy, such as wind.

Though the energy of the tides is freely available, the cost of harvesting it is high. The cost of the energy comes from the research and development costs, site assessment and permitting, capital costs of tidal energy converters, bases, monitoring devices, subsea cables and on-shore connection to the electrical grid, installation, environmental monitoring and reporting, lease and insurance costs, maintenance and periodic overhauls, and decommissioning costs.

An example of a 1 MW tidal energy investment is detailed in the toolkit. A 1 MW device would be required in the deep and fast waters of the Minas Passage. The median cost of electricity of the single 1 MW device at the demonstration stage is estimated to be $683 per MWh or $0.683 per KWh. The estimated energy output is estimated to be 3,500 MWh per year. To achieve economies of scale, an array of tidal energy converters would need to be connected to the underwater cables and electrical grid. The profits generated from the sale of the power to Nova Scotia Power Inc. (NSPI) would go to the project developer, the project's lenders, and shareholders. The four tidal energy test berths in the Minas Passage are leased by consortia of large companies that include technology developers such as Marine Current Turbines and Atlantis Resources and their partner companies, Minas Basin Pulp and Power, Irving Shipbuilding, and Lockheed Martin.

Small scale tidal energy devices, designed to produce less than 0.5 MW of electricity, can be placed in arrays in smaller, lower flow areas such as Digby Gut, and Petit and Grand Passages. The cost of energy generated by early stage tidal energy converters in the development stage was estimated by Synapse Consulting to be $652 per MWh or $0.652 per kWh. Each device could deliver an estimated 1,620 MWh to the distribution system. The small scale projects fall under the Nova Scotia Community Feed-in Tariff program if they are at least 51% owned by local communities. The profits generated from the sale of the power would go to the local owners who are partnering with companies that have developed tidal energy conversion technology or assisted with project development.

MODULE 8 - OPPORTUNITIES AND STRATEGIES FOR COMMUNITIES

Authors: Alan Howell and Dr. John Colton

SECTION 1: BENEFITS OF TIDAL ENERGY DEVELOPMENT FOR COMMUNITIES.

Tidal energy represents a unique opportunity for communities across Nova Scotia. Tidal energy development will create jobs, support research, and provide cleaner energy. Understanding the opportunities and challenges of tidal energy can help communities make informed choices and support community buy-in.

What are the Opportunities Both Large and Small Scale?

Small scale projects that are COMFIT eligible are currently the primary opportunity for communities. Being awarded a COMFIT provides a community a guaranteed price for the energy it produces. While the initial revenue will likely be used for debt repayment, the life of a project can span decades and can contribute to the long term stability of a rural coastal community. A COMFIT award can also be an opportunity for partnership. Organizations or groups who may not have the capital necessary to develop a project alone have the opportunity to partner with other entities to support a COMFIT project.

Large scale opportunities are also available to communities, but long term benefits will not materialize until the tidal energy industry matures in Nova Scotia. Communities across Nova Scotia will have something to gain from the development of a large scale tidal energy industry. Communities that are located near tidal energy deployment and servicing sites will likely see the greatest proportion of benefits.

Important Questions

Often, the first question community members ask is, “how many jobs will this create?” or “how will it benefit the economy?” These are valid and important questions. They are, however, difficult to answer precisely. The employment and economic benefits of tidal energy development are not well documented, largely because few projects have been completed to date. Also, the number of jobs created is highly contingent on the size of the project and who develops it, especially where the development is not a COMFIT. Large scale or tidal array developments will have greater demand for labour and expertise, which will mean more job creation opportunities; this is balanced against the complexity of such projects that may require materials, equipment, and expertise not available locally. Potential direct job ranges of 2 to 22 jobs per MW capacity have been cited by researchers and industry experts. It is almost certain that any tidal energy project will have an economic impact in the local community. Jobs can come from directly working on a project (welding, vessel operation, etc.) as well as from the increased demand for services in the community (lodgings, food, and retail). At the outset, it is expected that there will be a mix of direct and service related jobs. Other benefits to communities include increased economic diversity, tourism potential, education and research opportunities, and skills and capacity building for local organizations, workers, and administrators. Perhaps one of the most significant opportunities tidal energy presents is the ability to reduce reliance on energy sources that damage the air, water, and soil. Local renewable energy projects are part of a broader provincial, national, and international solution to improve the quality and sustainability of our environment.

What are the Challenges to Attaining Benefits?

Communities can face many challenges to attaining the benefits they want and not all benefits will be available for all communities. Geography, demographics, and local labour force characteristics may not support the development of local jobs. There are no local content rules for renewable energy development in Nova Scotia; however, using local expertise and materials is often in the developer’s best interest. Local opposition to tidal energy can stop projects in their tracks. Fostering good working relationships amongst tidal project teams and local communities members, especially if they come from very different backgrounds, can be time consuming and difficult. However, as has been shown in the United Kingdom, United States, British Columbia, and here in Nova Scotia, open, honest, and frank discussions of tidal energy can help to overcome challenges and result in both large and small benefits for local communities.

SECTION 2: STRATEGIES FOR COMMUNITIES AND BUSINESSES TO GARNER SOCIO-ECONOMIC BENEFITS

Nova Scotia and other Atlantic Provinces have a pool of knowledge, infrastructure, and services related to ocean and marine technology and industry. Collectively, this combination of knowledge, infrastructure, and services has been used to develop a state-of-the-art commercial fishery, ship building enterprises, oil and gas development, and barge hauling services. Local, regional, provincial, and federal governments have invested significant resources into exploring how the skills associated with these types of industries can be used in other industrial sectors. This is important, as communities are looking for strategies to become more *resilient* to weather the changes brought about by economic uncertainty and the *booms and busts* associated with certain industries. Exploring a community's infrastructure, skills and knowledge of its citizens, its services and amenities, and understanding how these can collectively contribute to and support tidal energy development may provide for greater resiliency and sustained community development.

Strategies for community development have evolved from a traditional top-down approach to a grass-roots approach. Traditional economic development models have focussed on job creation by encouraging greater economic diversity to stimulate economic growth in regions. Increasingly, this development approach is being replaced by a more holistic approach that focuses on socioeconomic growth. Inherent in this shift have been the role of the citizen and the focus of development. Citizens and other stakeholders in this new model of development become active agents in shaping their communities through harnessing local assets found in their communities and businesses. This approach to development moves beyond job creation by broadening its focus to *community* development. With this approach, the community is examined through another lens: that of *Community Capital*. Researchers have identified a variety of types of community capital: natural capital, physical capital, economic capital, human capital, social capital, and cultural capital.

Tidal energy development may provide rural, island, and other remote communities with energy that may allow for development of local small-scale industries such as greenhouses, tourism-related activities/facilities, or small-scale manufacturing. Any ownership model can produce these types of opportunities. Choosing the model will depend on resources available, the mix of stakeholders, and the willingness to take on the risks associated with ownership.

MODULE 9 - OPPORTUNITIES AND STRATEGIES FOR BUSINESSES

Authors: Elisa Obermann and Dr. Shelley MacDougall

The development of tidal energy projects will require a supply chain of multiple services, supplies, and expertise including marine scientists and engineers, mechanical and electrical technicians, vessels, sensory instruments, divers, steel fabricators, manufacturers and supporting expertise such as insurance, legal, transportation, and financial services. The building of a supply chain is important to support the advancement of tidal energy development and it also represents a new economic opportunity.

Due to the early stage of development of the tidal energy industry, there are presently supply chain gaps in capability and capacity regionally, as well as internationally. The current gaps identified are in device manufacturing, engineering construction, foundations, and anchoring. At the same time, Natural Resources Canada identified areas where Canada has evident strengths to support tidal energy development, including deep sea ports, marine construction, resource monitoring and analysis, environmental assessment, marine supplies, commercial diving, and transport. These challenges and strengths present opportunities for businesses, communities, and individuals in Nova Scotia with applicable expertise and skills sets to contribute to development domestically, nationally, and globally.

Getting involved in the supply chain side of tidal energy development requires an understanding of the supplies, services, and skills required for a tidal energy project. Every project is different depending on location, size, and technology used and this could dictate the supplies and services required. There are **six project stages,** each requiring an array of technical as well as supporting and enabling services:

1. Research and Development: The research and development stage includes research and testing of tidal energy technologies to test and refine a prototype design that can be developed into a commercial-scale device. Typically, R&D activities are conducted by specialized centers belonging to companies, universities or government entities.

2. Site Screening and Project Feasibility: The first stage of project development is aimed at identifying potential sites, learning characteristics of the sites, and determining feasibility of a project at those sites. After a potential site has been identified through a site screening, a site resource assessment is completed. The next step is to conduct various feasibility studies that consider the resource identified, resulting in detailed modeling of potential constraints to the project.

3. Planning: During the planning stage, tidal energy developers engage in environmental and technical studies and activities to help inform project design and provide details necessary for determining what types of permits, licenses and authorizations will be required to move forward with the project.

4. Project Design & Development: Tidal energy developers typically progress to the project design and development stage if the outcome of feasibility assessments meets the project objectives. During this stage, a developer typically performs activities necessary for gaining project approvals and permits and as design progresses, technical information feeds into the regulatory process.

5. Project Fabrication: This stage focuses on the implementation of the selected procurement strategy for elements of the project that are to be contracted out. Device, project components, and infrastructure begins to be manufactured according to standards, timescales and costs agreed to in the contract.

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

7. Operations and Maintenance: The project development process will be designed to ensure cost-effective and safe operation throughout the life of the project. Maintenance will be scheduled to enable efficient performance and mitigate environmental impact. This stage will likely require technical support from the installation contractor, equipment supplier, and technology developer at early stages of operation.

8. Decommissioning: Once a project reaches the end of its operating life, it will be decommissioned and the associated infrastructure removed in a safe and environmentally sustainable manner and in accordance with regulatory requirements.

Growth of the tidal energy sector in Nova Scotia and globally will be highly dependent on having a supply chain with the right businesses, skills, and expertise to support project and industry development. Nova Scotia and the Atlantic region are well suited to pursue involvement in the growing tidal energy industry by transferring skills and expertise from related sectors including: offshore petroleum, ocean technology, wind energy, marine structure fabrication and marine transport, and port facilities.

An effective strategy for taking up the commercial opportunities presented by tidal energy is industry clustering. An industry cluster is a geographic concentration of companies (suppliers of goods and services, their customers, and related companies) and organizations (research labs, universities, industry associations, standards associations) in the same industry. Companies in the cluster share common needs, opportunities, constraints, and obstacles to productivity. They both compete with one another and cooperate. The most famous of industry clusters is Silicon Valley in California.

To develop an industry, "cluster thinking" is needed: an orientation toward groups of organizations, rather than individual firms. Many of the pieces are in place for the Nova Scotia tidal energy industry to develop as a cluster.

One of the advantages of an industry cluster is strength in numbers. Another advantage is the proximity of suppliers and customers, which facilitates the development of new technologies and processes by being able to meet regularly, face-to-face. The rate of innovation in clusters tends to be greater than outside clusters, at least during the growth stage. Beyond the construction and deployment of the tidal energy devices in local waters, Nova Scotia has the opportunity to develop technologies and expertise associated with them that will be in demand worldwide. Developing and exporting innovative products and process expertise will generate local economic benefits. Industry clustering can help achieve these innovations.

MODULE 10 - FINANCING, GOVERNMENT SUPPORTS, AND RISK

Authors: Dr. Shelley MacDougall and Melissa Beattie

Technologies for tidal energy conversion are in the early stages of development. Devices are still expensive to build and their performance in waters outside of test sites is still uncertain. Companies developing the technologies will seek to deploy them where electricity can be sold. Developing projects involves many steps: feasibility assessment, planning and permitting, design and construction, manufacture, installation, operation and maintenance, and finally, decommissioning. There are various supports provided by governments, mostly at the technology research and development stage. When the "heavy lifting" begins, finding financing is a considerable barrier for all but the very largest companies. Tidal energy projects have very large upfront costs and very long pay back periods.

There are also significant risks inherent in tidal energy projects. The largest is technology risk – simply the unpredictability of if and how well the new technology will perform once it is installed. Until devices and arrays are deployed commercially, setbacks are hard to predict and mitigate. Insurers do not have sufficient actuarial data to set insurance premiums. Besides technology risks, there are construction risks, potential problems with equipment and manufacturing accessibility, cost overruns, a lack of capable operators, and political and regulatory risk. Of course, health and safety of workers and other users of the waters, damage to the environment, and, in reverse, damage to the equipment by the environment and other users are significant risks. Another, less understood, risk is community dissent toward a development. There are steps that can be taken to mitigate many of the risks, but still, a substantial amount of remain.

Once tidal energy devices are in the water and operating, the rate of project development should increase as financing becomes easier to attract. However, government support is needed to help get the technology through the so-called "technology valley of death": the pre-commercialization stage for which there is scarcity of financing. Supports being provided by the federal and provincial government through the various stages of technology and project development include legislated renewable energy targets, research and development funding, feed-in tariffs, community economic development investment funds (CEDIFs), flow-through shares, accelerated depreciation, and the Scientific Research and Experimental Development (SR&ED). There is still a need for further government interventions, such as loan guarantees, to enable developers to access financing in order to move forward.

MODULE 11 - ASSESSING THE POTENTIAL ECONOMIC IMPACTS OF A FIVE MEGAWATT TIDAL ENERGY DEVELOPMENT IN THE DIGBY AREA OF THE BAY OF FUNDY

Author: Dr. Brian VanBlarcom

The economic impacts of tidal energy development are largely unknown because few commercial scale developments exist to date; those that do exist have only been in operation for a short time. What we do know is that tidal energy projects involve multiple stages and inputs. Inputs cross multiple sectors. This module attempts to model the potential impacts of a theoretical 5MW tidal energy facility that consists of several tidal generation devices with a capacity of 0.5 MW or less and that is capable of being interconnected with the electrical grid through a distribution system. The total estimate cost for this project is $50 million.

Why the Digby Area?

Digby was chosen for analysis based on a number of potential sites being identified in that area. Fundy Tidal Inc. has received regulatory approval for a 1.95 megawatt tidal power project in Digby County. Small scale tidal developments are the focus of the case study since the applicable technology/costs/degree of local inputs, etc. for larger (150 MW range) developments are significantly less precise at this point in time. Impacts would be different in other areas of the province due to differences in the type and number of businesses and the make-up of the labour force.

The Input/Output (I/O) Model

An input/output (I/O) model is used to estimate potential economic effects. An input/output model attempts to estimate total impacts across all sectors in an economy by modeling the total demand for goods and services from, for example, the insertion of a tidal energy project into an economy. An I/O model attempts to estimate the total direct, indirect, and induced effects of a project. Direct effects occur when firms involved in tidal power development buy goods and/or services from local firms. Indirect effects occur when local firms buy local inputs (goods/services) as a result of the direct impact. The economic activity resulting from the re-spending of income generated by the direct and indirect effects is known as the induced effect. The induced impacts are additional expenditures resulting from increased income brought about by increases in final demand.

This module makes a few assumptions:

1. The cost of development is approximately $10 million per MW for a tidal energy facility.
2. A tidal project 5MW in size will take 5 years to complete and spending will be equal each year.
3. Seventy percent of all the required inputs for the facility will come from within the Digby area.
4. Those living and working in the Digby area will spend all of their earnings within that area.
5. The size and way the economy of Digby currently functions will remain static, with the only significant change being the 5MW tidal energy facility.

The model is not a precise tool for estimating economic and job growth; however, it does provide insight into the potential impacts of tidal energy development on the scale of 5MW in the Digby area.

The I/O model indicates that:

- A 5MW project would provide steady work for 48 people for the 5 years of the project develoment and construction, with an estimated annual income of $60,000 per person.
- Over the lifetime of the tidal facility (estimated at 20 years), an equivalent of two full-time jobs would be created.

Photo Credit: Greg Trowse

INTRODUCTION

INTRODUCTION TO THE COMMUNITY AND BUSINESS TOOLKIT FOR TIDAL ENERGY DEVELOPMENT

Author: Dr. Shelley MacDougall

The Community and Business Toolkit for Tidal Energy Development, produced by the Acadia Tidal Energy Institute, is a comprehensive guide for the sustainable development of in-stream tidal energy. It has been written for people who wish to broaden their understanding of what tidal energy is, what is involved in its development, and what potential impacts and benefits it will have.

The Toolkit provides broad coverage of the challenges and opportunities of sustainably developing in-stream tidal energy. It describes the location of suitable tidal resources in Nova Scotia, environmental assessment, technologies, community and business opportunities, strategies for garnering economic benefit, community engagement, costs, financing and risk. The Toolkit has been developed to provide a foundation of knowledge to empower local stakeholders who are interested in learning more about the many issues related to tidal energy development. The regional focus of the Toolkit is Nova Scotia, Canada, though much of the information is applicable nationally and internationally.

The Community and Business Toolkit for Tidal Energy Development was funded by the Atlantic Canada Opportunities Agency Innovative Communities Fund, Nova Scotia Rural Economic Development and Tourism, Municipalities of Digby County, Cumberland Regional Economic Development Association (Cumberland Energy Office), AECOM Canada Ltd., Fundy Tidal Inc., Jasco Applied Sciences, Minas Basin Pulp and Power, Nortek USA, VEMCO, Offshore Energy Research Association (OERA), Fundy Ocean Research Centre for Energy (FORCE), and Acadia University. We are grateful for their support.

THE ACADIA TIDAL ENERGY INSTITUTE

The Acadia Tidal Energy Institute is located in Wolfville, Nova Scotia, Canada, near the shores of the world-renowned Bay of Fundy. The vision of the Acadia Tidal Energy Institute is a world that benefits responsibly from tidal energy. The Acadia Tidal Energy Institute aims to be a hub of scientific and socioeconomic research that will help advance knowledge of tidal energy that respects the environment and supports socioeconomic prosperity by leading and disseminating collaborative, objective research regionally, nationally, and internationally.

AIM AND TARGET AUDIENCE OF THE COMMUNITY AND BUSINESS TOOLKIT FOR TIDAL ENERGY DEVELOPMENT

People and organizations in Nova Scotia and elsewhere have already begun work on developing tidal energy. Therefore, this toolkit does not teach engineers how to engineer devices, developers how to develop projects, environmental assessors how to assess the environmental impacts, financiers how to finance, nor community engagement facilitators how to facilitate community engagement. Rather, the Toolkit is primarily designed to inform stakeholders of the steps involved in the process of developing tidal energy. Though most stakeholders will find new information in all modules, including those in the area of their expertise, they will gain particular benefit from toolkit modules that discuss aspects outside their area of expertise. Developers can read about community engagement. Environmentalists can read about the technology being used. Community members can become informed of the environmental assessments to be undertaken. Town councillors can read about the supply chain needs and opportunities and how to keep economic benefits local. Any stakeholder can find out what permitting procedures and government supports are in place.

The toolkit is accessible and downloadable as a PDF file from the Acadia Tidal Energy Institute website (http://tidalenergy.acadiau.ca/). The modules from the toolkit can also be downloaded individually.

ORGANIZATION OF THE TOOLKIT

The Community and Business Toolkit for Tidal Energy Development contains eleven modules. They are organized into three broad themes:

A. WHAT IS IN-STREAM TIDAL ENERGY ALL ABOUT?

This first section provides an overview of tidal energy and its history (Module 1), explains the location and measurement of tidal energy resources (Module 2), and describes the generic designs of tidal energy turbines (Module 3).

B. HOW IS IN-STREAM TIDAL ENERGY MANAGED RESPONSIBLY?

This section discusses three aspects of sustainability – environmental, social, and financial. The modules in this section outline the regulatory regime in Nova Scotia for tidal energy (Module 4), environmental risk assessment (Module 5), stakeholder and community engagement (Module 6), and financial evaluation and cost of energy (Module 7).

C. OPPORTUNITIES PRESENTED BY IN-STREAM TIDAL POWER AND HOW COMMUNITIES AND BUSINESSES CAN TAKE HOLD OF THEM.

This section outlines the opportunities presented by tidal energy and strategies for communities (Module 8) and businesses (Module 9) to take up those opportunities. Sources of financing, government supports, and the risks inherent in tidal energy projects are identified and information is given on how to manage those risks (Module 10). Finally, an assessment of the potential economic impact of a hypothetical five megawatt tidal energy development in the Digby area of the Bay of Fundy is summarized (Module 11).

In each module, there are web links and references for readers who want to seek out further information. Each module also includes definitions, examples, vignettes, and so on. These can be found in various boxes located on pages throughout the toolkit.

BOXES IN THE TOOLKIT	
Best Practice	Examples of how things have been done effectively elsewhere in the world or in other industries, such as wind energy, are provided in these boxes.
Emergent/Discussion	These boxes describe subjects on which “the jury may still be out” or for which no empirical evidence is available. The expectation is the issue may require consideration but there is no solution yet.
Foundational Concepts	New concepts and definitions are explained in these boxes.
Nova Scotia In Context	These boxes highlight situations and examples specific to Nova Scotia.
Toolbox	These boxes describe practical tools or checklists available for use.
Vignettes	Vignettes provide the reader with real-world examples to help understand a process or concept.

FREQUENTLY ASKED QUESTIONS

Business and community members have asked the toolkit writers many questions about tidal energy and the toolkit was written to help answer them. Key questions are below, along with where answers can be found in the toolkit.

WHY CONSIDER TIDAL ENERGY?

Nova Scotia generates a large amount of its electricity from imported coal. The emissions, such as CO_2, SO_2, and particulate matter, and the cost and price uncertainty of this fuel source make this unsustainable. Jurisdictions that generate electricity from their own natural resources not only have greater energy security, they enjoy economic spinoffs, such as jobs. As in many jurisdictions, the government in Nova Scotia recognizes the need to change the province's energy mix and develop its own sources of renewable energy.

Globally, in-stream tidal electricity generation is very new. Research, development and testing are being done in several countries, such as Ireland, Scotland, Australia, South Korea, and the USA. With the world-class tidal resource in the Bay of Fundy, we have an opportunity to become a global leader in this new industry, be it through new designs of turbines, bases, electrical systems, monitoring devices, methods of deployment, and operating procedures, or through environmental impact assessment and protection. Developing expertise, products, and processes that will be of use around the world is good for local economic development.

HOW IS TIDAL ENERGY CAPTURED? WILL WE BE ABLE TO SEE THE TIDAL TURBINES?

There are various ways to capture tidal energy but this toolkit deals primarily with in-stream tidal energy devices. Tidal in-stream energy converters, otherwise referred to as "turbines," "TEC," or "TISEC devices," are submerged in the tidal currents. Though some are suspended from barges or mounted on pin piles, others are mounted on the ocean floor or tethered to the bottom with cables. With many designs, the equipment is not visible from the land. The turbines rotate slowly under the water and do not create noise above the surface. For information about the various ways of capturing tidal energy, see *Module 1: Overview of Tidal Energy*. To read about various designs of tidal in-stream energy devices and bringing the electricity to shore, see *Module 3: Tidal Power Extraction Devices*.

WHERE WILL THE TURBINES BE? HOW MUCH ELECTRICITY CAN WE GET?

There are a limited number of locations where the flow of the water is great enough to develop tidal energy. In Nova Scotia, the Minas Channel, Digby Gut, Petit Passage and Grand Passage, Great Bras d'Or Channel, and the Barra Straight are possibilities. Only in the Minas Channel is large-scale tidal energy development possible. The other locations are suitable for small-scale tidal energy development. *Module 2: Measuring and Assessing the Tidal Resource* provides information about where the tidal resources are, what power can be extracted, and how such an assessment is done.

HOW DID WE GET TO THIS POINT?

Nova Scotia has a very long history of trying to harness the energy of the amazing Bay of Fundy tides. *Module 1: Overview of Tidal Energy* explains what tidal energy is, its history, how in-stream tidal energy converters work, and some of the environmental effects.

HOW MANY JOBS WILL IT CREATE?

The number of jobs created will depend on how much tidal energy we develop. There are several initiatives being explored at present: community-owned, small-scale tidal energy projects in the Grand Passage, Petit Passage, Digby Gut and Bras d'Or Lakes; and large-scale 1-MW device testing in the Minas Passage. In both cases, there will be need for tradespeople, marine services, engineering, hotel accommodation and restaurants, and so on. Small-scale tidal energy development needs these in much smaller quantities. Much of it will probably be within the capability of existing Nova Scotian companies, providing them with more work. Large-scale tidal energy development, depending on if it goes beyond testing to become a commercial-scale tidal energy-farm, will require many more products, services, tradespeople, knowledge workers, and infrastructure. Several modules in this toolkit provide information about the jobs needed for development. If you are seeking estimates of how many jobs or "person-years" of employment that could be generated in Nova Scotia during construction and operation, read *Module 11: Assessing the Potential Economic Impacts of a Five Megawatt Tidal Energy Development in the Digby Area of the Bay of Fundy.* If you are interested in knowing what kinds of products, services, skills, and expertise will be needed and at what stage, go to *Module 9: Opportunities and Strategies for Business. Module 9* also provides details on where supply chain businesses can get information and how to get involved.

WHAT ABOUT THE OTHER PEOPLE WHO USE THE WATER – FISHERS, MI'KMAQ, TOUR OPERATORS, RECREATIONAL USERS, COMMERCIAL NAVIGATORS, AND SO ON?

Just like on land, there are many competing uses for the water and many people make a living from it. Marine spatial planning and coastal zone management are useful tools for managing conflict between marine uses. How to best apply these tools to tidal energy in Nova Scotia is not fully understood at this point. However, consultation with the members of the communities near the tidal energy sites is important for understanding the needs of the various users and for finding compromises for sharing the water, both above and below the surface and through the seasons. *Module 6: Stakeholder and Community Engagement* provides guidance on how to effectively consult and engage with people who have an interest in the same waters. *Module 6* also provides information on the opportunities for users of the water to express their concerns and suggestions.

WHAT ABOUT THE FISH AND MARINE MAMMALS?

Being low-carbon and renewable are not the only important environmental aspects of tidal energy. The effects on the ecosystem, the tides, marine mammals, fish, and other organisms that depend on the tides should be considered. Care must be taken. If you are interested in knowing more about this, there are two modules that should be useful to you. *Module 4: The Regulatory Regime for Tidal Energy* describes the regulations, permitting and licensing processes, and requirements for environmental impact assessments. *Module 5: Environmental Risk Assessment* provides guidelines for project planners to assess the environmental risks and how to reduce the impact on the ecosystem.

WILL THE ENERGY BE CHEAPER?

This is another element of sustainability – financial. It is early days in the global tidal energy industry. Right now, the TEC devices being tested are expensive to build and install, but engineers are working to bring the costs down in order to be economical. The energy, being ever present in the tides, is free, but there are many costs involved in harnessing that energy, converting it to electricity, and getting it to the electrical distribution or transmission grid. Equipment needs to be built, installed, and maintained, and data need to be collected and monitored. There are insurance premiums, wages, taxes, etc., to be paid. In short, the energy will be expensive in the beginning, but it is believed the cost will come down to be competitive with other renewables. If you are interested in the cost of tidal energy and what makes this cost up, you can read up on it in *Module 7: Financial Evaluation and Cost of Energy.*

WHAT IS IN IT FOR OUR COMMUNITY? HOW WILL IT AFFECT US?

Communities could see some new industrial activity and perhaps some new tourism. They may have the opportunity to garner benefits from tidal energy development. There could also be some negative effects. *Module 8: Opportunities and Strategies for Communities* discusses these and strategies for mitigating the negative impacts and keeping benefits local. *Module 6: Stakeholder and Community Engagement* describes methods project developers can use to engage and consult with members of the community. The process of stakeholder and community engagement includes meetings held in affected communities in order to give people a chance to learn what is going on and to express their concerns.

WILL TIDAL ENERGY DEVELOPMENT PAY OFF? WHAT ARE THE RISKS? HOW CAN THEY BE REDUCED? WHAT ABOUT FINANCING? WHAT HELP IS THERE FROM GOVERNMENT?

There are several modules to answer questions such as these. In *Module 9: Opportunities and Strategies for Business*, supply chain opportunities are detailed and strategies for businesses to take them up are described. While the industry is new and small, business startups may be premature, but many of the businesses in our maritime economy have the skills and expertise to provide services and products for the development of tidal energy.

Module 7: Financial Evaluation and Cost of Energy describes the costs and what must be included in the cost-benefit analysis of tidal energy projects – both small-scale tidal and large. It also describes the levelized cost of energy calculations, an industry-standard measure for comparing costs of energy from various sources.

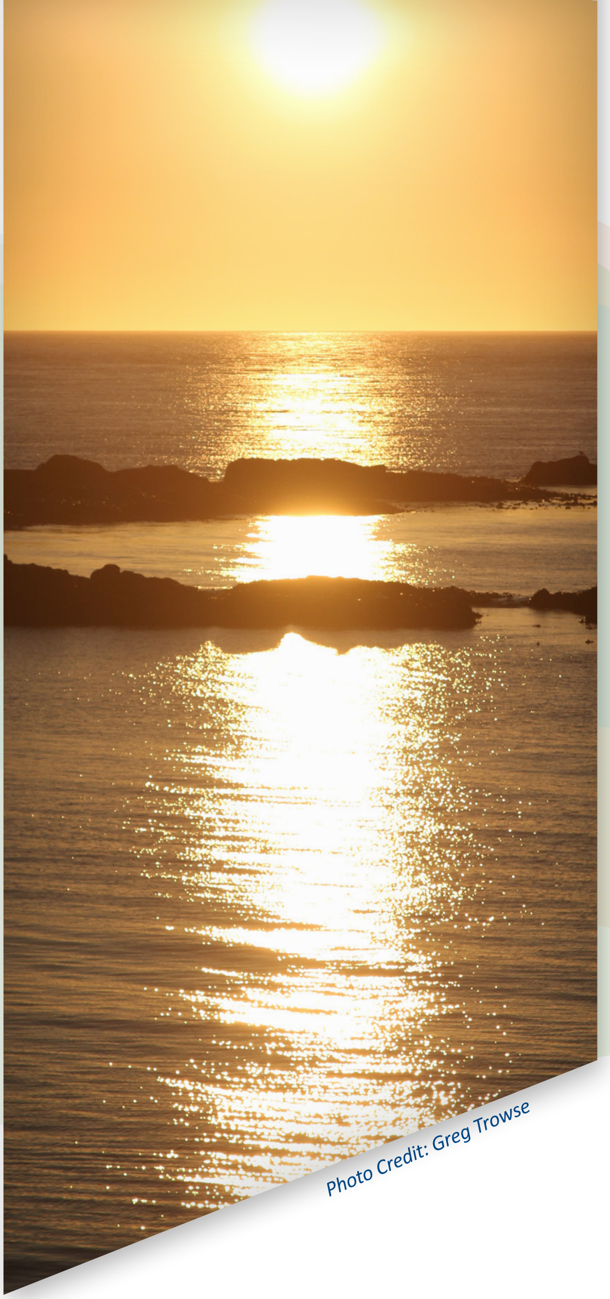
Module 10: Financing, Government Supports, and Managing Risk outlines the financing available at the various stages of technology and project development, as well as the gaps in financing. Methods of financing are explained and supports provided by the federal and provincial governments in Nova Scotia are outlined, with web links to relevant government information. Finally, the module discusses the risks inherent in a tidal energy project and how to mitigate them.

Guidelines for project developers for consulting and engaging stakeholders and communities are provided in *Module 6: Stakeholder and Community Engagement.* Few things can derail a project like community dissent, so undertaking forthright and thorough community consultation and engagement is not only good stewardship, it is good business.

In summary, the Community and Business Toolkit for Tidal Energy Development has been written to inform the responsible development of tidal energy, empower stakeholders with up-to-date and comprehensive information, and lead communities toward a greener, more secure source of electricity.

Photo Credit: Richard Karsten

A | WHAT IS TIDAL ENERGY ALL ABOUT?



1 OVERVIEW OF TIDAL ENERGY

Concerns over climate change and the increasing costs of non-renewable fossil fuels to generate electricity have resulted in a major shift in thinking about how we can meet our future energy needs.

1 - OVERVIEW OF TIDAL ENERGY

Author: Dr. Graham Daborn

WHAT DOES THIS MODULE COVER?

This module provides an introduction to the subject of tidal power – a form of marine renewable energy that depends upon the flow of tidal waters. Here you will find a brief summary of the history of tidal power in Canada, an outline of some of the devices that are being considered for generating electricity from tidal waters, and an indication of the technical, environmental, and social issues that surround tidal power. It is intended for the general reader and will serve as a guide to the more detailed information contained within the *Community and Business Toolkit for Tidal Energy Development*.

Using the energy of the tides is a very old human activity. The power in flowing tidal waters has been used for about two thousand years: the Egyptians, Greeks, and Romans used tidally-driven water wheels to grind grain, and remains of a tidal mill dating to 620 AD have been found at a monastery in Northern Ireland. Even the famous London Bridge contained four tidal wheels that drove pumps providing water to the city in the 17th century. In Canada, Champlain built a tidal mill at Port Royal (Nova Scotia) in the early 17th century and other mills existed in New England and Passamaquoddy Bay (New Brunswick) in the 1800s. These were all mechanical mills; the energy of flowing water being used to turn wheels for grinding grain or pumping water.

1.0 - INTRODUCTION: WHY CONSIDER TIDAL ENERGY?

Concerns over climate change and the increasing costs of non-renewable fossil fuels to generate electricity have resulted in a major shift in thinking about how we can meet our future energy needs. There is no doubt that the planet is getting warmer and little doubt that the extensive use of fossil fuels (i.e. oil, coal and natural gas) is playing a role in global warming. These fuels are non-renewable and have very high value for other uses (e.g. plastics and pharmaceuticals). Consequently, major efforts are being made to shift towards greater use of renewable energy sources, particularly for the generation of electricity.

There are several renewable sources available: solar, wind (both on land and offshore), waves, tidal and river currents, and biomass. Solar power is, of course, only available during the day and must be stored, or an alternative found to provide energy needs during the night. In the far north, it may not be available for months at a time. Much effort has been put into the use of wind and wind farms are now regularly appearing over the landscape and nearby sea. The limitation of wind, apart from the relative cost, is that it is not very predictable. There are times when the wind appears to blow everywhere, so that all wind farms are operating; but at other times, when it does not blow at all, electricity generating companies have to find an alternative source. Tidal flows, however, are eminently predictable: one can forecast exactly when the tide will be running, and roughly how fast, for years in advance. It is a clean energy source in the sense that it does not contribute greenhouse gases and may be tapped in ways that do not result in flooding of land. (This is unlike traditional hydro power, where land flooding associated with hydroelectricity developments can result in increased release of greenhouse gases such as methane and carbon dioxide, so that although the generation phase may not release GHGs directly, the development is not strictly 'green').

Additional benefits that could come from tidal power include:

- Reduction of the environmental effects of energy production by other means, including fossil fuels, hydro, or nuclear power;
- Enhancing regional and national energy security by minimizing dependence on sources of fuel from other countries;
- Long term price stability;
- The ability to build generating capacity in an incremental way (unlike a dam-based system that requires the dam be completed before any electricity is generated or revenue earned); and
- The potential for building supportive industries (e.g. associated with turbine manufacture, etc.) that could develop exportable products and skills.

Many of these advantages are explored in this toolkit.

1.1 - TIDAL POWER

For the last hundred years, tidal power proposals have been aimed at generating electricity. This reflects the versatile nature of electricity as a form of energy, the importance of electrical devices in our lives, the developing expertise in hydroelectricity in the 19th and 20th centuries, and the ability to transport electricity over considerable distances. Electricity's major limitation, however, lies in the fact that, once generated, it is difficult to store in large quantities; consequently, it needs to be fed into an electrical grid, where it may displace some other energy source or be used immediately to drive machines or produce heat, etc. In some situations, excess electricity is used to pump water up into a reservoir ('pumped storage') from which it can be used to generate electricity again when needed.

Batteries provide a means of storing small quantities of electricity, but have so far not been developed to handle large amounts. There have been suggestions for storing unused electricity as compressed gas (e.g. compressed air or hydrogen), but these have yet to prove economically or environmentally feasible.

FOUNDATIONAL CONCEPT: WHAT IS A WATT?

Electrical power is commonly expressed in terms of watts (W), kilowatts (kW), megawatts (MW), or gigawatts (GW). A watt is a measure of power equal to one joule per second.

1,000 W = 1 kW;
1,000 kW = 1 MW;
1,000 MW = 1 GW.

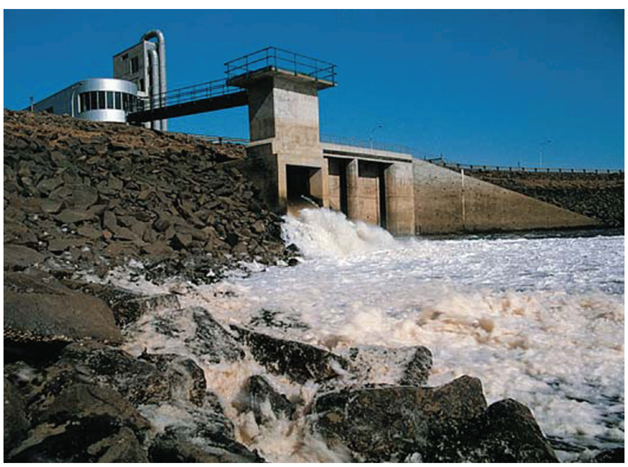
Typical power ratings for familiar electrical devices are as follows: an incandescent light bulb might be 60W; an equivalent CFL light bulb of the same light output might be 18W. A small television and your refrigerator might be rated at 60 – 160 W, the water heater in your house might be about 3,800 W (or 3.8 kW), and your electrical oven about 2,000 watts (or 2 kW).

The energy consumed depends upon the length of time that any device is working, so the important figure is a combination of the power of the device and the number of hours it is running. Power usage (which is what the electricity company charges you for) is measured in kilowatt-hours (or kWh). For example, a 60W light bulb left on for 5 days (120 hours) will consume 7,200 watt-hours, or 7.2 kWh. The average household uses about 1,500 kWh per month (and about 18,000 kWh per year), provided the house is not heated electrically; if it is, the consumption will obviously be much higher.

Proposals for generating electricity from tidal flows began in the early 20th century for the Bay of Fundy, Canada, and the Severn Estuary, Britain. Most of the proposals have resembled a dam-based hydroelectricity station: a dam was to be built across one or more tidal channels to create an impoundment (the 'headpond'), which could be filled by the rising tide. At high water, all gates would be closed, keeping the water in the headpond. When the sea level had fallen sufficiently outside the dam, turbine gates would be opened, allowing the water to flow through and the turbines to generate electricity. Until recently, when South Korea opened a 250MW tidal power project, the largest dam-based tidal power stations were a 240 MW plant at La Rance (France) and the 18 MW plant at Annapolis Royal, Nova Scotia (Figure 1-1).

In Nova Scotia: Annapolis Tidal Generating Station.

The Annapolis TGS was opened in 1984. It has a single 'Stra-Flow'™ turbine with a rated capacity of 18 MW and generates 80-100 MWh per day. The station was installed in a pre-existing causeway built in 1960 to provide a river crossing and flood protection for agricultural land upstream. Research has included studies of fish mortality, the effects on shoreline erosion, and salt water intrusion into groundwater. Fish mortalities were found to be higher than predicted as a result of physical contact and pressure changes occurring as the fish pass through the turbine. There have been no documented effects on marine mammals, although seals and whales occasionally find their way upstream of the causeway, presumably in pursuit of fish.



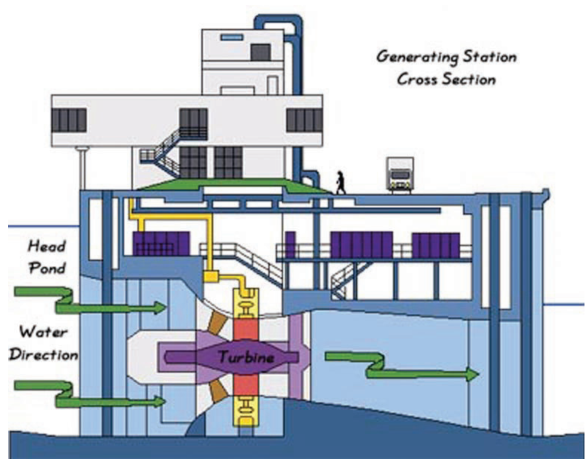


Figure 1-1: Annapolis Tidal Station, Annapolis Royal, Nova Scotia

Source: Kids Encyclopedia Britannica
http://kids.britannica.com/comptons/art-126923/The-Annapolis-Tidal-Generating-Station-in-Nova-Scotia-successfully-harnesses

Source: Library and Archives Canada
http://www.collectionscanada.gc.ca/eppp-archive/100/200/301/ic/can_digital_collections/west_nova/tidal.html

Such dam or barrage-based hydro and tidal electricity generation enables the conversion of the potential energy stored in the water held in the reservoir or headpond; however, when water is flowing, it has kinetic energy that can also be captured in the same way the kinetic energy of the wind is captured and converted by a windmill. Tidal power projects that convert the potential energy of the water are referred to as tidal range developments, whereas devices that generate electricity from free-flowing tidal water are often generically called tidal energy converter– or TEC -- devices. (See the box titled Concept: Tidal Range vs. Tidal Stream, for the distinction between tidal range and tidal stream approaches.)

1.2 - ELECTRICITY FROM WATER

About 60% of the electricity generated in Canada comes from water through numerous hydroelectricity stations, commonly called 'hydro plants' (NRCan 2011; Environment Canada). Typically, a hydroelectricity station is constructed on a river system by building a dam that holds the water back in a reservoir. In most cases, the site chosen for the dam is where the elevation of the land changes suddenly, such as at a waterfall, and the dam creates a large impoundment, often resulting in an increase in the distance through which the water will fall. The difference in water levels provides the force needed to drive the turbines (Figure 1-2).

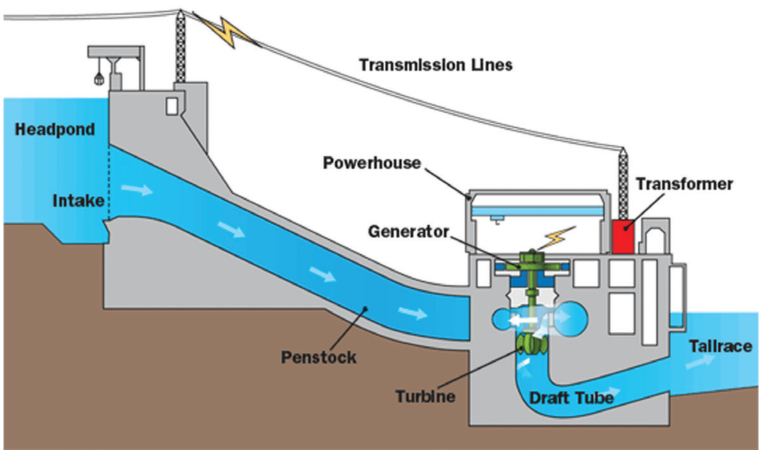


Figure 1-2: Diagram of a Hydro-electric Plant

Source: New Brunswick Power, Hydro http://www.nbpower.com/html/en/safety_learning/learning/electricity_generated/hydro/hydro.html

The amount of hydroelectricity generated depends upon the quantity of water available and – critically – on the height through which the water falls. In most cases, where the dam creates a large water reservoir, the plant can be used to generate electricity continuously and therefore supply a constant amount of electricity that can meet the continuing demand – or 'base load' – requirements.

Large hydroelectricity generating stations of this kind can provide continuous power, but smaller installations tend to be used primarily to meet peak power demands. Thousands of such dams have been created around the world since the latter part of the 19th century.

FOUNDATIONAL CONCEPT: TIDAL RANGE VS. TIDAL STREAM

Tidal range refers to the vertical difference in water level between the times of high tide and low tide. Estuaries or other coastal bays that have a large tidal range such as the Bay of Fundy in Canada, the La Rance Estuary in France, and the Severn Estuary in the United Kingdom have been considered as places to generate electricity for decades. The most common approach considered for these high tidal range locations involves building a dam or barrage across the estuary to create an area for storing water brought in by the flooding tide. Turbines located in the barrage would be turned as a result of the difference in water level between the headpond, upstream of the dam, and the falling sea level on the downstream side (i.e. converting some of the potential energy of the stored water into electricity). This can be done either just on the ebb tide (one-way generation), or on both the rising and falling tides (two-way generation). Such an approach is termed tidal range generation. Building a barrage across an estuary has a number of undesirable environmental consequences and, for this reason, is a less popular solution these days. However, creating a lagoon or shore-connected impoundment in an estuary or bay with high tidal range could provide some of the advantages of tidal range generation with some fewer environmental concerns. (See below for more on lagoons, etc.)

Tidal stream refers to the motion of flowing water. The force of flowing water can drive a turbine just as the wind does a wind turbine. There are numerous different designs for devices that will convert some of the kinetic energy of fast-flowing water into electricity. These are generally called tidal energy converters, or TECs. Further details can be found below and in Module 3 of this toolkit.

FOUNDATIONAL CONCEPT: ENVIRONMENTAL ISSUES OF BARRAGE-BASED TIDAL POWER STATIONS

Building a barrage or dam across an estuary can produce major changes to the ecosystem, with significance for other inhabitants (e.g. marine mammals, birds, fish, and their food supplies) or for other uses of the estuary (e.g. shipping, fishing, or recreation). The dam itself may limit access by migrating fish to spawning or feeding grounds in the upper estuary or the rivers that feed into it, and if they do pass through the dam, they may suffer injury or death because of contact with moving parts of the turbine or changes in pressure, etc. The dam also restricts water flows and so may modify the tidal movements on both the sea and landward sides of the barrage. Changes to intertidal zones may include a reduction in the area exposed at low tide and major changes to sediment distributions, which in turn may affect fish, birds, and other animals that live in or depend on the intertidal zone. In the case of the Bay of Fundy, some of the larger barrage proposals considered in the 1970s would have modified the tidal range throughout the Bay and the Gulf of Maine, with significant changes that could affect fisheries and shoreline properties.

1.2.1 - CURRENT APPROACHES TO TIDAL ENERGY

The present considerations for tidal electricity generation are primarily based upon new designs for tidal energy converters that convert the kinetic energy of the flowing water. TEC devices have a long history at the concept level, including in Canada. Clarkson, in 1915, developed a mechanical pump driven by tidal flows that could pump seawater up to a considerable height, from where it could be used to drive a conventional turbine, and the National Research Council assisted in the development of the Davis vertical axis turbine (based on the Savonius rotor) more than 30 years ago. Most of the more mature TEC technologies are either horizontal or vertical axis designs (Figures 1-3 and 1-4). Converting the kinetic energy of flowing tidal water using TEC devices is the major focus of tidal power investigations in Canada, Europe, and the U.S.A. at the present time and the subject of this toolkit.

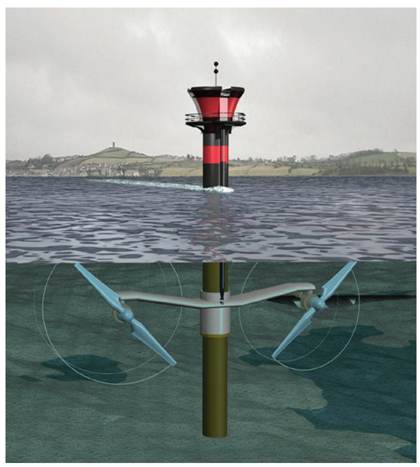


Figure 1-3: Horizontal Axis Turbine - Marine Current Turbines -SeaGen

Source: SeaGen turbine: http://www.alternative-energy-news.info/seagen-tidal-power-installation/

Figure 1-4: Vertical Axis Turbine, New Energy Corporation

Source: New Energy Corporation, http://newenergycorp.ca/Default.aspx

1.3 - WHY TIDAL POWER?

The tide, like the wind, is a renewable energy source that does not consume any fossil fuels (after construction, at least) and generates neither greenhouse gases nor waste heat. Unlike the wind, however, the flow of the tides is very predictable. It is possible to forecast the state of the tide and the velocity of the water reasonably accurately for any given place and time, years into the future. This predictability makes it easier to integrate tidal energy into an existing electrical grid system than other intermittent renewable resources such as wind, wave, or solar power. Around Canada and some other parts of the world, there are many locations where strong currents occur as a result of tidal movements. Where these sites are close to cities or towns or near major industrial users of electricity, the predictability of tidal power generation is very appealing. Thus, in addition to the advantages of reducing fossil fuel use for energy production, there may be considerable economic and social benefits from developing tidal power such as: providing a local supply of electricity, rather than transmitting from a distant power plant; providing local employment in the construction and/or maintenance of the devices; or encouraging new industrial development. Many of these aspects are detailed in Modules 8 and 9 of this Toolkit.

FOUNDATIONAL CONCEPT: 'RUN-OF-RIVER'

Where large river flows combined with a steep river slope are naturally sufficient to run a hydro plant without a large storage reservoir, the development is termed a 'run-of-river' hydro plant (e.g. many places in British Columbia). Since there is no large storage, output from such an installation will vary according to the seasonal changes in river flow. Such 'run-of-river' stations can generally only be used for peaking power, not base-load power.

1.4 - HOW TIDAL ENERGY CONVERTERS (TECS) WORK.

Tidal energy converters extract some of the kinetic energy of fast-flowing tidal waters. At present, more than 40 different devices are in varying stages of development, but most are still in prototype or demonstration phases. These devices vary significantly in orientation, material construction, efficiency, scale, and power output. In addition, anchoring and deployment details will be highly variable, depending upon substrate and current conditions on site (PCCI, 2009). The present concepts may be classified into several general but occasionally overlapping categories: vertical axis (or axial flow), horizontal axis (or cross-axis), rim generators, venturi devices, paddlewheels and fanbelts, and fluttervanes. A review of some 40 devices was prepared for Natural Resources Canada (NRCan 2011). The more mature technologies, particularly those that are being considered for deployment in Canada, are discussed in more detail below.

Water is more than 800 times denser than air. As a result, moving water contains much more energy than does wind: for example, water flowing at ten knots contains as much energy per unit area (e.g. per square metre) as a hurricane force wind. A TEC device, therefore, can be much smaller than a wind turbine that generates the same amount of power.

Thus, in addition to the advantages of reducing fossil fuel use for energy production, there may be considerable economic and social benefits from developing tidal power such as: providing a local supply of electricity, rather than transmitting from a distant power plant; providing local employment in the construction and/or maintenance of the devices; or encouraging new industrial development.

1.4.1 - VERTICAL AXIS

Vertical axis TEC devices rotate around a vertical axis, with a gearbox and generator that may be above or below the water level; such devices are relatively independent of changes in the direction of current flow (see Figure 1-4, above), and for that reason are suitable for locations in which the direction of the current changes over time. These devices tend to have rather lower energy conversion efficiencies than do other designs and may also have difficulty starting to rotate again once they have stopped. At the present time, vertical axis devices tend to be of small power yield: in the 50 to 250 kW range. A Canadian company, New Energy Corporation, has tested a 5kW version of its EnCurrent™ device in the outer Bay of Fundy and is working towards testing of devices up to 250kW.

FOUNDATIONAL CONCEPT: WHAT IS A KNOT?

1 knot (1 kt) is a measure of speed: 1 nautical mile per hour.

1 kt = 1.8 km per hour or approximately 0.51 metres per second.

1.4.2 - HORIZONTAL AXIS

Horizontal axis devices (see Figure 1-3, above) include designs with propeller-like blades rotating around a central hub that usually contains the gearbox and generator coils; reorientation of these devices to a variable current direction may be required and designs for self-adjustment of orientation constitute a significant feature of their development. Horizontal axis designs can be scaled up to yield relatively large amounts of power, in the range of 1-2 MW, but there is some opinion that, unlike wind turbines, this will be about the largest scale feasible for tidal stream devices.

A few horizontal axis devices (e.g. Figure 1-5) have dispensed with the gearbox found in wind turbines and some propeller-like tidal turbines in favour of generating electricity in the shroud surrounding the rotating blades. This 'rim generator' design has allowed for the elimination of the bulky central core and for symmetrical aspects that enable the device to operate in two directions without realignment. These may be most applicable in rivers or in reversing-stream tidal situations (where ebb and flood directions differ by 180º); otherwise, they will require arrangements for passive or active re-orientation. Several horizontal axis designs have a bell-shaped entrance (a 'duct' or 'shroud') that serves to accelerate the flow of water through the generator, yielding higher efficiencies and more power.

Figure 1-5: Rim Generation Tidal Device, Clean Current

Source: Recharge News, North America http://images.businessweek.com/ss/09/07/0714_sustainable_planet/7.htm

1.4.3 - TIDAL LAGOONS AND SHORE-ATTACHED IMPOUNDMENTS

Although tidal range energy conversion (see notes above) has been less popular in recent decades, some companies are considering the use of artificial tidal lagoons in coastal areas to create a head of water that can be used to drive conventional low-head hydro turbines. The lagoon (see Figure 1-6) consists of an impoundment created from relatively inexpensive material (e.g. a rubble mound) located in shallow waters of an estuary or bay that has a large tidal range. The enclosing dyke contains a turbine generating station with bulb turbines that can operate in both directions and thus extend the generation time over most of the tidal cycle. By dividing up the inside of the lagoon into separate sections and operating the different sections as high and low basins, it is theoretically possible to provide continuous electrical output from the facility.

An alternative approach is to create an impoundment using part of the natural shoreline rather than completely surrounding a region of the ocean with a dyke, as in the case of a lagoon. These shore-based impoundments (Figure 1-7) would operate in a similar manner to the lagoon. Analogous in some ways to a barrage, especially in the fact that the scheme converts the potential energy of the contained water into electricity, the lagoon and shore-attached concepts differ in that the impoundment does not totally cut off the estuary from the sea, allowing water and marine life to move past the structure. However, in order to capture sufficient water, the impoundments have to enclose a relatively large area and within this area, there will be significant habitat changes. Three projects have been proposed for tidal lagoons of varying sizes for installation in Wales: Swansea Bay (30 MW), Fifoots Point (30 MW), and North Wales (432 MW); other proposals exist for the Canada, Korea, and China. None have yet been built. Further information can be obtained from http://tidalelectric.com/.

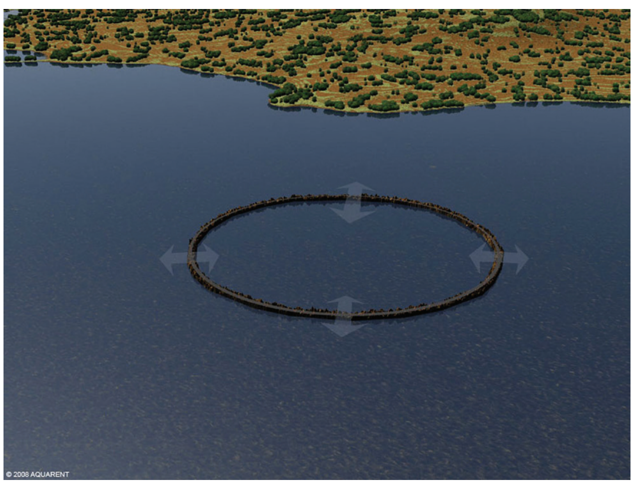


Figure 1-6: Diagram of a Tidal Lagoon.

Source: http://www.wisions.net/index.php?item=6&modus=technology&need_id=3&subneed_id=&start_tech=136&technology_id=77l

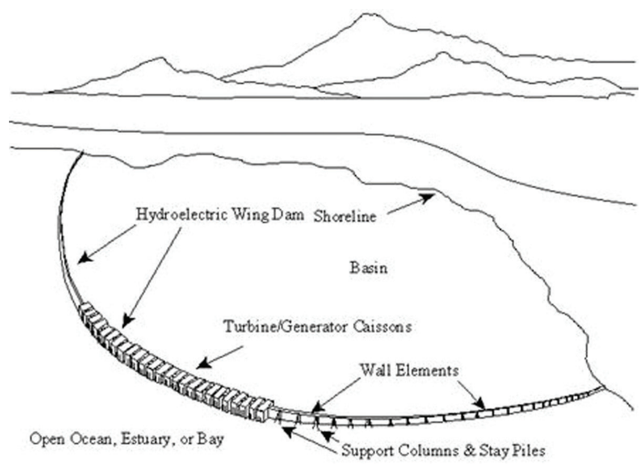


Figure 1-7: Diagram of a Shore-attached Tidal Impoundment.

Courtesy: Halcyon Inc.

Natural Resources Canada identified more than 190 sites on the three ocean coasts of Canada (see Figure 1-9) as having potential to generate more than 1 MW of power from tidal currents.

1.5 - TIDAL POWER OPPORTUNITIES IN CANADA

Natural Resources Canada identified more than 190 sites on the three ocean coasts of Canada (see Figure 1-9) as having potential to generate more than 1 MW of power from tidal currents (NRCan 2006). The total tidal energy available in the country was estimated at more than 42,000 MW. Most of the resource is found in Nunavut, particularly in the vicinity of Hudson Strait and Foxe Channel, and thus relatively remote from major areas of electricity demand. However, TEC devices could be used effectively to provide consistent, predictable, renewable energy suitable for support of local communities that are presently dependent on imported fossil fuel. Most other sites having more than 1 MW potential were found in British Columbia, whereas on the Atlantic coast, a few sites with high potential were identified in the Bay of Fundy and Cape Breton.

In Nova Scotia, there are a number of locations where electricity could be obtained from tidal waters, either using tidal range or tidal stream approaches. If one were to accept the consequences of building barrages, lagoons, or other tidal range structures, it would be possible to generate several gigawatts of power—far more than the current total energy demand in Nova Scotia, which is about 2200 MW (or about 2.2 GW). With tidal stream approaches, however, the potential is much lower because TEC devices can capture only a smaller portion (up to 30%) of the kinetic energy in the water. An early study in 2006 suggested that about 1,000 MW could be generated by arrays of TEC devices in the various portions of the Bay of Fundy (Bedard et al. 2006). More recent work, outlined in Module 2 of this toolkit, suggests that this may be a considerable underestimate. Many of the narrow passages in the Bay of Fundy or around the Bras D'Or lakes in Cape Breton have the potential for producing only a few MW.

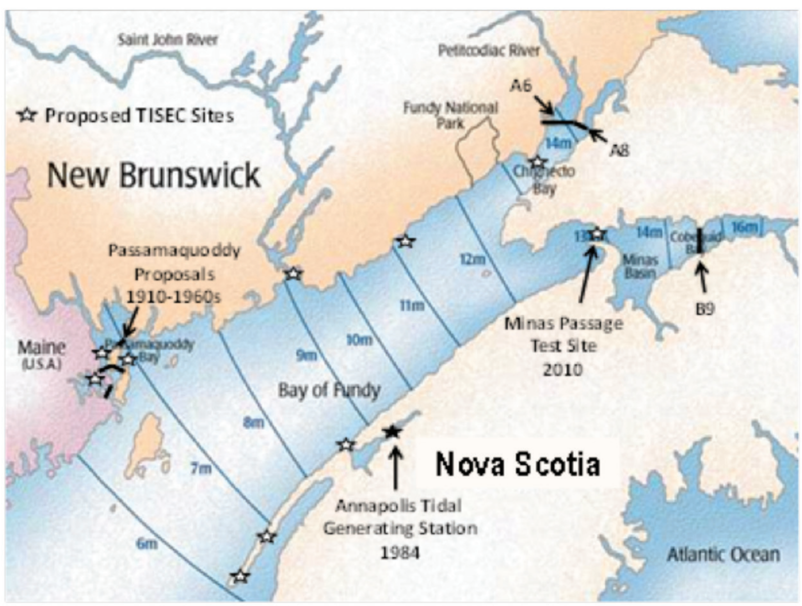


Figure 1-8: Locations of Proposed and Current Tidal Power Developments in the Bay of Fundy, 1910-2010.

Sites A6, A8, and B9 were sites considered for barrage-style tidal power developments in the 1970s. Lines drawn across the Bay of Fundy represent the approximate maximum tidal range (m).

Source: Base map: www.thehopewellrocks.ca

Canada Potential Tidal Current Resource Sites

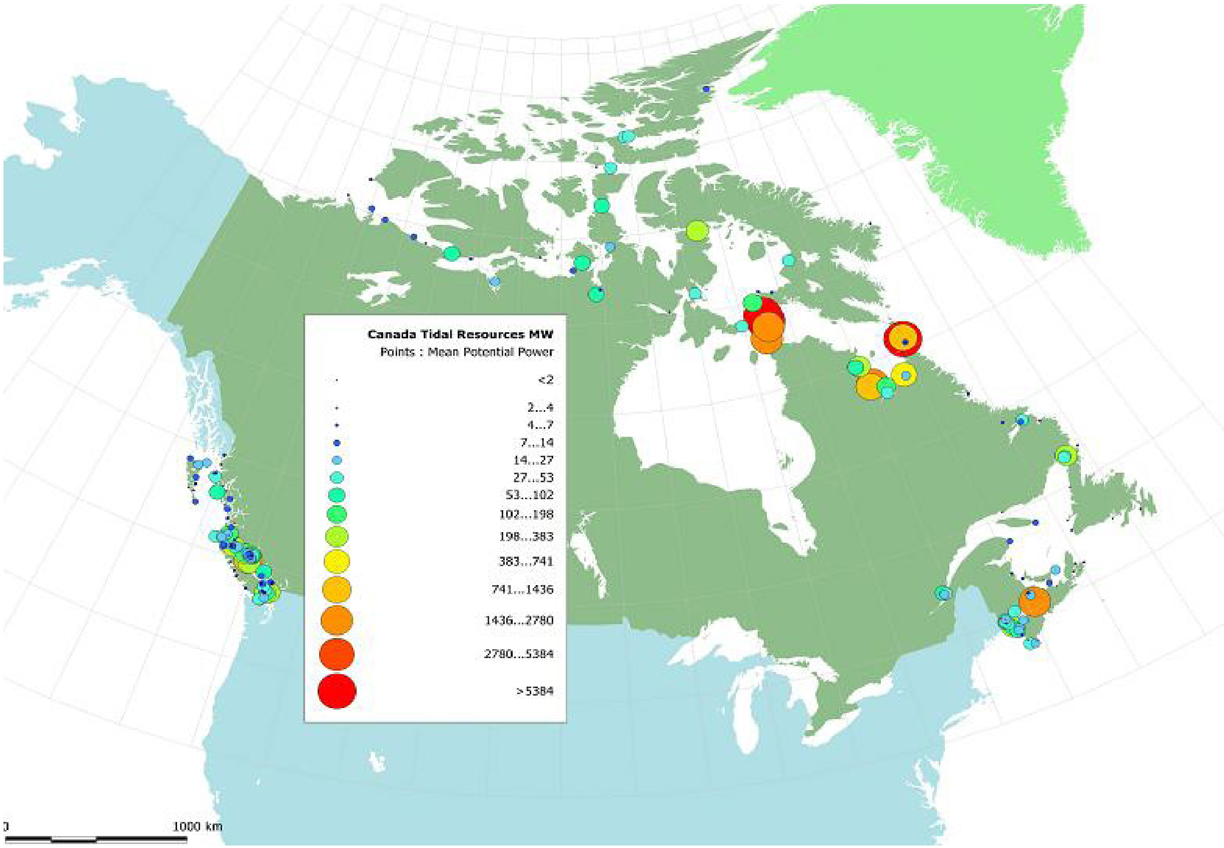


Figure 1-9: Canadian Tidal Energy Resources in MW

Source: NRCan (2006). Canada Potential Tidal Current Sites [Map], Canadian Hydraulics Centre - National Research Council Canada

1.5.1 - GENERATING ELECTRICITY FROM THE TIDES USING TIDAL ENERGY CONVERTERS (TEC) DEVICES

In-stream tidal technologies are diverse, with many design concepts still evolving. Few of these have reached the stage of testing at full commercial size. As a result, sufficient information to assess the environmental risks of TEC developments is currently lacking for the following reasons:

- Few full-size devices have been deployed in natural environments for prolonged periods of time;
- Environmental effects are likely to be technology-, site-, and scale-specific;
- The most favoured locations for deployment exhibit challenging physical conditions – consequently, effective physical and biological data collection and effects monitoring are difficult and sometimes limited by the availability of suitable monitoring technology;
- Absence of monitoring results to confirm predictions of environmental assessments; and
- Many of the sites with highest potential for marine renewable energy are insufficiently studied for the environmental implications to be assessed with confidence.

1.5.2 - SITE CONSIDERATIONS

Sites suitable for tidal in-stream generation must have high tidal flows, both in terms of the speed of the water and the amount of water passing through that location. The power potential of any site is a combination of water velocity and volume, so that wide, deep channels with high flows could be tapped to generate large amounts of electricity. This advantage, however, is counter-balanced by some significant limitations: the forces that the device must withstand and the potential environmental effects that might be associated with converting the energy of the flowing water into electricity.

Most of the horizontal axis turbines are designed to begin electrical generation when the flow reaches 2-3 knots (1 to 1.5 metres per second). The maximum water velocity at which they will continue to operate is very variable, but many of the most advanced designs are controlled to yield a consistent amount of electricity at any velocity above a chosen level. The forces exerted on the turbine increase dramatically as speed increases. If the speed of the water doubles, the forces involved increase by 4 times and the power by about 8 times (see Figure 1-10). Consequently, very high velocities such as those in the Bay of Fundy (up to 10 or 11 knots, or more than 5 m/second), represent extremely powerful locations and demand that the tidal generators be very well constructed.

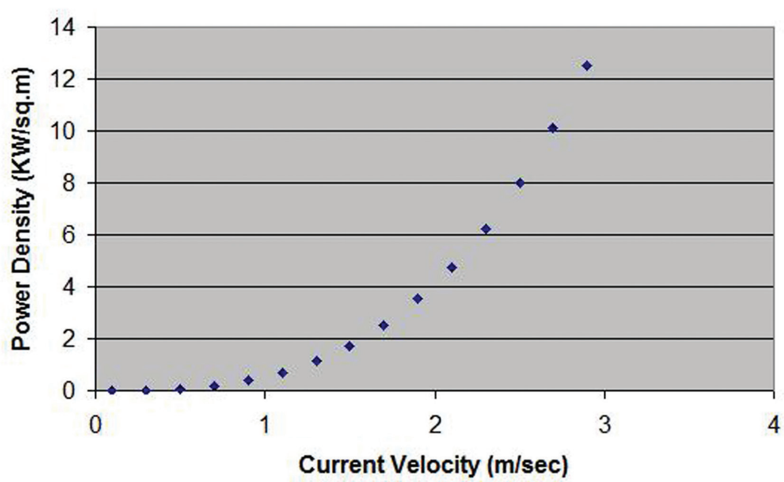


Figure 1-10: Relationship Between Power and Water Velocity.

Much of the attention at the present time is focused on sites like the Minas Passage in the Bay of Fundy, which could support large amounts of electricity generation from arrays of multiple turbines. Such developments would be aimed at feeding electricity into the grid to displace the use of fossil fuels. There are many other sites, however, that would be suitable for one or a few turbines only, providing energy for a more local demand. Obviously, the implications of these different sites and development scales vary. For more information on site and scale relationships see Module 5 of this toolkit.

1.5.3 - ADVANTAGES OF TIDAL POWER

The obvious advantage of tidal power is that it is a renewable resource with no continuing fuel costs and is not associated with emissions of greenhouse gases. Like wind energy, tidal energy is variable over time, but unlike wind, it is eminently predictable. The tides and their movements are well known (see box below); they result from the gravitational attraction of the Moon and the Sun, and we can therefore forecast when the tides will flow with reasonable accuracy for years ahead. Even though predictable, the intermittent nature of tidal stream generation presents a challenge, whether the electricity is fed into the grid where it can displace other forms of energy, or is to be used locally.

FOUNDATIONAL CONCEPT: TIDAL CYCLES

Tides are caused primarily by the gravitational attractions of the Moon and Sun on the Earth and its waters. The Moon is much closer to Earth, and therefore its influence on the tides is about twice as great as that of the Sun.

Most suitable locations in Canada have semi-diurnal tides, which means that there are approximately 2 tides each day; a few locations sometimes have one strong tide plus a much smaller second tide each day as a result of local conditions. The time between one high tide and the next is about 12.4 hours. Because the Moon orbits the Earth in the same direction as the Earth spins, two successive tides actually take 24 hours and 50 minutes, so that the time of a particular high tide on one day is about 50 minutes later than the corresponding tide the day before. When the tide reverses at high water and low water, there is a brief period in which the water is not flowing at all, or is flowing too slowly to drive a turbine. These 'slack water' periods vary in length, being as short as 20-30 minutes (as in the Bay of Fundy) or as long as an hour, and no electricity can be developed from tidal stream devices over this period. Consequently, TEC generators can produce power for perhaps 10 or 11 hours in each 12.4 hour period, and the time of this generation will become later each day by just under one hour.

In addition to the twice-daily rise and fall of the tide, there are longer cycles in which the range of the tide (i.e. the vertical difference in water level at high tide and at low tide) varies over days, months, and years. Some of these variations are related to the interaction between the Moon and Sun; at times they are pulling on the Earth and its waters in more or less the same direction causing larger, so-called spring tides, whereas the next week, their gravitational effects tend in different directions, resulting in smaller tides (known as neap tides). Also, the distance between the Moon and the Earth changes during each month because the Moon goes around the Earth in an ellipse, rather than a circle. As a result, twice each month the Moon is closer to the Earth (the lunar perigee), causing greater tides, and twice each month it is further away (the lunar apogee), resulting in smaller tides. Similarly, the Earth travels around the Sun in an ellipse, so that at two times each year it is relatively close and at other times further away. All of these variations produce changes in the speed with which tidal waters move and therefore will tend to affect the amount of energy that can be captured. However, all of these changes are predictable.

What is not so predictable, however, are the additional effects resulting from wind and river flows, which may increase or decrease the water flows at any given location. In regions with naturally large tides, these are usually relatively minor effects, except during storm conditions.

1.6 - ENVIRONMENTAL ASPECTS OF TIDAL POWER

One hundred years of consideration of tidal power energy as a source of electricity has taught us a great deal about the natural environmental features of these strong tidal areas. The environmental implications vary considerably depending upon the characteristics of the locality chosen for development, whether the approach is based on tidal range or tidal in-stream designs, and the scale of the development. More details on the site and scale issues can be found in Module 5 of this Toolkit. This section will briefly summarize the major issues.

1.6.1 - ENVIRONMENT-RELATED ISSUES OF TEC DEVELOPMENTS

The major environmental questions raised by TEC proposals are as follows:

- What will be the effects of removing energy from tidal waters on the flow and tidal characteristics (e.g. current velocity, timing, turbulence, mixing, temperature distributions, sediment loads), both near to the site of development and further away?
- What are the effects of electromagnetic fields produced by the generators and the cables carrying electrical currents on the organisms in the vicinity?
- What might be the effects of floating debris or ice on the infrastructure?
- What are the risks of corrosion or abrasion to the infrastructure?
- What is the potential for organisms to grow on and interfere with the operation of the TEC device infrastructure? This is referred to as biofouling.
- What risks are posed by the infrastructure for animals (e.g. entrainment, avoidance, and attraction)? Principal concerns relate to marine mammals, turtles, fish, and marine birds.
- What indirect effects might there be on organisms resulting from changes in current flow patterns and timing, turbulence, mixing, sediment transportation and deposition, and habitat changes?
- What will be the effects on marine organisms and habitat as a result of construction, installation, and decommissioning of the infrastructure?

Determining the feasibility of any given location for tidal power development requires an extensive background investigation of the conditions at the site. Surveys of local bottom conditions, flow rates, habitat properties, and the use of the area by organisms will often require investigations that may be both costly and time consuming. Knowing the nature of the substrate is critical for design of the structures that would be used to support the turbines, and the presence of sediments or debris being carried by the water will affect decisions about the materials to be used in construction of the devices. Many coastal sites are used by mammals and fish during feeding or spawning migrations, and thus these animals may only be present for limited periods of time during the year. Methods for conducting such surveys are changing continuously as technologies improve. In order to forecast the risks to such animals, biological surveys may take more than a year to complete. It is, consequently, a feature of good practice to initiate such background studies as early as possible.

Critical information about current flows is obtained from bottom-mounted acoustic devices that record the velocity of the water at different depths at very fine time intervals. Combined with computer-based numerical models, these records provide the detailed information a developer needs to estimate the potential power production at the site. Because tidal movements change over time (e.g. the spring-neap cycle and seasonal variations associated with the distances between the Earth, Moon, and Sun), measurements of current flows need to be made over periods of weeks or months. Fine scale surveys of bottom conditions can now be carried out using acoustic, video, and other imaging devices deployed from boats in place of the traditional sampling techniques using grabs or surveys by divers, but although these new technologies provide an unprecedented level of information, they require extensive analysis and are often quite costly. Monitoring of animal movements, especially fish and mammals, remains a challenge because the high rates of flow and extreme turbulence of TEC sites limits the effectiveness of existing video or acoustic technologies. At present, many studies have to depend upon active acoustic tagging techniques in which fish are fitted with acoustic devices that emit an identification signal that can be picked up if the fish is close enough to a recording device. Some mammals, such as porpoises and dolphins, emit their own sounds that can be picked up by similar receivers and can often provide identification of the species, but such passive techniques have not yet been developed for many of the larger whales. All of this information, however, is necessary in order to assess the risk of a tidal power development to these valued species.

In addition to the generators themselves, installing TEC devices in high flow areas requires a substantial and varied amount of other infrastructure. This infrastructure includes cables for transmitting the electricity to shore; support structures for the turbines, such as massive gravity bases, pilings, pins, or cables; anchors for monitoring or other equipment, including navigation aids; and various subsurface or surface floating devices. These are described in Module 3 of this toolkit. Depending upon the local site conditions and the choice and number of TEC device(s), all this equipment may be below the surface, essentially out of sight, or some may remain at the surface. Land-based infrastructure will include facilities for landfall of the electrical cable, transformer and transmission lines, and staging and repair areas. These structures need not be near the installation site for the device; however, shorter distances are preferable from a project planning perspective.

All of these structures and facilities have important environmental and socio-economic implications. A summary listing of the issues is included here.

1.6.2 - EFFECTS ON OTHER MARINE RESOURCES

The coastal marine environments where TEC development might take place are often important for other established resource-based industries such as fisheries, aquaculture, mining (including some fossil fuels), and recreation. Whether these activities are compatible with tidal power development will depend upon local conditions at the site(s) and the scale of the development. In particular, exclusion zones created to protect energy developments from accidental interference may represent important limitations for local fisheries, transportation, or recreation. These topics are normally addressed in environmental assessments that would have to be prepared for larger projects, but might be omitted for smaller ones.

IN NOVA SCOTIA: BAY OF FUNDY STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA).

A Strategic Environmental Assessment is a systematic process for evaluating the environmental consequences of a proposed policy, programme, or development so that environmental implications can be incorporated into strategic planning and decision-making.

The Bay of Fundy SEA began in 2007 and was completed in 2008 by the Offshore Energy Environmental Research Association, a not-for-profit corporation dedicated to fostering offshore energy and environmental research and development, including examination of renewable energy resources and their interaction with the marine environment.

"The objective of the SEA [was] to assess social, economic and environmental effects and factors associated with potential development of renewable energy resources in the Bay of Fundy with an emphasis on in-stream tidal. The SEA will inform decisions on whether, when and under what conditions to allow pilot and commercial projects into the water in the Bay of Fundy and under what conditions renewable energy developments are in the public interest over the long term."

Source: Fundy Tidal Energy Strategic Environmental Assessment: Final Report, (2008) prepared by the OEER Association for the Nova Scotia Department of Energy. http://www.offshoreenergyresearch.ca/LinkClick.aspx?fileticket=DwM56WU51T0%3d&tabid=312&mid=992

A secondary benefit of the Fundy SEA was the opportunity to increase public awareness of the potential and issues relating to TEC development in the Bay of Fundy region, and to enable public input into decision- and policy-making. To that end, several public consultations were held and a representative stakeholder group engaged to review public input and the SEA Report and Recommendations. The Fundy SEA is being reviewed, as planned, in 2013.

Large scale development of electricity using tidal in-stream devices (or lagoons) will have important and varied economic implications associated with the materials needed, the availability of skilled labour for construction and maintenance, and financing.

1.6.3 - SUPPLY-RELATED ISSUES OF TEC DEVELOPMENTS

Large scale development of electricity using tidal in-stream devices (or lagoons) will have important and varied economic implications associated with the materials needed, the availability of skilled labour for construction and maintenance, and financing. The requirements of the early construction phase of a TEC development, in terms of material or personnel, are similar to many other marine construction activities, including harbour construction, off-shore platforms (e.g. for oil and gas development), and offshore wind farms. TEC devices can be installed in a variety of ways: suspended from floating structures, attached to pilings drilled into the seabed, sitting on gravity bases on the seabed, or suspended from cables anchored to the bottom, for example. These installation options are discussed in Module 3 of the toolkit. Once the devices are installed, however, maintenance operations may require availability of several different forms of skilled labour, including a great variety of technology specialists, boat and heavy equipment operators, and even divers (where suitable conditions exist). The supply chain issues and opportunities for local businesses and labour force are explored in depth in Module 9 of the toolkit.

1.7 - FINAL WORDS

In order for tidal power development to become successful, it must be able to generate electricity reliably for a prolonged period of time – generally many years -- under difficult environmental conditions. Estimating the ongoing operational or maintenance costs is difficult at this early stage of the industry, when few devices have been successfully deployed for long periods of time. Nonetheless, it is critical that confidence can be had in the durability and operating properties of the equipment. In this context, it is also important to recognise that tidal ecosystems, no matter how stable or constant they may seem, do themselves change continuously over time as a result of natural events (e.g. storms, shoreline erosion, sea level rise, etc.), and as a result of human intervention (e.g. dredging and harbour construction, bridge and causeway construction, effects of climate change, etc.). These kinds of long-term and large-scale changes require that the assessment of any site for tidal power development needs to be comprehensive and extensive in both space and time.

It is hoped that this toolkit will enable you to understand the issues, to find answers, and to become engaged in the decisions regarding tidal energy.

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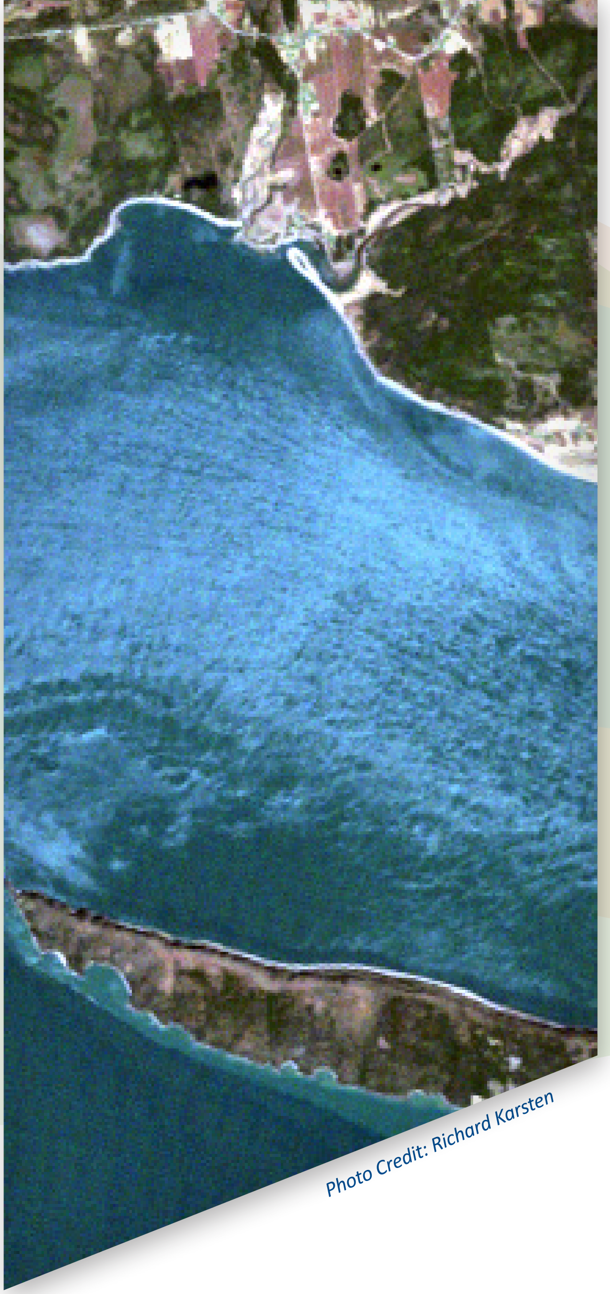

2 MEASURING AND ASSESSING THE TIDAL RESOURCE

A critical aspect of tidal power development is an accurate assessment of the power resource.

DEFINITION:
TYPES OF RESOURCE

Theoretical Resource is the power contained in the entire resource.

Technical Resource is the proportion of the theoretical resource that can be captured using existing technology.

Practical Resource is the proportion of the technical resource that is available after consideration of external constraints – for example, environmental impacts.

Economic resource is the proportion of the practical resource that can be economically captured.

(Adapted from a number of sources.)

2 - MEASURING AND ASSESSING THE TIDAL RESOURCE

Author: Dr. Richard Karsten

WHAT DOES THIS MODULE COVER?

The following module describes the tidal resource in Nova Scotia.
It contains:

- Maps of Nova Scotia showing the locations of the largest in-stream tidal resources.
- Calculated extractable power at each location.
- Calculated potential installed capacity of the turbine array that could be deployed at each location.
- A discussion of site assessment.
- A detailed analysis of Minas Channel including bathymetry, tidal flow, and the impact of extracting power.

IS THIS MODULE FOR YOU?

This module is for anyone interested in the size of the potential in-stream tidal resource in Nova Scotia as a whole and at specific locations. It is also for anyone interested in the method of assessing the total resource and the resource at a specific site. It will be of interest to anyone wanting to learn the terminology of tidal resources.

2.0 - INTRODUCTION: NOVA SCOTIA TIDAL RESOURCE

Nova Scotia has significant tidal energy resources. The Bay of Fundy has the world’s highest tides, routinely reaching over 16 m in range in the Minas Basin. Several passages along the coast of the Bay of Fundy have strong tidal currents that are suitable for the deployment of tidal energy converters (TEC) that extract energy from the fast moving currents. A critical aspect of tidal power development is an accurate assessment of the power resource. The following two sections summarize the in-stream tidal resource as described in Karsten (2012).

2.0.1 - EXTRACTABLE POWER

The map in Figure 2-1 shows the extractable power for each of the major passages in Nova Scotia. The extractable power is the maximum amount of power that can be taken from the flow through the passage.

The map shows that Minas Channel is, by far, the largest resource in Nova Scotia with 7200 MW of extractable power. The extractable power in Minas Channel is roughly three times Nova Scotia’s maximum electricity usage. It is an incredible resource, resulting from the world's highest tides in Minas Basin and the associated large volume of flow through Minas Channel every tidal cycle.

Although smaller in scale, the passages along Digby Neck (Digby Gut, Petit Passage, and Grand Passage) still have significant extractable power, between 16 and 180 MW. These sites have sufficient power to support the deployment of arrays consisting of 10 to 50 turbines. Although the three passages are similar in size and location, Digby Gut has considerably more extractable power because it is the sole connection between Annapolis Basin and the Bay of Fundy.

The passages in Cape Breton (Great Bras d'Or, Barra Strait) are again smaller in scale. Development here would consist of only a few turbines. Other sites around Nova Scotia may allow for a similar level of development, but these have not been fully assessed at this time. **The extractable power listed on Figure 2-1 is the maximum power that can be removed from the flow through the passage and does not correspond to the electricity that could be generated by a particular tidal energy converter.** The fraction of the extractable power that could (or should) be converted into electricity depends on many factors: the acceptable reduction in flow through the passage, the design of the TEC, the size and arrangement of the array of TECs, the limitations of the supporting infrastructure, etc.

DEFINITION:
EXTRACTABLE POWER

Extractable power is a measure of the theoretical resource. It is the in-stream power that can be extracted from a given tidal resource while accounting for the resulting reduction in the flow speed. The extractable power is the total power removed from the flow, not only the power to generate electricity. Extractable power can be calculated using theory or numerical simulation.

The extractable power in Minas Channel is roughly three times Nova Scotia's maximum electricity usage.

DEFINITION:
MEAN POWER, ANNUAL ENERGY PRODUCTION

Mean Power: The average power produced usually measured in megawatts (MW). For tidal flow, it is roughly 40% of the maximum power that would be produced.

Annual Energy Production (AEP): The total power produced in a year, usually measured in TWh. It can be calculated by multiplying the mean power by the number of hours in a year.

In 2010, Nova Scotia had a total electricity generation of about 11.7 TWh, or a mean generation of 1340 MW. http://www.statcan.gc.ca/pub/57-601-x/2011002/t124-eng.htm

DEFINITION: INSTALLED CAPACITY

Installed capacity is the maximum power generation capacity of a given turbine array. For example, an array of 10 turbines rated to produce 1.2 MW would have an installed capacity of 12 MW.

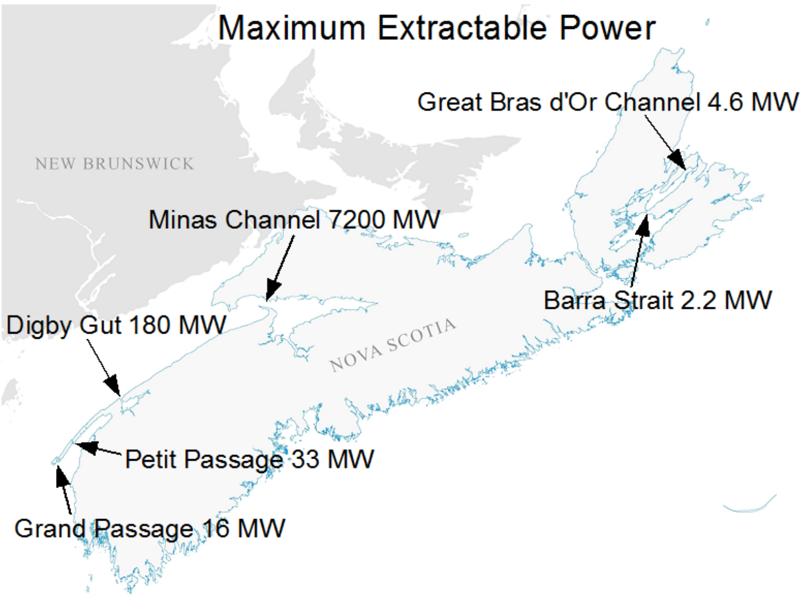

Figure 2-1: Estimated Maximum Extractable Power from Tidal Passages in Nova Scotia

2.0.2 - INSTALLED CAPACITY

The size of turbines and turbine arrays are usually discussed in terms of the installed capacity - the maximum power the turbine array can produce. The map in Figure 2-2: Estimated Maximum Installed Capacity for Tidal Passages in Nova Scotia gives the Karsten (2012) estimate of the maximum installed capacity that each passage could support. The installed capacity at a given site is only a fraction of the extractable power – for the sites examined, the installed capacity ranged from 15% to 40% of the extractable power.

The estimates of the installed capacity for the passages give a rough idea of the size of the turbine array that might be deployed at each site. Current TEC technology has focused on turbines with a capacity of roughly 1 MW. As such, Minas Channel could support an array of roughly 1000 turbines, Digby Gut around 50 turbines, Petit and Grand Passages 5 to 10 turbines each, and the Cape Breton passages (Great Bras d'Or, Barra Strait) 1 large or 2-3 small turbines. Although these are rough estimates, they do give a first idea of the size of industry that might develop around each site.

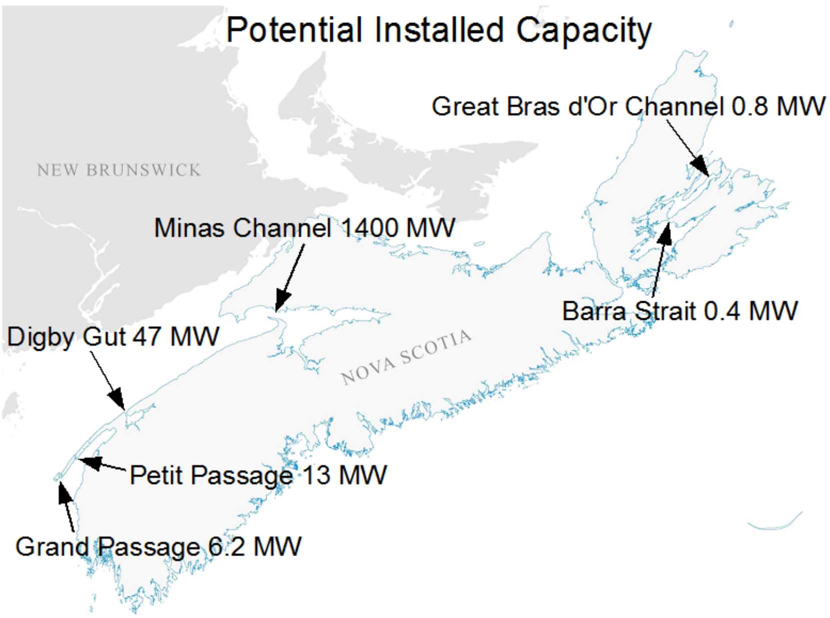

Figure 2-2: Estimated Potential Installed Capacity for Tidal Passages in Nova Scotia

In Table 2-1: A Comparison of Installed Capacity, from Karsten (2012) and EPRI (2006), the power estimates and installed capacity in Figures 2-1 and 2-2 are compared to the estimate of installed capacity in the Electric Power Research Institute (EPRI) report (Hagerman et al. 2006). This comparison is presented to emphasize that such estimates will change depending on how the analysis is completed and the accuracy of the data used. As well, the changes are not uniform for all passages. The Karsten (2012) estimates for tidal-basin systems, like the Minas Channel-Minas Basin and Digby Gut-Annapolis Basin systems, are larger than the EPRI (2006) values. On the other hand, the estimates for the other passages are smaller.

Table 2-1: A Comparison of Installed Capacity from Karsten (2012) and EPRI (2006). Values are in MW.

LOCATION	INSTALLED CAPACITY (KARSTEN 2012)	EPRI INSTALLED CAPACITY
Minas Channel	1400	595
Digby Gut	47	9.8
Petit Passage	13	18
Grand Passage	6.2	13
Great Bras d'Or Channel	0.8	2.8

2.0.3 - POWER DENSITY

The extractable power and installed capacity are not the only measures to consider when assessing potential in-stream tidal power. The velocity of the tidal current plays a critical role in determining if a site can be developed and what technology can be deployed. The power generated by a TEC increases with the cube of the water speed. Therefore, a small increase in tidal currents will result in a significant change in the amount of power that can be generated. The power of a flow is typically given by the power density – the power per unit of cross-sectional area.

In Table 2-2, the mean speed and mean power density for the Nova Scotia passages are listed. It should be noted that a time-averaged or mean speed of 2m/s corresponds to maximum speeds during a spring tide of 4 to 5 m/s. As can be seen in the table, the power density can be converted into the power an idealized 16 m diameter turbine, operating at 40% efficiency, would produce. Such a turbine would be rated to produce 1 MW at a rated speed of 2.9 m/s. The information provided in Table 2-2 illustrates that the high flow speeds in Minas Channel and Petit Passage can produce significantly more power for a given turbine than the other passages. Such numbers make it obvious that the development of each of these passages will require different turbine technologies.

Table 2-2: Typical Mean Speed, Mean Power Density, and Mean Power for a 16 m Diameter Turbine (kW) by Tidal Passage

LOCATION	TYPICAL MEAN SPEED (M/S)	MEAN POWER DENSITY (KW/M^2)	MEAN POWER FOR A 16 M DIAMETER TURBINE (KW)
Minas Channel	2	6.8	540
Digby Gut	1.2	1.5	120
Petit Passage	2.2	9.0	720
Grand Passage	1.6	3.5	280
Great Bras d'Or Channel	~1.0	0.85	68
Barra Strait	~0.7	0.3	23

2.1 - SUMMARY

In summary, Nova Scotia has significant tidal power resources. Minas Channel is in a category on its own, with an extremely high extractable power resource and a high energy density. Digby Gut has a high extractable resource, but a lower power density. Taking advantage of the large power resource will require a large number of turbines that run efficiently at lower flow speeds. On the other hand, Petit Passage has a much lower total power resource, but a high power density. This means a moderate amount of power could be generated by a few properly designed turbines. Grand Passage has a lower total power and moderate power densities, and may be better suited to testing turbines. The Cape Breton passages are low-level resources, both in terms of extractable power and power density, suitable for only a couple of low-flow turbines.

2.2 - SITE ASSESSMENT

When we shift our focus to specific sites, we must address questions like:

- how should a specific site be chosen,
- what size of turbine array could be deployed,
- what type of turbines should be used,
- how much power can be generated, and
- what impact will installing the turbines have on the environment?

2.2.1 - MEASUREMENTS OF TIDAL FLOW

As mentioned in the section on resource assessment, the speed of a tidal flow is critical in determining the resource and the technology that is best to deploy. The velocity of the tidal flow is most often measured using an Acoustic Doppler Current Profiler (ADCP). ADCPs provide a vertical profile of the flow, from near the bottom to near the surface, every sampling period, which can vary from 1 second to several minutes. Since ADCPs give velocity data at a single location, the deployment of several ADCPs at different locations around a site may be required to properly observe the tidal flow.

Typically, ADCP measurements of the tidal currents must be taken for at least 35 days. This allows a tidal harmonic analysis of the flow to be completed. This analysis can be used to predict the tidal flow for years into the future, as is done to predict tidal heights and times for most harbours. The ADCP data also allow the analysis of other details of the flow: the asymmetry in amplitude and direction of the flow between the flood and ebb tide; the variation in the direction in flow within a given flood or ebb tide; the mean vertical profile of the flow and the variation in this profile; information about the bottom boundary layer; and the amplitude and spectra of the turbulence in the flow.

All these characteristics can be important in the choice of turbine to be deployed. For example, the tidal constituent analysis will be used to calculate a histogram of water speeds over a typical year. Combined with a power curve for a given turbine, the histogram can be used to predict the Annual Electricity Production (AEP) for the turbine. Other characteristics of the flow may favour a specific turbine design. For example, if there is a large asymmetry between the ebb and flood direction, a turbine that yaws (changes direction) or a vertical axis turbine may be more suitable for the location. If there is strong vertical shear or a high level of turbulence, the result could be much larger forces on a turbine - in particular, large twisting forces on the turbine blades. Such a site may require a more robust turbine or may not be suitable for turbine deployment at all.

DEFINITION: TIDAL HARMONIC ANALYSIS

A tidal harmonic analysis can be completed on any data connected to tides – water depth, water velocity, turbine power. The analysis connects the data to the regular, predictable motions of the Earth, Moon, and Sun (see discussion of tidal cycles in Module 1). Each tidal constituent describes one aspect of these motions with a particular period. For example, the M2 tide is the primary tide associated with the Moon and has a period of 12.42 hours, while the S2 tide is primarily associated with the sun and has a period of exactly 12 hours. A tidal harmonic analysis calculates an amplitude (i.e., the height of the tide) and a phase (i.e., the time when high tide occurs) for each tidal constituent. The results can be used to predict the tidal data at any time. This type of analysis is used to generate the tide predictions in typical tide charts.

For more discussion and a list of tidal constituents, see http://en.wikipedia.org/wiki/Theory_of_tides#Harmonic_analysis.

2.2.2 - NUMERICAL MODELING AND FLOW IMPACT

Numerical models of the circulation around a proposed site can also be an important part of the flow analysis. The numerical models complement the ADCP data, confirming many of the results above. As well, the numerical model can give the spatial variation of these characteristics, leading to the choice of a site with the most suitable conditions for turbine deployment. Numerical model results will also highlight surrounding bathymetric features that can produce eddies or waves that may disturb the tidal flow and make a site less desirable. The predictions of a tidal model can also be used to improve deployment and scheduled maintenance.

Finally, validated numerical models should be used to determine the impact that a turbine array will have on both the local and far-field flow. The cumulative impact of an array of turbines may not be a simple multiple of the impact of a single turbine; that is, 100 turbines may not have 100 times the impact of one turbine. This is especially true for large arrays that occupy a large portion of a passage. As well, turbine arrays can have effects far from where they are deployed. For example, turbines placed in Minas Passage will reduce the flow through the passage and therefore reduce the tidal range in Minas Basin, but, they will also have a small impact on the tides throughout the rest of the Bay of Fundy and the Gulf of Maine.

2.2.3 - OTHER SITE ASSESSMENT FACTORS

Many other factors may affect the assessment of a site for turbine deployment. Here, we list some that should be considered for all sites:

WAVES: The wave conditions at a site are important. Large waves can affect the loading on a turbine and turbine performance even when the turbine is well below the surface. Large waves can also cause difficulty during deployment and maintenance. In general, the smaller the waves and swell are, the better.

WEATHER: The weather conditions can also change the flow. Large pressure systems can enhance or reduce the tidal flow and storm surges can cause strong flow that can damage turbines. Weather can also affect deployment and maintenance by limiting access to the site.

SEA BOTTOM: The sea bottom may determine if specific turbines can be deployed, or how the turbine will be moored in place. Careful geotechnical analysis of the seabed is required to determine if it can support large gravity bases or will allow for piles to be drilled into the seabed. The bottom roughness and sediments may also affect deployment or lead to a turbulent near-bottom flow.

PROXIMITY TO SHORE, GRID CONNECTION, PORTS, ETC.: The geographic location of a site will often determine its suitability. How close the site is to shore and a suitable grid connection or how near it is to ports with suitable infrastructure for deployment and maintenance can have an important effect on the cost of turbine deployment, power production, and maintenance.

2.2.4 - TIDAL ARRAYS AND BLOCKAGE RATIO

When a large array of turbines is to be deployed, all the above issues must be considered, not only for the individual turbines but for the array as a whole. It is critical that there is sufficient space to deploy the array so that the wakes of the turbines do not interfere with the performance of turbines downstream, since the turbine wake is an "energy shadow." Recent studies suggest a downstream spacing of 10-20 times the diameter of one turbine may be required. On the other hand, keeping the turbines as close together as possible may reduce costs. The optimal design of turbine arrays --a design that reduces costs while optimizing power -- is an active area of research. Multiple turbine farms can be deployed in a single passage. The total power they extract from the resource will result in a reduction in flow through the passage that will affect all the turbine farms.

A specific issue that needs to be considered when designing a turbine array is the **blockage** ratio – the portion of the cross-sectional area of a channel that is occupied by turbines. It is known that increasing the blockage ratio can increase the efficiency of turbines substantially. But, taking advantage of an increased blockage ratio would require that the turbine be specifically designed for the site. There are many other concerns that limit the blockage ratio. First, creating a very high blockage ratio requires a very high turbine density. For example, consider the case where 20m diameter turbines are deployed across an entire passage that is 30 m deep, with a spacing of 20 m between the turbines. The blockage ratio in this case is only 26%. Second, the spacing of turbines may be determined by their deployment or the need to access them for maintenance. Third, other marine activities (fishing, recreation, marine traffic) may require that a portion of the passage be free of turbines. And, finally, if fish and marine mammals travel through the passage, the blockage ratio may be required to be kept small, leaving routes through the passage that are free of turbines. It is important to ensure that any tests that examine turbine performance, whether in laboratory tank, numerical simulation, or in an actual tidal flow are conducted with a blockage ratio that is similar to the one where the turbine will actually be deployed.

Over the next few years, considerable knowledge about turbine arrays will be gained as small arrays are deployed around the globe. This research will lead to a reevaluation of which site characteristics are most important for a successful deployment.

2.2.5 - EFFECTIVE ASSESSMENT METHODOLOGY

The determination of all the factors that make a site suitable for the deployment of turbines is a considerable task. Site assessment for turbine arrays remains an active area of research. Over the next few years, considerable knowledge about turbine arrays will be gained as small arrays are deployed around the globe. This research will lead to a reevaluation of which site characteristics are most important for a successful deployment. In this section, we have focused on the assessment of the physical characteristics of the site. Social and economic assessment, however, can be equally important aspects of choosing a site.

2.3 - DETAILED ANALYSIS OF MINAS CHANNEL

In this section, we give a more detailed analysis completed for Minas Channel by Karsten (2012). The Minas Channel connects Minas Basin to the Bay of Fundy. It is some 50 km in length, with a width of 20 km in the outer channel that reduces to only 5 km in Minas Passage. The water depths are 50-100 m in the outer channel, increasing to over 150 m in Minas Passage (see Figure 2-3). It has some of the strongest tidal currents in the Bay of Fundy, particularly in Minas Passage where water speeds can reach over 5 m/s. The volume flux through the passage can reach 1,000,000 m^3/s during the largest spring tides, more than the flow of all the rivers in the world combined.

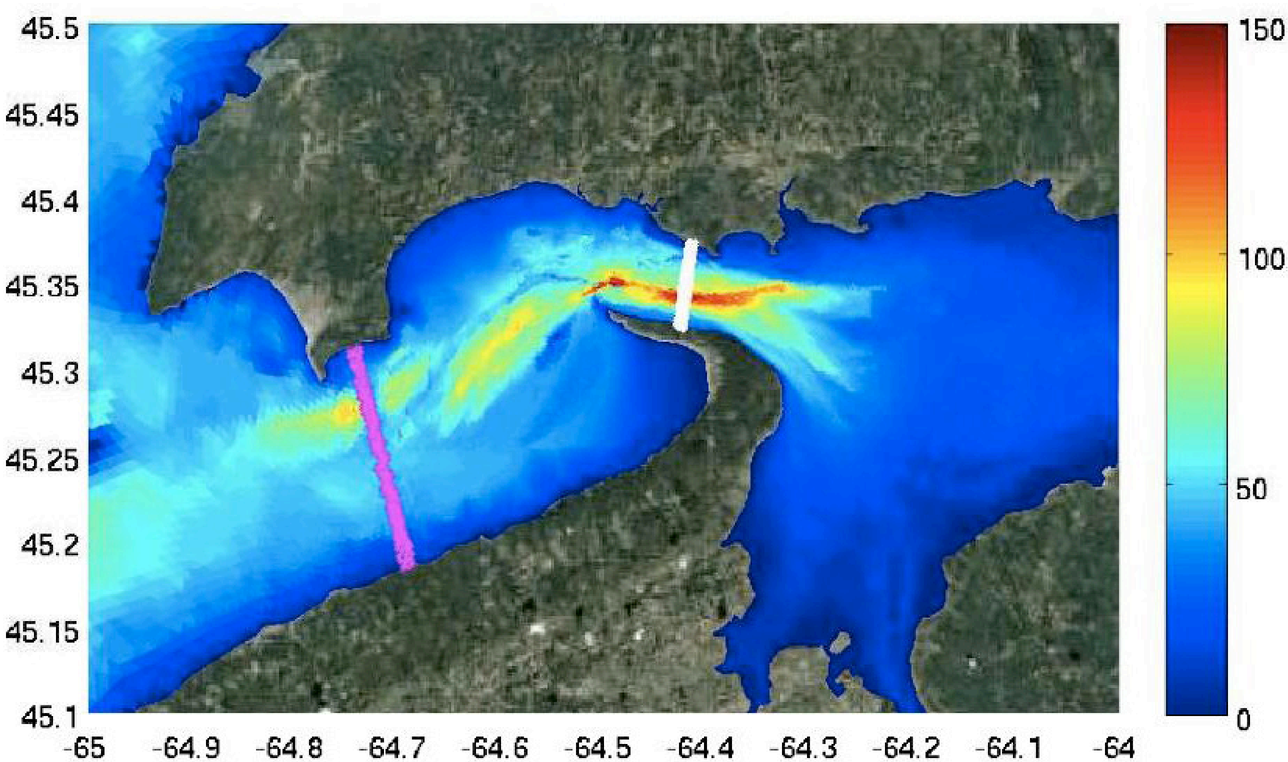

Figure 2-3: The Bathymetry of Minas Channel Used in the Numerical Simulations.

(The colours are the mean water depth in metres. The pink line is the location of the Minas Channel turbine fence; the white line is the location of the Minas Passage turbine fence. These fences are hypothetical and are used for modeling purposes only.)

In Figure 2-4 and Figure 2-5., the mean speed and mean power density for Minas Channel are plotted. Throughout much of Minas Passage, the mean depth-averaged speed exceeds 2 m/s, with maximum depth-averaged speeds between 3 and 4 m/s. The power density in Minas Passage often exceeds 8 kW/m^2. The outer Minas Channel has considerably slower flow, with mean speeds around 1 m/s and only a small region where the mean speed exceeds 1.5 m/s. As such, the power densities in the outer channel are much less than the inner channel, with most of the area below 4 kW/m^2. Therefore, extracting significant power from the outer channel would require a low-flow TEC.

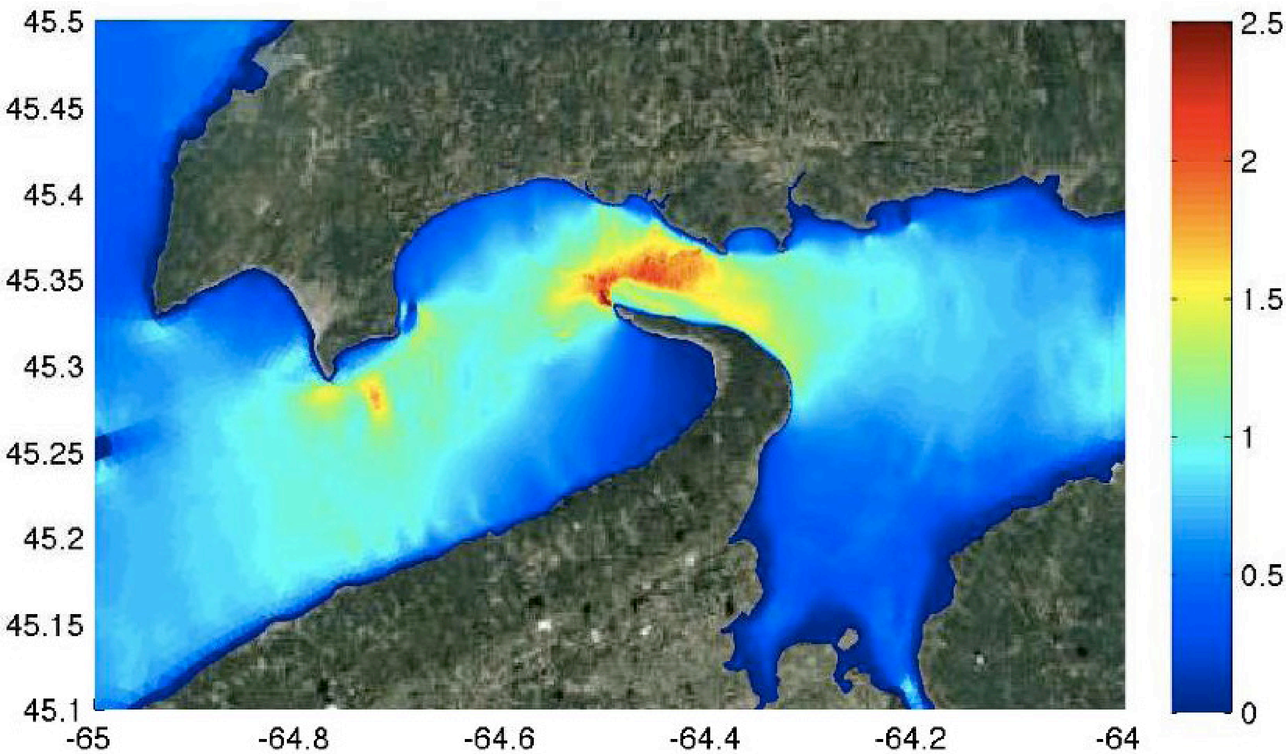

Figure 2-4: The Mean Depth-Averaged Speed in m/s

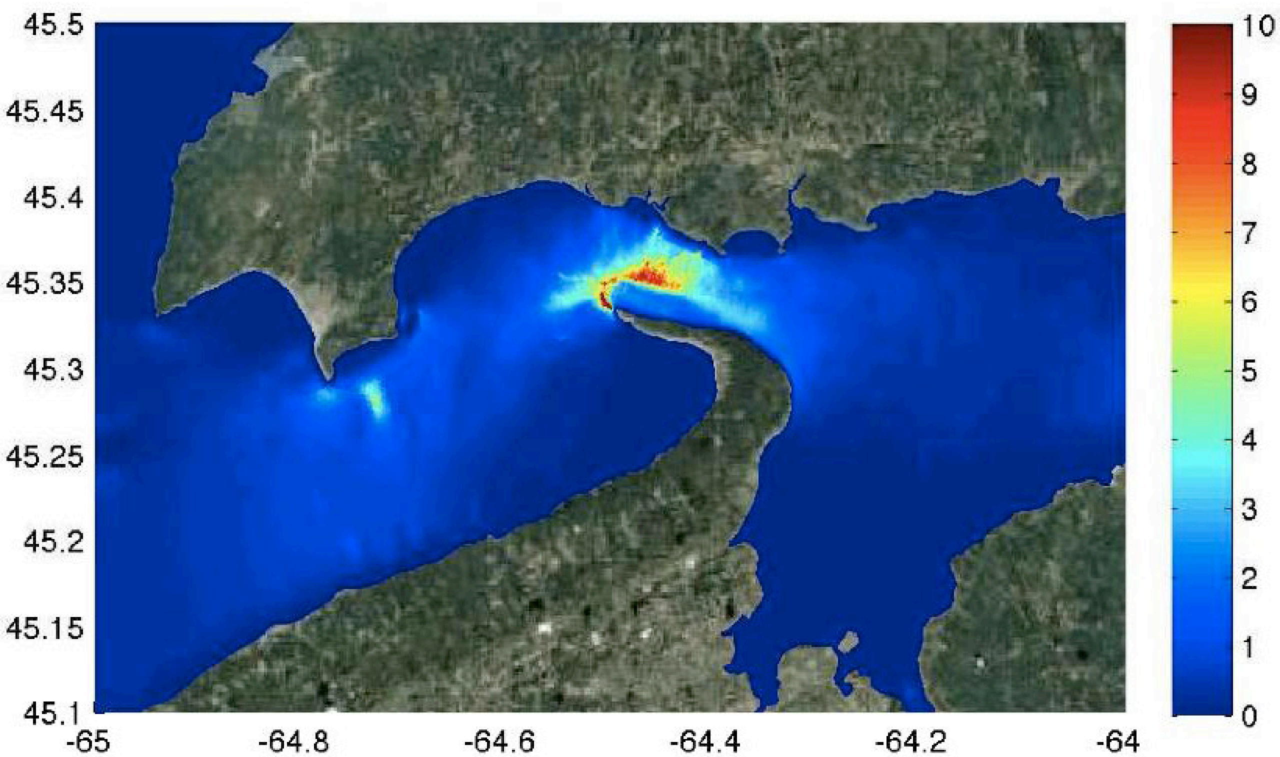

Figure 2-5: Mean Power Density in kW/m^2 for Minas Channel

Possibly, the single most important fact about Minas Channel to keep in mind is that it is a single system. The power that drives the flow through Minas Channel is the tidal head across the channel - the difference in tidal elevation between the opening of Minas Channel and Minas Basin. Any turbines placed at any location in Minas Channel will be extracting power from this same source.

In order to calculate the power potential of the channel, numerical simulations were run with a fence of turbines at two different locations as shown in Figure 2-3. The turbine fences extend across the entire channel at each location. For each simulation, the drag coefficient of the fence is altered and the mean power extracted by the fence and the mean volume flux through the fence are calculated. The extracted power versus reduction in volume flux can be plotted, as in Figure 2-6. This curve is for the outer Minas Channel fence shown in pink in Figure 2-3. The figure shows how the extracted power increases rapidly for a relatively small reduction in the flow through the passages. As the power extraction increases, the reduction in flow becomes greater until a maximum power extraction is reached.

It should be noted that the power curve changes very little if the power is extracted from fences at different locations along the channel. For example, if power is extracted from a fence in Minas Passage, the shape of the curve is the same as that shown in Figure 2-6, but the maximum power is only about 6000 MW or roughly 80% of the total available at the outer channel location, since the turbine fence in Minas Passage cannot extract power from the tides in the outer Minas Channel. If power is extracted from both a fence in the outer channel and a fence in Minas Passage, the power curve still remains the same shape, with a maximum power that lies between that of Minas Channel and Minas Passage fences alone. While more power can be extracted from the outer Minas Channel than Minas Passage, the power densities in the outer Minas Channel are significantly less than the values in Minas Passage (see Figure 2-1). Extracting power from the outer Minas Channel will likely require a different technology than extracting power from Minas Passage.

Finally, it should be emphasized that any reduction in flow through Minas Channel will proportionately reduce the tidal range in Minas Basin. As a result, a 5% reduction in flow through the channel could have significant impacts on the intertidal zones of Minas Basin. A 5% change in the tidal range in Minas Basin could result in significant areas along the coast of Minas Basin that no longer flood regularly during high tide or no longer go dry at low tide. Calculating these changes requires numerical simulations with improved coastal bathymetry and much higher resolution in the intertidal zones.

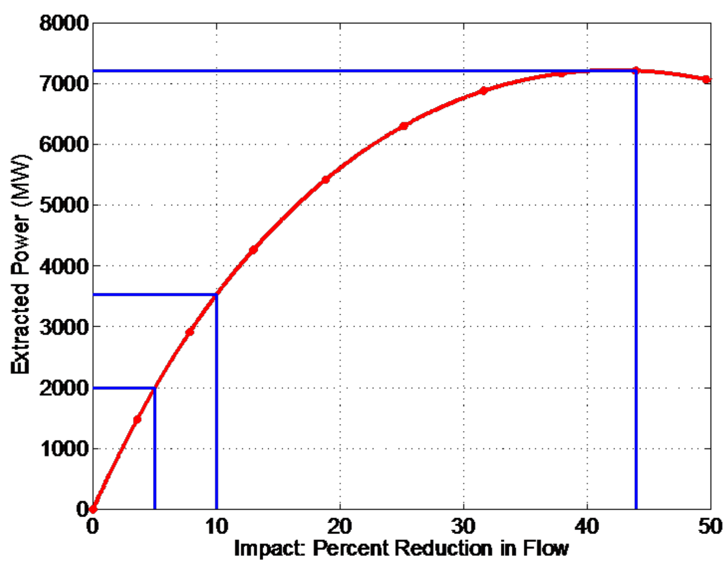

Figure 2-6: Extracted Power versus the Reduction in Flow Through the Channel for Minas Channel. (The blue lines highlight the maximum extractable power, the extractable power with a 10% reduction in flow, and the extractable power with a 5% reduction in flow.)

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Photo Credit: Elisa Obermann

3 TIDAL POWER EXTRACTION DEVICES

3 - TIDAL POWER EXTRACTION DEVICES

Authors: Dr. Sue Molloy and James Taylor, P.Eng.

WHAT DOES THIS MODULE COVER?

This module outlines the basics of the technology and infrastructure for tidal energy devices. The module serves as a very general primer on the three main types of tidal energy devices and the transmission systems needed to get energy generated from tidal devices to shore.

The module will cover the following main areas:

- Types of turbines developed to date,
- Mooring types,
- Considerations related to the installation and maintenance of turbines, and
- Power systems and components including cabling to shore.

3.0 - INTRODUCTION

Tidal turbines are in the early stage of development. Currently, developers are focusing on getting devices operational and the overall development costs reduced. Optimization of devices is further down the line. As a result of this, the configuration of the devices that are currently being tested and demonstrated may look very different from the devices we will see being installed five years from now.

This section will focus on what can be seen as the primary configurations currently being considered by developers and the corresponding structural considerations that need to be made to install some of these designs (Figure 3-1). The installation, maintenance, and cabling are also addressed. It is important to note that these areas are a large focus of research and development and are the source of the highest costs in the commissioning of tidal power today.

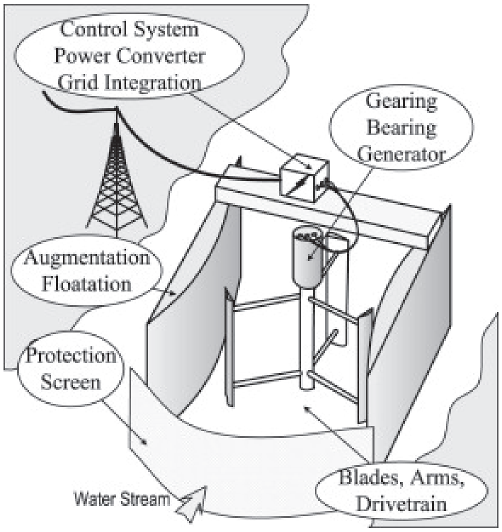

Figure 3-1: Schematic of Vertical Axis Turbine (Khan et al. 2009)

3.1 - TURBINES

The high current speeds of the Bay of Fundy (more than 5m/s) offer developers both a unique opportunity and formidable challenge.

Tidal turbines are being called by a number of names, including:

- Tidal power extraction devices (TPED),
- Tidal In Stream Energy Converters (TISEC),
- Marine Energy Converters (MEC), and
- Marine Hydrokinetic (MHK) turbines.

However, the International Electrotechnical Commission (2012) has chosen TEC – Tidal Energy Converter and turbine as official terms. In Nova Scotia, tidal devices are often referred to as TISEC. In this module, devices will simply be referred to as turbines.

Turbines rotate in tidal currents of typically 2m/s-- 4m/s (metres/second) (4-8 knots). This rotational energy turns an axle that creates electrical energy through a generator. That electrical energy is then used to provide power for a specific user or is added to the central power grid. The amount of power generated is directly related to the speed and flow rate of the current, where speed is how fast the current travels and the flow is the volume of water that passes a location in a given time. The high current speeds in some regions the Bay of Fundy (more than 5m/s) present developers with both a unique opportunity and a formidable challenge.

Turbines do not use fossil fuels and few require power to initiate rotation; in most cases, the tidal current is enough to begin the rotation of the turbine. Some vertical designs require a small amount of power to give them an initial push (Kahn et al., 2009).

Turbines in development today are being designed in consideration of the environment in which they will operate. Fish guards, protection screens, speed controls, and more are being used to mitigate the chances of fish strikes, to reduce the impact the turbine has on the environment, and to reduce the impact the environment has on the turbine.

A general attitude in the tidal industry right now is that turbine designs need to be kept simple. Fewer parts in the design mean less maintenance will be required over the life of a turbine and a simple design enhances the ability of the device to work in the marine environment.

Some questions currently facing designers include:

- What is the marine environment like at the installation site?
- How will the turbine be installed?
- How accessible will the turbine be for maintenance?
- How long will the turbine last before maintenance is required?
- What kind of maintenance can be expected?
- How much time will there be to access the turbine at slack tide?
- Should the turbine be installed on the sea floor or floated at the surface?
- How will the geological marine environment affect the turbine and vice versa?

As projects progress, these questions get asked over and over again, and each new marine environment requires a new set of answers. At present, turbines need to be customized for an environment as there are no “one size fits all” turbines at the moment. Some solutions to these types of questions have been successful in one location and found to be completely inappropriate in others. For example, the Bay of Fundy has approximately 20 minutes of slack tide and very high current speeds, which makes drilling to install concrete piles unattractive. However, piles have been used successfully to support many turbines in the ocean around the European Marine Energy Centre Test Centre in the Orkney Islands in Scotland, where the currents are somewhat slower.

3.2 - TYPES OF TIDAL TURBINES

There are three main configurations or styles of tidal turbines; within those configurations, there are many designs (Kahn et al., 2009). Horizontal and vertical axes are the most popular configurations and right now, horizontal axis turbines are the dominant style with developers. Horizontal axis turbines look similar to propellers and wind turbines, but the blades rotate at much slower rates. The configuration of a vertical axis turbine is like an eggbeater. The third main style is the crossflow turbine, which has a horizontal axis that is perpendicular to the flow; the configuration is like a push-style lawnmower.

VIGNETTE: SEAGEN

The longest commercially operating tidal turbine is the SeaGen turbine located in Strangford Lough in Northern Ireland (http://www.seageneration.co.uk). It is a horizontal axis turbine. At maximum capacity, SeaGen generates 1.2MW of electricity.

3.2.1 - HORIZONTAL AXIS TURBINES

When a turbine has a horizontal axis, the axis of rotation is designed to be parallel or slightly off-parallel to the flow of the water (Figure 3-2). The blades that are used are lift or drag type blades. These are the blades used most often in propellers and wind turbines. The profile or shape of the blade and the orientation of the blade can be manipulated to maximize the power from the incoming flow. This means the blades are turned and shaped to get the most power out of the flow when it is directed into the turbine.

Some blades are designed to operate in both the incoming (flood) and outgoing (ebb) tidal flows and some blades are designed to operate in more turbulent flows. Most horizontal axis turbines work best when flow is in one direction and has very little turbulence.

Finally, open centre turbines are shaftless and have the blades connected to the outer rotating rim to allow current flow through a large, centered "hole." Open centre turbines are considered to be another style of horizontal turbine and there is considerable interest in applying this particular style of device in the Bay of Fundy.

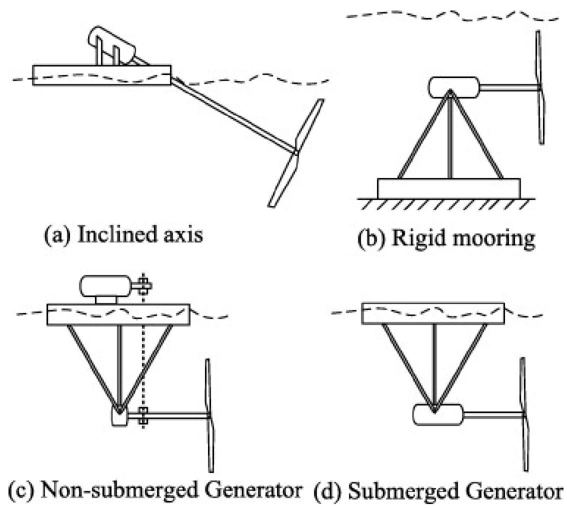

Figure 3-2: Horizontal Axis Turbines (Kahn et al. 2009)

VIGNETTE: CLEAN CURRENT

Open centre turbines are being considered for operation in the Bay of Fundy. One design is being developed by Clean Current, a Canadian company based in British Columbia.

3.2.2 - VERTICAL AXIS TURBINES

Vertical axis turbines have an axis of rotation that is perpendicular to the flow of water. This means the axle around which the blades rotate is vertical at 90° to the water flow direction. Again, the blades are lift or drag type blades and the turbines often resemble a weather vane or eggbeater. Some of the blades used in vertical axis turbines are designed to catch the water as it flows through the turbine and use that energy to turn the axle. The Savonius design, with the "catch-flow" style of blade, is inefficient but is valuable in slow flows (Figure 3-3). The Savonius style has been used in combination with other styles, such as the Darrieus, in order to get the rotation of the more efficient blade styles started. Vertical axis turbines frequently need to be started by an alternative power or blade source when the flow speed drops below a minimum level (Kahn et al., 2009).

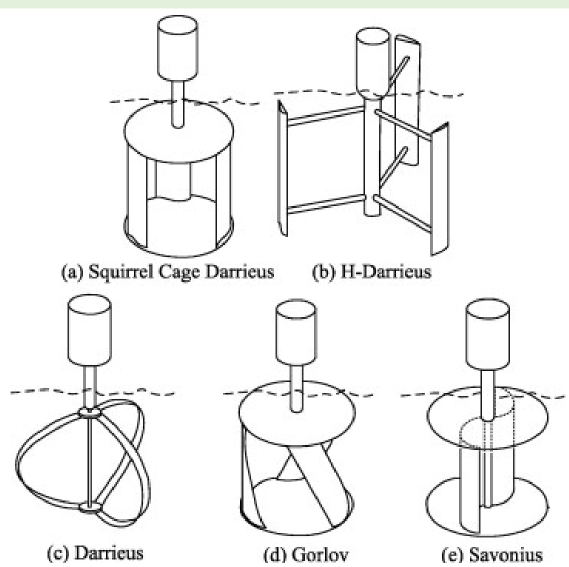

Figure 3-3: Vertical Axis Turbines (Kahn et al. 2009)

3.2.3 - CROSS FLOW TURBINES

Cross flow turbines have the axis of rotation across the flow of water, parallel to the water surface. Lift or drag type blades are also used in this style of turbine (Figure 3-4). This style of turbine is less commonly seen under development, but there are small-scale tidal power projects where it is being used. Fundy Tidal Inc. is considering a cross flow turbine for a project in the Bay of Fundy.

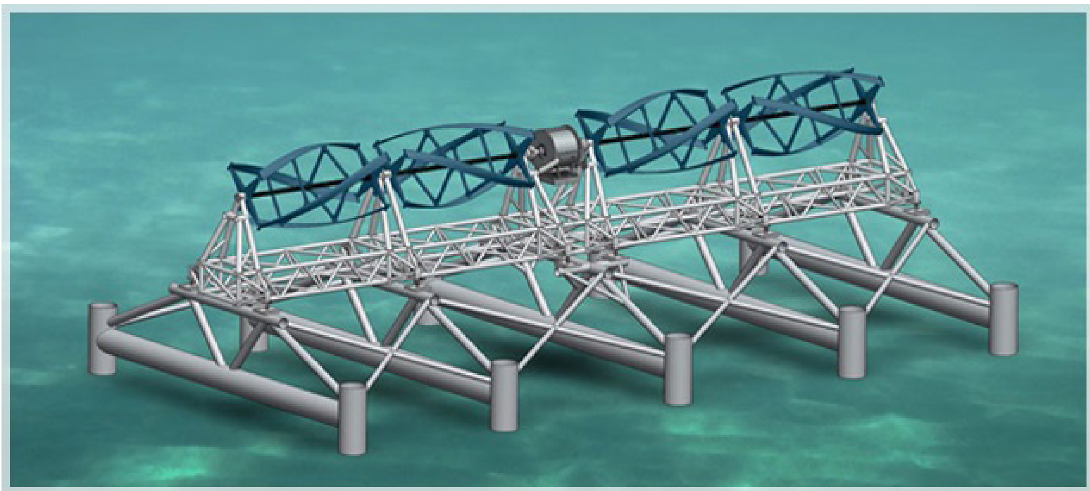

Figure 3-4 Cross Flow Turbine (TidGen)

Source: http://www.orpc.co/orpcpowersystem_tidgenpowersystem.aspx

3.3 - FLOW

The flow of the water into the turbine may need to be directed if the efficiency of the blades is significantly impacted by the flow direction or if the turbine is located at a particularly turbulent site. The general term for these flow directors is "duct" or "diffuser" (Figure 3-5). At the present time, ducts are more commonly seen on vertical axis turbines than horizontal axis turbines. The additional maintenance involved with a duct will depend on the style of duct chosen. The curvilinear duct, for example, has fewer parts than the multiple hydrofoil diffuser. This type of duct is in line with current thinking in turbine design that simple devices are more appropriate for the ocean environment (Kahn et al., 2009).

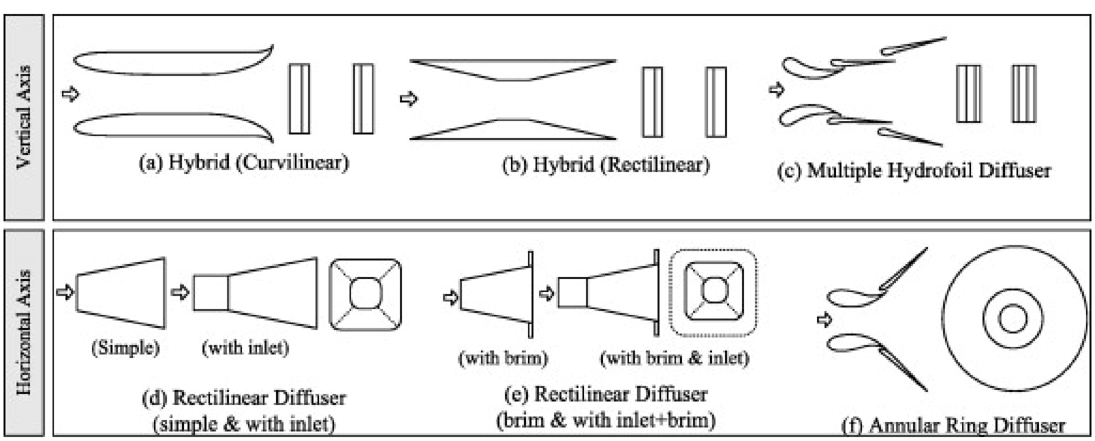

Figure 3-5: Duct Styles (Kahn et al., 2009)

3.3.1 - MOORING STYLE

The mooring requirements for the chosen tidal turbine will depend on the style of turbine. Styles of mooring are presented in Figure 3-6.

A floating structure mounting (FSM) is usually on a floating platform or set of pontoons.

A near-surface structure mounting (NSM) is often a pier mounted structure.

A bottom structure mounting (BSM) is often in the style of a gravity base (weighted base) or a pile driven into the sea bed.

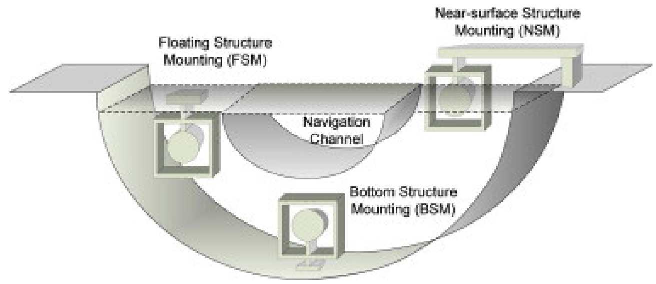

Figure 3-6: Mooring Styles (Kahn et al., 2009)

In general, vertical axis turbines have been designed to float at or near the surface to take advantage of the highest-speed currents, located approximately 1m below the surface (Karsten, McMillan, Lickley, & Haynes, 2008). This type of arrangement means mooring lines and anchors will need to be installed and the speed of the flow will directly affect the security of these lines.

In rivers, vertical and horizontal axis turbines have been placed near the surface in an overhang style or off a pier, which significantly reduces anchoring concerns and increases access for inspection and maintenance. If a barge or large floating turbine is planned as a semi-permanent structure, then anchor points need to be drilled in the bedrock to properly secure the turbine and/or barge (Wessner & Bear, 2009). A barge offers similar inspection and maintenance options as a pier, if the barge is designed appropriately.

Currently, most horizontal axis designs are being deployed on the sea bottom and are connected to a pile that is driven into the ocean floor or connected to a concrete surface that has been installed on the sea floor, known as a gravity base. The difficulties with this style of mooring include:

- the limited slack tide time available for easing pile or concrete platform installation,
- the cost of a drilling vessel,
- the time to install the turbine during slack tide,
- the availability and cost of a vessel capable of installing and lowering a very heavy (>1 ton) turbine,
- the accessibility of the turbine for inspection and maintenance, and
- the removal of turbine for maintenance.

Some of the clear benefits of the sea floor mounted turbines are:

- less interference with other marine activities,
- no line of sight concerns, and
- no shipping lane concerns.

Safety: It is important to note that no business goal should take priority over the safety of employees or the public. A full risk identification, analysis, and mitigation should be undertaken on the system design and all operational activities. The marine environment is unforgiving and conditions can change in a very short period of time. Training and a high awareness of employee safety is absolutely necessary.

3.4 - INSTALLATION

A large component of both the capital cost and ongoing operation and maintenance costs is the deployment and recovery of the tidal turbine. The design of the system should be done with a goal to minimize these costs.

Safety: It is important to note that no business goal should take priority over the safety of employees or the public. A full risk identification, analysis, and mitigation should be undertaken on the system design and all operational activities. The marine environment is unforgiving and conditions can change in a very short period of time. Training and a high awareness of employee safety is absolutely necessary.

To a large degree, the type of tidal turbine defines the type of fixing (i.e. foundation or mooring) necessary, which narrows the types of installation techniques and processes. For example, if the tidal turbine is supported by a floating platform, the installation consists of fixing the mooring requirements, floating the platform with the tidal turbine installed to the site, and attaching the device to the mooring cables. If the system design calls for a pile-driven support into the ocean floor, then specialized drilling/piling barges will be required, along with extensive knowledge of the geology in the area. The pile(s) are installed over the course of a few weeks, after which the tidal turbine can be fixed to it/them. In the case of gravity bases, such as the Open Hydro demonstration turbine that was in the Minas Passage, the system is floated out to the site and then sunk to its intended position.

The types of fixing have different requirements. However, in respecting that marine operations are very costly, two common themes emerge:

- Carry out as much work as possible on shore, using appropriate lifting devices, welding machines, etc. and creating safe and predictable working conditions.

- Minimize the time on the water and build that consideration into the design of the system.

3.5 - MAINTENANCE

Tidal turbines and their associated systems will be designed for a finite operating time between overhauls and for an overall life. Corrosion and biofouling are very common aspects of machinery of any kind operating in a marine environment. With experience, the time to remedy deterioration caused by corrosion or biofouling can be predicted. Less predictable are unforeseen events such as foreign objects striking the turbine or extreme weather events causing problems.

If the tidal turbine is supported from a floating platform, it is possible to build into the design, equipment to lift the device from the water for inspection and routine maintenance. Other designs will require the tidal turbine be recovered and returned to an onshore or near-shore maintenance facility.

A system deployed on a gravity base is an example of a device that needs to be recovered and returned to shore. Very little maintenance can be done in the open ocean. Subsurface inspections may be possible with manned or unmanned submersibles, though the tidal currents limit their effectiveness. Diving in the vicinity of an operating turbine in tidal currents requires extremely high attention to detail to ensure the safety of personnel.

The tidal turbine technology providers will have developed recommended maintenance protocols, both routine and for overhauls. Those recommendations should be followed. Careful and complete records should be maintained, either manually or in an automated system. Photographs are extremely useful and each should carry a complete description, along with time stamp.

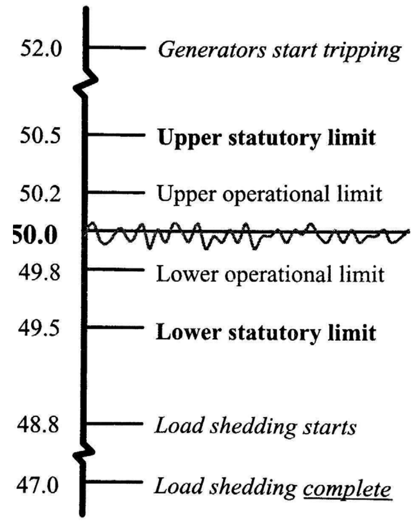

Figure 3-7: Frequency Range in hz (Freris & Infield, 2008)

3.6 - POWER

3.6.1 - DEMAND AND GRID CONNECTION

When thinking about the challenges of integrating renewable energy into the power grid of Nova Scotia, it helps to understand how the grid works.

Electrical transmission systems bring power across the province through power lines and are referred to as the "power grid." Distribution systems take power from the grid through substations and then distribute it to local customers.

The grid is a dynamic system that transmits power across the province; there is no power stored in the grid. This means the amount of power that is being made available through coal-fired plants, wind, hydro, and potentially, tidal, must be balanced with the amount of power being used by the population that is served (referred to as "load"). In electrical terms, the frequency of the power moving through the grid must stay within a restricted range (Figure 3-7, a graphic from the UK power network). In North America, this range is around 60hz. If the load on the grid is too high, the frequency will drop. If the power is too high, the frequency increases. The power transformers and elements of the electrical transmission systems are all designed to move power in a restricted frequency range; if the power moves out of that range, the transformers could become over-heated or damaged and the grid may fail.

Demand on the electrical system changes throughout the day, peaking in the evening when many people get home from school and work (Figure 3-8). The power that is generated must continually adjust through the day to meet the expected demand or load.

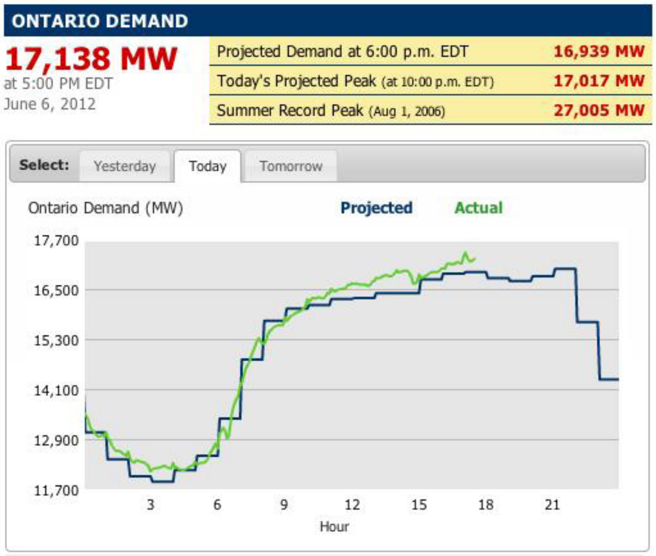

Figure 3-8: Ontario Demand Over 24 Hours

Source: www.ieso.ca

Tidal power is produced according to the tide, so this means traditional power demand cannot be met solely by tidal power, unless storage is used. Options to address this issue include combining tidal power with other renewable energy sources (wind, solar), fill-in power systems, and changing the community power use pattern (e.g. have communities use dryers at night or only allow electric vehicle charging overnight).

Tidal power is produced according to the tide, so this means traditional power demand cannot be met solely by tidal power, unless storage is used. Options to address this issue include combining tidal power with other renewable energy sources (wind, solar), fill-in power systems, and changing the community power use pattern (e.g. have communities use dryers at night or only allow electric vehicle charging overnight).

NOVA SCOTIA IN CONTEXT: NOVA SCOTIA POWER INCORPORATED'S GENERATION INTERCONNECTION PROCEDURES

In Nova Scotia, the energy distribution system is managed by Nova Scotia Power Incorporated. To gain access to the distribution or transmission system and start selling energy, a standard set of interconnection studies and procedures must be followed. To read more, see Nova Scotia Power Incorporated's Generation Interconnection Procedures. http://oasis.nspower.ca/en/home/oasis/generationinterconnectionprocedures.aspx

3.6.2 - CABLES

Many tidal turbines require electrical power and often data interconnection to shore. The data cable is necessary to supply important performance information about the turbine in real time. Subsea cables are commonplace around the world; however, routing of these cables for the purposes of interconnecting islands, for example, is often designed to avoid high currents in order to ease installation and increase the survivability of the cable. For tidal turbines, high currents are necessary. There are specialized companies with experience in subsea cable installation (see Module 9: Opportunities and Strategies for Businesses for more detail on subsea cable inputs).

The design of the turbine will establish the magnitude of the voltage (volts) and current (amps) at the generator terminals. One way of visualizing current is to see it as the speed of water. Voltage can be seen as the height of water that is dropping to a lower level. Current and voltage have a relationship with respect to power: Power = Voltage x Current. Therefore, it can be seen that the higher the voltage, the lower the current (amps) for the same amount of power. The resistance of the wires transporting the power through the moving current causes some power to be lost in the form of heat. Copper has low resistance and is used for more efficient power transmission. When power is transported over a cable with high voltage and low current, there is less of an electrical power loss than when the current is high and the voltage is low. If the current is low, then there will be less copper needed, which reduces the overall cost of supply and installation. Because of this, there can be consideration for offshore power conditioning (which regulates voltage) and transformer equipment. Using conditioning, the voltage of the output from the turbine can be increased, the current decreased, and then smaller diameter cables (with less expensive copper) can be run to shore. However, more commonly, because of the expense to deploy and maintain electrical equipment in a marine environment, the voltage is usually maintained as generated and a larger diameter cable is used to accommodate the larger current.

The data cable can be included in the overall cable covering. The electrical insulation must be kept dry so the integrity of the covering and the electrical connectors is very high. If the covering and insulation fails, the system fails. In high current environments, an additional layering of armour is common. The cable is often installed in trenches, where possible. Trenching is a common practice to increase the survivability of the cable and keep it where it was placed. In some cases, naturally occurring trenches along the seabed can serve as a protective route for cables. The design can be either alternating current or direct current, as required by the generator.

3.6.3 - ONSHORE FACILITIES

Once the cable makes landfall, if it is being conveyed at generator terminal voltage, there should be power conditioning equipment, protection, control, and an electrical transformer as close as practical. Nova Scotia Power Incorporated will provide engineering assistance in designing these requirements. The developer is responsible for the provision of the equipment. This will reduce further losses by increasing the voltage to the level necessary for interconnection to the grid. The electric utility will provide interconnection requirements, which will allow the power conditioning equipment and protection and control to be designed and provided.

The data coming onshore can easily be accessed over standard telecommunications methods and monitoring can be done from anywhere. It is unlikely a dedicated onshore “operations center” is necessary.

For overhauls, a maintenance facility is required. Because of synergies between ship building and tidal energy, existing equipment at shipyards is likely adequate. Experienced tradespeople are also a significant asset found at existing shipyards and other marine-related industries, including offshore oil and gas. The equipment and infrastructure needed at maintenance facilities would include, but not be limited to:

- dry dock facilities;
- overhead cranes;
- laydown space for assembly, as well as welding machines; and
- metal forming tools and composite forming stations.

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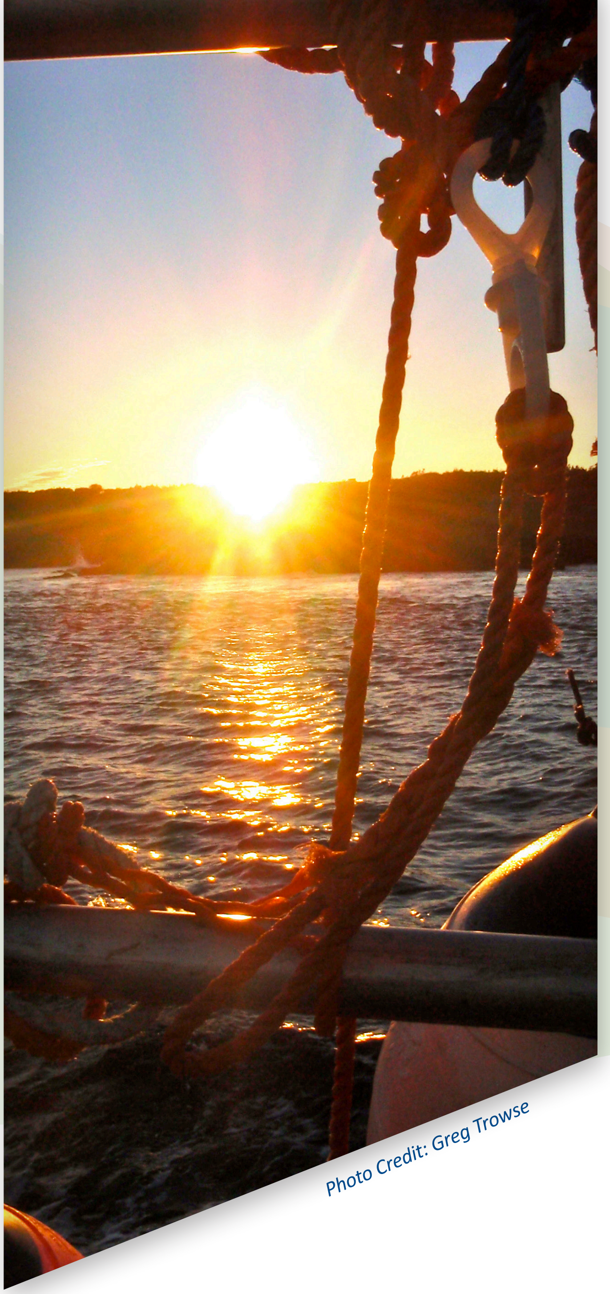


B | HOW IS TIDAL POWER MANAGED RESPONSIBLY?

4 THE REGULATORY REGIME FOR TIDAL ENERGY

4 - THE REGULATORY REGIME FOR TIDAL ENERGY

Author: Elisa Obermann

WHAT DOES THIS MODULE COVER?

This module outlines the policy and legal considerations of developing a tidal energy resource. It is intended to give you an understanding of what laws apply to tidal energy, which authorities are responsible for regulation, and how to navigate through the regulatory process. It also provides background on the policies that have been developed to support tidal energy development.

As such, this module outlines the answers to the following questions:

- What permits and approvals are required to develop a tidal energy project and what is the process to get them?
- Who are the regulatory authorities involved?
- What laws ensure that tidal energy is developed in safe and sustainable manner?
- What are the rules for community engagement?
- What policies exist to support tidal energy development?

WHY SHOULD YOU READ THIS MODULE?

This module is for anyone wanting to learn more about the legal framework for tidal energy development in Nova Scotia such as project developers, investors, and communities.

- Learn about the rules and laws governing tidal energy development and how they may apply to you.
- Find out who the tidal energy regulatory authorities are for each level of government.
- Understand the regulatory processes, permits, and approvals required to develop a tidal energy project.
- Find out about new policy and proposed legislation included in Nova Scotia's Marine Renewable Energy Strategy.

4.0 - INTRODUCTION

Tidal energy is a public resource, and like many natural resources, tidal energy is governed by several pieces of legislation, regulations, and overarching policies. These laws and policies are designed to ensure that the development of this resource is carried out in the best interest of the public and the environment. As the marine ecosystem supports multiple users and uses, legislation strives to provide suitable licensing processes, environmental protection, worker/public safety, resource conservation, recognition of other users, community benefits, and economic benefits.

Unlike other natural resources with established market values, there is currently no specific regulatory scheme for tidal energy or marine renewable energy in Nova Scotia or anywhere in Canada. Therefore, there are multiple federal, provincial, and potentially municipal authorities involved in the regulation of tidal energy. Nova Scotia's current regulatory framework reflects the varied and complex public interests associated with tidal energy. These public interests include multiple uses of the marine environment; potential conflicts among these uses; granting rights to produce energy from a shared, public resource (oceans); and the sale and distribution of electricity through a regulated, integrated utility (Nova Scotia Power Inc.).

Tidal energy is a public resource, and like many natural resources, tidal energy is governed by several pieces of legislation, regulations, and overarching policies.

4.1 - SNAPSHOT OF PROVINCIAL & FEDERAL SUPPORT IN NOVA SCOTIA'S TIDAL ENERGY SECTOR

The following is a list of various studies, reports, and recommendations that have received government support or that have demonstrated provincial and federal support for the tidal energy sector.

2007

- Offshore Energy Environmental Research Association commissioned to carry out a Strategic Environmental Assessment (SEA), focused on the Bay of Fundy

2008

- Bay of Fundy SEA recommendations released
  - o 29 recommendations including development of demonstration centre/site, legislation, and research
- Province selects three developers and commits to support tidal centre (i.e. FORCE)

2009

- FORCE Environmental Assessment approved (5 MW, 1.5km2 test area)
- Nova Scotia Power deploys OpenHydro device at FORCE (first large-scale device in North America)
- Environmental monitoring program at FORCE begins

2010

- Renewable Electricity Plan released
  - o Support for tidal energy development through feed-in tariffs, enhanced net metering
- Renewable Electricity Regulations
  - o Province puts tidal feed-in tariff into regulation
- Marine Renewable Energy Legislation public consultation

2011

- Marine Renewable Energy Legislation public consultation recommendations released ("The Fournier Report")

2012

- Community-based feed-in tariff price for tidal energy set by Utility and Review Board (65.2 cents/kilowatt hour)
- Marine Renewable Energy Strategy released and included direction for the following initiatives:
  - o Two-track licensing process with aspiration of 300 MW commercial development in the Bay of Fundy.
  - o Enhanced mandate for FORCE to act as the hub of knowledge for applied research, technology, testing, and operation for both small and large scale technologies.
  - o Exploring options for incubation facilities to test devices and associated technologies.
  - o Development of marine renewable energy legislation and establishment of tidal regulatory authority.
- Development of Statement of Best Practices
- RFP issued for vacant 4th berth at FORCE
- Cape Breton Strategic Environmental Assessment (SEA) initiated
- UARB process for setting Developmental Tidal Array commences

2013

- Cape Breton SEA completed.

4.2 - POLICY AND PROGRAMS FOR TIDAL ENERGY

Nova Scotia has been working to advance the sustainable development of marine renewable energy, and specifically tides, due to advantages in resource potential and the resources' potential to help meet renewable electricity targets and contribute towards economic development. The advancement of tidal energy has been supported through enabling policies, strategies, plans, programs, and regulatory development. This section will provide a background of key provincial policies, programs, and legislation addressing tidal energy development that have been established in recent years. Many of them inform the current regulatory requirements and processes for tidal energy.

4.2.1 - THE BAY OF FUNDY STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

In 2007, the Government of Nova Scotia commissioned the Offshore Energy Environmental Research Association (OEER) (now called the Offshore Energy Research Association) to conduct a SEA of the Bay of Fundy. This was one of the first steps the province took towards developing marine renewable energy. The SEA was intended to provide advice on whether, when, and under what conditions tidal energy demonstration and commercial projects should be allowed in the Bay of Fundy.

The SEA process provided an assessment of the social, economic, and environmental effects and factors associated with potential development of renewable energy sources in the Bay of Fundy. It addressed all forms of marine renewable energy technology and approaches—offshore wind, wave, and various tidal methods. The main focus, however, was on tidal in-stream energy conversion (TISEC) devices, as the Bay of Fundy is most promising as a source of tidal energy.

The final SEA report consisted of 83 pages and 29 recommendations. Some recommendations pointed to immediate action, while others pointed to future decision-making and the need to be cautious. Recommendations included the following:

- Adopt ten sustainability principles as outlined in the SEA.
- Allow the demonstration of TISEC technologies and develop a demonstration facility.
- Take a cautious approach.
- Develop marine renewable energy legislation.
- Allow for incremental and removable development.
- Compensate fishers in the occurrence of negative effects.
- Engage in consultation with First Nations.

All reports, analysis, and details regarding the Bay of Fundy SEA process can be found here: http://www.offshoreenergyresearch.ca/OEER/StrategicEnvironmentalAssessment/tabid/117/Default.aspx.

In 2013, the Province of Nova Scotia completed a SEA in the Cape Breton region.

FOUNDATIONAL CONCEPT: WHAT IS A STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)?

SEAs involve the evaluation of potential environmental effects of a policy, plan, or program. They are normally undertaken by or on behalf of a regulatory or government department with jurisdiction over the region or resources that may be affected by the policy, plan, or program. Increasingly, SEAs are becoming an essential aspect of planning as they can identify and predict cumulative effects of broad governmental policies early in the planning and design process. Additionally, SEAs promote public participation and provide alternative forums for public debate of policy or regional-scale issues associated with development that might otherwise surface during project level assessments where existing processes are ill-equipped to deal with such issues.

In April 2010, the Government of Nova Scotia released its Renewable Electricity Plan to support and encourage increased development of renewable energy resources for electricity generation. The plan sets out a detailed path for the province to gradually move away from predominately coal-fired electricity to energy sources that are more local, clean, secure, and sustainable.

4.2.2 - RENEWABLE ELECTRICITY PLAN

In April 2010, the Government of Nova Scotia released its Renewable Electricity Plan to support and encourage increased development of renewable energy resources for electricity generation. The plan sets out a detailed path for the province to gradually move away from predominately coal-fired electricity to energy sources that are more local, clean, secure, and sustainable. The plan sets the course for achieving a 25% renewable electricity supply by 2015 and establishes an ambitious goal to have 40% of Nova Scotia's electricity supply (sales) produced from renewable resources by 2020. That 2020 goal is now legislated in Nova Scotia's Electricity Act.

To achieve the 2015 target, the plan outlines new mechanisms and programs to increase renewable energy development that all Nova Scotians, from Nova Scotia Power (NSPI) and large independent power producers, to community organizations and committed citizens, can take part in. The following is a description of the legal framework and those programs developed as a result of the Renewable Electricity Plan that are pertinent to tidal energy development.

4.2.3 - RENEWABLE ELECTRICITY REGULATIONS

The Renewable Electricity Regulations were established under Nova Scotia's Electricity Act in October 2010 to provide a legal basis for many of the actions put forward in the Renewable Electricity Plan. The regulations outline many of the legal criteria and requirements for the Community Feed-In Tariff (COMFIT) program as well as the establishment of a One-Window Process to review COMFIT applications and details on the developmental tidal FIT.

To view the Renewable Electricity Regulations, please visit: http://www.gov.ns.ca/energy/electricity/regulations.asp.

To learn more about the COMFIT program, see the description below. To get more detailed information about COMFIT requirements and One-Window Process, please visit: www.nsrenewables.ca.

FOUNDATIONAL CONCEPTS: WHAT IS A FEED-IN TARIFF (FIT)?

A "feed-in tariff" (FIT) is a rate per kilowatt hour that small-scale energy producers are guaranteed for a fixed period of time. This provides them with enough economic certainty to invest in renewable energy projects. "Feed-in" means that energy produced by these projects will be fed in to the province's electricity grid.

As of early 2012, FITs have been implemented in at least 65 jurisdictions and 27 states,* notably in Spain, Germany, Vermont, and Ontario to accomplish specific policy objectives including renewable electricity acceleration, employment creation, and industry building.

*"Renewables 2012 Global Status Report", Renewable Energy Policy Network for the 21st Century

http://www.ren21.net/Portals/0/documents/activities/gsr/GSR2012_low%20res_FINAL.pdf

4.2.4 - ENHANCED NET-METERING

Net-metering is a utility-led program by Nova Scotia Power that allows a consumer to meet his or her annual electricity needs with a low impact renewable electricity generation facility of up to 1 MW capacity. The facility must be connected to the distribution grid through a meter that measures electricity flows in two directions. Tidal energy is considered a low impact renewable resource that qualifies for this program.

More information about the enhanced net-metering program can be found in the following documents and websites:

- Nova Scotia Power website: http://www.nspower.ca/en/home/environment/renewableenergy/enhanced/default.aspx
- Bill 64--Amended Electricity Act
- Regulation 3.6 Net Metering Service
- Interconnection Guidelines (Customer Generation with Capacity up to 100 kW)
- Net Metering Interconnection Agreement.

4.2.5 - COMMUNITY-BASED FEED-IN TARIFF (COMFIT) PROGRAM

The COMFIT program was created to encourage and support smaller-scale renewable energy projects that are developed and owned by community-based groups such as municipalities, First Nations, co-operatives, and not-for-profit groups. The focus on community-based projects is designed to ensure that projects are rooted in the community and investment returns remain there.

Projects will be connected to the grid at the distribution level. The province's current distribution capacity is roughly 200 MW, but changes as new customers are added or deleted. Some of that capacity is located in areas that are not well suited for development. Therefore, the Province is expecting roughly half that capacity may be used, or about 100 MW. Each distribution connection has its own capacity that is set by the size of the electricity demand or load that it serves.

Tidal energy is a qualifying renewable resource under the COMFIT program. Devices that are 0.5 MW or less and connected at the distribution level can receive a small-scale tidal COMFIT rate of 65.2 cents/kWh. This rate was set during a hearing process led by the Nova Scotia Utility and Review Board (UARB), as directed by Nova Scotia's Renewable Electricity Regulations. For more information on the setting of the COMFIT rate and to read the UARB's formal decision concerning the first set of COMFIT rates established in July 2011, review the final decision document here: http://www.nsuarb.ca/images/stories/pdf/Decisions/11Sep/comfit%20order%20with%20tariffs.pdf.

Terms of the agreement to receive the COMFIT rate are included in a power purchase agreement (PPA). The COMFIT PPA establishes an agreement between COMFIT proponents and Nova Scotia Power for the sale of renewable electricity for a period of 20 years. In the fall of 2012, a draft PPA was submitted to the UARB for approval through a hearing process.

NOVA SCOTIA IN CONTEXT: TIDAL ENERGY COMFIT PROJECTS

Since the COMFIT program was established, five small-scale tidal energy COMFIT approvals have been awarded to Fundy Tidal Inc.—three in Digby County and two in Cape Breton:

- Grand Passage (500 kW)
- Petit Passage (500 kW)
- Digby Gut (1.95 MW)
- Great Bras d'Or Channel (500 kW)
- Barra Strait (100 kW)

For more information on these projects, visit Fundy Tidal Inc.'s website: http://www.fundytidal.com/index.php?option=com_content&view=section&id=7&Itemid=24.

In addition to the requirements set out by the Renewable Electricity Regulations for the COMFIT program, several directives have been developed to guide the program by developing standards and definitions. Directives that may be applicable to tidal energy projects can be accessed here: https://nsrenewables.ca:44309/comfit-key-documents.

For more information about the COMFIT program and the application process for small-scale tidal energy projects, please visit www.nsrenewables.ca.

Please see section 4.3 in this module for more information on the COMFIT program application process and associated permitting process.

4.2.6 - DEVELOPMENTAL TIDAL ARRAY FEED-IN TARIFF (FIT)

As tidal energy devices are still in the demonstration phase, the Government of Nova Scotia established a FIT specific to large-scale tidal arrays. Developmental in-stream tidal arrays that are connected at the transmission level using devices greater than 0.5 MW may qualify for this tariff.

The Province directed the UARB to commence the process to set a Developmental Tidal Array FIT for tidal devices and arrays. The UARB is expected to look at a variety of factors when setting the feed-in tariff rate for large-scale tidal including installation, interconnection and capital costs, operations, and maintenance, as well as predictions around capacity factors, financing, and expected output.

The number of devices added will be determined by the existing environmental and renewable electricity regulations, the private sector, and the state of technology moving forward. It is anticipated that the FIT rate will be set in early 2013.

For more information about the Developmental Tidal Array FIT, please visit www.nsrenewables.ca.

4.2.7 - LARGE-SCALE PROJECTS AND THE RENEWABLE ELECTRICITY ADMINISTRATOR

In addition to the COMFIT program, the Renewable Electricity Plan also established a policy for a minimum of 300 GWh to be procured from independent power producers (IPPs). IPP projects are at a larger-scale and while they typically have been wind projects in Nova Scotia, tidal energy is also under this umbrella. The Renewable Electricity Administrator (REA), is an independent body, which was established by the Government of Nova Scotia in 2010. The REA oversees the competitive bidding processes and is intended to promote, fairness, transparency, and efficiency. In July 2011, Power Advisory LLC was appointed to serve as the REA after a competitive application process.

Requests for Proposals (RFP) are issued for large-scale renewable electricity projects to identify IPP projects that represent the best value for electricity ratepayers while ensuring a transparent review and decision-making process. To date, the RFP process managed by the REA has only included commercially-viable renewable energy sources and therefore, tidal energy has not been part of this process. However, tidal energy is included in the terms of reference for the REA and therefore, it is important to note that this is another mechanism that could apply to tidal energy in the future.

NOVA SCOTIA IN CONTEXT: LARGE-SCALE WIND ENERGY PROJECTS

In order to meet the legislated target of 25% renewable electricity by 2015, most of Nova Scotia's renewable electricity will come from large and medium-scale projects. A minimum of 600 gigawatt hours (GWh) of larger-scale renewable energy projects are required to meet the target. To ensure value for ratepayers, the Government of Nova Scotia decided that there will be an equal split for project development between independent power producers (IPPs) and Nova Scotia Power for access to these transmission connected projects.

In 2011-2012, a large-scale RFP process for IPPs was used for procuring wind energy projects. Nineteen proposals were received and evaluated and three contracts were awarded for 355 GWh of wind energy.

The three projects are scheduled to be in service by January 2015 and will bring local benefits to the province's communities, including jobs and local investments. The average purchase price from these three projects is in the mid-$70/MWh range, causing them to be the lowest cost renewable energy projects procured in Nova Scotia since renewable energy targets were set in 2007.

4.2.8 - MARINE RENEWABLE ENERGY LEGISLATION

The Bay of Fundy SEA recommended that legislation specific to marine renewable energy (tidal, waves, and offshore wind) be created to manage the long-term development and use of the resource. The Government of Nova Scotia adopted that recommendation and made a commitment to develop Marine Renewable Energy Legislation that would provide clear, predictable, and efficient processes to support the sustainable growth of the sector including tidal, wave, and offshore wind energy.

In the fall of 2010, the Province commissioned Dalhousie oceanographer, Dr. Robert Fournier, to lead a public consultation process regarding options for marine renewable energy legislation. As a result of the consultation process, Dr. Fournier delivered a final report –the "Fournier Report"—to the government that included 27 recommendations for the creation of future marine renewable energy policy and legislation. The report included specific direction on planning, economic opportunities, research, and regulation.

The Fournier Report can be viewed here:
http://www.gov.ns.ca/energy/resources/spps/public-consultation/marine-renewable-energy/Fournier-Report-English.pdf.

Background papers on Marine Renewable Energy Legislation in Nova Scotia can be viewed here:
http://www.gov.ns.ca/energy/resources/spps/public-consultation/NS-MRE-Policy-Background-Final.pdf
http://www.gov.ns.ca/energy/resources/spps/public-consultation/NS-MRE.pdf.

4.2.9 - NOVA SCOTIA MARINE RENEWABLE ENERGY STRATEGY

In May 2012, the Government of Nova Scotia released its Marine Renewable Energy Strategy. The strategy was a key recommendation of the 2010 Marine Renewable Energy Legislation public consultation process. The final report from this process, the "Fournier Report" included a recommendation to develop a strategic plan for marine renewable energy with an immediate emphasis on in-stream tidal energy.

The Marine Renewable Energy Strategy establishes new policies, tools, and legal direction to support the development of tidal energy from the demonstration phase to commercialization. The strategy builds on Nova Scotia's vision to be "a leader in the development of technology and systems that produce environmentally sustainable, competitively priced electricity from the ocean." It outlines research, development, and regulatory initiatives to help achieve an internationally active industry, while ensuring adaptive and responsible management of the resource to protect the environment and other marine users.

The strategy includes enabling mechanisms and activities to help advance tidal energy in Nova Scotia, including a feed-in tariff scheme coupled with a licensing process that will be established in legislation to provide a pathway for projects to proceed from the testing state to demonstration and finally, to commercial development. *(See section 4.4 in this module for more information on the future licensing process).*

The Marine Renewable Energy Strategy can be viewed here: http://www.gov.ns.ca/energy/resources/publications/Nova-Scotia-Marine-Renewable-Energy-Strategy-May-2012.pdf.

The Marine Renewable Energy Strategy establishes new policies, tools, and legal direction to support the development of tidal energy from the demonstration phase to commercialization. The strategy builds on Nova Scotia's vision to be "a leader in the development of technology and systems that produce environmentally sustainable, competitively priced electricity from the ocean."

4.2.10 - STATEMENT OF BEST PRACTICES

The Government of Nova Scotia has been working with the federal Department of Fisheries and Oceans (DFO), other federal and provincial partners, research organizations, and industry to develop a Statement of Best Practice for the development of in-stream tidal technologies. In June 2012, the Nova Scotia Government met with stakeholders, experts, industry, and other regulators to seek input on the key elements of the Statement. A draft Statement of Best Practice is currently under development. (Please see section 4.4 for details on how the Statement of Best Practices will function in current and future licensing processes.)

The goal of the Statement is to contribute to improved regulatory review and environmental assessment processes for an adaptive approach to the growth of the tidal energy industry in Canada, leading to improved environmental review and management processes. The Statement represents an innovative tool to harmonize development and environmental interests to ensure the industry grows in an environmentally and socially responsible manner.

The Statement embeds standard requirements and practices for risk assessment as well as options for precautionary and adaptive environmental assessment, licensing and management, site assessment and environmental monitoring requirements, modeling and monitoring energy production, deployment of devices, stakeholder consultation and engagement, and transparency in environmental data collection and dissemination. These minimum requirements and practices will complement existing regulatory processes, and are intended to formalize and standardize the mitigation measures in Canada with respect to the development and deployment of tidal energy. The Statement will apply to all tidal energy activities and come into effect through existing respective regulatory authorities and instruments.

By using the Statement of Best Practices, respective governments, regulators, tidal developers, community, and the general public will have the assurance that there will be a safe path ahead of them in the development of a in-stream tidal energy industry.

4.3 - THE PERMITTING AND LICENSING PROCESS FOR TIDAL ENERGY

Tidal energy development is subject to a number of provincial and federal laws and regulatory authorities as both governments have certain jurisdictional roles regarding matters related to marine resources. There may also be municipal laws to consider, depending on the location of the project.

Constitutionally, the Province's responsibilities arise from its ownership and related jurisdiction over areas of the seabed, while federal responsibility primarily arises based on its constitutional jurisdiction for fishing and navigation rights. These constitutional jurisdictional boundaries are only the starting point of multifaceted regulatory frameworks relevant to marine renewable energy at both the provincial and federal levels.

Given the complexity of the regulatory environment for tidal energy, this section aims to provide clarity for developers, communities, and individuals interested in developing a project or those having a general interest in how industry is facilitated and regulated. This section will provide a detailed how-to, step-by-step process and supporting information for how to obtain permits and licenses for small and large-scale tidal development and identification of all associated legislation, regulations, and authorities.

Please note: This section is subject to change once Nova Scotia's Marine Renewable Energy Legislation is developed and enacted. Please visit www.gov.ns.ca/energy for the most recent tidal energy policy and legislation information.

4.3.1 - SMALL-SCALE PROJECTS: COMFIT PROGRAM APPLICATION PROCESS

Both small-scale (0.5 MW and below) and large-scale tidal energy projects (greater than 0.5 MW) are typically subject to many of the same provincial and federal regulatory requirements given that many aspects of the marine environment such as navigation, transportation, and habitat are governed by federal government; the smaller size of a project does not necessarily mean it will not require the same permits and oversight as a larger project. However, projects under 2 MW will not trigger the provincial environmental assessment. All aspects of a project are considered in terms of technology, location, size, number of devices, etc. that may dictate the regulatory requirements and processes.

Currently, small-scale tidal energy projects that are proposed to be 0.5 MW or below, connected at the distribution system, and owned by an eligible community-based group can apply to the provincial COMFIT program. The COMFIT application process is a separate activity from the permitting and licensing process that has been established for tidal energy projects. However, many of the steps and activities included in the COMFIT application process overlap with other federal and provincial regulatory requirements.

For more information and detail on COMFIT requirements and the application process, please view the COMFIT guide here: http://nsrenewables.ca/comfit-key-documents.

4.3.2 - WHO'S INVOLVED

The framework currently being used for all tidal energy project development was developed in August 2012 and based on the 2007-2008 Bay of Fundy SEA. It includes a One-Window Committee to coordinate the permits and approvals required by federal and provincial regulatory authorities to ensure a timely, coordinated, and efficient regulatory process for prospective tidal energy developers. The One-Window Standing Committee includes key federal and provincial regulators and government departments interested in, or with authority for, marine projects.

Table 4-1: One Window Standing Committee for Tidal Energy

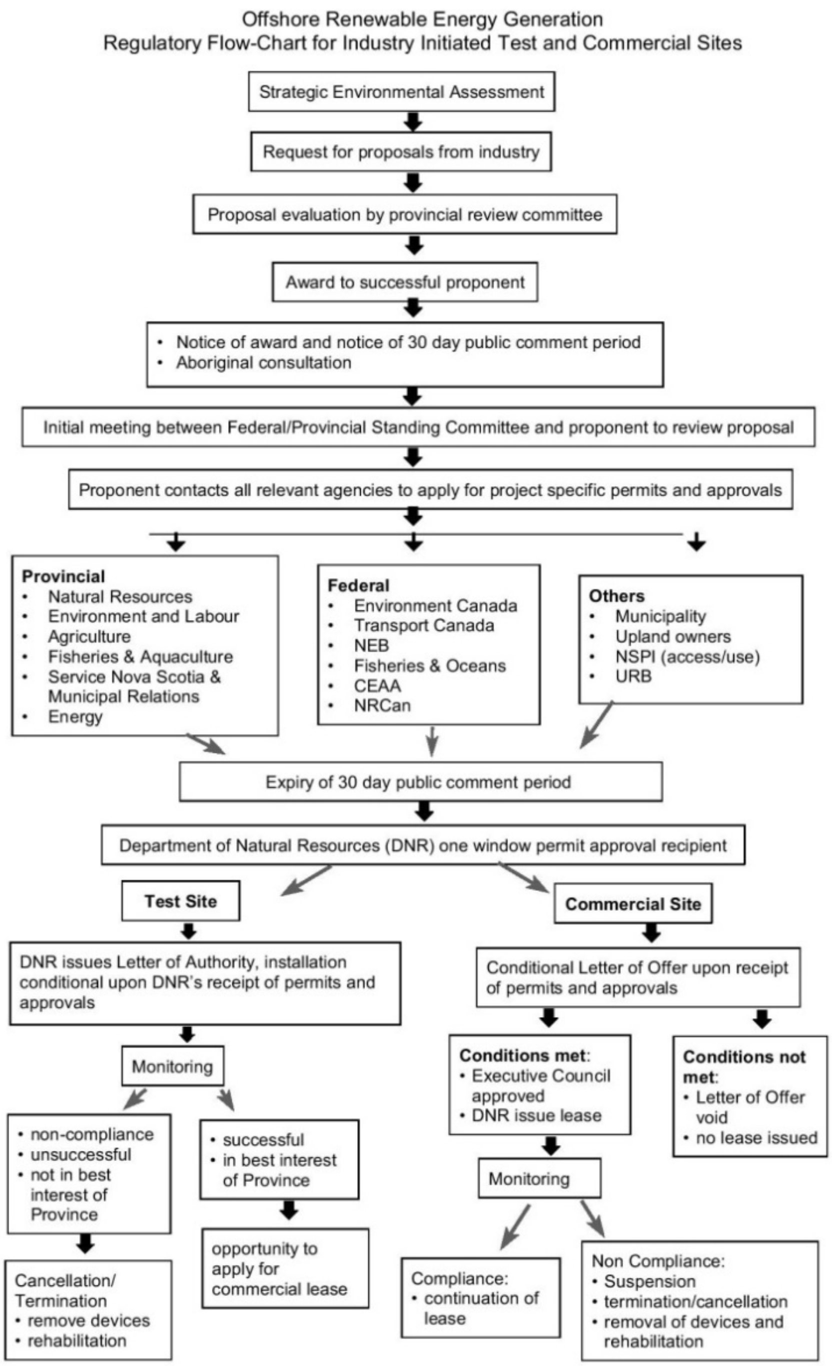
ONE WINDOW STANDING COMMITTEE FOR TIDAL ENERGY*	
PROVINCIAL AUTHORITIES	FEDERAL AUTHORITIES
Department of Energy (lead)	Natural Resources Canada
Department of Environment	Environment Canada
Department of Labour	Fisheries and Oceans Canada
Department of Fisheries and Aquaculture	Canadian Environmental Assessment Agency
Department of Natural Resources	Transport Canada
Office of Aboriginal Affairs	

**Other federal and/or provincial authorities in addition to this committee may be involved in the permitting and approval of tidal energy projects depending on details specific to individual projects.*

The One-Window Standing Committee was used for the permitting and licensing of the Fundy Ocean Research Center for Energy (FORCE) and was recognized as being quite effective for that project. However, the Government of Nova Scotia has recognized that a more formal, integrated approach will likely be necessary as the level of activity in the marine renewable energy sector grows.

4.3.3 - THE PERMITTING PROCESS

As depicted in the flowchart below, a framework and process has been established to guide proponents interested in developing a tidal energy project in Nova Scotia. A brief description of the step-by-step process depicted by the flowchart is included after the image.



For detailed guidance of this process, please see the Guidelines for Permitting of a Pre-Commercial Demonstration Phase for Offshore Renewable Energy Devices (Marine Renewables) in Nova Scotia established by the Nova Scotia Department of Energy here: http://gov.ns.ca/energy/resources/EM/tidal/Final-Guidelines-for-Permitting-Demonstration-Phase.pdf.

1. PROJECT PROPOSAL

A project proposal including the following information should be prepared by the proponent:

- Proposed location and size of the project;
- Description of technology and feasibility;
- Knowledge and understanding of local environment, sensitive areas, and risks;
- Financial feasibility;
- Insurability; and
- Decommissioning plan and financial surety.

Proponents should consult the Statement of Best Practice in the early stages and throughout the project planning process to ensure the safe and responsible development of their project(s).

2. PROPOSAL SUBMISSION

Proposals are required to be submitted to the Nova Scotia Department of Energy, who will then distribute the proposals to members of the One-Window Committee.

3. PROPOSAL EVALUATION

An interdepartmental provincial review committee (Review Committee), comprised of staff from the Departments of Energy, Natural Resources, and Environment, as well as technical experts and others as required, will evaluate and review the proposal before convening the One-Window Standing Committee.

4. DETERMINATION OF REGULATORY APPROVALS/PERMITS

Depending on the completeness and deemed potential of a project, a proponent will be invited to meet with the One-Window Standing Committee consisting of provincial and federal government departments to determine required permits and approvals that may be required.

This helps to ensure that the regulatory process is coordinated, efficient, and streamlined as much as possible.

Table 4-2 is a list of legislation and regulations that may be applicable to a tidal energy project.

Table 4-2: Relevant Legislation and Regulatory Authorities for Tidal Energy

PROVINCIAL				
AUTHORITY	**LEGISLATION**	**DESCRIPTION**	**APPROVAL REQUIRED & CORRESPONDING LEGISLATION**	**WEBSITE**
Department of Communities, Culture, and Heritage	Special Places Protection Act (SPPA)	Provides the Heritage Division with a mandate to protect important archaeological, historical, and paleontological sites and remains, including those under water.	Resource Impact Assessment (needed for development that will potentially disturb or alter the landscape, thereby endangering archaeological sites):Special Places Protection Act, S. 8. Heritage Research Permit (needed for exploration for, or excavation of, fossils or archaeological sites): Special Places Protection Act, S. 8.	http://nslegislature.ca/legc/statutes/specplac.htm
Department of Environment	Nova Scotia Environment Act (NSEA)	States that environmental assessments for tidal energy projects over 2MW are mandatory.	Environmental assessment: Environment Act, S. 49 Environmental Assessment Regulations, Schedule A	http://nslegislature.ca/legc/statutes/envromnt.htm
		Concerns projects that alter surface watercourse or the flow of water.	Water approval: Environment Act, S. 66 Activities Designation Regulations, S. 5	
	Wilderness Areas Protection Act (WAPA)	Provides the legal framework for establishing, managing, protecting and using Nova Scotia's designated wilderness areas. The Act's primary objectives are to protect natural processes, biological diversity, and outstanding natural features. The secondary objectives are use-related. Activities such as wilderness recreation, environmental education, and scientific research are encouraged.	Authorization by the Minister: Wilderness Areas Protection Act, S. 11, 17, & 19	http://www.gov.ns.ca/nse/protectedareas/docs/Wilderness_Act_Sum.pdf
Department of Fisheries & Aquaculture	Fisheries and Coastal Resources Act (FCRA)	Specifically addresses approvals for aquaculture activities below the coastal low-water mark. Potential conflicts are always possible between a licensed aquaculture operation and tidal in-stream activities, although the need for elevated tidal currents in the latter could ultimately reduce potential overlap.		http://nslegislature.ca/legc/statutes/fishand.htm

AUTHORITY	LEGISLATION	DESCRIPTION	APPROVAL REQUIRED & CORRESPONDING LEGISLATION	WEBSITE
Department of Natural Resources	Endangered Species Act (ESA)	Mandates the compilation of a listing of endangered or threatened plant and animal species out to the coastal low-water mark.	Potential disturbance of any species listed under the Nova Scotia Endangered Species Act or designated critical habitat (Endangered Species Act, S 13)	http://www.gov.ns.ca/natr/wildlife/biodiversity/legislation_nsesa.asp
	Crown Lands Act (CLA)	Submerged land located along the coast of Nova Scotia is considered to be Provincial Crown Land, owned by the province, unless it has been sold by way of provincial or federal grant or it is considered to be a federal public harbour. Under the Crown Lands Act, the Minister of Natural Resources is responsible for Crown Lands, including submerged lands along the coast of the province.	See Table 4-3 below for description of licenses, lease options, and approvals.	http://www.gov.ns.ca/natr/land/submerged-land.asp or http://nslegislature.ca/legc/statutes/crownlan.htm
	Beaches Act (BA)	Provides "for the protection of beaches and associated dune systems as significant and sensitive environmental and recreational resources; provides for the regulation and enforcement of the full range of land use activities on beaches, including aggregate removal, so as to leave them unimpaired for the benefit and enjoyment of future generations; controls recreational and other uses of beaches that may cause undesirable impacts on beach and associated dune systems." This Act applies to both Crown and privately owned protected beaches.	Permit (If project requires removal or placement of material from a beach, operation of vehicle on a beach, or the construction or placement of any structure on a beach): Beaches Regulations, S 5, 7, 9	http://nslegislature.ca/legc/statutes/beaches.htm
	Provincial Parks Act		Authorization by the Minister (If the project has the potential to disturb the flora and fauna located in a provincial park): Provincial Parks Act, S. 13, 17	http://nslegislature.ca/legc/statutes/provpark.htm

AUTHORITY	LEGISLATION	DESCRIPTION	APPROVAL REQUIRED & CORRESPONDING LEGISLATION	WEBSITE
Service Nova Scotia & Municipal Relations	Municipal Government Act (MGA)	Outlines the powers, responsibilities, administrative structure, and procedural steps that municipalities are required to follow. The Act deals with municipal services, methods that municipalities are allowed to use to generate revenue (property tax, service fees, fines), and how they manage development processes. The MGA incorporates 8 older acts into one.		http://www.gov.ns.ca/snsmr/muns/manuals/mga.asp

Table 4-3: Provincial Land Leasing & Licensing

PROVINCIAL LAND LEASING & LICENSING: POTENTIAL REQUIREMENTS UNDER NOVA SCOTIA'S CROWN LANDS ACT FOR TIDAL ENERGY		
ACTIVITY	APPROVAL	LEGISLATION
Requires exclusive use of Provincial Crown Land	Crown Lands Lease	Crown Lands Act, S 16
Requires non-exclusive use of Provincial Crown Land	Permit, Letter of Authority or License	Crown Lands Act, S 16
Use of Provincial Crown Land to access project site or for transmission lines	A Permit for Access Across Crown Land, A Right of Way, or Easement	Crown Lands Act, S 16
Removal of Trees on Crown Land during construction	A Letter of Authority or Timber License	Crown Lands Act, S 28
Setting up test, experimentation equipment or instruments on Provincial Crown Lands	Letter of Authority or License for the short term use of Crown Land	Crown Lands Act, S 16
Establishing or re-establishing a legal survey, land boundary line, or marker on or adjoining Provincial Crown Land	Survey Order	Crown Lands Act, S 13
The use or improvement of any road on Provincial Crown Land	Permit for Access Across Crown Land, Right of Way, or consent of pre-existing Crown Land Licensee	Crown Lands Act, S 16

Table 4-4: Relevant Federal Legislation

FEDERAL			
AUTHORITY	**LEGISLATION**	**DESCRIPTION**	**WEBSITE**
Canadian Environmental Assessment Agency	Canadian Environmental Assessment Act (CEAA)	Addresses projects that involve federal decision-makers, fall under federal legislation, use federal funding, contain federal proponents, take place on federal lands, or fall under federal jurisdiction.	http://laws-lois.justice.gc.ca/eng/acts/C-15.2/
Environment Canada	Species at Risk Act (SARA)	Designed to protect identified species considered to be at risk on federal lands, including territorial seas and internal waters. Species are protected through a process of general prohibitions combined with project permitting requirements to avoid certain potentially harmful activities.	http://www.ec.gc.ca/alef-ewe/default.asp?lang=en&n=ED2FFC37-1
	Canadian Environmental Protection Act (CEPA)	Protects the environment and human health, applies the precautionary principle that, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation, and promotes and reinforces enforceable pollution prevention approaches. Outlines public participation requirements related to the administration of the Act.	
	Migratory Birds Convention Act	Provides for the protection of migratory birds through the Migratory Birds Regulations.	http://www.ec.gc.ca/nature/default.asp?lang=En&n=7CEBB77D-1
Department of Fisheries & Oceans Canada (DFO)	Fisheries Act (FA)	Applies to all fishing zones, territorial seas, and inland waters of Canada and is binding to federal, provincial, and territorial governments. As federal legislation, the Fisheries Act supersedes provincial legislation when the two conflict.	http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14151-eng.htm
	Oceans Act	Deals with all internal waters and within the territorial zones of Canada.	
Transport Canada	Navigable Waters Protection Act (NWPA)	Administered by Transport Canada, applies to the Bay of Fundy because it is navigable water and a permit is required for any work that is built, placed in, on, over, under, though, or across any navigable water.	http://www.tc.gc.ca/eng/marinesafety/debs-arctic-acts-regulations-nwpa-1308.htm
National Energy Board	National Energy Board Act (NEBA)	Applies to all projects that cross provincial boundaries, extend beyond the territory of a province, or include an inter-provincial or international power line; a certificate or permit is required.	http://www.neb.gc.ca/clf-nsi/rpblctn/ctsndrgltn/ct/ntnlnrgybrdct-eng.html

5. FIRST NATIONS ENGAGEMENT

Proponents are encouraged to engage with the Mi'kmaq of Nova Scotia early in project development. The Province of Nova Scotia may delegate certain procedural aspects of consultation with First Nations to proponents. In instances where there is no Crown duty to consult, proponents may still wish to engage the Mi'kmaq of Nova Scotia to share information about their project.

For more information, see The Proponent's Guide: Engagement with the Mi'kmaq of Nova Scotia here: http://www.gov.ns.ca/abor/docs/Proponants-Guide.pdf.

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

6. COMMUNITY ENGAGEMENT

The marine environment is complex and has many uses: tourism, landscapes, seascapes, habitats, fisheries, and ecosystems. It is a public resource and as such, the owners— Nova Scotians—must trust how marine renewable energy is developed and operated to ensure sustainable and beneficial growth. Public acceptance and trust must be earned and maintained. Regardless of the size of project, it is important for proponents to engage with local communities that may be affected by the project.

Community and public support are very important to the success of energy projects and it is critical to inform the surrounding community about project intentions and to receive input and questions about the projects. Further, community engagement can provide vital local knowledge, reduce the risk of challenges and delays, and identify how a project can bring value to a community.

Proponents who are seeking COMFIT approval are required to have evidence of community support. This can be demonstrated by providing a municipal council resolution indicating support from the municipality within which the project is to be located or written evidence of support for the project from members of the community in which the project is to be located.

The COMFIT program has provided some helpful guidance for engaging communities and the process for providing evidence of support, which can be viewed in the COMFIT Guide here: http://www.ren21.net/Portals/0/documents/activities/gsr/GSR2012_low%20res_FINAL.pdf. Module 6 of this toolkit also provides details about engaging communities.

Proponents are also encouraged, through this process and the subsequent environmental assessment process, to engage potentially affected fishers. An early, proactive approach serves to benefit from industry knowledge and ensure that fishers are heard and considered. For example, FORCE's tidal projects in the Minas Basin involved early dialogue between the developers and the fishing community. This dialogue is encouraged throughout the permitting, development, and operations phases.

It is anticipated that the Government of Nova Scotia will develop formal rules about engagement and tidal energy interaction with fisheries in its Marine Renewable Energy Legislation. A discussion of fisheries issues and options related to tidal energy can be found in the Marine Renewable Energy Legislation for Nova Scotia - Discussion Document. http://www.gov.ns.ca/energy/resources/spps/public-consultation/NS-MRE-Policy-Background-Final.pdf

7. DETERMINATION OF MUNICIPAL REQUIREMENTS AND IMPACTS

Tidal energy project activities could affect local communities with respect to land-based associated energy facilities or transportation/servicing infrastructure that fall under the jurisdiction of municipalities for appropriate zoning and property taxation. Additional permits may be required at the municipal level and therefore, it is important that municipalities are kept informed regarding new projects or developments.

More information regarding municipalities, engagement, and possible planning issues can be obtained from:

- Union of Nova Scotia Municipalities (UNSM): www.unsm.ca;
- Service Nova Scotia and Municipal Relations: www.gov.ns.ca/snsmr.

8. APPLICATION SUBMISSION

Once a proponent has completed the steps above, he or she is ready to submit an application for development of the project to each of the regulators identified in step 4. This application should also include decommissioning plans and financial security arrangements. It is recommended that a project application be submitted to the Nova Scotia Department of Energy and the Canadian Environmental Assessment Agency to initiate the process among the provincial and federal governments.

9. DETERMINATION OF ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Proponents will need to determine whether an environmental assessment is required for their project. Environmental assessment ensures that environmental, human health, socio-economic, cultural, historical, archaeological, and architectural concerns from all stakeholders are identified and addressed at the earliest stage of development planning. Through consideration of these broad environmental issues and public concerns, federal and/or provincial government decides whether or not the development can proceed in an environmentally sustainable manner.

Environmental assessment is used in every province and territory in Canada and in many countries worldwide. It is a tool that promotes good project planning, thereby avoiding or minimizing environmental effects caused by a development. It also allows developments to incorporate environmental considerations at the planning stage, which may avoid expensive changes once the project design has been finalized.

If environmental assessment legislation is triggered by federal and/or provincial legislation, proponents and regulators are required to consider the following factors related to the project:

- environmental effects, including environmental effects caused by accidents and malfunctions, and cumulative environmental effects;
- significance of those environmental effects;
- public comments;
- mitigation measures and follow-up program requirements;
- purpose of the designated project;
- alternative means of carrying out the designated project;

- changes to the project caused by the environment;
- results of any relevant regional study;
- any other relevant matter.

There are different types of environmental assessments depending on the scope, size, and details of a project. Both provincial and/or federal assessments may be required and the following provides a brief summary of legislated environmental assessment triggers and links to further information for business and communities:

Provincial: Under Nova Scotia's Environment Act, projects that are 2 MW or greater trigger an environmental assessment. For more information, see:

The Province of Nova Scotia's website regarding environmental assessment
http://www.gov.ns.ca/nse/ea/

The Proponent's Guide for Environmental Assessment
http://www.gov.ns.ca/nse/ea/docs/EA.Guide-Proponents.pdf

A Citizen's Guide to Environmental Assessment
http://www.gov.ns.ca/nse/ea/docs/EA.Guide-Citizens.pdf.

Federal: A federal environmental assessment under the Canadian Environmental Assessment Act could be triggered if other federal legislation is elicited (regardless of project size or aggregate capacity) under the Fisheries Act, or Navigable Waters Protection Act. For more information, see:

Basics of Environmental Assessment:
http://www.ceaa.gc.ca/default.asp?lang=En&n=B053F859-1.

10. LEASE ISSUANCE

The Nova Scotia Department of Natural Resources may issue a Letter of Authority containing a condition prohibiting installation of devices until all copies of written approvals and permits are received. The fee for the Letter of Authority will be $200.00.

To learn more about Crown Land in Nova Scotia, please visit the Department of Natural Resources website here: http://www.gov.ns.ca/natr/land/.

11. DEVELOP AND IMPLEMENT A MONITORING PROGRAM

Successful proponents will be required to develop a monitoring program for the project. The implementation of a monitoring program is required subsequent to installation. Precise monitoring conditions will vary between devices, projects, and sites.

4.4 - THE FUTURE REGULATORY AND LICENSING SYSTEM FOR TIDAL ENERGY

Nova Scotia's Marine Renewable Energy Strategy includes a plan to develop new legislation, including a licensing process for tidal energy projects. This means that some of the direction and guidance provided in section 4.3 may change in the near future. As the regulatory and licensing system is on the cusp of change, this section aims to provide some preliminary details regarding the proposed licensing process and future regulation of tidal energy in Nova Scotia.

4.4.1 - THE REGULATORY AND ENVIRONMENTAL PROTECTION SYSTEM

As part of new legislation, a strong focus will be on the regulatory and environmental protection system. This system will focus on a staged, progressive, and adaptive approach to development and deployment of in-stream tidal devices.

Similar to the current system, the regulatory process will begin with a SEA to provide a broad understanding of the ecosystem and socioeconomic issues. Potential project developers will then be required to follow the Statement of Best Practice, which is currently under development. More information on the Statement can be found in section 4.2.10.

4.4.2 - LICENSING SYSTEM

The Province of Nova Scotia is currently developing a licensing process for tidal energy development to provide a clear, predictable, and efficient process. Currently, in order for project developers to proceed with developing a project on submerged provincial Crown land in the Bay of Fundy, a Letter of Authority or Crown Land Lease is issued by the province, as described in section 4.3.3. Once new Marine Renewable Energy Legislation is in place, a license will be the primary tool for defining project- or company- specific opportunities and obligations.

The licensing process will include two licensing streams—one for technology development and the other for commercial power development. The following is a description of each license type and criteria.

4.4.2.1 - TECHNOLOGY DEVELOPMENT LICENSES

Technology development licenses cover activities where the focus is mainly on technology-specific improvements to create reductions in electricity production costs. This could include medium-scale projects for developers testing prototypes, small-scale devices, and community projects. All such projects would be eligible for either the COMFIT or FIT rates. The distinction between technology development licenses issued for the testing and demonstration phases is summarized in Table 4-5.

Table 4-5: Technology Development License Details: Testing and Demonstration Phase

TECHNOLOGY DEVELOPMENT LICENSE		
	TESTING PHASE	DEMONSTRATION PHASE
Definition	Deployment of single device or series of small devices.	Acknowledged growth of activity and experience beyond levels permitted under the COMFIT program or deployment at FORCE.
Production Capacity	≤ 500 kW; for small devices connected to the distribution system. > 500 kW up to 5MW; for larger devices or arrays connected at the transmission level.	Arrays of devices under COMFIT, but > 500 kW (including future permits for arrays under COMFIT). Growth in activity for a COMFIT project beyond permitted levels (≈ 3MW).
Requirements	Data for resource and environmental effects must be collected and made available to the government and the public as information to be considered in future regulatory filings.	Consultation regarding the timeline for technology improvements and number of devices needed to demonstrate significant cost-reductions. Prospects for development in NS and opportunities to advance the MRE strategy. Minister authority to set targets for the amount of electricity purchased. “Plans, commitments, and requirements …” encompassing quantum of energy to be extracted and sold into the NS electricity market, proposed R&D plan leading to reduced generating costs in the future, and anticipated contribution to the development of the MRE sector.
Market Support	COMFIT Testing Rate for eligible entities for systems ≤ 500 kW connected at the distribution level. Current COMFIT rate as set by the UARB = $0.652 per kWh (to be reviewed in 2014).	New COMFIT Demonstration Rate for eligible entities for systems ≤ 500 kW connected at the distribution level. Rate to be established by the UARB after consultations with small-scale developers concerning technology improvements and cost reductions (separately or as part of UARB’s 2014 review of COMFIT).
	FIT Testing Rate for devices > 500 kW up to 5MW for larger devices or arrays connected at the transmission level. The rate is to be determined by the UARB in 2012.	FIT Demonstration Rate for transmission connected devices that are greater than 500 kW up to a set amount. Rate for medium-scale projects will be set by the UARB, and DOE is working with industry to determine the scale of the project(s) needed to advance industry development. Province will provide “regulatory and licensing direction to ensure there is a proper balance” between the economic benefits of MRE development and the interests of ratepayers. Possible provincial assistance in the development of technology companies through investments by Innovacorp.

4.4.2.2 - POWER DEVELOPMENT LICENSE

Power development licenses cover large-scale, commercially-viable projects to provide grid-connected in-steam tidal power. The emphasis for this type of license is the demonstrated ability and willingness to commit "market-ready" technology to the development of a large scale, grid-connected tidal energy project up to 300 MW. Once the industry has reached the stage where developers demonstrate they are ready to pursue a project of this scale, a call for bids will be issued. The outcome of a successful bid process will be an exclusive license and Crown land lease providing rights to produce up to 300 MW of power. Both exclusivity and granting the right to develop the full capacity at the onset will be necessary for developers to secure the financing needed to complete a project of this scale. Similar to the Technology Development License, a phased approach will be used for the Power Development License, with three stages—investigation, demonstration, and commercial deployment. A description of the elements included in each stage of the license is provided in Table 4-6.

Table 4-6: Power Development License Details: Testing

REQUIREMENTS AT VARIOUS STAGES FOR POWER DEVELOPMENT LICENSES	
Investigation Stage	Proponents are required to file a Power of Development Project Plan addressing plans and commitments for: • Level of investment at all stages of the project. • Incorporating best-in-class technology, improving the state of technology and business knowledge in the MRE sector in NS, and deploying that knowledge from NS to outside markets. • Developing NS and regional "capacities and capabilities" for R&D, engineering, design, and manufacturing. • Monitoring and avoiding significant adverse environmental impacts. • Operating safely and adhering to best practices developed for the MRE sector. • Collecting and reporting of data concerning resource and environmental effects. • Progressing from the investigation stage through to a specific site for a demonstration and/or a market-ready commercial project. • Identifying market for energy to be supplied by the project. • Engaging the Mi'kmaq and the community. • Analyzing resource and geotechnical features to evaluate the suitability of a specific project site (within an area that has had a SEA). • Deploying devices to measure resources and environmental effects, and ensuring this data is available to the Government and the public.

Demonstration Stage	The Demonstration Stage of a Power Development License includes: • Deployment of an array of devices for the production of a set capacity at a site identified at the Investigation Stage. • Eligibility for market support mechanisms that are available under the Technology Development License. • Confirmation of the plans and commitments made at the Investigation Stage subject to any amendments permitted by the Minister of Energy due to a change in market, environmental, or technical conditions that take place in the Investigation Stage.
Commercial Deployment Stage	The Commercial Deployment Stage of a Power Development License includes: • Deployment of arrays at a site identified at the Investigation or Demonstration Stage. • Confirmation of the plans and commitments made at the Investigation Stage with further detail and experience gained during the Demonstration Stage. • A rate for electricity similar to competing renewable electricity sources available to the Nova Scotia market.

4.4.2.3 - TIDAL RANGE TECHNOLOGIES AND THE LICENSING PROCESS

Tidal range technology extracts energy from the rise and fall of the tide. This approach uses a holding basin and a dam, barrage, or lagoon structure. As these technologies may not be adaptable to an incremental approach and the staged nature of the licenses described above, the Government of Nova Scotia has provided some guidance as to how these projects may be considered in the proposed licensing process under new legislation (included in the Marine Renewable Energy Strategy, p. 40). Proponents will be required to:

- Demonstrate the project plans present no expected harm to other marine renewable resource opportunities. Evidence must be shown through robust and credible numerical and physical monitoring.

- Demonstrate that there are no expected significant adverse environmental or socioeconomic effects or impacts. Evidence must be shown through a robust independent environmental panel review.

Upon providing positive results and successfully completing these processes, a proponent would be eligible to receive a Power Development License under new Marine Renewable Energy Legislation.

Photo Credit: Greg Trowse

5 ENVIRONMENTAL RISK ASSESSMENT

5 - ENVIRONMENTAL RISK ASSESSMENT

Authors: Lisa Isaacman and Graham Daborn

WHAT DOES THIS MODULE COVER?

The following module is intended to provide guidance for project planners and reviewers in the assessment and mitigation of environmental risk for Tidal Energy Convertors (TEC) development proposals and projects. The guidance is based on "A Framework for Environmental Risk Assessment and Decision-Making for Tidal Energy Development in Canada" developed for the Department of Fisheries and Oceans (DFO) and the Nova Scotia Department of Energy (DOE) by independent scientific experts.

This section outlines the key steps and considerations for identifying, assessing, and addressing the environmental risk of TEC projects based on the best available scientific knowledge, expert advice, and best practices for environmental risk and impact assessment. Through this guidance, project planners and reviewers can also gain insights as to:

- site-appropriate project design and size consideration,
- the type and scale of information that should be included in initial project descriptions or registration documents,
- the level and type of environmental review/assessment a project may require,
- the level and type of baseline studies and monitoring that may be required,
- methods of mitigating or reducing the level of risk of a project, and
- evaluations measures or trigger points for adaptive management actions.

IS THIS MODULE FOR YOU?

This module is for anyone interested in understanding the potential environmental implications of TEC development and what can be done to assess and mitigate the environmental risks of a specific development proposal and project.

5.0 - INTRODUCTION: WHAT ARE THE POTENTIAL IMPLICATIONS OF TEC DEVELOPMENT FOR THE ENVIRONMENT?

TEC projects have the potential to cause dozens of individual and interconnected effects on the environment. An environmental effect is understood as any response or change that a project may cause in an ecological component. The following logic models (Isaacman & Daborn, 2011) were developed for the Department of Fisheries and Oceans (DFO) to illustrate the nature and breadth of the potential environmental effects. This type of model is called a Pathways of Effects (PoE). The models were developed in consultation with scientific experts from across Canada and the US.

The PoE models include the predicted stressors associated with in-stream tidal power technologies and the environmental effects they may have on specific ecological components or receptors. The six key stressors and some of their potential environmental effects are:

1. Changes in current energy: modification of water movement patterns due to energy extraction affecting sediment dynamics (alteration of substrates, sediment erosion, transport, and deposition patterns) and tidal dynamics (alteration of tidal amplitude and current velocity).

2. Effects of artificial structures: change in habitat structure and complexity, attraction or avoidance of marine life, barrier to migration.

3. Physical interactions with infrastructure: physical or physiological injury to marine organisms from passing through TEC devices (e.g. blade strikes, entanglement, pressure flux, stress, or disorientation).

4. Noise, vibration, and light emitted from devices: behavioural changes and physiological responses in marine organisms, including stress, and avoidance of habitat sites and migration corridors.

5. Emitted electro-magnetic fields: device generator and power electronics and sub-marine power cable emissions causing behavioural changes and physiological responses in marine organisms.

6. Release of contaminants: chemical pollution from paints, anti-foulants, and lubricants affecting water chemistry and marine organisms' health.

The probability and magnitude of the potential effects, if any, will vary with the specific nature of the project and the sensitivity of the ecosystem components at any given location. Thus, planners and reviewers should take all these potential interactions into consideration in the planning and implementation of TEC project proposals.

For more information on the potential environmental implications of TEC devices, see:

1. Environmental Effects of Tidal Energy Development. Proceedings of a Scientific Workshop March 22-25, 2010
http://ir.library.oregonstate.edu/xmlui/handle/1957/21617?show=full

2. Pathways of Effects for Offshore Renewable Energy in Canada
http://fern.acadiau.ca/document_archive.html?action=view&id=178.

DEFINITION: PATHWAYS OF EFFECTS

Conceptual representations of predicted relationships between the pressures or stressors created by human activities and the environmental effects they may have on ecosystem components, and in turn, the socio-cultural and economic interests and values (often termed valued ecosystem goods & services) that are linked to and rely upon them.

DEFINITION: ECOSYSTEM COMPONENT

Fundamental elements of the natural environment. Components can include wildlife, physical habitats (sediment, water, vegetation, geology), and ecosystem processes (e.g. biophysical dynamics, interactions).

To improve clarity of the Pathways of Effects (PoE) models, components have been grouped into four broad wildlife-based categories. These categories are intended to encompass physical habitats (sediment, water, vegetation, geology) and ecosystem processes (e.g. biophysical dynamics, interactions).

PLEASE NOTE:

Although they may share some similar characteristics, the design and mode of operation of TEC devices, and the consequent nature of their interaction with the environment, differ substantially from the more well-established hydroelectric and tidal barrage technologies. Due to these differences, TEC devices are expected to have less of an environmental impact.

Figures 5-1, 5-2, and 5-3 illustrate the complexity and interconnectivity of the potential environmental effects of the three main phases of a TEC development:

a) 5-1: Site Investigations;

b) 5-2: Construction, Maintenance, and Decommissioning; and

c) 5-3: Operations.

Photo Credit: Greg Trowse

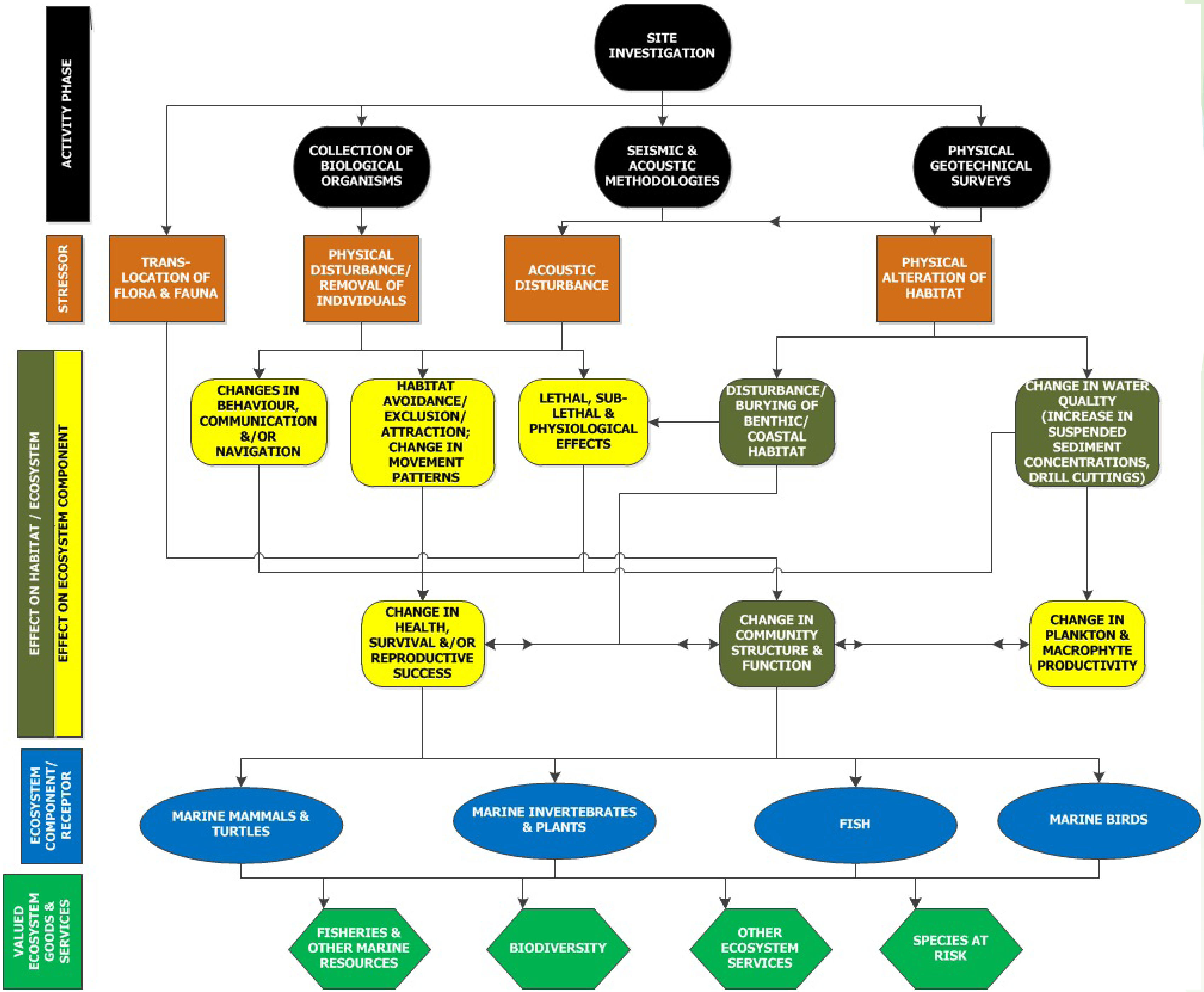


Figure 5-1: Pathways of Effects - Site Investigation

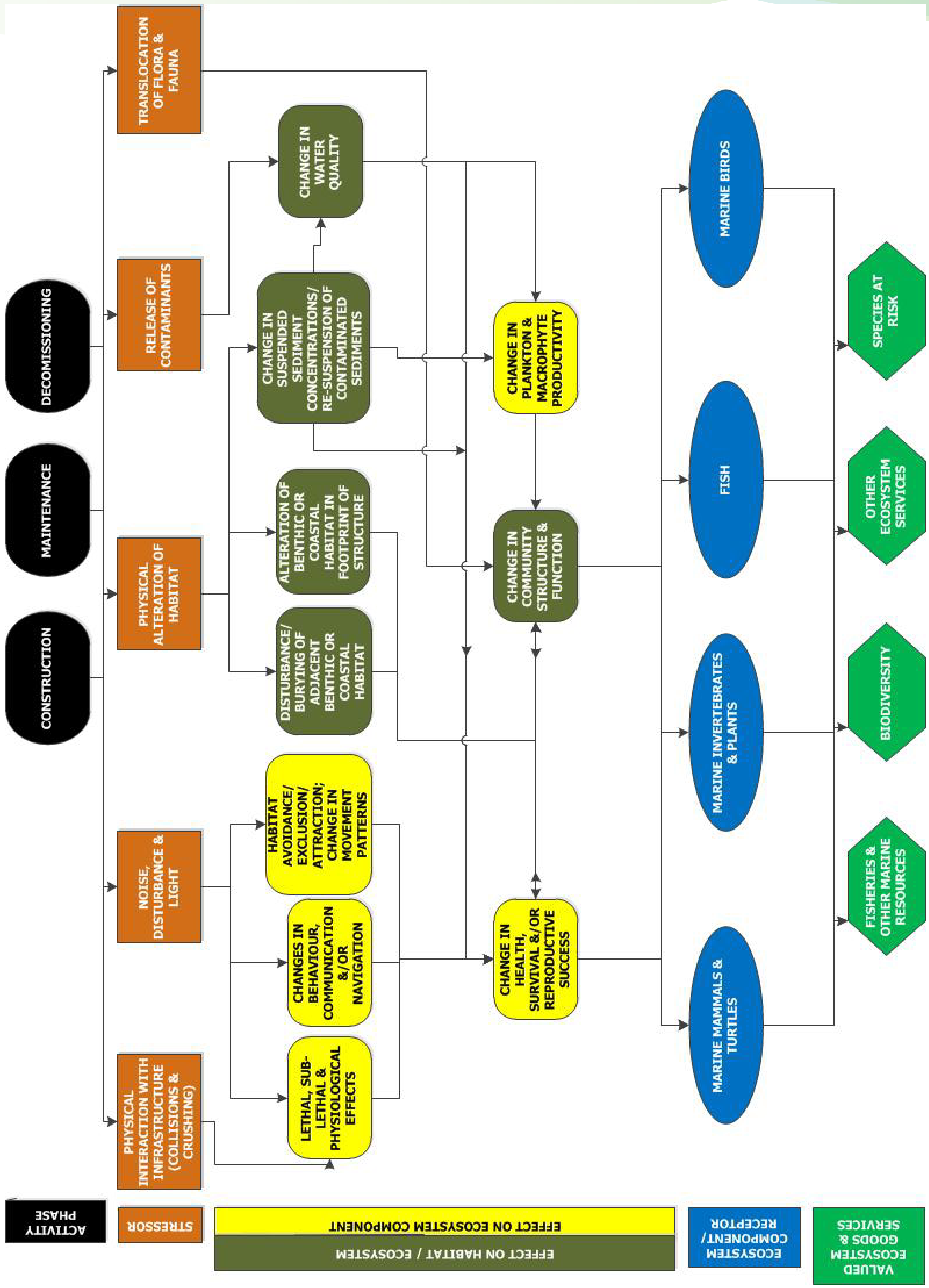


Figure 5-2: Pathways of Effects - Construction, Maintenance, and Decommissioning

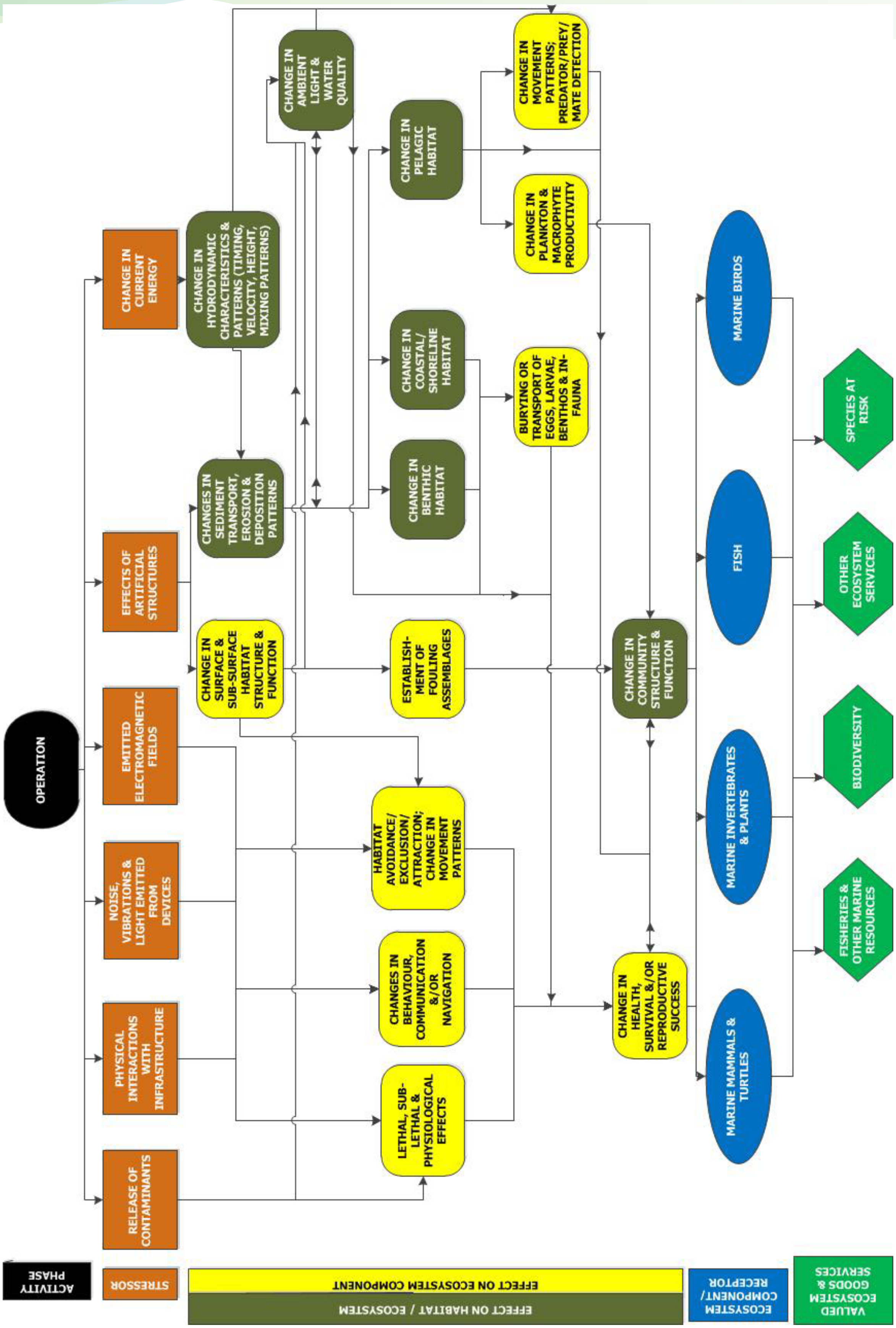


Figure 5-3: Pathways of Effects - Operations

To date, no significant impacts have been reported from any TEC development site in the world. However, monitoring results from only a few demonstration sites in the US and UK are currently available.

PLEASE NOTE:

Most of the uncertainty is associated with the operational aspects of TEC developments, which pose novel and poorly understood effects on the marine environment. The potential effects associated with site investigation and construction activities are largely comparable to those presented by other marine sectors.

5.1 - UNCERTAIN ENVIRONMENTAL RISKS OF TEC DEVELOPMENTS

TEC technologies are diverse and continue to evolve, with most still at the testing phase. As a result, there is currently a high level of uncertainty regarding the potential implications of TEC development on the biophysical environment, largely because:

- Few full-size devices have been deployed in natural environments for prolonged periods of time.
- Environmental effects are likely to be technology, scale, and site-specific.
- The most favoured locations for deployment exhibit challenging physical conditions – consequently, effective physical and biological data collection and effects monitoring are difficult and sometimes limited by the availability of suitable monitoring technology.
- There have been insufficient monitoring results to confirm predictions of environmental assessments.
- Many of the sites with high potential are insufficiently studied for the environmental implications to be assessed with confidence.

Both project planners and reviewers currently lack sufficient knowledge or experience to be able to assert, with an appropriate degree of confidence, whether a project is likely to cause adverse environmental effects. Due to these varied uncertainties, development of the tidal energy sector in Canada should proceed using a precautionary and adaptive management approach.

To date, no significant impacts have been reported from any TEC development site in the world. However, monitoring results from only a few demonstration sites in the US and UK are currently available. These monitoring programs have been short and sporadic, mainly focusing on the near-field potential impacts (in the immediate vicinity of the turbine) of a single device. The challenges of monitoring a high-energy marine environment create the need for new technologies and monitoring techniques to be employed; many of the new methods applied in studies thus far have yet to be verified as effective and accurate. While these monitoring programs provide insight into potential monitoring methodologies and help identify ecosystem components that may require particular attention, the results should not be used to draw conclusions about the general risks, nature, or magnitude of environmental impacts of TEC.

Findings of environmental monitoring programs are freely available for:

Marine Current Turbine's SeaGen Demonstration Project in Strangford Lough, Ireland (Royal Haskonings 2012).
http://seageneration.co.uk/files/SeaGen-Environmental-Monitoring-Programme-Final-Report.pdf

Verdant Powers Roosevelt Island Tidal Energy (RITE) Project in Eastport River, New York (Verdant Power 2011)
http://www.nyserda.ny.gov/Publications/Research-and-Development-Technical-Reports/Environmental-Reports/EMEP-Publications/EMEP-Final-Reports.aspx

5.1.1 - PRINCIPLES FOR OVERCOMING UNCERTAINTY

To deal with this uncertainty, the following are guiding principles for the effective and objective review of environmental risk of a TEC project. These principles include:

1. adequate consideration of ecosystem-scale and cumulative effects (see below);

2. a precautionary and adaptive management approach (see below);

3. the need for appropriate and early initiation of baseline studies;

4. the need for risk evaluation criteria and indicators that are relevant and flexible, and that can be consistently applied to projects of any type, size, or location (see below);

5. consideration of other human uses of the ecosystem (see below); and

6. early and on-going First Nations engagement (for more detail see Modules 4 and 6).

Environmental information relevant to assessing the risks associated with in-stream tidal energy developments takes a long period of time to acquire; therefore, early initiation of benchmark studies is crucial.

A basic prerequisite to making scientifically sound and well-informed decisions is the availability of information of sufficient detail and quality on the nature of the project proposal and the physical and biological environment at the site. Therefore, all project proposals **must start with a detailed project description and benchmark site assessment / characterization.** Given it is not practical to measure and monitor every parameter; the challenge is identifying the appropriate parameters to assess operation-induced change. The scope of the baseline survey requirements should be aligned with the anticipated scale of the project and its associated effects. The criterion and indicators identified below can provide a guide to potential priority parameters and benchmark surveys. Environmental information relevant to assessing the risks associated with in-stream tidal energy developments takes a long period of time to acquire; therefore, early initiation of benchmark studies is crucial.

It is well known that coastal ecosystems undergo significant changes over time, some cyclical (e.g. seasonal, annual, or multi-year) and others progressive (e.g. continuing system changes associated with sea level rise, shoreline erosion, subsidence, or human modifications such as causeways). In the face of this variability and changing environments, identifying and quantifying the effects of marine energy extraction or the direct effects of the devices on organisms is extremely difficult.

Given these circumstances, the *precautionary approach* needs to be applied to protect the environment against significant and/or irreversible damage. This approach entails a risk assessment and decision-making process that errs on the side of caution in situations where there is a lack of full scientific certainty. Notwithstanding recognition and adoption of the precautionary approach, inability to provide a complete assessment of the project and its environmental effects in the preliminary review or assessment of the proposal would not necessarily preclude the possibility of the project moving forward. Resolving gaps in scientific knowledge will require practical real-world experience, which cannot be achieved without putting devices in the water at various scales and locations.

Adaptive management is the preferred approach to dealing with projects where there is insufficient experience with the technologies, a lack of knowledge about the ecosystem for which the development is proposed, or both. In fact, the novelty and continued need for refinement of the technology makes in-stream tidal energy development an ideal candidate for a staged and adaptive development approach. Most large scale tidal developments will consist of arrays of devices that could be installed over time with some units coming on stream long before the full development is completed. The ultimate scale of a permitted project may be determined over time based on monitoring and interpretation of the results, conducted as follow-up to confirm the predictions of the environmental assessments. As projects expand to full commercial scale potential, there will be a need for continuing reassessment of the implications of the development.

DEFINITION: PRECAUTIONARY APPROACH (ALSO KNOWN AS THE PRECAUTIONARY PRINCIPLE)

This term can be defined generally as 'where there is a lack of full scientific certainty, decisions or actions should err on the conservative or cautious side (i.e., assume that an effect is more rather than less adverse)'. Please note there are many similar, but differing definitions and interpretations of this term.

The precautionary approach is a standard guiding principle in Canadian environmental policy, although its application varies among departments and jurisdictions. The 1999 Canadian Environmental Protection Act (CEPA 1999) defines the precautionary principle in slightly narrower terms as "… where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The principle is also enshrined, in general terms, in the 2012 The Canadian Environmental Assessment Act and in Fisheries and Oceans Canada operational policies.

DEFINITION: ADAPTIVE MANAGEMENT

A planned and systematic process for continually improving environmental management practices by learning about their outcomes. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project. Adaptive management requires continual oversight and environmental monitoring and the ability to make modifications to projects as new information is acquired. An adaptive management plan should be a requirement for project approvals, with procedures that enable rapid responses when and where an effect is detected.

ADAPTIVE MANAGEMENT IN PRACTICE

Author: Monica Reed

Adaptive management measures are often part of the Environmental Assessment (EA) process in Canada. Although the 2012 Canadian Environmental Assessment Act does not contain specific requirements that pertain to adaptive management practices, follow-up programs often incorporate adaptive management measures. Depending on the nature of the project, either the review panel or the responsible authority determines if a follow-up program is mandatory for a project. Adaptive management is implemented in follow-up programs in order to provide flexibility to identify and implement new mitigation measures or to modify existing ones in light of real-world experience. Given the continually changing environmental conditions and scientific uncertainties associated with in-stream tidal energy development, developers require the ability to modify monitoring studies and mitigation methods as experience is gained. In the US, Ocean Renewables Power Company (ORPC) in Maine has developed an adaptive management plan for their Cobscook Bay Tidal Power Project, as required by their U.S. Federal Energy Regulatory Commission (FERC) pilot project license. An Adaptive Management Team has been created to implement the adaptive management plan, which has been defined as "A collaborative, consultative process among ORPC management, state and federal agencies, and stakeholders that monitors and reviews the results of policies, project actions and environmental data, and integrates this new learning into policy and management actions, adapting as necessary"(ORPC, 2012).

Cumulative effects represent another element that requires adaptive and continual reassessment. Follow-up must recognize that small, possibly incremental changes to critical ecosystem processes may not be evident for a long time after completion of the array, although such changes may well affect critical aspects of the environment (e.g. habitat) or progressively interact with other established resource uses. These additional elements of uncertainty require that any established commercial-scale development be reassessed at intervals of time over the life of the project.

DEFINITION: CUMULATIVE EFFECTS

Additive or multiplicatory effects of a project or activity on the environment when the effects are combined with other past, present, or future human activities. These activities may be taking place within the same ecosystem or affecting the same ecosystem component (e.g. migratory species) that may move between ecosystems and be subjected to more than one development.

5.2 - STEPS TO PLANNING FOR AND ASSESSING THE ENVIRONMENTAL RISKS OF A PROPOSED PROJECT

Project planners and reviewers should follow the steps provided below (Figure 5-4: Framework to Reduce Risk):

1. Define the scope of the review.

2. Evaluate the project site characteristics.

3. Evaluate the environmental risk of the project proposal based on a set of standard defined criteria and indicators.

4. Identify risks of interference with other human uses of the ecosystem (e.g. fisheries, recreation).

5. Categorize the overall risk of the proposed project and make a management decision.

6. Propose supplementary mitigation measures to reduce the overall risk of the project, when applicable.

7. Prepare the environmental monitoring and follow-up activities, and an adaptive management program for an approved project.

In the Framework to Reduce Risk (Figure 5-4), socio-economic assessment /stakeholder consultations are shown as a step in the framework. The dashed line indicates that this process is not a strict requirement of environmental assessment and is often external to the environmental assessment process. It is included because it is recognized as an important component of the assessment process; however, the focus of this framework is on environmental assessment.

Photo Credit: Greg Trowse

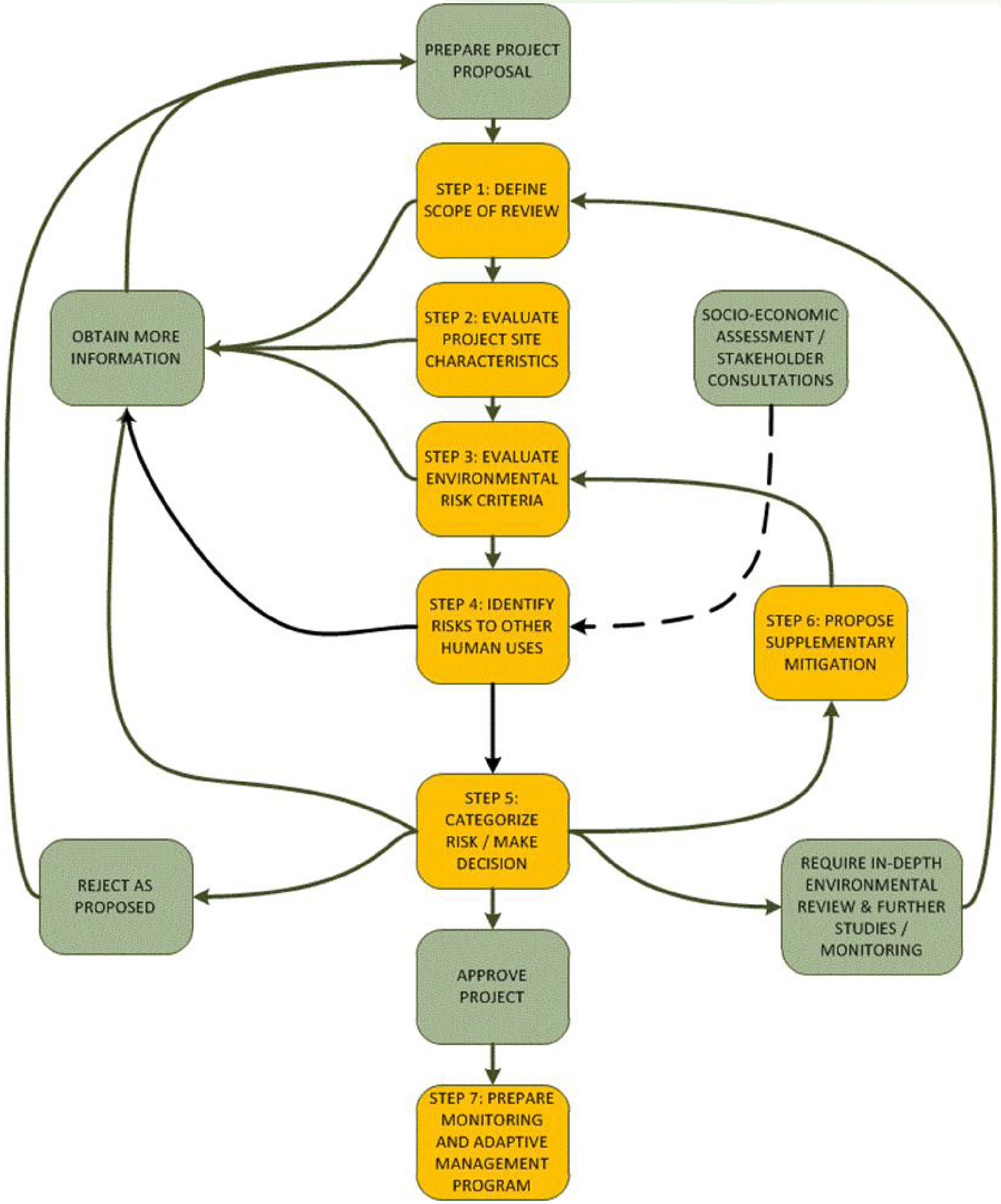


Figure 5-4: Framework to Reduce Risk (Isaacman, Daborn & Redden, 2012)

DEFINITIONS: MARINE LIFE

Planktonic organism - any organisms that live in the water column and are incapable of swimming against a current.

Benthic – refers to the bottom of a body of water (i.e. seabed) and to the organisms living in or on it.

Pelagic – refers to the zone above the seafloor, including the water column up to the surface.

Developers have a stewardship responsibility to ensure their projects do not cause a significant adverse change to the environment.

5.2.1 STEP 1: DEFINE THE SCOPE OF THE REVIEW

5.2.1.1 - WHAT ACTIVITIES SHOULD BE COVERED?

It is important to plan for and mitigate environmental risks occurring throughout the life of the project from initial site investigation (baseline studies) to construction to operations to decommissioning. The environmental risks associated with site investigation, construction, maintenance, and decommissioning activities, as well as the potential releases of chemical contaminants (e.g. anti-foulants, lubricants), should be consistent with those typical of most marine in-water activities. Both the risk and mitigation options are fairly well understood by those experienced with marine development. By following the generally-accepted guidelines and best practices for these types of in-water activities, the environmental effects from these activities should be adequately mitigated and do not require further review.

However, the risks related to the presence and operation of a TEC development are novel and poorly understood and cannot be adequately addressed using current procedures and best practices. Thus, a review of these risks is necessary prior to the approval and implementation of any project.

5.2.1.2 - WHAT PROJECTS SHOULD BE REVIEWED?

Scientists and regulators have generally considered small-scale, short-term deployments (e.g. single device prototype or pilot trials) to present a fairly low environmental risk that could be addressed by application of standard mitigation measures, especially given the option to cease operations if a problem becomes detectable. However, at least until more knowledge and experience are gained on the interactions of moderate- to large-scale devices or multi-device arrays with the environment, any demonstration or commercial scale deployments should undergo, at minimum, a preliminary review and risk assessment, following the framework prescribed below.

5.2.1.3 - FOLLOW AN ECOSYSTEM APPROACH

Developers have a stewardship responsibility to ensure their projects do not cause a significant adverse change to the environment. This includes both direct effects on a population, species, and habitat and broader-scale effects on dynamic ecological functions and processes that are critical to the ecosystem's role in a larger coastal context.

While a thorough examination of every ecosystem component may not be practical or warranted, a proper risk assessment must recognize the complexity of the interconnections among and between species and the physical environments. Following an ecosystem approach, the review should cover the following:

- fish;
- marine mammals;
- marine plants and invertebrates, including shellfish, crustaceans, and planktonic organisms;
- marine birds; and
- the biophysical habitats and ecosystem processes upon which the species depend.

All life stages (e.g. eggs, larvae, juvenile, and adult stages), as well as populations, should be considered. Habitat is defined broadly as the benthic, pelagic, shoreline and/or surface areas, and the physical, chemical, and biological conditions, on which individual species depend, directly or indirectly, including the following:

- spawning, nursery, rearing, or food supply areas;
- migratory routes;
- refuges from predation (e.g. seaweed beds, marshes, etc.); and
- biological community and food-web structure and interactions.

5.2.1.4 - SPATIAL SCOPE

A key aspect of the environmental review of a tidal project is defining the geographic scope of the affected area. Due to the nature of in-stream tidal energy, the scope of the affected area may extend well beyond the area of direct physical occupation of infrastructure such as, direct and indirect effects on flow characteristics and marine life. Therefore, it is important to consider both localized (near-field) and system-wide (far-field) effects (Table 5-1). While information may be insufficient to accurately define the entire extent of affected area, a conservative and scientifically justifiable approximation must be considered when assessing each of the criteria.

While a thorough examination of every ecosystem component may not be practical or warranted, a proper risk assessment must recognize the complexity of the interconnections among and between species and the physical environments.

DISCUSSION: CONSIDERING THE WHOLE ECOSYSTEM.

Please note that while federal and provincial regulators may be primarily concerned with certain species or habitats of social or economic importance (such as commercially valuable fish species, marine mammals, or species at risk), legislated review and permitting processes (e.g. under the Fisheries Act, Canadian Environmental Assessment Act, and provincial environmental assessment acts) recognize the need to consider the effects on the whole biological community, as well as the physical habitats on which they depend.

Table 5-1: Examples of Near Field and System-wide Environmental Effects

EXAMPLES OF NEAR FIELD AND SYSTEM-WIDE ENVIRONMENTAL EFFECTS		
RISKS	POTENTIAL NEAR FIELD EFFECTS	POTENTIAL SYSTEM-WIDE EFFECTS
Effect on Water Movement and Sediment Dynamics	Change in hydrodynamic characteristics and patterns in close proximity to TEC device altering local sediment dynamics (scour, sediment deposition, and erosion).	Change in regional and/or coastal/shoreline habitat due to alteration of sediment dynamics (transport, erosion, and deposition pattern) and tidal processes (timing, height, mixing patterns, current velocity).
Extent of Habitat Alteration Due to the Presence of Physical Infrastructure	Change in benthic habitat composition and complexity due to scour and presence of device base and submarine cables.	Change in biological community structure and function with trickle down ecosystem effects.
Physical Obstacle to Marine Organisms	Physical interaction with device or stress induced by pressure flux causing injury or death of marine organisms.	Impact on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function.
Noise, Vibrations, and Turbulence Effects on Marine Organisms Due to Turbine Operation	Alteration of marine organism behaviour (e.g. habitat avoidance, change in movement patterns, decreased mate and prey detection).	Impact on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function.
Effects of Other Signals Emitted by Project Infrastructure	Electromagnetic field and artificial light resulting in stress, physiological damage, and behavioural changes (avoidance/attraction, communication, movement patterns).	Impact on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function.

5.2.1.5 - CUMULATIVE EFFECTS

It is highly probable that successful deployment of devices will stimulate further tidal developments within the same tidal energy resource area. Cumulative effects have always been difficult to forecast. Most oceanographic relationships are non-linear, so that modification of one parameter (e.g. current velocity) may result in a magnified change in related parameters (e.g. turbulence, water column mixing, etc.), producing system-wide changes that may seem out of proportion to the original disturbance.

All proposals should be evaluated in the context of other established or projected human activities in the affected area. For example, while a given turbine or array may be expected to result in only a minor reduction in tidal energy or affect only a small fraction of habitat in the system, many activities (tidal or other) acting in concert (cumulatively or synergistically) may result in major changes to the tidal ecosystem.

Specifically, consideration of cumulative effects should include the following:

- regional system-wide effects (i.e. other than just local, direct effects);
- effects during a longer period of time into the past and future; and
- effects on ecosystem components due to interactions with other past, existing, and future (e.g., reasonably foreseeable) activities, and not just the effects of the single project under review.

For more guidance on this topic, see Cumulative Effects Assessment Practitioners Guide. http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=43952694-1

5.2.1.6 - TIMESCALE

Effects may change, intensify, or only become detectable over a period of time. Thus, effects should be assessed over the entire predicted life of the project.

5.2.1.7 - STAGED DEVELOPMENTS

Although proposals for single or small-scale devices or demonstration projects may not exhibit a high risk or trigger environmental assessment requirements, proponents and regulators should keep in mind any intentions for expansion (scaling-up) of the project, as larger, longer-term projects will present different environmental risks in a given area. By considering projected scale-ups in the review of early phase proposals, regulators and proponents can be better prepared to address potential future environmental concerns, including preparation of adaptive management strategies and initiation of data collection and monitoring programs. This consideration would permit a streamlined and progressive environmental assessment process in the event that an expansion is pursued.

5.2.2 - STEP 2: EVALUATING THE PROJECT SITE CHARACTERISTICS

5.2.2.1 - SITE SCALE RELATIONSHIPS

Assessing the implications of TEC developments requires recognition of the important interrelationship between the scale of the development and the size and characteristics of the site itself. TEC developments require high flow locations. Strong current flows, sufficient for renewable energy extraction, are found in three different situations: through the narrow entrance of a coastal basin, through multiple passages between landforms, and in certain coastal areas offshore (Figure 5-5).

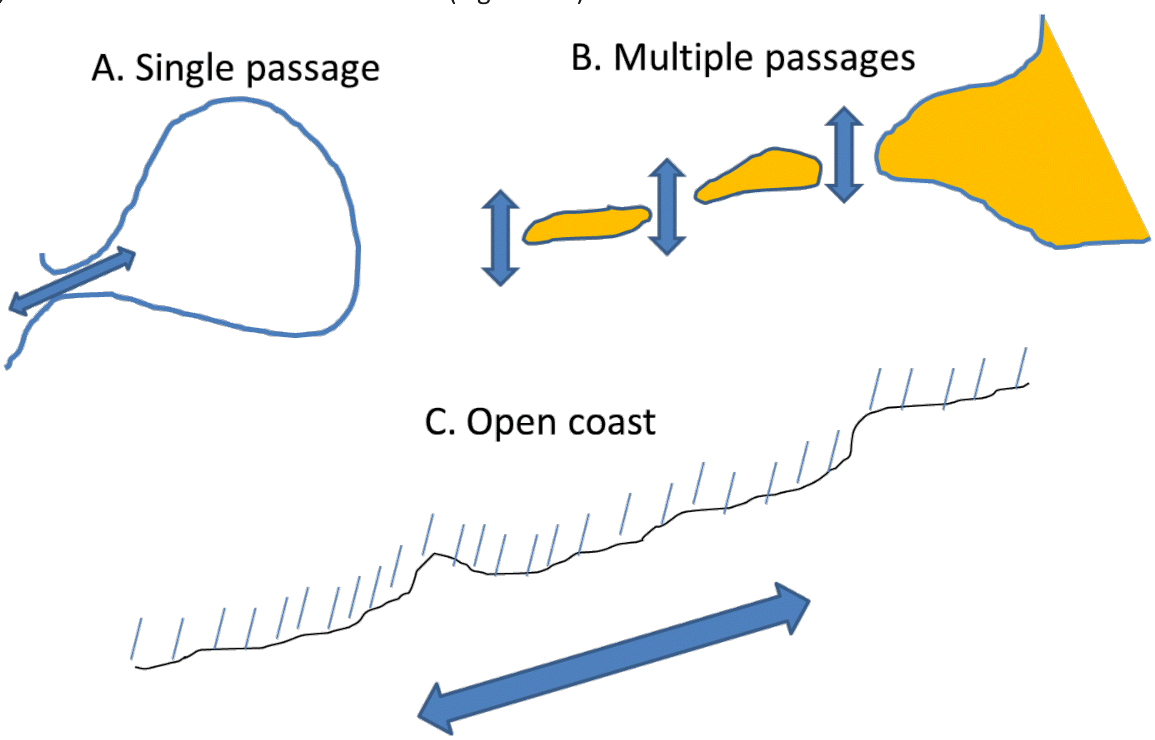


Figure 5-5: Types of Tidal Energy Sites

The environmental effects of energy extraction in these three situations differ significantly, as discussed below.

A. SINGLE NARROW PASSAGE

The confined entrance to a basin or bay represents the only passage through which water and migrating animals can pass. TEC devices will resist and divert flow into and out of the basin, resulting in increasing elevation differences (and hence faster flows up to a point – cf. Garrett & Cummins, 2008) on either side of the passage, until increasing friction begins to limit flows and therefore, decrease kinetic energy. As the scale of development increases relative to the width (scale) of the passage, a TEC array would begin to act more like a barrier, affecting the tidal resonance and hence, the amplitude as well as the phase of the tide. In general, a basin entrance location is more likely to produce system-scale effects than either inter-island or coastal locations. The problems for organisms are varied: decreasing water velocity behind the array would be expected to affect sediment erosion and deposition, and hence, benthic habitat and biota in the bay; migrating fish have no alternative but to pass through the passage, and as the scale of the development increases, this will represent an increasing risk of encountering the devices; and noise and turbulence in the passage will change, with consequent effects on animal communication, prey/predator detection, etc.

B. MULTIPLE PASSAGES BETWEEN LANDFORMS

Canada's three ocean coasts exhibit numerous sites with multiple high flow passages between islands and other landforms. Because there are alternate pathways that the water can follow, the restrictive effects of TEC devices will be different: increasing resistance to flow will mean that more water will pass through other open passages. Similarly, tidal amplitudes, flow velocity, and resonance relationships are likely to be less affected than in a single narrow passage site. Whether any alternate passages can be used by migrating animals will depend upon local circumstances (e.g. water depth, current velocities, etc.) and perhaps also on stock genetic characteristics that might determine migratory route.

C. OPEN COAST

By comparison, open coast sites with high current speeds exhibit few of the above interrelationships. Increasing array size will have much less effect on flow dynamics or tidal characteristics, and animal movements will be far less restricted. For the biota, the localized effects (e.g. entrainment, benthic and pelagic habitat characteristics, noise and turbulence, etc.) are likely to be of greatest importance.

5.2.2.2 - PRESENCE OF SPECIES AND/OR HABITATS OF HIGH CONSERVATION CONCERN

Projects proposed to take place in an area containing one or more ecosystem components (species or habitats) of high conservation concern (HCC) should automatically be flagged as potentially high risk.

HCCs are more susceptible to being significantly and adversely affected by added stressors and less capable of recovery (low reversibility). Thus, there would be higher consequences to assuming risks from the project. For a project to be approved or permitted to continue, adequate mitigation measures must be put in place to ensure no adverse impacts to HCC.

DEFINITION: HIGH CONSERVATION CONCERN (HCC)

A habitat or species of HCC are ecosystem components that are considered to be of ecological, economic, or cultural concern or are sensitive to disturbance. Valued Ecosystem Components is the more commonly used term in environmental assessment to signify this type of habitat or species.

Table 5-2: Species and Habitats of High Conservation Concern

SPECIES AND HABITATS OF HIGH CONSERVATION CONCERN		
HCC		**EXPLANATION**
Species - resident or seasonal	Federally or provincially listed Species at Risk, their residence and/or critical habitat.	Species at Risk are protected under federal and/or provincial Species at Risk legislation. Given they are already vulnerable and at low numbers, the loss or disturbance of even one or small number of individuals can be significant and thus pose unacceptable consequences to the survival of the species. Many Species at Risk require specific habitat conditions; such species will be more sensitive to changes caused by TEC developments and thus risks may be higher.
	Non-listed species that are at risk or regionally rare	Although not listed under legislation, many species have been identified as at risk or rare through various national or international scientific assessment bodies like Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or International Union for Conservation of Nature (IUCN). Given they are already vulnerable and at low numbers, the loss or disturbance of even one or a small number of individuals can be significant and thus pose an unacceptable consequence to the survival of the species. Many species at risk require specific habitat conditions; such species will be more sensitive to changes caused by TEC developments and thus risks may be higher.
	Species harvested in commercial, recreational, or aboriginal fisheries	Harvested species may be less able to tolerate the added stressors from tidal developments. Moreover, changes caused by tidal developments may affect the productivity and sustainability of fisheries and thus will be under a higher level of public scrutiny. It should also be noted that commercially important species may be harvested in regions well away from the spawning or rearing habitat where the tidal developments may occur.
	Marine mammals, sea turtles, and other species of high public concern	Whether or not considered at risk, many species may be highly valued by the public and the loss or disturbance of even one individual may be deemed unacceptable. Where these species are present, a proposed project will be under greater public scrutiny.
	Migratory species (especially those that cross international boundaries)	Species that migrate between habitats may be subject to additional stresses. There may also be legal implications if a species crosses an international boundary between feeding and spawning habitats.
	Species known to be highly sensitive to disturbance.	Some species have limited tolerance to changes in environmental parameters (e.g. temperature, turbidity, etc.); such species will be more sensitive to changes caused by TEC developments and thus risks may be higher.
Habitat	Habitat of listed or unlisted, at risk or rare species	Areas designated as residences or critical habitats for species at risk are protected under provincial or federal legislation. Whether legally designated or not, risks to the essential habitat of an at-risk or rare species need to be minimized to ensure the survival of the species. Rare or uncommon habitats are often important to rare or uncommon species, and therefore, are of concern for conservation of biodiversity.
	Ecologically significant or rare ecosystems	Some areas may be regionally, nationally, or internationally recognized and thus any activities in those areas would be under high public scrutiny (e.g. marine protected areas). By definition, ecologically significant areas have a high ecological value, in terms of providing valuable ecological services, supporting high levels of biodiversity, or containing unique or rare features or species. They are often also more sensitive to perturbation. Even a small loss or disturbance of an ecologically significant or rare ecosystem can have significant consequences.
	Regionally uncommon habitat that is essential for one or more species	Even where the habitat is not considered rare, it may be regionally uncommon. Local populations that depend on these habitat conditions may be harmed if they do not have access to other areas of similar habitat in the region.
	Habitats highly sensitive to perturbation	Habitats characterized by soft or loose sediments are more prone to sedimentation and erosion as a result of changes to current flows, turbulence, or water column mixing, with consequent effects on the biota. Moreover, some habitats are sensitive to changes in tidal range, such as seagrass, macro-algae (seaweed) and salt marshes, which may be present in lower flow environments within the system-scale affected area.

5.2.3 - STEP 3: EVALUATING THE ENVIRONMENTAL RISK

Planning and regulatory decision-making (e.g. approval or rejection, degree of environmental assessment) is made easier when the indicator(s) or thresholds of risk can be expressed in quantitative terms. For example, the current regulatory thresholds for tidal energy projects for deciding whether a given proposal requires a limited or full environmental assessment are based on total energy production capacity (5MW for a Comprehensive Study under the CEAA and 2MW for Class 1 environmental assessment in Nova Scotia). However, these values are essentially arbitrary and do not necessarily reflect the potential that the project may cause significant adverse damage to the environment. For example, thresholds based on energy production, or size of the project, are what are typically used for other types of energy projects. However, these criteria considered in isolation from the physical and biological characteristics of the proposed site are inadequate, by themselves, to reflect the environmental risk or impact of a project. For example, the impact of a 2MW array in an open high energy site, without sensitive habitats or species, may be low, whereas the same 2MW array may have a significant impact in a semi-enclosed or lower energy site or area with sensitive species or habitats.

Because of the rapid development of this field, the highly variable nature of the environment and technologies, the limited knowledge of ecosystems, and the complex scale relationships (e.g. device/array scale vs. site scale), it may not be scientifically justifiable to select any one meaningful and durable universally applicable threshold for decision-making.

5.2.4 - MULTI-CRITERIA APPROACH

To overcome the above mentioned challenges, an approach based on multiple qualitative and numerical science-based evaluation criteria and indicators of risk, which are adjustable to particular project designs and sites, is recommended.

The following section offers a set of science-based criteria and indicators that:

- are relevant, flexible, and can be consistently applied to projects of any type, size, or location;
- address directly or indirectly the major environmental concerns related to the operation of in-stream tidal devices;
- relate to specific and characterizable attributes of a development project and the environment; and
- are based on best available scientific knowledge.

In cases of uncertainty, the risk evaluator should err on the side of precaution, and either request more information from the proponent or rate the criterion as higher risk.

While it may not be possible to make a thorough and individualized risk evaluation for each species or habitat (due to lack of resources or knowledge), a generalized assessment needs to be made based on the best available information on the types of species and habitats present. Given the higher concern and risk, it may be reasonable to focus the review on HCC species and habitats. Risk levels associated with each indicator should be based on the attributes of the forecast effect listed in Table 5-3.

PLEASE NOTE:

Whether or not HCC components are likely in the affected area, risks to ecosystems and marine organisms are present and potentially significant. Even where HCC components are present, a project may not be considered a high risk if none of the criteria fall outside acceptable parameters. Conversely, a project in which a criterion has been flagged could be considered a high risk even if no HCC components are present.

Table 5-3: Attributes of the Forecast Effect upon which to Assess Indicators

ATTRIBUTES OF THE FORECAST EFFECT UPON WHICH TO ASSESS INDICATORS	
CHARACTERISTICS	**NATURE OF THE FORECAST EFFECT**
Probability	What is the likelihood of the stressor or effect occurring?
Detectability	1. Magnitude of the anticipated impact. Is the effect forecast to be within detectable levels? 2. Measurability. Is it directly or indirectly measurable using currently available tools?
Spatial extent (near and/ or system-scale)	Variability in effects throughout the entire affected area should be recognized.
Significance	To the species, population, habitat, or ecosystem (e.g. how sensitive is the receptor to changes, are the consequences ecologically acceptable?).
Duration	Most operational effects should be considered long-term (for the duration of the project) or permanent.
Reversibility	This is the ability of the ecosystem component to recover (return to approximate pre-development conditions) once the stressor is removed. It is not a measure of whether the stressor itself can be removed. Some effects may be reversible if detected and appropriate actions (e.g. mitigation, cessation of operations, and removal of structures) are taken in a timely manner. Others may be irreversible, such as destruction or harm to rare or at risk species or habitats. Even where direct effects are reversible once a stressor is removed (e.g. the effect on hydrodynamic and sediment processes and patterns due to removal of tidal energy), it may not be possible for habitats, populations, or community structure to recover from long-term changes (i.e. to return to previous conditions).

Photo Credit: Greg Trowse

5.2.4.1 - CRITERION 1: EXTENT OF HABITAT ALTERATION DUE TO THE PRESENCE OF PHYSICAL INFRASTRUCTURE

This criterion addresses the physical effects of infrastructure on the habitat within the 'localized' area of the project. This includes the physical space of benthic, pelagic, and coastal habitat occupied, or directly affected by, the physical infrastructure, including cables and inter-structure gaps.

Table 5-4: Criterion 1 - Extent of Habitat Alteration Due to the Presence of Physical Infrastructure

CRITERION 1 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Physical presence of infrastructure on Benthic (seabed) habitat	**Alteration could include:** • Physical loss of habitat of a particular type (e.g. covering, clearing, smothering, or flattening); • Change in the composition (e.g. hard versus soft-sediments) and complexity of the habitat. This may result in a change in the biological community, especially in areas with soft-sediments, vegetation, and/or homogeneous habitats; and • Potential for erosion and/or sedimentation. Are structures placed on soft or loose sediments vulnerable to erosion / scour around the bases of structures? Are any mitigation measures in place to address this issue? Is it possible to forecast the fate of sediments mobilized by the infrastructure? Will scouring be continuous or progressive during the existence of the project?
Physical presence in the water column	**The structure may:** • Create an obstacle for some organisms; • Serve as an artificial reef or aggregation device for some organisms; • Provide surfaces for macro-algae (seaweed) and invertebrate colonization, especially where sheltered from strong currents (These may include alien species); and • Cause wake / turbulence effects.
Physical presence on the surface	**Some technologies may have components at the water surface. The increase in structure may:** • Create an obstacle for some marine mammals or seabirds; • Act as an aggregating device or provide haul-out or roosting surfaces; • Provide surfaces for macro-algae and invertebrate colonization; and • Affect light levels penetrating through water column.

5.2.4.2 - CRITERION 2: EFFECT ON WATER MOVEMENT AND SEDIMENT DYNAMICS

Table 5-5: Criterion 2 – Effect on Water Movement and Sediment Dynamics

CRITERION 2 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Amount of kinetic energy expected to be extracted by the project compared to the total available kinetic energy in the system (percentage).	The intent is to compare the amount of energy being removed from the system with that required to maintain natural processes and patterns. The higher the percentage, the greater the likelihood to cause noticeable changes to localized, and/or system-scale water and sediment dynamics.
Physical configuration of the site in which the development is to be located (site-scale relationship).	The project might be placed in a single narrow passage (entrance to a basin), a multi-passage system, or open coast environment. (See 5.2.2.1 Site Scale Relationships). Each type of site may experience different localized and regional system-scale changes due to resonance effects, turbulence, and proximity to coastlines. The size and configuration of the development needs to be scaled to the type of site.
System characterized by seasonal or spatial fluctuations in natural flow patterns that may be affected by a regulation or disruption of current flow.	The intent is to identify the degree of dependence of ecosystem processes and species on seasonal and spatial fluctuations and variability. This acts as a qualitative measure of the significance of forecasted change in tidal energy and associated processes.
Other TEC developments, in operation or planned, in the system (cumulative effects).	The proposed reduction in tidal energy of the present proposal should be considered in combination with that of the other developments to address the potential for cumulative or synergistic effects.

5.2.4.3 - CRITERION 3: TIMING OF SHORT-TERM PROJECTS

This criterion seeks to account for changes to time and season sensitive habitats and species.

Table 5-6: Criterion 3 -Timing of Short Term Projects

CRITERION 3 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Timing of project activities in relation to known spawning, nursery, migratory, or other critical time periods.	Where projects will be in place for less than one year, the intent is to ensure that the potential risks from short-term deployments (e.g. demonstrations or trials) are not discounted due to their temporary nature. While the stressor may be temporary, long-term and population-scale effects may be possible.

5.2.4.4 - CRITERION 4: PHYSICAL OBSTACLE TO MARINE ORGANISMS

This criterion is intended to serve as a measure of:

A. the potential of injury or mortality to organisms from collisions with (e.g. blade strikes or encounters with cables) or passing through (e.g. entrainment in downstream turbulence or pressure effects) project infrastructure; and

B. the potential of the project to impede natural movement or migration patterns, either through (A) or active avoidance.

Table 5-7: Criterion 4 –Physical Obstacle to Marine Organisms

CRITERION 4 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Capability of marine organisms to Detect and actively avoid the array	This is intended as a measure of the risk of injury from physical interaction with project infrastructure that is applicable regardless of the characteristics of the specific type of device or array. This measure is based on the assumption that passing through the site occupied by the turbine (localized) increases the risk of physical or physiological injury. Signals produced by the devices, including visual, noise, vibrations, electromagnetic field, and turbulence may enhance their detectability by marine organisms and thus reduce the potential for physical encounters. This is only the case for organisms able to take evasive actions and/or take another route. Some organisms may be stronger or more agile, able to overcome currents and swim around multiple obstacles, while weaker swimmers or non-motile organisms (that travel with the currents) may be unable to avoid entrainment or navigate through complex obstacles. Given that the ability of many species and life stages to detect and avoid these devices is poorly understood, this indicator, should at minimum, be based on the general understanding of swimming ability and behaviours, where known. Please note, the signals emitted by the device(s) may be far-reaching and thus affect the movements and behaviours of organisms well beyond the localized area. Moreover, these signals may have negative consequences for organisms unable to avoid the affected area (see Criterion 5 and 6).
Proportion of the specific pathway occupied by the project	This is a measure of whether the project presents a total or partial obstacle to the use of the particular route in which the project is located. Given the above, will the species be able to follow their natural migration route / movement pathway without having to pass through the array (i.e. is there available and suitable space to go around it)? Both the horizontal (e.g. width of the channel) and vertical range (depth in the water column) must be considered.

CRITERION 4 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Presence and suitability of other natural pathways available to the population to move between habitats	This is a measure of how important the specific pathway in which the project is to be located is to the population and the ability / probability of individuals and/or the entire population to take an alternate route. An example may be where the project is placed in one of multiple channels in the system (see 5.2.2.1. Site Scale Relationship). However, in this case, it should not be assumed that all the channels may serve as suitable routes. Some considerations include: • The frequency of use of the route and its alternatives by each population. o Is the project placed in the primary or a less frequented route? • Are individuals strongly predisposed (e.g. genetically or behaviourally) to prefer one route over another or are they equally likely to take more than one route? • Capability of marine organisms to actively avoid the array (see above). • Are the alternate routes capable of supporting a higher level of traffic and/or could there be a cost to concentrating movement through fewer routes (e.g. increased competition, risk of predation)?
Presence of other developments in the area that may also present an obstacle to movement of marine organisms (cumulative effects)	Either within the particular pathway or within alternative routes.

5.2.4.5 - CRITERION 5: NOISE, VIBRATIONS, AND TURBULENCE EFFECTS ON MARINE ORGANISMS DUE TO TURBINE OPERATION

The intent of this criterion is to serve as a measure of the likelihood that noise, vibrations, and/or turbulence produced by the operation of tidal turbines will adversely affect the behaviour or physiology of marine organisms.

Responses to noise and vibrations could include the following:

- avoidance of affected areas (may exclude a species from habitat or be a barrier to movement);
- interference with navigation or orientation mechanisms/cues;
- increased stress;
- interference with communication, and mate and prey detection; and
- physical or physiological damage to auditory systems.

PLEASE NOTE:

While the intensity may be highest in the immediate vicinity of devices, noise and other disturbances emitted by devices may be detectable well beyond the immediate location of the project, producing potentially adverse behavioural and physiological responses to sensitive species at some distance from the actual project site. Thus, reviewers should consider the detectability and reactions of organisms present in both the localized and system-scale area.

Where solid data are too limited for reliable estimates to be made, a generalized, qualitative comparison should be made.

Table 5-8: Criterion 5 – Noise, Vibrations, and Turbulence Effects on Marine Organisms due to Turbine Operation

<table>
<tr><th colspan="3">CRITERION 5 INDICATORS OF RISK</th></tr>
<tr><th>INDICATORS</th><th>NOISE AND VIBRATIONS</th><th>TURBULENCE</th></tr>
<tr><td>Predicted noise and turbulence output generated by devices at the specified scale of development (i.e. actual size of devices, number of turbines, and associated infrastructure)</td><td colspan="2">A valid estimate based on the best available data and models should be made, where possible. This estimate can then be compared with ambient conditions and known response thresholds of organisms, where available. Where solid data are too limited for reliable estimates to be made, a generalized, qualitative comparison should be made.</td></tr>
<tr><td>Characteristics of ambient conditions</td><td colspan="2">This is intended as a measure of whether the signals are likely to be detectable by marine organisms against pre-existing conditions. Marine organisms may respond to sounds or vibrations of a greater intensity or different quality than they are accustomed to. Even in noisy or turbulent environments, the operation of devices may alter the sound or vibrational environment for a considerable distance. However, in a naturally noisy and/or turbulent environment, the additional signals generated by the turbines may be masked by (undetectable against) the natural conditions. Moreover, marine organisms in the area may be accustomed to that type of an environment.</td></tr>
<tr><td>Presence of other anthropogenic signals</td><td colspan="2">Pre-existing anthropogenic activities, including other tidal developments, may already be producing similar or greater signals, which may mask or offset the risk of any additional signals produced by the proposed project. However, it is possible that the signals from each of the activities may interact to produce an even greater response in marine organisms.</td></tr>
<tr><td>Presence of species known to be sensitive</td><td>Given that a full assessment of this criterion is both labour and data intensive, focus should be placed on HCC and other species known to be particularly sensitive to this stressor (e.g. marine mammals). Several syntheses of information on impacts of tidal turbine noise on marine organisms are available (see References at the end of this Module).</td><td>Lower mobility organisms, including smaller fish, invertebrates, plankton, eggs and larvae, may be particularly vulnerable to entrainment in and disturbance by turbulence, rendering them more susceptible to predation.</td></tr>
<tr><td>Ability of organisms to evade affected area</td><td colspan="2">Noise, vibrations, and turbulence signals produced by the devices may enhance the detectability of the turbines by marine organisms and thus reduce the potential of physical encounters by organisms able to evade the structures or take another route. In fact, the use of noise-making devices (e.g. seal deterrents) may be considered as a mitigation measure to reduce the likelihood of strike or entrainment by deterring organisms (particularly marine mammals) from the site.

Please note that not all organisms may be able to leave or avoid the affected areas, especially where the signals extend well beyond the localized area (see Criterion 4).</td></tr>
</table>

5.2.4.6 - CRITERION 6: EFFECTS OF OTHER SIGNALS EMITTED BY PROJECT INFRASTRUCTURE

The intent of this criterion is to serve as a measure of the likelihood that signals emitted by the project infrastructure, other than those dealt with in Criterion 5, will adversely affect the behaviour or physiology of marine organisms.

Signals to consider include the following:

A. electromagnetic fields produced by the power cables or turbines,

B. artificial light, and

C. other emissions produced during operations, as identified by proponent or regulator.

These stressors are generally considered to present less of a risk to marine organisms than those in Criterion 5 at the present time. Moreover, there is great uncertainty regarding whether electromagnetic fields produced by power cables of the type used in tidal projects are at levels that would be detectable or of concern to marine organisms, and if so, at what distances and directions. Nevertheless, these stressors are of public concern and may be determined to present a higher risk as more experience is gained.

Responses could include the following:

- avoidance or attraction to affected areas,
- interference with navigation or orientation mechanisms/cues,
- increased stress,
- interference with communication and mate and prey detection, and
- physical or physiological damage.

Photo Credit: Greg Trowse

Table 5-9: Criterion 6 - Effects of Other Signals Emitted by Project Infrastructure

CRITERION 6 INDICATORS OF RISK		
INDICATORS	**ELECTROMAGNETIC FIELD**	**ARTIFICIAL LIGHT**
The extent of the power cabling and lights	If possible, a valid estimate of electromagnetic field output should be made based on the best available data and models. Where solid data are too limited for reliable estimates of electromagnetic field outputs to be made, a generalized, qualitative comparison should be made based on the assumption that the more extensive the cabling and higher the transmission capacity, the greater the potential intensity and spatial influence. This should also take into consideration whether the cables are shielded and/or buried. Characteristics of the transmission (e.g. Dc vs. AC) are also important.	This would only be a factor associated with surface structures.
Characteristics of ambient conditions	This is intended as a measure of whether the disturbance is likely to be detectable by marine organisms against pre-existing conditions. Marine organisms may respond to electromagnetic fields of a greater intensity or different quality than they are accustomed to. While it is possible that fields may be masked by (undetectable against) the natural conditions or that marine organisms may be accustomed to such signals, this should not be assumed.	n/a
Presence of other anthropogenic signals	Pre-existing anthropogenic activities, including other tidal developments, may already be producing similar or greater signals, which may mask or offset the risk of any additional signals produced by the proposed project. However, it is possible that the signals from each of the activities may interact to produce an even greater response in marine organisms.	
Presence of species known to be sensitive	Given that a full assessment of this criterion is both labour and data intensive, focus should be placed on HCC and other species known to be particularly sensitive to this stressor. Several syntheses of information on impacts of electromagnetic fields on marine organisms are available (see References). For example, elasmobranchs (i.e. sharks, rays, and skates) are known to be particularly sensitive to electromagnetic fields and may exhibit behavioural reactions to underwater power cables of the type associated with tidal turbines (including avoidance, attraction, and aggression towards the cables). Benthic organisms may also be particularly vulnerable to electromagnetic fields given their proximity to the source of the emissions.	Artificial lights may attract certain organisms, particularly marine birds, mammals, and turtles, which may increase risk of strikes or entrainment.
Ability of organisms to evade the affected area	Some organisms may be repelled by electromagnetic fields. This may reduce the potential of physical encounters by organisms able to evade the structures or take another route. However, not all organisms may be able to relocate or avoid the affected areas, especially those that extend across migratory pathways or if the site has extensive cabling systems (see Criterion 4).	Artificial lights may enhance the detectability of the turbines by marine organisms and thus reduce the potential for physical encounters by organisms able to evade the structures or take another route.

5.2.5 - STEP 4: IDENTIFYING RISKS OF INTERFERENCE WITH OTHER HUMAN USES

One non-scientific factor that is appropriate for inclusion as a distinct criterion in the categorization of risk level is the potential for interference with other human uses of the marine and coastal ecosystem. Examples of relevant human uses include the following:

- commercial, recreational, subsistence, and aboriginal fisheries;
- aquaculture;
- marine transportation/navigation;
- tourism and recreational uses (e.g. boating, surfing, diving, whale watching, beaches);
- subsea cabling and pipelines; and
- mining and oil and gas operations.

Some uses may be displaced or disrupted by the presence of a tidal energy development. Others may be able to coexist without significant disruption. Both current and probable future uses should be considered. However, the risk level may be weighted higher for current uses. By incorporating implications for the environment and other human uses, an integrated management approach can be taken in project planning and decision-making, including the design of mitigation and adaptive management measures. Information on the degree of risk to various uses may be available through a marine spatial planning, socioeconomic impact assessment, and/or consultations with stakeholders.

Given the purpose is to support objective planning and decision-making that prevents development projects from causing significant adverse effects on the natural environment, other socioeconomic values, such as effects on the local and regional economy, jobs, business development, and contribution to meeting renewable energy targets should not be considered within the environmental risk assessment and decision-making process. These may be considered after the project is determined to be environmentally acceptable.

5.2.6 - STEP 5: CATEGORIZING RISK

Once a project proposal is completed, reviewers (e.g. planners or regulators) would assess the available information against each criterion. Each criterion (environmental and other human uses) should be considered of equal weight. Therefore, following a precautionary approach, a high risk score in one criterion could place the entire project in the high risk level. With no high risk criteria, and even one moderate, the overall risk level of the project would be moderate. If all criteria are low risk, the project would be classified as low risk.

Each risk level is associated with an appropriate management decision on whether or not the project is suitable to proceed.

Table 5-10: Categories of Risk of a Proposed Project

CATEGORIES OF RISK OF A PROPOSED PROJECT	
RISK LEVEL	**RECOMMENDED MANAGEMENT DECISION**
Low	Project may proceed without further review.
Moderate	Project as proposed will require a more detailed review and/or environmental studies and/or monitoring program before receiving approval.
High	Project as proposed will require an in-depth review with further environmental studies and/or monitoring before receiving approval.
Extremely high	Project poses an unacceptable risk and may not proceed as proposed. Major redesign and/or relocation are required. Revised proposals will need to be re-submitted.

5.2.7 - OTHER CONSIDERATIONS

For large-scale commercial projects, where there may be a greater potential for an environmental impact, the risk can be mitigated using an adaptive, staged development approach, where the development is scaled-up, in terms of size (number of devices, production capacity), in incremental stages over time. Proposals for larger-scale projects that incorporate an incremental growth approach may qualify at a lower risk, requiring a less extensive initial review (than an equivalent project without staged growth) as long as a well-designed monitoring, re-assessment (at each stage) and adaptive management procedure is put in place.

By developing commercial-scale projects in a staged, precautionary and adaptive manner, regulators, scientists and developers will be able to gain valuable knowledge and experience on the baseline environment and the effects of the technology. Since project proponents cannot be expected to be responsible for research and monitoring beyond the scope of their project, credit should be given to projects that include a strong independently-run environmental research program. Applied research and monitoring will benefit both proponents and regulatory agencies by facilitating efficient project planning, environmental assessment, monitoring, and mitigation.

5.2.8 - STEP 6: SUPPLEMENTARY MITIGATION

Moderate and/or high risk projects face delays and added costs associated with the need for a more in-depth review, baseline studies and monitoring program, as well as the continued risk that the project could be rejected. However, the project may be downgraded to a low risk level by applying appropriate mitigation measures that address all the indicated risks (both to the environment and other human uses), thereby allowing the project to proceed without the need for further review. Mitigation may involve relocation to a site less likely to be negatively affected, change in the timing of project activities (especially for short-term projects), adjustments to the size or configuration of the development, or use of mitigation devices, such as erosion protection or fish/marine mammal deterrents. Extremely high risk proposals require major revisions and must again proceed through all the steps.

5.2.9 - STEP 7: PREPARING A MONITORING AND ADAPTIVE MANAGEMENT PROGRAM

When a project is approved, follow-up activities, including research and monitoring, are key to reducing scientific uncertainty and allow improved decisions to be made in the future. These activities should be incorporated into the conditions for approval of any project.

An iterative process of risk assessment and mitigation is required. At minimum, both proponents and regulators need to work together from the outset to design a long-term adaptive environmental monitoring and management program. Such a program would include the following:

- monitoring requirements,
- timelines and/or conditions for re-assessment, and
- an adaptive response plan.

While specific adaptive management measures may not be identifiable at that point, a strategy or plan should be developed to provide context on when, how, and where adaptive management may be used. Decisions to adopt specific adaptive management measures can be identified later during the project life-cycle based on the results of the follow-up or monitoring program.

Part of the role of monitoring will be to confirm the predictions of the environmental assessment and demonstrate that mitigation is functioning as intended. If unanticipated changes are detected, the adaptive response plan will ensure that appropriate and timely actions are taken to mitigate the cause of the change and minimize the potential for a significant adverse ecological effect to result. Response(s) could include the following:

- modification of project design or expansion plans;
- modification or addition of mitigation measures; or
- if necessary, cessation of operations and/or removal of some or all devices.

Following the adaptive response plan, reassessments would occur at a predefined interval or condition and/or as new or improved information is gained on the baseline environment or impacts. Where new risks are identified or previously predicted risks are unsubstantiated, monitoring and mitigation requirements can be adapted.

For more information on this topic, see: Operational Policy Statement: Adaptive Management Measures under the Canadian Environmental Assessment Act. http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=43952694-1

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Photo Credit: Elisa Obermann

6 STAKEHOLDER AND COMMUNITY ENGAGEMENT

6 - STAKEHOLDER AND COMMUNITY ENGAGEMENT

Author: Dr. John Colton

WHAT DOES THIS MODULE COVER?

The purpose of this module is to provide information on concepts, processes, and tools to support effective community and stakeholder engagement related to tidal energy development. Because tidal energy development is in its infancy, lessons learned from other renewable energy sectors provide significant insight into effective community and stakeholder engagement.

IS THIS MODULE FOR YOU?

This module is for anyone who is interested in better understanding the range of stakeholder issues and how to determine stakeholders associated with tidal energy development. It also provides information on how to effectively plan a stakeholder engagement strategy.

This module outlines a series of steps and methods on how to effectively commence and manage a stakeholder engagement process. In doing so, it addresses several key issues:

- setting out principles for engagement,
- identifying how to define and locate stakeholders,
- identifying stakeholder concerns and issues,
- engaging First Nations,
- setting out an engagement strategy, and
- choosing the right tools and methods for effective engagement.

MODULE ORGANIZATION

This module is organized into several themes. The first part of the module focuses on principles of engagement, such as transparency and respect. The module then discusses methods for identifying stakeholders, including First Nation stakeholders. Methods and strategies for stakeholder engagement are then discussed.

6.0 - INTRODUCTION

Effective community and stakeholder engagement will likely determine the success of a tidal energy project. There is no better strategy for mitigating the risk associated with developing a tidal energy project than to develop a stakeholder engagement process that is inclusive of all stakeholders.

Given that communities represent a diverse range of interests and stakeholder perspectives, this module does not differentiate between communities and other stakeholders.

Many examples used to discuss engagement are drawn from offshore and onshore wind energy projects, as development of tidal energy is in its early stages. Included in this module are principles and strategies for effective community and stakeholder engagement.

6.1 - TIDAL ENERGY DEVELOPMENT AND ENGAGEMENT

Tidal energy projects will require approval from various levels of government prior to proceeding (Module 4- The Regulatory Regime for Tidal Energy). Because of this, organizations, including local government and industry, spend a great deal of time engaging stakeholders as they move through the regulatory process. Successful development of a tidal energy project will also depend on the support of the local community, businesses, and other organizations. Past experience has clearly demonstrated that neglecting these stakeholders in the early stages of the development process imperils the success of the project in both the short and long term.

The purpose of community and stakeholder consultation is to enable all stakeholders to make their views known and to work together to ensure they are addressed.

Successful development of a tidal energy project will also depend on the support of the local community, businesses, and other organizations.

DISCUSSION: WHAT IS COMMUNITY ENGAGEMENT?

Community engagement includes following a process that ensures communities determine local priorities and all stakeholder groups are represented. Citizens need to be at the center of the community engagement process. This process ensures communities are empowered and have control over their resources and the decision-making process. For further information, see: Tamarack: An Institute for Community Engagement. http://tamarackcommunity.ca/

TIDAL PROJECTS: HOW TO GET A COMMUNITY'S THUMBS UP

In Tidal Today, author Elisabeth Jeffries discusses the importance of early community engagement. She notes that nearly half of the applications for wind farms are rejected. While this is most often due to technical reasons, many projects are rejected due to local opposition. It makes sense to engage stakeholders. Articulating the benefits of tidal energy projects and addressing stakeholders' concerns are paramount. Doing this in the early stages is critical. Involving stakeholders in the naming of the energy project might be one useful suggestion for engaging stakeholders.

For more information, see Tidal Today, April 2012.

6.1.1 - PUBLIC PERCEPTIONS OF TIDAL ENERGY

Stakeholders form opinions on renewable energy developments based on their perception of the environmental, socioeconomic, and emotional impacts the proposed development has on them and their area. Opinion studies conducted in Europe and the US generally indicate the public is supportive of developing alternative energy sources, specifically onshore and offshore wind energy. Public acceptance of offshore wind energy in Denmark and the UK show strong trends in the following topics:

1) The public is in favour of offshore wind energy, including in the region where they reside.

2) Visual impacts appear to be the primary issue of public concern.

3) NOISE is a concern here; information can rectify/address this concern.

4) Offshore wind park development appears to gain public approval as the community is exposed to operational projects.

5) Early local input to the planning process is critical to gain public acceptance.

Coastal and offshore regions are used by a multitude of users, often with differing interests, which may result in space-use conflicts. Potential space-use conflicts common to all types of offshore renewable energy projects include:

- commercial fishers,
- subsistence fishing,
- marine recreational activities (boating, fishing, sea kayaking, diving, surfing, etc.),
- sand and gravel extraction,
- oil and gas infrastructure,
- navigation,
- ecotourism (whale watching),
- aquaculture, and
- proximity of designated conservation areas and/or other renewable energy projects.

VIGNETTE: REAL TIME INTERACTIVE MAPPING TO IDENTIFY STAKEHOLDER CONCERNS

Using a real-time interactive mapping device (touch- table) and stakeholder workshops, researchers gathered data and facilitated negotiation of spatial trade-offs at a potential site for tidal renewable energy off the Mull of Kintyre (Scotland). Conflicts between the interests of tidal energy developers and those of commercial and recreational users of the area were identified, and use preferences and concerns of stakeholders were highlighted. Social, cultural, and spatial issues associated with conversion of a common pool to a private resource were also revealed. The method identified important gaps in existing spatial data and helped to fill these through interactive user inputs. The workshops developed a degree of consensus between conflicting users on the best areas for potential development, suggesting this approach should be adopted during Marine Spatial Planning (MSP).

Source: Alexander, et al. (2012). Interactive marine spatial planning: Siting tidal energy arrays around the Mull of Kintyre. PLoS ONE 7(1)

While people are generally supportive of renewable energy development, often a "Not in My Backyard" (NIMBY) effect occurs. Therefore, it is important to learn about the stakeholders, in particular the community stakeholders. Do your homework first and consider the types of effects on the following:

- onshore and coastal use—both locally and regionally;
- marine ecosystems;
- possible tax increases;
- greater tax revenues;
- employment opportunities;
- landowner opportunities;

- tourism development;
- service industry (accommodations and food)opportunities;
- local commercial and recreational fishery;
- local and regional economic development opportunities; and
- opportunities for local businesses/suppliers to transition to supplying new economic development opportunities.

6.2 - UNDERSTANDING PRINCIPLES OF ENGAGEMENT

Credibility is important to the process of stakeholder engagement. Without credibility, the support needed to review tidal energy projects, explore site locations, administer development agreements, and develop a management plan will become increasingly difficult over time. Engaging stakeholders early and continuing engagement throughout the duration of the project can establish credibility. Providing access to research and other relevant material for stakeholders is important as well. Examples from wind energy development describe the impacts of the development process where credibility has been lost among certain stakeholder groups. In these cases, development was delayed significantly or stopped altogether. Among the most often cited issue in these cases is the lack of transparency.

Other key principles to guide the stakeholder engagement process include:

Respect – Acknowledging the inherent worth, dignity, diversity, and the abilities of individuals, families, community groups and businesses to contribute to decision-making processes.

Transparency – Beginning the entire process by stating the specific objectives and expectations of what is possible and what level of commitment is sought.

Inclusive Participation – Recognizing the broader community, and making efforts to reach out to marginalized groups and engage them in an appropriate and empowering process.

Coordination – Managing and implementing engagement initiatives to minimize duplication and the potential of 'consultation fatigue.'

Information for Participation – Sharing information that is objective, clear, sufficient, timely, and in appropriate formats such as Fact Sheets.

Appropriate Timelines – Recognizing that engagement should begin as early as possible and should have a defined period for each stage.

Responsiveness – Respecting that decision-makers must use community input as a key source of information and expertise.

While people are generally supportive of renewable energy development, often a "Not in My Backyard" (NIMBY) effect occurs.

FOUNDATIONAL CONCEPT: TRANSPARENCY IN STAKEHOLDER ENGAGEMENT

Transparency is a process in which all decision-making is carried out publicly. This includes public and other stakeholder access to all background documents for and against a proposed project, and all final decisions; additionally, the decision making process itself is made public and remains publicly archived.

The importance of the process in planning and conducting successful stakeholder collaboration cannot be overemphasized. Good-faith efforts are often derailed because the parties are not skilled in the collaboration and facilitation process, and because insufficient attention is given to designing and managing it.

Accountability – Demonstrating how and where stakeholder input received was incorporated into decision-making.

Evaluation – Ensuring engagement efforts are meeting established objectives and sharing best practices to improve future engagement activities.

Additional principles drawn from the United Kingdom's experience in wind energy development include:

- Responsibility for the process and the feedback needs to be shared - Many consultation processes fail because needs of stake holders are not met or because participants feel they have not been kept fully informed of what has been done with their ideas and opinions. It is up to those convening the process to ensure everyone's needs are met and to take responsibility for disseminating the results and information about how their input is linked to decision-making processes.

- The use of independent professional facilitators should be considered. Independent facilitators can ensure that meetings are conducted impartially, and as balanced and even-handed as possible.

Framing the process around these or other agreed-upon principles is important. Having the conversation with other stakeholders about these principles is even better.

The importance of the process in planning and conducting successful stakeholder collaboration cannot be overemphasized. Good-faith efforts are often derailed because the parties are not skilled in the collaboration and facilitation process, and because insufficient attention is given to designing and managing it. Using an inclusive, transparent approach during project development and implementation will help build the necessary relationships.

6.3 - IDENTIFYING STAKEHOLDERS

Identifying your stakeholders, seeking methods for meaningful engagement, and working to understand their values and perspectives is good stakeholder engagement. A stakeholder can be defined as any person, group, or organization that has a stake in a tidal energy development and who can affect and be affected by the actions taking place prior, during, or after the development, and also affect or be affected by the objectives and policies involved (EquiMar, 2011). At the initial stages of an array development, the stakeholder body might typically include owners (shareholders), developers, suppliers, employees, the three levels of government, unions, and individuals or whole communities located in the vicinity. When the array is fully operational, creditors and energy end-users could be included as well.

The British Wind Energy Association (BWEA) conducted extensive stakeholder processes with offshore wind farm developments in the UK. The BWEA developed a document titled "Best Practice Guidelines: Consultation for Offshore Wind Development," which can be of use for tidal energy stakeholder engagement processes.

The BWEA breaks down stakeholders into the following groups:

- **Statutory consultees**
Statutory consultees are authorities, agencies, groups, or bodies defined in local, national, or international legislation, which the developers are obligated to consult. The developer usually follows a pre-defined statutory process, but at the same time, no restrictions exist on including this category of stakeholders in non-statutory consultation as well.

- **Strategic stakeholders**
This category includes local, regional, national, or international organizations (and their representatives) that have important information, experience, and expertise to contribute to the overall progress of the development. If the development refers to an array of onshore or near-shore marine energy converters with onshore support facility requirements, landowners may be part of this category as well.

- **Community stakeholders**
This category includes any individual, groups of individuals, or organisations, whose lives, interests, and welfare can be affected by the development.

- **Symbiotic stakeholders**
Symbiotic stakeholders can be owners or organisations who may have an interest in or who may have mutual benefits from a co-development.

NOVA SCOTIA IN CONTEXT: NOVA SCOTIA'S MRE STRATEGY

Guiding principles of the Nova Scotia Marine Renewable Energy Strategy include:

- Embracing collaboration and consultation, and

- Recognizing and respecting other uses and users of the ocean and balancing interests. To support these and other values outlined in this strategy, a Tidal Energy Stakeholder Forum has been established and will serve as an advisory body to the formative stages of tidal energy development. Access to a range of information of tidal development activities will be provided. Members of this committee include industry, academia, government, Mi'kmaq, and communities.

For more information on this strategy, see the following: Nova Scotia Marine Renewable Energy Strategy. http://www.gov.ns.ca/energy/resources/publications/Nova-Scotia-Marine-Renewable-Energy-Strategy-May-2012.pdf.

Table 6-1: Examples of Stakeholder Categories

STATUTORY CONSULTEES	STRATEGIC STAKEHOLDERS	COMMUNITY STAKEHOLDERS	SYMBIOTIC STAKEHOLDERS
First Nations	University/R&D Partners Investors	Resident Associations	Offshore Wind Energy Industry
Department for Environment, Food, and Rural Affairs	Marine Archaeological Interests	Individual Residents	The Wind Industry Supply Chain
Department of Culture, Media, and Sport	Marine Conservation Society	Sailing Clubs	Offshore Oil Industry
Department of Trade and Industry	National Fishermen's Organisations	Recreational Groups	Electrical Grid Owners
Department of Transport, Local Government, and the Regions	National Trust	Regional or Local Fishermens' Associations	
Centre for Environment, Fisheries, and Aquaculture	Ramblers Association	Local Companies	
Civil Aviation Authority	Societies for the Protection of Birds	Local Touristic Agents and / or Agent Associations	
Countryside Agency	Yachting Association	Women's Institutes	
Local Authorities	Fishery Committees	Community Councils	
National Heritage and Nature	WWF	Church Groups	
Ministry of Defence	Greenpeace		
Maritime and Coast Guard Agency	Surfers Against Sewage		
National Parks	Surfriders Foundation		
	The Wildlife Trust		
	Trade Unions		
	Land Owners		
	Project Developers		

Source: EquiMar. (2011). Deliverable D5.8 Impacts upon Marine Energy Stakeholders, p. 2-2.

Identifying stakeholders may be a challenge; however, it is important to include as many stakeholders as possible to avoid excluding a stakeholder who may be crucial to the process. Experience from wind energy development demonstrates that not addressing local stakeholder issues at the local level can cause delays or cancellations in the overall development.

NOVA SCOTIA IN CONTEXT: COMMUNITY FEED-IN TARIFF

The Community Feed-In Tariff (COMFIT) program is designed to increase local ownership of small-scale renewable energy projects throughout the province. Community engagement is a requirement for the COMFIT program and stipulates that at least two community/stakeholder meetings be organized to address community issues. Evidence of community engagement can include a resolution adopted at a municipal meeting and/or minutes of a public forum. Evidence must be provided of this engagement and must be completed within 12 months of receiving the COMFIT award. For more information, see: Community Feed-in-Tariff Program FAQ - http://nsrenewables.ca/comfit-frequently-asked-questions.

The following questions aid in identifying stakeholders:

- Who is investing in the development?
- Who will the development affect, either positively or negatively?
- What changes will the development bring and who supports or opposes such changes?
- What are the official leadership positions in the community?
- Who is influential in the local community?
- Who are the representatives of local organisations with environmental or social interests?
- Who are the representatives of local organisations with economic interests?
- Who are the representatives of similar (if any) developments in the area, such as existing offshore wind farms?
- Who has been involved in similar issues in the past?
- Who are the local policy makers?
- Who are the representatives of the local / regional research community?
- Who else should be involved?

6.3.1 - ENGAGING FIRST NATION STAKEHOLDERS

First Nation organizations have indicated an interest in tidal energy development. Given that their perspectives have largely been marginalized over the last several decades, it is reasonable to expect a level of distrust towards governments and resource developers. Yet, there are increasing examples across Canada where First Nation communities have developed strong collaborative relationships with stakeholders and played an equal role in decision-making related to renewable energy development.

In the case of wind energy, First Nation communities have invested heavily in its development. In Nova Scotia, Canada, for example, significant research that explores the potential for wind energy development on aboriginal lands and the ensuing socio-economic benefits from this type of development has been supported by the Atlantic Chiefs Policy Congress (Campbell, 2012). In Nova Scotia, First Nations have submitted several COMFIT applications for wind projects.

When considering the potential for tidal energy development in an area, it is important to identify any First Nation communities in the region. Keep in mind that these communities do not have to be necessarily close to the proposed tidal energy site to be considered an important stakeholder. Treaty rights can extend across hundreds and, in some cases, thousands of square kilometers, including both terrestrial and marine ecosystems.

When considering the potential for tidal energy development in an area, it is important to identify any First Nation communities in the region. Keep in mind that these communities do not have to be necessarily close to the proposed tidal energy site to be considered an important stakeholder. Treaty rights can extend across hundreds and, in some cases, thousands of square kilometers, including both terrestrial and marine ecosystems.

IN NOVA SCOTIA: ENGAGING THE MI'KMAQ

Aboriginal community engagement is important in Nova Scotia. In the early stages of development, it is important to communicate with local Mi'kmaq communities, the Atlantic Chiefs Policy Congress and the Confederation of Mainland Mi'kmaq. It may also be important to partner with local Mi'kmaq communities to conduct cultural/archaeological site assessments to determine if potential sites for tidal development are located adjacent to these significant cultural areas.

For more information on protocols for engagement with Mi'kmaq, refer to the Proponent's Guide: Engagement with Mi'kmaq of Nova Scotia.

http://www.gov.ns.ca/abor/docs/Proponants-Guide.pdf

IN NOVA SCOTIA: MI'KMAQ ECOLOGICAL STUDIES

Mi'kmaq Ecological Study (MEKS): The MEKS Protocol was ratified in November 2007. The purpose of the MEKS is to capture Mi'kmaq traditional knowledge from elders and other knowledge holders. When conducting a MEKS, ecological information regarding Mi'kmaq/Aboriginal use of specific lands, waters, and their resources are identified and documented by the project team. MEKS I was for the Bay of Fundy in relation to the development of the FORCE project. MEKS II is focused on the outer Bay of Fundy, Digby Gut, Petit, and Grand Passages.

The Crown or government has the legal authority to consult with First Nation communities, but it is incumbent on tidal energy developers to play a role as well.

Key steps in your planning process should include:

- Approaching Chief and Council and their economic development officer. Work to understand their points of view and discuss ways to develop meaningful stakeholder relationships.
- Approaching Elders. Seek their perspectives on the project and, where appropriate, offer gifts (this is common practice for many Aboriginal communities and demonstrates respect to the Elders and their knowledge).
- Being prepared to offer financial assistance to the First Nation community to participate in the consultation process.

Be prepared for prolonged engagement; as a result, it is important to start early. Learn as much as you can about the community, their history, identify the informal leaders in the community, and communicate effectively. It is critical that you provide information to Chief and Council prior to making public announcements. This is true in all cases of community/municipal engagement.

6.4 - OUTLINING THE ENGAGEMENT STRATEGY

It is important to outline an engagement strategy and to share this with stakeholders. Examples from wind energy development in the United Kingdom and Canada provide insight into the development of engagement strategies associated with tidal energy development.

6.4.1 - STAGE 1: STARTING THE CONSULTATION PROCESS

The first task is to select who will lead the consultation process (usually the developer or government) and maintain contact with stakeholders throughout the process. The steps are to:

- Identify the stakeholders and do a preliminary scoping of issues.
- Plan and design the consultation process, outline objectives and outputs, techniques, key events, timing, resourcing (including budgets), and cooordinate with other statutory and non-statutory processes.
- Draft invitations when meetings are required, and indicate with whom the stakeholders can liaise. Who sends the invitations and 'hosts' the events may vary (e.g. the developer, local councils, coastal partnerships, or an independent body such as a local college).
- Prepare presentations and documents for distribution before or during meetings in order to ensure efficient planning to help build confidence in the process.

This stage may take several meetings or it may be done via phone and email. Invitations need to be sent 3-6 weeks before events; notices of public meetings need to be published 3 weeks in advance and again 1-2 days before events.

A consultation plan will benefit both stakeholders and the development team by clarifying what the consultation process is, and clarifying links to statutory organisations, regulators, NGOs, and other relevant bodies. Generic elements of the consultation plan include:

- objectives and scope of the consultation process;
- environmental, economic, and social issues raised by the development;
- why the development is being proposed;
- the time-frame for consultation, set out in parallel with the timing of related activities;
- locations and logistics of consultation;
- tools and techniques of consultation;
- roles and responsibilities of those involved;
- allocation of resources for consultation; and
- feedback mechanisms.

6.4.2 - STAGE 2: LISTENING AND LEARNING

The main interactive work of the stakeholder process starts around the same time as work on the Environmental Impact Assessment is emerging. This stage needs to:

- clarify issues;
- expose assumptions;
- identify, manage, or reduce uncertainties;
- build on common ground;
- explore ideas to solve problems and resolve differences;
- establish what changes may need to be made;
- commission independent research and fact-finding;
- establish monitoring and reporting procedures, and make arrangements for responding to them; and
- generally try to improve communication and relationships.

Working groups can be established if there are other issues that need to be addressed by stakeholders.

6.4.3 - STAGE 3: MONITORING OF THE CONSULTATION PROCESS, EVALUATING, AND MAINTAINING CONTACT

As the development process continues, the consultation process should continue checking the following:

- whether all appropriate stakeholders have been consulted;
- whether the stated objectives of the Environmental Impact Assessment (EIA) and consultation processes have been achieved;
- what changes to the project have been made as a result of the consultation process and why;
- whether the consultation process has allowed sufficient time to consider social, economic, and environmental impacts to the depth necessary; and
- whether stakeholders feel that the consultation has been conducted in a way that has enabled them to contribute fully and freely to the EIA process.

The consultation plan needs to identify techniques that monitor consultation objectives. An example might be a core group of stakeholders who meet periodically during the process or the entire lifetime of the project, so if concerns or opportunities arise, there is an immediate forum to discuss them.

Photo Credit: Leigh Melanson

6.5 - STAKEHOLDER ENGAGEMENT AND THE EIA PROCESS

A more specific process is outlined below that is inclusive of the Environmental Impact Assessment (EIA) process, as in many jurisdictions, this process runs in parallel with the stakeholder engagement process. Table 6-2 shows how the EIA process links to the stakeholder consultation process. Note the stages may not happen exactly in parallel, as shown in the table, and stakeholder consultation processes need to be iterative. In other words, information gained in Stages 2 or 3 may make it essential to return to Stage 1.

Table 6-2: Summary of Statutory and Stakeholder Processes

STAKEHOLDER CONSULTATION PROCESS	ENVIRONMENTAL IMPACT ASSESSMENT AND PLANNING PROCESS
Stage 1: Identifying Stakeholders, Issues, and Processes • Create core team to advise on consultation • Identify stakeholders and issues • Establish key contacts • Draw up detailed consultation process plan • Prepare information for dissemination	**Stage 1: Site Selection and Scoping** • Undertake pre-feasibility studies • Site selection • Screening under the habitats directive, if appropriate • Outline environmental profile • Consideration of alternatives • Scoping exercise (identification of main environmental effects) • Production of scoping report
Stage 2: Listening and Learning • Clarify issues, expose assumptions, reduce uncertainties, build on common ground, and explore ideas to resolve differences • Commission independent research and fact-finding to avoid the 'adversarial science' problem • Improve communication and relationships • Manage ongoing uncertainties • Turn new ideas into solutions • Agree on changes to existing plans where nec essary/possible • Develop continuing commitments • Establish monitoring and reporting procedures	**Stage 2: Commission EIA and Scheme Design** • Description of the development • Description of existing environment • Description of environmental impacts • Identify residual effects • Interpretation of scale and significance of impacts • Identification of mitigation measures • Development of management systems and controls to avoid, reduce, and enable mitigation • Propose possible monitoring and reporting measures • Advertise application and lodge in public domain for review and comment
Stage 3: Monitoring, Evaluating and Maintaining Contacts • Reporting back to stakeholders on results of consultation • Reporting back to stakeholders on how results were used as part of decision-making process es on the development • Evaluating the consultation process • Ongoing contact • Returning to earlier stages if and when necessary	**Stage 3: Post Granting of Consents** • Implementation of mitigation or compensation and control measures • Monitor and report • Continual adjustment where monitoring reveals undesirable results

(Source: BWEA, 2002).

6.6 - CHOOSING THE RIGHT TOOLS AND TECHNIQUES FOR STAKEHOLDER ENGAGEMENT

Choosing the most appropriate methods of communication and consultation are critical steps in the engagement process. The Canadian Wind Association suggests that in developing the engagement process and selecting tools of communication, three important aspects be considered: Opportunity, Information, and Response.

6.6.1 - OPPORTUNITY

Make every effort to inform relevant stakeholders. Carefully consider those stakeholders least able to participate and seek to include them in the process. Consider the daily routines of stakeholders, responsibilities with children, the elderly, those with disabilities, and seasonal activities that might preclude participation. This could include harvesting activities, hunting, seasonal vacations, and holidays. Ensure all public meetings are advertised well in advance.

It is important to remember that engagement goes in both directions. Provide accurate contact information on printed material, websites, and public notices in newspapers. Develop consultation sessions that provide opportunities for discussion and dialogue with stakeholders.

6.6.2 - INFORMATION

Developing a consistent message is important when communicating with stakeholders. All communication should deliver the same message. Avoid jargon and use language that is easy to understand. Consider the following means of communicating to your stakeholders:

- Tidal energy project websites;
- Town hall type meetings;
- Direct mail (the message could be included with local water bills or other items sent by municipality, if appropriate);
- Advertising in local papers;
- Community posters;
- Information booths set up at local fairs and/or farmers' markets;
- Local websites and/or on-line community forums.

6.6.3 - RESPONSE

Every stakeholder deserves responses to his or her questions. Whether you agree or disagree, it is important all questions and/or queries are responded to within 48 hours. Given that many development projects are subject to rumour, especially since a development project will involve new technology in a marine environment, it is critical to respond effectively to all questions raised by stakeholders. The quality and timeliness of your response will set the tone for your interactions with stakeholders. While this can be a time consuming process, engagement should be looked upon as an opportunity to develop meaningful relationships with all stakeholders.

6.7 - COMMUNITY ENGAGEMENT SPECTRUM OF PUBLIC PARTICIPATION

The International Association of Public Participation developed the Spectrum of Public Participation, shown in Figure 6-1. Inherent in the model is the increasing level of stakeholder engagement that evolves through a series of engagement activities to the point where participants in the process are empowered by their involvement. Associated with the different levels of engagement are methods that facilitate stakeholder involvement.

Increasing Level of Public Impact →

	Inform	Consult	Involve	Collaborate	Empower
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
Promise to the public	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Example techniques	▪ Fact sheets ▪ Web sites ▪ Open houses	▪ Public comment ▪ Focus groups ▪ Surveys ▪ Public meetings	▪ Workshops ▪ Deliberative polling	▪ Citizen advisory committees ▪ Consensus-building ▪ Participatory decision-making	▪ Citizen juries ▪ Ballots ▪ Delegated decision

Figure 6-1: Spectrum of Public Participation

Having community and stakeholder participation in projects is typically seen as a best practice. However, some academics have pointed out that current permitting and approval processes entail lengthy and at times, ad hoc consultation procedures, which may not yield meaningful or focused results and preclude a larger participatory process.

Some communities may be willing to participate in more active and participatory ways than others; for example, rural residents may be more likely to get involved in public participatory processes than their urban counterparts because the project may represent a significant economic opportunity.

VIGNETTE: LESSONS FROM THE UK SUSTAINABLE DEVELOPMENT COMMISSION'S PUBLIC AND STAKEHOLDERS ENGAGEMENT PROGRAMME ON TIDAL POWER

The UK Sustainable Development Commission (SDC) launched a research project on tidal power in the UK in 2006, which was followed by a public and stakeholder engagement programme. General aspects of what worked best included learning, having a say and being listened to, sharing views with others, small group discussions, and making contacts and networking. Participants placed a high value on talking with and listening to each other at meetings. General aspects of what was least successful included the need for more information and reporting back to participants.

6.7.1 - INFORMING PHASE

This is an important phase for tidal energy development. It will set the tone for future engagement and requires transparency and full disclosure of information relevant to the project to inform all stakeholders.

6.7.1.1 - INFORMING METHODS

Methods useful in this phase include:

A project website: A website will describe the tidal energy project and provide links to Fact Sheets and commonly asked questions about tidal energy. Full contact information should be made available on this website.

Open houses: An open house is an effective way to present information to the public. Careful consideration should be put into promoting this event and insuring that it is held at a time a day accessible to most people and at a time that does not conflict with other major community events. A drawback to this method is that it is impossible to predict turnout, which can be low despite the amount of effort put into promotion.

Fact Sheets: Stakeholders will have many questions about tidal energy development. Many of these questions can be addressed by developing Fact Sheets to address the most common issues raised by stakeholders.

6.7.2 - CONSULTING PHASE

Tidal energy projects will likely develop significant discussion. Stakeholders will discuss issues and analysis will be conducted of site locations and environmental impact assessments. Stakeholders will expect to be consulted and have their voices and concerns heard and reflected back to them. People involved in commercial fisheries, for example, might be concerned about the impacts of tidal energy projects on the fisheries and the potential for exclusion zones.

6.7.2.1 CONSULTING METHODS

Many methods exist to support the consulting phase. These methods require careful diligence in their development. Experienced facilitators are required to lead group discussions and, if surveys are used, specific types of knowledge are necessary to develop the questions so that they are unbiased and focus on the type of information required.

Specific methods include:

Focus groups: These groups provide opportunities for dialogue among the stakeholders. The optimal size for a focus group is 8-12 people. In these organized discussions, it is important the trained facilitator encourages participation from all group members.

Surveys: Surveys can be costly but effective in gathering information from a range of stakeholders. Care must be taken in developing surveys and response categories must offer a full range of options. Important with this method is the sharing of results through community newsletters, public presentation, and the tidal energy project website.

Public meetings: This is the method used most frequently. Often public meetings become heated and do not lead to meaningful engagement. It is important to consider that for many people, public meetings offer an opportunity to vent their frustrations and time should be allowed for this process at the beginning of the session.

FOUNDATIONAL CONCEPT: FOCUS GROUPS

Focus groups ideally consist of 8-12 people focusing on one topic of discussion. A facilitator will lead the group and keep them focused on the topic. The purpose is to collect in-depth information from a group of people who represent the population of interest. The main advantage of this method is you can collect information from thorough discussion among a group of interacting people. This interaction often results in new ideas and strategies to address local issues of concern.

For more information, see: Using Focus Groups.

http://www.thcu.ca/infoandresources/publications/focus_groups_master_wkbk_complete_v2_content_06.30.00_format_aug03.pdf

6.7.3 - INVOLVE PHASE

Important in the Involve Phase is the direct participation of stakeholders, when their issues, concerns, and perspectives are considered and understood.

6.7.3.1 - INVOLVE METHODS

Typical methods used at this phase include:

Workshops: These venues provide important opportunities for stakeholder involvement. Facilitators have numerous tools that provide opportunities for stakeholders to reflect on the issues at hand and provide meaningful input. Workshops can include community mapping, asset mapping of local resources (including people and places), and other engaging techniques.

Deliberative Polling: In this method, representative stakeholder groups are chosen to deliberate on issues relevant to the topic. It is important to have an unbiased and skilled facilitator. Through a series of smaller group discussions and plenary discussions, consensus is developed around key issues and then shared with the public.

6.7.4 - COLLABORATIVE PHASE

In this phase, stakeholders work in partnership to develop alternative solutions to problems and work toward preferred options. In the case of tidal energy development, this could imply working with stakeholders to choose the most preferred site location(s) for that development.

6.7.4.1 - COLLABORATIVE METHODS

A range of methods is used in this phase and most often includes the development of citizen advisory committees and/or stakeholder advisory groups. These committees must be representative of the stakeholder groups and chaired by someone considered the least biased among the group. These have proven very effective. Other methods include:

Consensus building: Consensus building entails a brainstorming session where all options are put on the table and participants collectively weigh the pros and cons of each option, finally narrowing their choices to a select few. These choices are then discussed until an agreed upon option (one that everyone can live with, as opposed to individuals' most preferred choice) is selected.

Participatory decision-making: Participatory decision-making is a creative process to give ownership of decisions to the whole group, finding effective options that everyone can live with.

6.7.5 - EMPOWER PHASE

This phase puts the decisions in the hands of community stakeholders. While this may run counter to other tidal energy stakeholders, a well-developed process of stakeholder and community engagement can move to this point and present development options that are agreeable to all stakeholders. This can only be accomplished by adherence to the principles of engagement (i.e., transparency, etc.) established at the start of the process.

6.7.5.1 - EMPOWER METHODS

Stakeholder juries and balloting are methods used to empower stakeholders. These methods are used on rare occasions and have not been typically used in renewable energy development projects.

TOOL: ASSET MAPPING

Asset mapping is an important method for engaging community members and other stakeholders. This method can often reframe engagement where people move from thinking about the challenges associated with a development project to a discussion focused on community assets (and opportunities) that can be enhanced through a project. The discussion will also consider how community assets can support a project.

Various methods support this process. For example, in some cases, an asset inventory is conducted that might list the various skills of community members (e.g., trades, IT, etc.), and social networks. Knowing this information will foster greater dialogue on community opportunities associated with a tidal energy project. Other methods might involve the development of a community map that highlights its assets that might include local fisheries, tourism and recreation opportunities, and places of local cultural or historical significance.

See the handbook highlighted below for further information. Asset Mapping Handbook: http://www.planningtoolexchange.org/sites/default/files/sources/asset_mapping_handbook.pdf.

6.8 - STAKEHOLDER ENGAGEMENT CHECKLIST

The following checklist highlights a series of questions that will assist in defining the scope, scale, and goals for a stakeholder engagement strategy.

Table 6-3: Stakeholder Engagement Checklist

STAKEHOLDER ENGAGEMENT CHECKLIST	
What do you want to engage about? • Set a clear aim • Know what can or cannot be changed • Consider the aims of ALL potential partners • Consider how aims might be compatible • Give potential partners the opportunity to be involved as soon as possible • What can people influence?	
Why engage? • What is the purpose of the activity? • To share information? Why? • To find out about needs? Why? • To be involved in setting priorities? Why? • To strengthen a community? Why? • To devolve services? Why?	**WHY ARE YOU DOING THIS?**

What results, benefits, or changes are wanted?
• Are the outcomes clearly defined?
• For each potential partner:
    • Identify contentious issues
    • Agree on compatible outcomes, targets, and milestones
    • Agree on how measurement will take place
• How will results be used?
	WHAT OUTCOMES ARE WANTED?

Who do you want to engage with? • Communities of interest? • Geographical communities? • User groups? • The general public? Individuals? • Other stakeholders • Are there others who need to be involved? • Are there others who want to be involved? • Consider why each partner should be involved • What might they contribute? • Explain what is expected • Listen to what is expected of you	**WHO WILL BE INVOLVED?**

STAKEHOLDER ENGAGEMENT CHECKLIST	
How will trust be established? • Do potential partners know each other? • Are you learning from history or ignoring local knowledge? • Is the community being "done to" or are they genuinely involved? • Is history being repeated (engagement fatigue)? Maybe it should be, but can you explain why? • What can be done to help build trust? • What can be done to remove cynicism? • Look out for saboteurs! • How will media communications be handled?	**TRUST**
DELIVERING COMMUNITY ENGAGEMENT: AN EFFECTIVE RELATIONSHIP	
What level of community engagement relationship will be effective? • Is an ongoing day-to-day working relationship helpful to this issue? • What % of costs is being invested in engageme-ent? Is it appropriate? • Are the selected techniques appropriate to this engagement? • Have non-traditional techniques been consid-ered? • Are there examples of best practice you could draw on?	**LEVEL OF ENGAGEMENT**
What information is needed for participants? • What is already known? • What information is available to ensure that evidence-based decisions are made? • Is information accessible, trusted, relevant, and 'reality checked'? • Is any information privileged? Are there con-flicts of interest? • Is information managed? By whom? • What formats and methods are best? • Is written information concise, understandable, and helpful? • Have jargon and technical terms been kept to a minimum? • Are local or cultural expressions understood?	**INFORMATION**

STAKEHOLDER ENGAGEMENT CHECKLIST	
Do key colleagues have effective communication skills in: • Listening? • Mediation? • Negotiation? • Is training needed and / or practical within required timescales? • Could a mediator or facilitator improve the process? • How will conflicts be resolved?	**SKILLS & QUALITY CONTROL**
What are the incentives and constraints to participation? • What are the incentives to participate? • What makes it worthwhile? • What are the constraints? • Have issues of access, transport, availability, and 'power balance' been considered? • Are there barriers to personal safety? • Have special interest and 'hard to reach' groups been effectively included?	**PARTICIPATION**
What is the timescale to deliver the agreed outcomes? • What are the time constraints? • Is the timetable realistic for all partners?	**TIMETABLES**
What are the available resources? • What types of resources are available (people, logistics, etc.)? • What are the resources required to achieve the outcomes? • Are there different ways of using resources to achieve the outcomes? • Is any other similar work currently taking place to share resources? • Has any similar work been done recently that could be used?	**RESOURCES**

STAKEHOLDER ENGAGEMENT CHECKLIST	
ASSESSING COMMUNITY ENGAGEMENT: A PROVEN RELATIONSHIP	
How will you know outcomes are achieved? • Has it made a genuine difference to local well-being? • Has something improved? • How will you ensure effective, ongoing performance management? • Who will you feedback to? • How will feedback take place? • Will feedback work both ways? • Who will performance be effective for? • How will results be used for long term benefits and to assist others? • Do partners still want to work with each other? • How will you celebrate successes? • How will you manage setbacks?	**PERFORMANCE MANAGEMENT**
SUPPORTING PARTNERSHIPS	
How might a relationship become an effective partnership? • What written agreement is needed? • What governance arrangements will you set in place? • What financial ‘regulations’ will you need? • What codes of conduct are necessary?	**PARTNERSHIPS**

6.9 - ADDITIONAL ON-LINE RESOURCES FOR LEARNING ABOUT STAKEHOLDER AND COMMUNITY ENGAGEMENT

The following on-line resources provide more information on engaging stakeholders and other communities of interest.

More than Wind: Evaluating Renewable Energy Opportunities for First Nations in Nova Scotia and New Brunswick Summary Guide. Atlantic Aboriginal Economic Development Integrated Research Program (2012)
http://www.apcfnc.ca/en/economicdevelopment/resources/MORETHANWINDSUMMARYGUIDE.pdf

Best Practices for Sustainable Wind Energy Development in the Great Lakes Region: Community Support through Public Engagement and Outreach (2011)
http://www.glc.org/energy/wind/pdf/bptoolkit/GLWC-BPToolkit-BP07.pdf

EquiMar Deliverable 5.8: Impacts upon Marine Energy Stakeholders (2011)
https://www.wiki.ed.ac.uk/download/attachments/9142387/WP5_d5.8_final.pdf?version=1

Best Practices Guidelines: Consultation for Offshore Wind Energy Developments. British Wind Energy Association (2002)
http://www.bwea.com/pdf/bwea-bpg-%20offshore.pdf

Wind Energy Development: Best Practices for Community Engagement and Public Consultation (2011)
http://www.saskatoonwindturbine.com/wp-content/uploads/2011/11/canwea-communityengagement-report-e-final-web.pdf

Guide to Developing a Community Renewable Energy Project in North America
http://www.cec.org/Storage/88/8461_Guide_to_a_Developing_a_RE_Project_en.pdf

Community Engagement Handbook: A Model Framework for Leading Practice in Local Government in South Australia
http://www.lga.sa.gov.au/webdata/resources/files/Community_Engagement_Handbook_March_2008_-_PDF.pdf

Towards Whole of Community Engagement: A Practical Toolkit (2004)
http://adl.brs.gov.au/brsShop/data/PC12804.pdf

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7 FINANCIAL EVALUATION AND COST OF ENERGY

7 - FINANCIAL EVALUATION AND COST OF ENERGY

Author: Dr. Shelley MacDougall

WHAT DOES THIS MODULE COVER?

Project developers, lenders, and equity investors will require some level of assurance that a tidal energy project is likely to be profitable over time. This section identifies the capital and operating costs and methods of evaluating the financial viability of the capital investment in in-stream tidal energy and the estimated cost of energy.

This module outlines the following financial considerations of developing a tidal energy resource:

- The capital, operating, and maintenance costs of a tidal energy project;
- The industry-appropriate methods to evaluate the financial viability of the tidal energy project;
- Methods for estimating the levelized cost (cost per MWh) of energy.

This module is for anyone interested in the costs of tidal energy and how such investments are evaluated.

7.0 - INTRODUCTION:CAPITAL INVESTMENT EVALUATION

Tidal energy devices are relatively immature technology. The investment horizons are long and the upfront investment is proportionately high. Much is still unknown about tidal in-stream energy conversion, but a modest amount of relevant knowledge can be garnered from the experiences with offshore wind energy and wave energy.

Eventually, electricity generated from tidal energy conversion (TEC) devices will need to be competitive with other renewable sources. Costs in the technology development and pre-commercialization stages are high. Engineers and scientists are working to lower the costs of the technology so TEC can be financially sustainable, which is critical for attracting the financing to proceed through the stages of commercialization.

In this section, the revenues, capital expenditures, and ongoing costs of tidal in-stream energy conversion will be described as they are understood today. Key cost drivers are also identified and the cost reductions expected as experience is gained and competition in the supply chain develops are noted. An example of the investment evaluation for a 1 MW test turbine is provided in Table 7-1 at the end of this module.

FOUNDATIONAL CONCEPT: CAPITAL INVESTMENT EVALUATION

A comprehensive account of costs to be estimated in the capital investment evaluation is included in the EquiMar Protocols. For more detailed information, refer to Chapter III.A of "Protocols for the Equitable Assessment of Marine Energy Converters," at http://www.see.ed.ac.uk/~shs/Wave%20Energy/Equimar%20protocols.pdf.

7.0.1 - CAPITAL EXPENDITURE (CAPEX)

The capital expenditures (capital costs) for tidal energy development begin long before construction starts. There are six major elements to capital cost: the project itself, the manufacture/supply of turbine(s), its foundation, electrical components, onshore facilities and monitoring equipment, installation and commissioning costs, and decommissioning (Renewable UK, 2011). Each of these elements will be described below.

FOUNDATIONAL CONCEPT: CAPITAL COST

Capital cost, for Canadian tax purposes, includes all the costs associated with getting the equipment built, shipped, installed, and commissioned. It includes such expenditures as legal fees, permitting costs, shipping charges, interest on construction loans, and sales tax. The total capital cost is used in the calculation of investment tax credits and is amortized (expensed for tax purposes) over the economic life of the asset.

7.0.1.1 - PROJECT COSTS

Project costs include those incurred during technology development, resource assessment, acquisition of permits, project management, and other administrative activities. Development costs are expenditures to design the technology, build the prototype and conduct trials. Resource assessment includes mapping, current measurements and modelling.

The permitting process includes the environmental assessment, wildlife surveys, engineering studies, planning and legal activities (Renewable UK, 2011), First Nations consultation and a Mi'kmaq Ecological Knowledge Study (MEKS). The permitting process can take a year or longer, and must be completed before construction can begin. The time it takes to go from application to approval is dependent on the complexity of dealing with multiple planning bodies. For more information, refer to Module 4: Regulatory Regime for Tidal Energy.

Project management includes administrative activities and professional services such as accounting, legal advice, and insurance (Entec, 2006). It also includes assurances of schedule, quality and cost.

7.0.1.2 - TEC DEVICE (TURBINE)

The cost of the TEC device includes the manufacture or purchase of the device itself and the electrical components (electrical systems that connect the device to the array cables) (Carbon Trust, 2005; Renewable UK, 2011). Included in this are the costs of materials, components and labour in manufacture, fabrication, and the assembly of the turbine components. The costs of transporting the components to a construction port may either be included in the construction cost or in the installation costs. Installation costs are also a capital cost and will be discussed below.

The turbine itself consists of steel and composite materials and requires fabrication. To convert the relatively slow moving water to usable electrical energy, blades, control systems, electrical generators, and in some designs, hydraulic systems, and a gearbox are needed. The cost will be greatly dependent on the resource where the turbine will be located. Considerations include water depth, mean water speed, rated power of the turbine, and rotor diameter. The location will also dictate the electrical cable length and the size and design of the foundation (Renewable UK, 2011), as will be discussed later.

FOUNDATIONAL CONCEPT: RATED POWER & CAPACITY FACTOR

The “rated power” or “nameplate power” of the device is how much power it can generate when running at its full capacity. When operating, it usually generates less. “Capacity factor” is the device’s average energy output as a percent of its rated power (Entec, 2006, p.12):

$$\text{Capacity factor (\%)} = \frac{\text{mean power output over a period of time (in MWh)}}{\text{rated power output over a period of time (in MWh)}}$$

Once the economical size of device is decided upon, the electrical and mechanical costs (size of generator needed, etc.) can be determined (Entec, 2006).

7.0.1.3 - FOUNDATION AND MOORINGS

The structure needed to fix the turbine in place depends on its design and location: water depth and speed, ground conditions, and the tidal range (the amount by which the water depth changes). It needs to be designed for the maximum load the turbine will encounter so it can stay in place in the roughest conditions (Entec, 2006).

The device may be held in place using a concrete gravity base, with a monopole, or supported from the surface. See Module 3: Tidal Power Extraction Devices for descriptions. The foundation and the cost of its manufacture vary greatly with the design of the TEC device.

7.0.1.4 - ELECTRICAL CABLES AND SWITCHGEAR

The electrical connections are not as new a technology as the TEC devices themselves, owing to the experience of offshore wind farms. They consist of cables required to interconnect individual devices to a common interconnection point in the tidal channel (EPRI, 2006), cables linking to shore, and onshore electrical systems, including onshore cables and a substation at the point of connection to the transmission system (Renewable UK, 2011), and power quality equipment (inverters, filters). Costs will be dependent upon distance to shore, ground conditions along any cable route (Entec, 2006), and voltage levels.

Whether the costs of the electrical connections are borne by the developer or by the transmission network owner depends on the jurisdiction. Costs will either be capital costs to the developer and associated maintenance costs as part of operating expenses, or be in the form of fees paid to the network owner.

IN NOVA SCOTIA: GRID INTERCONNECTION COSTS.

In Nova Scotia, grid interconnection costs for projects >100kW are borne by the developer. The work is done by Nova Scotia Power Inc. and the cost charged to the developer. The work includes the following:

1. Two studies
    a. Preliminary review
    b. System impact and facilities study
2. Generator tie-in line extension
3. Distribution/transmission system upgrades, if needed (Includes upgrade of one-phase distribution service, increasing conductor size, system voltage conversion, equipment relocations) (InnovaCorp Playbook, 2011, pp. 7-8).

7.0.1.5 - TIDAL FARM

To be commercially viable, an array of multiple TEC devices may be needed to obtain sufficient economies of scale. In the case of arrays, there will be additional capital costs (though less per unit) associated with civil engineering infrastructure. The costs will be based on the number of devices installed, their configuration within a farm, and inter-device spacing (EquiMar III.A, 2011). As well, in the case of tidal arrays, there may be one or more "redundant" devices, essentially excess capacity at the ready, so the downtime for routine repair and maintenance of individual units does not reduce the farm yield.

7.0.1.6 - ONSHORE FACILITIES AND EQUIPMENT

Onshore, there will be need for office and warehouse space. It is likely space can be rented in existing buildings, such as in a nearby industrial park. If leased, rental fees will be part of operating expenses; if built, the cost of construction will be a capital cost. Deployment, retrieval, and maintenance facilities may already exist at a nearby port for other maritime industries.

7.0.1.7 - INSTALLATION/DEPLOYMENT

Installation includes the transportation of the components to a construction port, onshore preparation, and setting the equipment in place and commissioning (Renewable UK, 2011). The method of installation depends on device design. Some devices may be towed to the site by tugs and anchored with an anchor handler. Others must be carried by a heavy lift vessel or barge or may require an expensive jack-up barge to install them (Entec, 2006). Costs of these can be estimated using vessel charter rates. Timing and availability of some equipment will affect these costs. Sea conditions and the tidal range also affect the choice and cost of vessel. The distance from port will have a bearing on the duration of the vessel charters.

In general, installation costs will be influenced by the water depth, tidal stream, tidal range, and distance from port (Entec, 2006). Installation costs will generally increase as the turbines are located further offshore due to transporting time, size and specialty of equipment required to do the work, and weather-related delays.

7.0.1.8 - PERIODIC OVERHAULS AND REFITS

The turbines and their moving parts (gears, bearings, seals), as well as the mooring cables and parts, will need to be overhauled during the TEC device's economic life. When, and how often, will depend on their design and the environment they operate in. For instance, overhauls may be scheduled in 5-year intervals. Unlike routine and emergency maintenance, overhauls and refits may be considered capital costs and be amortized over the life of the refit.

7.0.1.9 - DECOMMISSIONING

The costs of decommissioning include removing the device and cable from the water, and restoring the site to its original state. The cost of decommissioning may be defrayed through the reuse, recycle, or sale of the components and materials. The decommissioning expenditure is at the end of the device's economic life, which may be 20 years or more, so in present value terms, it is a comparatively small portion of total CAPEX. It is, however, harder to predict these costs since they occur well into the future.

BEST PRACTICE: COVERING DECOMMISSIONING COSTS

Decommissioning may be paid for through an upfront decommissioning bond or annual payments into an endowment fund over the life of the project (EquiMar Work Package 7.2.1, 2009).

7.0.1.10 - TAX CREDITS AND ACCELERATED AMORTIZATION

The costs of capital investments are defrayed by tax savings on the amortization (CCA tax shield) and investment tax credits (ITC). Expenditures in Canadian renewable energy are subject to accelerated amortization, allowing companies to claim larger amounts of amortization against taxable income in early years. This will be of limited value to a small company if it has insufficient income in the early years to take advantage of the tax deductible expense, but large companies can benefit immediately. More information on tax incentives is provided in Module 10: Financing, Government Supports and Managing Risk.

7.0.2 - OPERATING COSTS

One of the key advantages of tidal energy is the absence of primary fuel costs. The energy is renewable and provided by the moving water, in contrast to fossil fuels. However, the operating costs are significant and ongoing for the economic life of the turbine. The operating expenses of the tidal energy project are for monitoring and for routine and emergency maintenance activities.

7.0.2.1 - MONITORING

Monitoring occurs both remotely, onshore and on-site, where the turbines are installed. The devices can be equipped with monitoring equipment that can self-test device connection and stability. This data is sent via data cables and accessed online (Li, Lence, & Calisal, 2011). For some devices, monitoring of vibration and seal checks, if applicable to the technology being used, are done on-site (Li et al., 2011). The impact of the turbine on the local environment must be continually monitored.

The costs of monitoring include electrical power, data management, and salaries of skilled employees. There would also be costs of tools and devices, and if on-site checks apply, transportation costs.

7.0.2.2 - ROUTINE MAINTENANCE

The cost of preventative, routine maintenance depends on many variables, including the number of times it is scheduled, the number of turbines, labour hours per turbine, engineer and technician salaries, distance from shore, transportation costs (vessel charter costs), the need for special vessels, their travelling speed, the cost of electrical and mechanical tools, cleaning and protective equipment, and diagnostic equipment (Li et al., 2011; Renewable UK, 2011). Costs also include those necessary to protect the health and safety of workers.

The time turbines are shut down for routine maintenance results in lost revenue. As much work as possible is done during periods of slack tide; however, slack tide is a brief window of opportunity. Maintenance costs (and availability) will also depend on the maintenance scheme used, such as whether service is completed on-site or if the device is returned to shore for maintenance (EquiMar Work Package, 2009).

7.0.2.3 - EMERGENCY MAINTENANCE

If a breakdown has occurred or one is eminent, unscheduled maintenance or repair work must be undertaken. The costs of emergency maintenance include cost of replacement materials, plus many of the costs noted in routine maintenance (transportation, labour, etc.). Repair is difficult and expensive when it has to be conducted on-site (Li et al., 2011). With some device designs, on-site repair is impossible; the device must be taken to shore. The amount of downtime while crews access and repair the turbine also affects the output of the turbine, hence affecting the revenues generated from it.

Estimating emergency maintenance costs is difficult for new technology. Reliability is estimated during the design stage, based on tank tests and sea trials. As the technology matures, the frequency of failure and time to repair will be reduced and be more predictable (EquiMar Work Package 7, 2009, p. 3-3).

Key cost drivers of emergency maintenance include failure rates, severity of the failure, replacement cost of the broken components, turbine downtime, equipment needed (special vessels, cranes), skilled labour costs, accessibility of the materials needed for the repair, and accessibility of the turbine (Li et al., 2011). While there is an absence of warranties on these new technologies, these costs will often be borne by the project developer.

Weather and sea states add a level of uncertainty and variability to operating and maintenance (O&M) costs (Li et al., 2011). The threshold wind and water speeds for work to be done on site and of sufficient duration to complete the work need to be determined. A time series analysis of the tidal site will give information regarding the typical frequency and duration of suitable working conditions (EquiMar Protocol III.A, 2011).

7.0.2.4 - OTHER OPERATING COSTS

Other operating costs may include rental (or related ownership costs) of space for the control center, warehousing costs of components, port berthing fees, insurance, legal and accounting fees, bank charges, amortization, audit fees, seabed lease fees charged by the crown (Renewable UK, 2011), and transmission network charges, if applicable (UK ERC, 2010).

An example of an investment evaluation of a 1 MW turbine is in Table 7-1, located at the end of this module. An evaluation of a small-scale turbine (0.5 MW), done by Synapse Consulting for the Nova Scotia Utility and Review Board, can be found at http://www.nsuarb.ca/NSUARB_Exhibits_JOOMLA/get_document.php?doc=B-1&no=2422.

TOOLBOX: RETSCREEN

RETScreen is developed and distributed by Natural Resources Canada. It is an "Excel-based clean energy project analysis software tool that helps decision makers quickly and inexpensively determine the technical and financial viability of potential renewable energy, energy efficiency and cogeneration projects." RETScreen can be downloaded, free of charge, from www.retscreen.net .

7.0.3 - COST DRIVERS AND UNCERTAINTIES

Capital, operating and maintenance costs are difficult to estimate for TEC since there is little experience worldwide with installed devices. With time, as devices are deployed, learning will be gained and a supply chain established, so these costs will diminish.

7.0.3.1 - HIGH COSTS IN THE BEGINNING

In the early days of the industry, capital and operating costs will be high. Being "one-offs," causes of high costs in prototypes and initial farms include the following (Carbon Trust, 2005):

- In the absence of a supply of materials and parts to build the technology, developers need to use "off the shelf" components for some designs or "built from scratch" for others.
- There are few or no economies of scale in the manufacture of the technology and bases.
- There is limited experience with installation, operation, and maintenance of the plants. Contractors' perceptions of risk will be factored into the price of the service. Sometimes, very specific and expensive deployment vessels are needed.
- Hold-ups can occur in the nascent supply chain.

The supply chain may include the provision of seagoing vessels, gear boxes, blades, bearings, generators, cables for inter-array and connection to shore, transformers, foundations, field instruments, control systems, and power quality equipment. As for infrastructure, there needs to be port availability of sufficient size and capability. Installation vessels may include heavy-lift vessels and special vessels for cable laying. Dedicated equipment is non-existent in Canada and this will likely be the case until there is sufficient promise in tidal energy to warrant the investment by supply chain companies. Refer to Module 9: Opportunities and Strategies for Businesses.

IN NOVA SCOTIA: SUPPLY CHAIN

Presently, in Nova Scotia, the nascent tidal energy industry is without its own supply chain. Developers require the services of supply chain companies that are now focused on other industries, such as offshore oil and gas, shipbuilding, manufacturing, and wind energy. The tidal energy industry is not a strategic priority for these companies, so it must compete with the much larger, more lucrative customers. While the tidal energy industry needs to grow sufficiently to incent the supply chain companies to make the needed investments, it has difficulty achieving such growth without these very supply chain companies. Likewise, the needed skilled workers work in competing industries such as offshore oil and gas.

Delays, both in terms of absolute costs and revenue foregone, significantly affect the project's viability. These also serve as a deterrent in the supply chain since lengthy delays can undermine confidence in the potential of the tidal energy industry (UK ERC, 2010, p.xii).

7.0.3.2 - LOWERING OF COSTS

Over time, however, as the technologies and processes improve with experience, costs will decline. As well, economies of scale will arise as the size of units and scale of deployment increase. Operating and maintenance procedures will become more efficient through learning and incremental changes.

Competition in the supply chain will affect costs. While the industry is small, there will be insufficient suppliers of services, materials, and components. Inefficiencies and bottlenecks in the supply chain or infrastructure may occur, driving up costs. However, as the industry gains momentum, companies serving other sectors will expand to serve the marine renewable energy industry and new companies will enter, resulting in greater supply, economies of scale, and competition, all of which should reduce prices.

DISCUSSION: LOWERING COSTS – THE US EXPERIENCE WITH ONSHORE WIND

"Considering plausible assumptions for not only capital cost and capacity factor, but also O&M, financing & availability, the LCOE for 2012-2013 [onshore wind] projects is estimated to be as much as ~24% and ~39% lower than the previous low in 2002-2003 in 8 m/s and 6 m/s (at 50 m) resource areas, respectively (with the PTC/MACRS); when only considering capital cost and capacity factor, the reduction is ~5% and ~26%" (Weiser et al., 2012, p.116).

Other key cost uncertainties are commodity prices and foreign exchange rates. Over time, project cost uncertainties due to foreign exchange rates will be lessened as more work is sourced locally. Also, planning and consenting processes will become more streamlined, reducing costs related to delays (UK ERC, 2010).

7.0.4 - ENERGY PRODUCTION AND REVENUES

The revenues from tidal energy depend on the output of the turbine(s), availability (up-time), energy losses in the electrical cable to shore, and the price paid for electricity. Energy yield depends on a number of factors:

- energy available in the resource (tidal current velocity),
- design of the mechanical components that extract the energy from the resource,
- the power takeoff system that converts mechanical energy to electricity (power output),
- the extent to which the device's capacity for extraction/conversion is matched to the available energy resource,
- the efficiency of the system's energy conversion, and
- the device's availability (Carbon Trust, 2005; Entec, 2006).

FOUNDATIONAL CONCEPT: ENERGY YIELD

Energy yield is the amount of energy generated by a turbine during a period of time, measured in MWh.

Availability, or the amount of time the device is operational, will affect energy production and revenues. Availability is generally summarized in a single percentage, such as 90% availability. Failure rates and service time will affect availability. Failure rates can be estimated only through modeling until devices have been in the water and observations made. Time to repair depends on the particular failure, availability of parts and expertise, and whether the repair can be made remotely or not. Also, there may be "knock-on effects of faults" that subsequently require repair. With many components, all with different failure rates, predicting reliability is very difficult (Entec, 2006).

Annual energy production is estimated from:

- device characteristics for a range of sea conditions;
- number of times each sea condition occurs in an average year, combined with performance characteristics to estimate gross energy output;
- likely losses while transmitting energy to shore; and
- sea conditions, system complexity, and repair procedures (Entec, 2006, p.8).

Foundational Concept: Average Annual Energy Production and Long Term Capacity Factor

$$\textit{Annual average energy production} = \frac{\textit{Total amount of electricity expected over the service life}}{\textit{Length of service life}}$$

$$\textit{Long term capacity factor} = \frac{\textit{Average annual energy production}}{(\textit{Rated capacity} \times \textit{number of hours in a year})}$$

The newer the technology, the more difficult it is to estimate the energy to be produced. At the earliest stage, device performance and its ability to convert the theoretically available resource into usable energy will be based upon data generated through small-scale tank testing, then scale and full-scale prototype devices in sea trials, and then deployment in multi-device arrays (EquiMar Work Package D7.2.1, 2009).

The price paid for electricity is another variable. The price paid for electricity over the life of the project can be highly variable and difficult to predict. This makes government support in the form of a feed-in tariff highly beneficial for developers and investors since it reduces the uncertainty of the project's cash flows.

IN NOVA SCOTIA: FEED-IN TARIFFS AND RATE OF RETURN

In Nova Scotia, community feed-in tariffs have been set. The rate is intended to reflect the costs of energy plus a return of 15% to investors of small scale (≤ 0.5 MW) developmental, community-invested tidal energy projects. For larger developmental projects (>0.5 MW), feed-in tariffs are pending.

Lower rates will be set later for demonstration projects beginning in 2014 or later that will reflect the learning gained and the development of the technologies. Once projects are ready for commercial licences, they will be expected to produce electricity at a cost competitive with other renewable sources.

7.1 - CALCULATING THE LEVELIZED COST OF ENERGY

In the energy industry, the levelized cost of energy (LCOE), or more simply stated, the cost of energy, is the metric used to evaluate a project's financial feasibility. The cost of energy is calculated using present value calculations. Typically, all the costs are forecasted and present valued, using the net present value method, but not the revenues (See Appendix 7-1: Net Present Value and Internal Rate of Return and Weighted Average Cost of Capital).

One method of estimating the cost of electricity is to calculate the present value of all costs (capital costs, operations, and maintenance) and then calculate the annuity (annual amount) that would yield the same present value. This is called the equivalent annual cost.

To calculate the levelized cost of electricity using this method, the equivalent annual cost (EAC) is divided by the expected average annual output in MWh.

$$LCOE = \frac{\textit{Equivalent annual cost}}{\textit{Estimated annual energy output in MWh}}$$

Where:

$$EAC = \frac{PV\ (Capital\ Costs - ITCs - CCA\ Tax\ Shield + \Delta Net\ Working\ Capital + Annual\ after\text{-}tax\ \ O\&M\ Costs)}{\left[\dfrac{1 - \dfrac{1}{(1+WACC)^n}}{WACC}\right]}$$

$$Estimated\ Annual\ Energy\ output\ (in\ MWh) = Rated\ Power \times Capacity\ Factor \times 8760\ hours\ per\ year$$

Present valuing the project costs is done by discounting at the project developer's cost of capital (WACC), a weighted average of the after-tax cost of debt and the required return by equity investors. The resulting amount is an estimated cost per MWh. Converted to cost per kWh (divide by 1000), it can be compared to the price the market will bear for electricity or the feed-in tariff, if available. If the price paid for electricity will be greater than the estimated cost per kWh, the project is considered financially acceptable to investors. If not, the differential is the amount the government needs to make up in order to encourage development.

Referring to the cost estimates in Table 7-1, the estimated cost of energy for the "Median" scenario is as follows:

$$LCOE_{Median} = \frac{(\$1{,}904{,}628)}{(1MW \times 0.4 \times 8760)} = \$683/MWh$$

This translates into a median estimated cost, assuming a 40% capacity factor, of $0.683 per kWh. Note: This is the estimate of a one-off test turbine, so it is comparatively expensive.

Discussion: Calculation of LCOE by Utilities

Utilities commonly calculate LCOE using a slightly different approach, in which lifetime costs are present valued and then divided by the present value of the estimated lifetime output of energy.

$$LCOE = \frac{\textit{PV (Capital Costs - ITCs - CCA Tax Shield + ΔNet Working Capital + Annual after-tax O\&M Costs)}}{\textit{PV Energy produced over life of project in MWh}}$$

The denominator is the present value of the expected lifetime energy to be generated. If the MWh generated are expected to be level over the years, the two methods presented in this module will yield the same result.

7.2 - COST OF CAPITAL

The discount rate used in the above calculations can dramatically affect the Net Present Value (NPV) and the levelized cost of energy, so estimating it needs careful consideration. The discount rate used should be the weighted average of the estimated costs of financing. In some cost of energy calculations, a proxy is used that is a ballpark estimate of investors' required rates of return reflecting their perception of the riskiness of the project (i.e. 8% for debt, 15% for equity, debt/equity ratio of 50/50). This is proxy only; a better discount rate to use is the weighted average cost of capital (WACC). Refer to Appendix 7-1 for how to calculate the WACC.

The rates required by lenders and investors will be influenced by the proponent's ability to raise capital and perceived ability to manage the project. A utility or other large organization will be able to raise capital based on its general creditworthiness and project management experience at lower rates than a newer, small technology developer. The cost of capital will also reflect the technology and other risks. Investors will insist on a higher premium for higher risk.

Capital is raised by the developer in a combination of debt and equity; the rates of return required by lenders and equity investors will differ, so the combination of debt and equity used to finance the project will affect the overall cost. Debt is less expensive than equity because lenders' exposure to risk is less and interest expense is tax deductible.

Different financing arrangements will dramatically change the cost of financing, hence the discount rate, and by extension, the present value of the cash flows and estimated viability of the project.

Photo Credit: Leigh Melanson

Table 7 1: Example of a 1MW Turbine CAPEX, OPEX, LCOE (testing stage)

Source: Fundy Energy Research Network (Engineering Challenges Subcommittee), Feb. 2012.

	LOW	HIGH	MEDIAN	% of CAPEX	Notes
A. Preliminary Engineering					
Site Selection	$ 50,000	$ 250,000	$ 150,000	1%	Use public info
Resource Assessment	400,000	1,000,000	700,000	5%	Macro then micro siting
Environmental Permitting	300,000	2,000,000	1,150,000	8%	Adaptive management principles
Device Selection	50,000	100,000	75,000	1%	
Land Control	0	2,000,000	1,000,000	7%	Subsea leasing not yet understood
Total Preliminary Engineering	$ 800,000	$ 5,350,000	$ 3,075,000	21%	
B. Procurement					
IP		$ 1,500,000	$ 1,500,000	10%	
Detailed Engineering	800,000	1,200,000	1,000,000	7%	Much higher than typical mature project
Turbine/Generator	400,000	1,000,000	700,000	5%	
Gravity Base	500,000	1,000,000	750,000	5%	
Instrumentation/Data Management	200,000	600,000	400,000	3%	Includes on board processing
Cabling-Power/Communication	1,000,000	3,000,000	2,000,000	13%	Single unit to shore - less if array
On shore	800,000	2,000,000	1,400,000	9%	Modest buildings, grid connection
Power Conversion/Power Quality	200,000	600,000	400,000	3%	DC to shore or AC clean up
Total Procurement	$ 3,900,000	$ 9,400,000	$ 6,650,000	45%	
C. Construction					
Deployment	$ 800,000	$ 2,000,000	$ 1,400,000	9%	Still risky - one tidal cycle
Subsea Cable	1,000,000	3,000,000	2,000,000	13%	Many unknowns in an energetic resource
On Shore Electrical	500,000	2,000,000	1,250,000	8%	Function of grid connection
Total Construction	$ 2,300,000	$ 7,000,000	$ 4,650,000	31%	
D. Overhauls					
Overhauls (every 4 years, 25 year life)	$ 3,257,494	$ 6,514,988	$ 4,886,241	33%	Concept is to remove, replace, overhaul. See table below.
E. Decommissioning					
Retrieve equipment, restore site	$ 60,338	$ 166,264	$ 113,301	1%	Real $, present valued at 12%
F. CCA Tax Shield (present valued @12%)	$ (2,362,522)	$ (6,510,036)	$ (4,436,279)		
Present Value Net Capital Expenditure	**$ 7,955,310**	**$ 21,921,216**	**$ 14,938,263**	100%	Does not account for investment tax credits
G. Annual Operation, Maintenance					
Environmental Monitoring/Reporting	$ 300,000	$ 1,000,000	$ 650,000		
Lease/Insurance/Compensation	$ 200,000	$ 600,000	$ 400,000		
General	$ 200,000		$ 200,000		Small staff
Annual Operation, Maintenance(before tax)	**$ 700,000**	**$ 1,600,000**	**$ 1,250,000**		
PV Operation, Maintenance (after tax)	**$ 3,843,138**	**$ 3,843,138**	**$ 5,490,197**		
Equivalent Annual Cost (CAPEX & OPEX)	**$ 1,504,302**	**$ 3,284,954**	**$ 1,904,628**		
Levelized Cost of Energy $/MWh					
Capacity factor 40%					
Annual MWh generated	3,504	3,504	$ 3,504		
Cost of Energy $/MWh	$ **429**	$ **937**	$ **683**		Equivalent annual cost/estimated annual energy output Equivalent Annual Cost/(1 MW X 8760 hrs X c.f)
Capacity factor 60%					
Annual MWh generated	5,256	5,256	$ 5,256		
Cost of Energy $/MWh	$ **286**	$ **625**	$ **456**		

X. Other assumptions, input variables

Life		
TISEC	20 to 30 yrs	
Subsea Cable	25 to 40 yrs	
On shore	40 to 70 yrs	
Capacity Factor	35 to 65%	Fixed blades vs. pitching
Cost of capital (nominal):	15%	
Cost of capital (real)	12%	
CCA rate, declining balance	50%	
Corporate tax rate	30%	(Approx. combined federal & provincial)
Assumed economic life for calcuations	25	

Overhauls (4 year freq.)		LOW	HIGH	MEAN
Cost per overhaul (real dollars)		2,000,000	4,000,000	3,000,000
PV @ 12%	Year			
	4	1,271,036	2,542,072	1,906,554
	8	807,766	1,615,533	1,211,650
	12	513,350	1,026,700	770,025
	16	326,243	652,487	489,365
	20	207,334	414,667	311,000
	24	131,764	263,528	197,646
		3,257,494	6,514,988	4,886,241

*Capacity factor is energy produced in a time period divided by the energy produced if operated at nameplate (rated power) times 100%.

Appendix 7-1: Net Present Value, Internal Rate of Return, and Weighted Average Cost of Capital

NET PRESENT VALUE AND INTERNAL RATE OF RETURN

The typical approach for evaluating capital investments is to calculate either the Net Present Value (NPV) or the Internal Rate of Return (IRR). To calculate the NPV, all revenues and costs are estimated for the life of the project. These are all present valued to time zero (the start date of the project), discounted by the company's cost of capital or required rate of return. The present value of the expected capital costs and operating expenses are subtracted from the present value of expected revenues. If the NPV > 0, the project is expected to be profitable, based on forecasted numbers and probabilities, over and above the financing costs.

$$Net\ Present\ Value = \sum_{i=0}^{n} \frac{CF_i}{(1 + WACC)^i}$$

The internal rate of return is related to the NPV. Rather than discounting the cash flows at the weighted average cost of capital (WACC) to solve for the NPV, the NPV is assumed to be $0 (the breakeven scenario). The discount rate that equates the present value of inflows with outflows, so that the NPV will be $0, is the internal rate of return. If the IRR>WACC, the project is expected to be profitable, again based on forecasted numbers.

$$\$0 = \sum_{i=0}^{n} \frac{CF_i}{(1 + IRR)^i}$$

WEIGHTED AVERAGE COST OF CAPITAL

A company's cost of capital is a function of the returns required by lenders and equity investors, the tax deductibility of interest expense, and the proportions of debt and equity in the capital structure.

$$WACC = w_d r_d (1-t) + w_e r_e$$

Where: w_d is the proportion of the company's capital structure that comes from debt financing and w_e is the proportion from equity, r_d is the interest on the debt, r_e is the required rate of return by equity investors. The company's tax rate is represented by t.

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Photo Credit: Greg Trowse

C | OPPORTUNITIES PRESENTED BY IN-STREAM TIDAL POWER AND HOW COMMUNITIES AND BUSINESSES CAN TAKE HOLD OF THEM

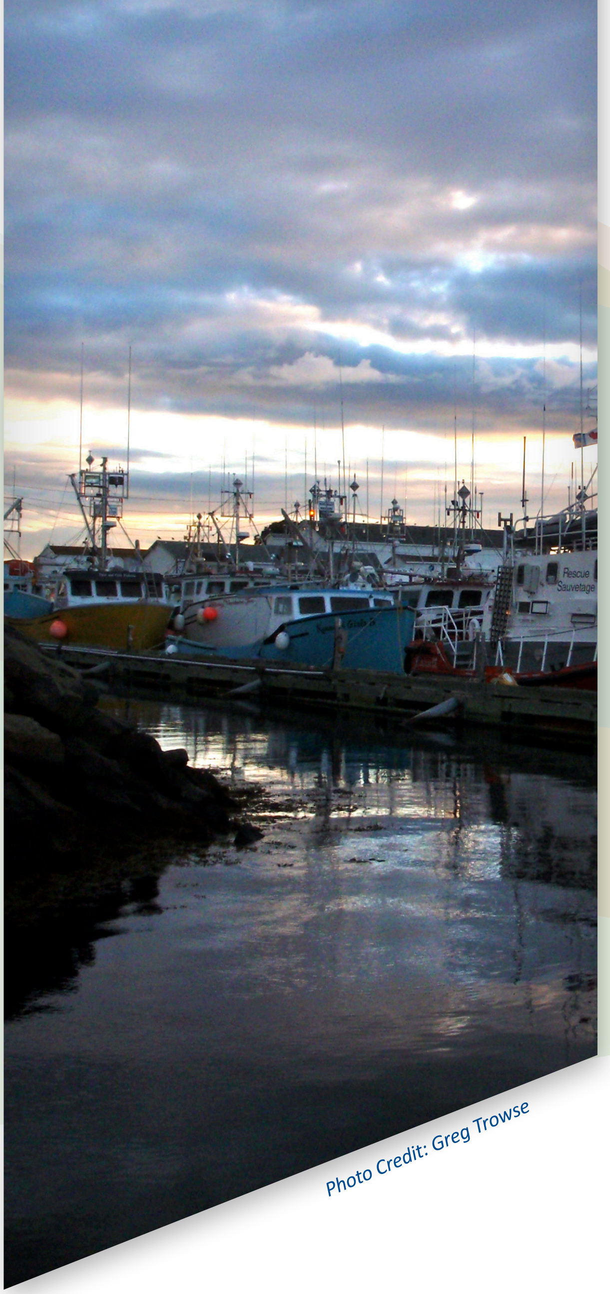

Photo Credit: Greg Trowse

8 OPPORTUNITIES AND STRATEGIES FOR COMMUNITIES

A tidal energy project can create demand for labour in multiple economic sectors and can draw on individuals and businesses from across the province.

8 - OPPORTUNITIES AND STRATEGIES FOR COMMUNITIES

WHAT DOES THIS MODULE COVER?

Tidal energy represents a unique opportunity for communities across Nova Scotia. Tidal energy development will create jobs, support research, and provide cleaner energy. Understanding the opportunities and challenges of tidal energy can support community buy-in and help communities make informed choices. This module will provide information on:

- community benefits and the types of opportunities and challenges associated with tidal energy development,
- strategies for development that harness local assets and support capacity building, and
- tidal development ownership types and their pros and cons.

The purpose of this module is to outline some of the social, economic, and other benefits that can come from the development of both small (COMFIT eligible) and large scale (FIT eligible) tidal energy development. Each community, tidal energy site, and project is unique and the challenges and potential benefits will be different in each context. The tidal energy industry is still in its infancy and there are few projects in the water. Therefore, examples and parallels from other renewable energy industries (onshore and offshore wind and other marine renewables) are used to illustrate what benefits could come from tidal energy development in Nova Scotia.

IS THIS MODULE FOR YOU?

This module is for anyone who is interested in the potential benefits of tidal energy development. It is also for anyone interested in how to strategically plan for these types of benefits and how to do so with respect to local assets and capacities.

This module includes:

- a list of tools and organizations that can assist communities in researching, planning, and understanding tidal energy projects;
- a review of ownership types and their pros and cons; and
- a community Q and A checklist to assist communities in exploring tidal energy development.

MODULE ORGANIZATION

This module is broken into two main sections. Section 1 of this module discusses, in general terms, the potential benefits to communities and local businesses from small and commercial scale tidal energy development.
Section 2 discusses community development strategies for harnessing benefits associated with tidal energy development. This discussion highlights the shift toward community/stakeholder engagement and harnessing the collective assets of the stakeholders to engage and support development projects.

8.0 - SECTION 1: SOCIAL AND ECONOMIC IMPACTS FROM SUSTAINABLE TIDAL ENERGY DEVELOPMENT

Author: Alan Howell

A tidal energy project requires a wide range of inputs. While each project may be different in size, technology, and site characteristics, each will likely include much of the following stages, infrastructure, vessels, and labour (For a more detailed account of development stages, infrastructure, vessels, and labour needs, see *Module 9: Opportunities and Strategies for Businesses*).

Table 8-1: Development Stages, Infrastructure, and Labour Needs for a Tidal Energy Project

STAGES OF DEVELOPMENT	INFRASTRUCTURE AND VESSELS	LABOUR NEEDS
The primary stages of a tidal energy convertor project include: • Research and development • Site screening and project feasibility • Planning • Project design and development • Project fabrication • Construction, installation, and commissioning • Operations and maintenance • Decommissioning	Infrastructure and vessels can include: • Wet and dry ports with lay down areas • Assembly and maintenance yards • Cranes and heavy lifting equipment • Barges and specialized vessels, such as dynamic positioning vessels • Underwater Remote Operated Vehicles (ROV's)	Labour needs will include many of the following: • Project managers • Engineers (naval, electrical, mechanical) • Biologists, environmental impact assessment professionals, and various other specialists in marine and life sciences • Vessel operators • Marine construction workers • Safety personnel • Core trades – welders, electricians, metal fabricators, tool and die, etc. • Stakeholder engagement facilitators • Financing and business development experts

A tidal energy project can create demand for labour in multiple economic sectors and can draw on individuals and businesses from across the province. The intent of current provincial legislation and policy, in particular the COMFIT program, is to support tidal and other renewable energy developments from which benefits remain in communities across Nova Scotia. See *Module 4: The Regulatory Regime for Tidal Energy* for more information on current tidal energy legislation and policy.

Tidal energy is still a developing technology. There remain many unknowns about the environmental and economic impacts, therefore, tidal energy should be pursued in a thoughtful and incremental manner. This toolkit and this module are a step along the path to a better understanding of the positive and negative impacts of tidal energy development from a community perspective.

FOUNDATIONAL CONCEPT: WHAT IS A COMMUNITY?

Communities are typically defined in two main ways: a) a geographical community defined by jurisdictional boundaries, such as a municipality, or b) a community of interest, such as fishers, trail users, or conservation advocates (Walker & Devine-Wright, 2008).

In the case of tidal energy development, there are many intersecting interests and stakeholders (for more detail on stakeholders, see Module 6 on Community Engagement). In general, anyone who lives in a geographical community should be considered a stakeholder. Communities of interest, on the other hand, may not be local and it may be difficult to identify members. Examples of communities of interest are:

- Commercial, subsistence, and sport fishers
- First Nations members and communities
- Tourism and boating
- Marine transport
- Environment and conservation advocates
- Business and business development.

8.1 - COMMUNITY BENEFITS

In this toolkit, community benefits are defined as any changes in the status quo that result in the positive enhancement or capacity for enhancement of the economic, social, or environmental state of a community, area, or region.

Often in economic analyses, the impact or effect of a project is measured in terms of how many jobs are created directly (e.g. direct spending on a project) and indirectly (e.g. a need for added labour due to demand for services and products to support a project).

Benefits are different from economic impacts or effects in a few fundamental ways; however, direct impacts can be considered a benefit.

- Benefits are typically understood as being direct, i.e. the benefit is received by an identifiable person, community, or organization. The one exception would be environmental benefits, such as reductions in GHG emissions, which will support healthier biota, air, water, and soil locally, regionally, and internationally. Environmental benefits in a marine context tend to be more dispersed than social or economic benefits, and as such, are not discussed in depth in this module.

- Benefits are usually negotiated with a project developer or form a part of a development agreement (a legally binding agreement between a developer and an administrative authority). Businesses that support tidal energy (e.g. fabricators, maintenance facilities) may be willing to discuss community benefits.

- Benefits can be in the form of cash, assets (such as buildings, art work, or land), or experiences (education, research, or knowledge and skill building activities).

- Benefits are largely defined by the legislation and development culture of an area. For example, in the United Kingdom, the provision of community benefits (payments, assets, and/or experiences) is well developed and has a place in development legislation. In Nova Scotia, community benefits are allowed to be part of development agreements; however, it is uncommon and often only in situations where a developer is asking for exceptions to regulations and standards.

Table 8-2 outlines a selection of community benefits that have been identified as outcomes of renewable energy projects. The identified benefits focus on the social and economic benefits associated with projects.

Table 8-2: Categories of Community Benefits

CATEGORIES OF COMMUNITY BENEFITS[1]
1) Conventional economic benefits • The use of local labour, goods, and services • Land rents and royalties • Local business taxes
2) Flows of financial benefits • Profit share (for employees of the energy company) or equity investment (for investors in an energy company) • Community fund contributions – annual or lump sum • Sponsorship of local events • Direct income from sale of power (i.e. a price paid per kWh)
3) Contributions in kind • Landscape or ecological enhancements • Facility upgrades or construction • Infrastructure upgrading or construction • Sharing data on natural and human environments
4) Provision of local services • Educational visits or educational programs • Tourism services
5) Capacity building • Increased experience in development for local administration and elected officials • Knowledge gathered from public consultation/collaboration process

8.1.1 - WHAT WE KNOW ABOUT COMMUNITY BASED ENERGY

Communities need to weigh the pros and cons of tidal energy development to be sure investing in tidal energy is the best course of action for them. There is limited understanding of the short- and long-term impacts associated with tidal energy projects. While a great deal of research is being conducted on the impact of TECs on ecosystems, mammals, and the tides themselves, few economic and social impact studies exist. However, there are insights that can be drawn from other renewable sources such as onshore and offshore wind.

- For areas with limited industrial activity or those that have seen a downturn in traditional industries, such as fishing, forestry, or mining, renewable energy provides an opportunity to capitalize on skills and resources present (marine navigation and safety, marine equipment repair and fabrication, and use of vessels and port facilities in the case of tidal energy) (Joseph & Gunton, 2008; Boettcher, Nielsen & Petrick, 2008).

- Community-based energy can provide a reliable source of revenue based on level of production (especially in the case of tidal energy). The initial capital outlay may be high, but over time, with a secure price for energy, costs can be recovered (TREC, 2012; Joseph & Gunton, 2008).

[1]Adapted from (Munday, Bristow and Cowell, 2011).

There is limited understanding of the short and long-term impacts associated with tidal energy projects.

- Energy projects that are supported by the community tend to be the most successful in delivering benefits (Munday, Bristow and Cowell, 2011; Brun & Jolley, 2011; Walker & Devine-Wright, 2008).

- Community-based renewable energy projects can raise awareness about other energy related issues, in particular efficiency and conservation. Renewable energy projects can create momentum for additional energy programs and support a culture of conservation and energy efficiency.

FOUNDATIONAL CONCEPT: DIRECT, INDIRECT, AND INDUCED ECONOMIC IMPACTS

Direct economic impacts of renewable energy initiatives come from on-site or immediate effects created by an investment or change in final demand for affected sectors. For example, the direct effects of a tidal project can be increases in the:

- sales of tidal turbines,
- income of local turbine manufacturers, and
- jobs of workers who assemble the tidal turbines at the manufacturing plant.

Indirect economic impacts result from changing demands for those sectors that help produce the technologies. For example, an increase in production of turbines can expand:

- sales of steel to supply the turbine manufacturers,
- income of supplier companies, and
- jobs of workers in companies that supply materials to the turbine assemblers.

Induced economic impacts occur when the income generated from the direct and indirect effects is re-spent in the local economy.

For example, induced benefits could include increases in:

- sales of groceries in the towns where turbine assembly workers live,
- income of local businesses in the towns where turbine assembly workers live and spend their money, and
- jobs for workers at the local grocery store because employees of turbine assemblers used their increased wages to buy groceries.

Source: United States Environmental Protection Agency, Quantifying Economic Benefits, para. 1, http://epa.gov/statelocalclimate/state/activities/quantifying-econ.html

8.2 - WHAT ARE THE POSSIBLE BENEFITS TO THE COMMUNITY?

The following section provides examples of benefits and when they could occur in the project development cycle. The benefits highlighted in this section are drawn from examples in Nova Scotia and other jurisdictions. Benefits described here represent potential rather than guaranteed outcomes. A TEC project will have unique impacts and yield different benefits, depending on whether the project is a small community-based or a large industrial-scale project. (For a more in-depth investigation of economic impact by sector, see *Module 11: Assessing the Potential Economic Impacts of a Five Megawatt Tidal Energy Development in the Digby Area of the Bay of Fundy)*. The benefits that accrue through a particular project or to a particular community are largely determined by a variety of internal and external factors.

Internal factors include:

- Local availability of skills and workers;
- Demography;
- Geography;
- Resource intensity;
- Land availability, in particular, industrial land;
- Local commercial and industrial land taxation rates;
- Economic mix, in particular, the level and type of activity related to coastal and marine industries;
- Availability of manufacturing facilities;
- Port infrastructure and availability of marine vessels;
- Political and administrative capacity;
- User conflicts such as subsistence and commercial fishing, shipping, or ferry services.

External factors include:

- Political stability and legislation around marine renewable energy;
- The established market price for renewable energy;
- Stability of energy project developers;
- Any new policy or legislation dealing with the pricing of negative externalities from energy production (e.g. a carbon tax).

8.2.1 - DISCUSSION OF SOCIAL BENEFITS

Knowledge of the social benefits of tidal energy is relatively limited at this point, compared to the economic and environmental benefits. This is due in large part to the small number of projects at this time. Social benefits largely stem from the possible increase in energy security and the long term stability of the price of energy. There is also the effect of reduced emissions and particulates from fossil fuel based energy, which has downstream benefits for health and wellbeing.

VIGNETTE: FEED IN TARIFF IN ONTARIO

Community-based energy production is growing in Canada. Currently, Prince Edward Island, Ontario, and Nova Scotia have Feed-in-Tariff programs for renewable energy. Ontario established a feed-in tariff program in 2009 to support the development of large and community-based renewable energy and to offset the use of coal fired power plants in the province. Similar to the COMFIT program in Nova Scotia, the FIT program in Ontario offered premium prices for specific types of renewable energy, with solar receiving the highest price for production. After two years, the FIT program in Ontario saw positive results.

- The government approved more than 2,500 small and large FIT projects that will produce enough electricity to power 1.2 million homes.
- The program attracted more than $27 billion in private sector investment.
- The program attracted more than 30 clean energy companies.
- The program created more than 20,000 jobs.

Source: Feed-In Tariff Program Two-Year Review – Government of Ontario http://www.energy.gov.on.ca/en/fit-and-microfit-program/2-year-fit-review/

Table 8-3: Potential Social Benefits of TEC Project Activities

POTENTIAL SOCIAL BENEFITS OF TEC PROJECT ACTIVITIES		
	OPPORTUNITIES	**CHALLENGES**
Involvement of local officials and citizens in the planning process	The development of a renewable energy project provides the opportunity for local officials and citizens to gain valuable experience in project planning and stakeholder engagement. Being involved in a project can lead to the development of skills like facilitating community meetings or negotiating contracts. It also provides an opportunity to collect information about citizen attitudes on other issues in the community.	Time restrictions due to work, seasonal labour, and having multiple responsibilities may limit involvement.

POTENTIAL SOCIAL BENEFITS OF TEC PROJECT ACTIVITIES		
	OPPORTUNITIES	CHALLENGES
Local facility or amenity improvements	Many smaller communities have limited capital to develop new amenities or improve existing ones such as recreation facilities. These types of amenities can serve as gathering places and add to the quality of life in a community. The cost of these amenities can be negotiated with the developer or through revenue from the community-owned project.	The first tidal energy developments will be expensive and project developers may not have funds to improve local facilities. Policy changes may reduce the tariff price for tidal energy.
Development of trails and access roads for the development	Depending on the project, access roads and similar infrastructure may need to be built. This can present an opportunity to increase access to natural areas or expand an existing trail network. However, if this is a goal, it should be articulated and incorporated into the project planning process at the outset.	Access roads may not be required for many projects, may be unsuitable for recreational use, or may not be in areas slated for residential, commercial, institutional, recreational, or industrial development.
Employment opportunities for new entrants or displaced workers	Projects will support a variety of jobs – the amount, type, length, and location of those jobs is defined by the project specifics. Increased employment opportunities can stem out-migration and support a more stable community.	Employment opportunities are largely contingent on the project and the local labour market.
Increased community capacity and broader discussion of socio-economic issues	Developing community capacity refers to the ability for communities to organize and move towards attaining desired goals such as increasing economic diversity or conservation of habitat. Training and workshops can provide skills and increase the human resource capacity of communities as a whole (Pembina Institute and Ecology Action Centre, 2011). Any stakeholder engagement activity has the potential to spur further discussion and strengthen connections within a community. However, some issues can be divisive, so a careful and well planned community engagement strategy with well-trained facilitators is essential.	Time restrictions due to work, seasonal labour, and having multiple responsibilities (work/home/volunteering) may limit citizen involvement.

8.2.2 - DISCUSSION OF ECONOMIC BENEFITS

Table 8-4 describes a variety of potential economic benefits from the development of tidal energy. As an industry still in development, tidal energy is not currently ready to support a robust supply chain. The ability of a community to garner economic benefits will depend on whether it has the necessary infrastructure, workforce, contractors, and experience for managing a tidal energy development project or power plant (Dalton & Ó Gallachóir, 2010). Many rural areas may not have the mix or scale of economic activity to provide 100% local content for a project. Generic services such as surveying or tradespeople (e.g. electricians), could meet some short and long term demand locally, such as project monitoring and minor maintenance. The benefit of not having all needed skills in one place means adjoining communities could fill in gaps. Consequently, tidal energy project spending becomes regional, rather than just local, thus spreading the economic benefits widely.

Table 8-4: Potential Economic Benefits of TEC Development

POTENTIAL ECONOMIC BENEFITS OF TEC DEVELOPMENT		
	OPPORTUNITIES	CHALLENGES
Direct employment; use of local content and contractors	The hiring of local residents or purchasing of locally produced goods for a tidal energy project is a significant opportunity. The inputs for a project will require highly technical to low-skilled labour. This provides opportunity for a broad range of employment opportunities.	The amount of labour and inputs sourced locally will depend upon the industrial and labour market characteristics of the area and the project itself. In some cases, a project will only require a limited amount of local goods or services. There are currently no local content rules for tidal energy development in Nova Scotia.
Land rental or lease fees	The rental or lease of land or office space may be required during the project planning, construction, operations, and decommissioning phases of a TEC project.	Rentals and/or leases may be contingent on the context and type of project.
Indirect employment opportunities	An influx of workers into a community will create demand for services indirectly related to the project such as lodgings, food, and other services.	This impact will likely only be significant during the construction and decommissioning phases of a project as this is when the most labour is required on site.

POTENTIAL ECONOMIC BENEFITS OF TEC DEVELOPMENT		
	OPPORTUNITIES	CHALLENGES
Potential for offseason employment for seasonal workers, including skills to assist in transitioning from traditional to newer marine industries	TEC site evaluations, data collection, deployment, safety, and monitoring activities can support additional employment for fishers, hunters, and other seasonal workers or income through the rental of vessels or other marine and coastal equipment and sites. Additionally, involvement in these activities can support the development of a broader skills base in rural and coastal communities; for example, data collection and monitoring.	The size and scale of a project will define the needs for additional staff. Smaller scale projects will likely have fewer requirements for activities like monitoring. Those hired to assist with project activities may only be required to be on hand in case of emergency and, consequently, will have limited opportunity to develop new skills.
Development of education and training programs	As the tidal energy industry grows, it will require a variety of skills and competencies at all levels. This can support the expansion of current programs or the creation of new ones in universities and community colleges to support the demand of the industry.	It is difficult to ensure that training is available ahead of labour demand, at a level that meets the industry's skills needs, and that supplies enough graduates. Industry and developers will need to work closely with training institutions.
Additional revenue or payment to the community	Community-owned projects can provide-- given limited downtime of TEC devices-- a consistent stream of revenue from the sale of energy.	High project costs, debt payments, and unforeseen technology failures or damages may a) increase the time before a project generates profit or b) limit the amount of energy sold.
Tourism opportunities	The tidal barrage interpretive centre in Annapolis Royal, Nova Scotia is a tourist attraction. Wind energy projects elsewhere have also been shown to draw tourists to an area.	TEC projects are, for the most part, entirely underwater and out of view. Consequently, they provide little in the way of an attraction. The building of an interpretation centre around TEC projects may not be affordable for some projects.
Long term stability of energy prices	Investment in renewable energies is costly. However, because the fuel for renewable energy such as tidal is free, it may be less costly than relying on fossil fuels over the long term.	Stability is contingent on continued political will to provide renewable energy projects access to markets.

POTENTIAL ECONOMIC BENEFITS OF TEC DEVELOPMENT		
	OPPORTUNITIES	CHALLENGES
Research and Development opportunities	The processes and technology needed for all stages of TEC projects still require extensive research. There is a need for research facilities and marine areas to test out new processes and technologies. This presents an opportunity for communities to capture some of the research and development funds associated with the industry either directly through employment opportunities or through providing services to researchers such as office space, accommodations, and food.	Companies and university researchers may opt to not take research out into communities and instead, do all, or most, of the work in-house. The most expensive research occurs around device testing and the Fundy Ocean Research Centre for Energy is expected to be the only large-scale testing site for TEC devices in Nova Scotia. A site for small scale testing is yet to be established; however, the area of Brier Island has been proposed. This limits the opportunity for TEC technology testing; however, other types of research opportunities may be available.

8.2.3 - DISCUSSION OF ENVIRONMENTAL BENEFITS

The environmental benefits of tidal energy development are not often discussed at the project level because the focus in the environmental literature has been on mitigating negative impacts. Projects are often presented in terms of how they will mitigate negative outcomes, if any, rather than in terms of their environmental benefits. The near and far field effects of TEC on the marine and coastal environment are largely unknown; therefore, benefits must be weighed against any negative impacts on the natural environment caused by TEC development.

There are some well accepted environmental benefits of renewable energy. The reduction of emissions from fossil fuel combustion supports cleaner air, water, and soil. Renewables also support reduced use of fresh water used in electricity production. [1]

[1] Water is used in conventional and renewable energy production systems. Per kWh, 0.2 – 0.6 gallons of water are used depending on the technology employed. Between 3.5 – 61 gallons are used to create one litre of ethanol (Synder & Kaiser, 2009). Oil sands extraction uses between 2 to 4 barrels of fresh water for one barrel of bitumen (Pembina Institute, Oils Sands Watch, Water Impacts, para. 2).

Table 8-5: Potential Environmental Benefits of TEC Development

POTENTIAL ENVIRONMENTAL BENEFITS OF TEC DEVELOPMENT		
	OPPORTUNITIES	CHALLENGES
Detailed information on local biotic and abiotic marine and coastal systems	All projects will require some documentation of the physical and ecological systems in the project area. The larger the project and the expected impact, the more detailed the information. This information, if made available to the public, can provide invaluable information for communities to support conser-vation, education, tourism, and research opportunities.	The level of information collected is contingent on the project and the ability of the team collecting it. Access to summary information versus raw data may vary.
Hiding and resting space for marine life	Establishing fishing exclusion zones around converters may help increase the amount of shelter for marine life. Such zones could possibly increase habitat for certain benthic species.	Creating exclusion zones may be more applicable to offshore wind, but tidal arrays may offer this op-portunity.
Increased stewardship of coastal and marine areas	The attention drawn to coastal and marine areas by tidal energy may encourage greater appreciation and interest in these environments and associated biota.	Attention may create backlash to development.
Potential for coastal defence	Taking some energy or slowing the velocity of water as it reaches shore may provide erosion protection to some coastal areas.	This is speculative and is very con-tingent on the site and project.

8.2.4 - RESOURCES FOR UNDERSTANDING AND ESTIMATING ECONOMIC AND SOCIAL IMPACTS OF TIDAL ENERGY DEVELOPMENT

The following is a selection of tools and information to better understand the economic and social impacts of tidal energy.

Nova Scotia Department of Energy - ***COMFIT Tool Kit***
The COMFIT Tool Kit consists of materials designed for eligible entities to educate individuals, groups, and communities about the Nova Scotia Community Feed-In Tariff (COMFIT) Program. It also contains a high level discussion of what community benefits could come from renewable energy development.
http://nsrenewables.ca/comfit-tool-kit

Department of Natural Resources – ***RETScreen International***
RETScreen is Excel-based clean energy project analysis software tools, that helps decision makers quickly and inexpensively determine the technical and financial viability of potential renewable energy, energy efficiency, and cogeneration projects. The Department of Natural Resources also provides a suite of training materials to help new users learn how to use RETScreen effectively and has recently developed a policy development toolkit to compliment the RETScreen application.
http://www.retscreen.net/ang/home.php

TREC Renewable Energy Co-operative – ***Community Power Toolkit***
TREC is creating a series of free tools that address various aspects of project development. Each tool contains key information about topics like Member Management in a Renewable Energy Co-op and Community-Corporate Partnerships. The toolkit is based on Ontario legislation, but much of the key information is transferable to Nova Scotia.
http://www.trec.on.ca/services-resources/toolkit

United States Environmental Protection Agency – ***Quantifying Economic Benefits***
This page provides links to a variety of free and fee-for-service models that estimate the cost, return on investment, job creation potential, and overall economic impact of renewable energy projects and investments.
http://epa.gov/statelocalclimate/state/activities/quantifying-econ.html#a04

Fundy Energy Research Network - ***Scoping Study on Socio-Economic Impacts of Tidal Energy Development in Nova Scotia: A Research Synthesis & Priorities for Future Action***
The scoping study highlights many of the socio-economic issues related to tidal energy development and discusses best practices, case studies, and tools that have been developed to facilitate positive socio-economic benefits and community development. The report provides an overview of research and best practices developed in Canada and abroad in relation to tidal energy developments and other renewable energy technologies.
http://fern.acadiau.ca/custom/fern/document_archive/repository/documents/139.pdf

Chris Joseph & Dr. Thomas Gunton. Overview of the Socio-economic Impacts of Renewable Ocean Energy Development on the BC Coast. (2008) Prepared for the Department of Fisheries and Oceans.
Details available at: http://waves-vagues.dfo-mpo.gc.ca/waves-vagues/search-recherche/display-afficher/332868

The Department of Fisheries and Oceans has commissioned this report to:

- review the socio-economic impacts of renewable ocean energy development and the mitigation measures that can be used to address these impacts;
- identify key knowledge gaps;
- describe the scale of ROE resources of the BC coast;
- describe the extent of planned ROE development on the BC coast;
- scope potential socio-economic impacts of ROE development on the coastal communities and First Nations of the BC coast;
- identify ROE industry best practices; and
- describe the institutional structure and approvals process for ROE on the BC coast.

8.3 - SECTION 2: STRATEGIES FOR COMMUNITIES AND BUSINESSES TO GARNER SOCIO-ECONOMIC BENEFITS

Author: Dr. John Colton

Nova Scotia and other Atlantic provinces have a pool of knowledge, infrastructure, and services related to ocean and marine technology and industry. Collectively, this combination of knowledge, infrastructure, and services have been used to develop a state-of-the-art commercial fishery, ship building enterprises, oil and gas development, and barge hauling services. Local, regional, provincial, and federal governments have invested significant resources into exploring how the skills associated with these types of industries can be used in other industrial sectors. This is important, as communities are looking for strategies to become more resilient to weather the changes brought about by economic uncertainty and the booms and busts associated with certain industries.

Exploring a community's infrastructure, skills and knowledge of its citizens, and its services and amenities and understanding how these can collectively contribute to and support tidal energy development may provide for greater community resiliency.

This section provides strategies and information for communities, along with their local governments, to take up the potential opportunities provided by tidal energy. It also profiles various ownership models, each of which provides different benefits to the community.

8.3.1 - COMMUNITY STRATEGIES

Strategies for community development have evolved from a traditional top-down approach to a grass-roots approach. Inherent in this shift has been the role of the citizen and the focus of development. Rather than development driven primarily by economic considerations, development is focussed on supporting people and building communities (that can still include economic development). Citizens and other stakeholders in this new model of development become active agents in shaping their communities through harnessing local assets found in community capital.

Traditional economic development models have focussed on job creation and creating greater economic diversity to stimulate economic growth in regions. Increasingly, this development approach is being replaced by a more holistic approach that focuses on socio-economic growth. This approach to development moves beyond job creation by broadening its focus to community development. With this approach, the community is examined through another lens: that of community capital. Researchers have identified a variety of types of community capital: natural capital, physical capital, economic capital, human capital, social capital, and cultural capital. Examples of these capitals are noted in Table 8-6.

Exploring a community's infrastructure, skills and knowledge of its citizens, and its services and amenities and understanding how these can collectively contribute to and support tidal energy development may provide for greater community resiliency.

FOUNDATIONAL CONCEPT: RESILIENCY

Resiliency is "the capacity for humans to change their behaviours, economic relationships, and social institutions such that economic vitality is maintained and social stresses are minimized" (Quigley et al., 1996:35).

Table 8-6: Types of Capital

Natural capital	Physical capital	Economic capital
• Land • Soil • Groundwater • Surface water • Air • Minerals and Non-renewable Resources	• Infrastructure • Land • Transportation • Housing and Living Conditions • Public Facilities	• Labour • Job Creation • Financial Resources • Economic Structure • Economic Diversity
Human capital	**Social capital**	**Cultural capital**
• Education • Health and Well-being	• Citizenship • Safety • Social Networks	• Cultural Heritage • Identity and Diversity • Community Pride

Source: Based on Centre for Sustainable Community Development (2012) http://www.ccscan-ca.cscd.sfu.ca/stocks/

8.3.2 - SOCIAL CAPITAL

Social capital has received the most attention, as it is the social networks, relationships among stakeholders (i.e. trust, norms, shared values), and the level of citizenship that support the other types of community capital. Unlike the other forms of community capital, social capital cannot be observed on its own, but only in the interactions between individuals and among groups. As such, social capital does not simply exist, as a building or lake does, but requires action to establish and maintain it. The social networks that comprise social capital allow for groups to access resources and support, and to problem-solve. Activities within a community that help create feelings of tolerance, altruism, trust, and security can help to build social capital within a community. Conversely, situations that promote intolerance, greed, distrust, and fear will degrade social relations that promote community capital (Callaghan & Colton, 2008).

TOOL: COMMUNITY CAPITAL SCAN

The Community Capital Scan (CCS) is an Internet-based instrument developed by the Center for Sustainable Community Development of Simon Fraser University (Vancouver, Canada) and Telos, the Brabant Center for Sustainable Development of Tilburg University (Netherlands). The CCS offers the opportunity to gain advance insight into how projects or programmes are expected to contribute to the sustainable development of a community. This insight is obtained by asking all the relevant stakeholders involved in a project or programme to give their opinion of it by means of a structured questionnaire. The questions relate to the six capitals of sustainable community development: natural capital, physical capital, economic capital, social capital, human capital, and cultural capital. To facilitate interpretation, the outcomes are presented graphically. In addition, the scan offers an opportunity to make a wide range of suggestions for improvements to the project. There is also the option to fill in the CCS scan individually.

See: Community Capital Scan http://www.ccscan-ca.cscd.sfu.ca/ccs/

Tidal energy projects can support community capital by considering how the project can support and enhance other types of capital in the community, in addition to economic capital. Questions that can be considered include:

- In what ways can the community engagement process be leveraged to create ongoing community dialogue around other important community development issues?
- How can tidal energy development be approached in a way that enhances pride in community?
- How can tidal energy development support community health and wellness?
- How can tidal energy development enhance community capacity?
- How can tidal energy development be leveaged into other socioeconomic development opportunities?
- How can tidal energy development support/contribute to other community infrastructure?

Being thoughtful and deliberate is essential in contributing to community capital in the development approach. In planning a tidal energy project, these and other questions should be raised. There should be deliberate attempts to enhance community capital, as opposed to it being an unplanned by-product of a development process.

A critical component of working to increase community capital is by building community capacity. **Asset-Based Community Development (ABCD)** is a model for strengthening community capacity by focussing on the powers of local organizations and associations, the supportive functions of local government and non-government institutions, and the skills and knowledge of local residents and other stakeholders. ABCD has become a popular approach to development as it has reshaped how development occurs. Rather than approaching development based on the end goals of the community (e.g., jobs), it focuses on community/individual assets within a community (what currently exists) and how these might be used and simultaneously strengthened through an asset-based approach to development.

There are six important categories of assets within any community:

1. Assets of individuals,
2. Assets of associations,
3. Assets of institutions,
4. Economic linkages and business assets,
5. Natural resource assets,
6. Previous processes and plans for community and economic development.

For more information see: The Asset-Based Community Development Institute http://www.abcdinstitute.org/.

Tidal energy developers can benefit from using an ABCD approach by better understanding other assets in the community other than tidal assets (i.e., natural assets). For example, local people involved in commercial fisheries will have local knowledge of tides, fish, and marine mammals. They may have boats that may be able to service aspects of the tidal energy development activities.

VIGNETTE: TEAM TIDAL DIGBY

The Municipality of the District of Digby, in partnership with the Town of Digby and the Annapolis-Digby Economic Development Agency, have developed an economic development team called Team Tidal Digby. Team Tidal Digby is focussed on bringing tidal energy-related development to the Port of Digby and the local area. Team Tidal Digby is working to make the Town of Digby the port of choice for tidal energy developers in the Bay of Fundy. Recent promotional activities have had a high impact in terms of media coverage and in raising awareness of the Port of Digby's infrastructure and related amenities. Attendance at key tidal energy stakeholder symposiums, road shows to promote the Port of Digby, and well developed promotional material, including a brochure, have positioned the Town of Digby and the Port of Digby as a place to do business.

Underlying this strategy is an understanding of the needs of the tidal energy industry. Also, there is recognition the Port of Digby is well positioned geographically to deliver services to the tidal energy industry. Key capabilities at the Port of Digby that Team Tidal Digby promotes are fabrication, maintenance, repair and overhaul, testing, and deployment.

8.3.3 - COMMUNITY ASSET-MAPPING

Asset mapping has grown in popularity and is now seen as a critical tool in community and regional economic development. Used as a tool, it can provide the foundation for community development and strategic planning.

Asset mapping can involve:

- an inventory of community assets,
- a ranking of the most valued assets,
- an understanding of the connections among and between these assets,
- an understanding of why these assets are valued, and
- an understanding of the community's vision for the future.

Asset mapping is intended to promote connections and/or relationships among people, between people and organizations, and between organizations. Collectively, this knowledge can support development by building on the strengths inherent in the community. Asset mapping also identifies gaps and where they exist; planners, developers, and community leaders can coordinate initiatives to fill these gaps.

Methods used for asset mapping vary, but generally include participatory approaches that engage citizens and other local stakeholders. The Asset Mapping Handbook (http://www.rwmc.uoguelph.ca/cms/documents/11/Asset_Mapping1.pdf) provides examples of the methods that can be used in asset mapping.

8.4 - NICHE COMMUNITY-BUSINESS OPPORTUNITIES

Further, socio-economic benefits can be garnered by developing niche business opportunities that complement tidal energy development. Niche businesses often correspond directly to local community assets and community capital. Community-based business and entrepreneurial activities could include:

- Tourism: Tourists are increasingly interested in learning through experiential activities during their travel. Interpretive centres that provide hands-on learning, meaningful engagement opportunities with local people, and a chance to purchase a unique item/gift from the community or interpretive centre are important. Tourism development may complement a tidal energy development project as it presents an opportunity to teach people about the ecology (including human ecology) of the marine environment, the nature of the tidal cycle, the process of energy extraction from the tides, and the types of research undertaken that provides significant insight into the types of impacts of this type of energy extraction. The Tourism Industry Association of Nova Scotia's (TIANS) Best Practices (http://www.tians.org/programs/best-practice-resources) provides information on tourist markets, marketing, and product development.

- Greenhouses: For communities producing energy for locally-distributed grids (e.g. COMFITS), investing in greenhouses for growing fruits and vegetables presents both an opportunity and fills a need for locally produced goods. This opportunity might be especially important for remote communities. Specialty products, such as some herbs, can be grown and made available off-season to local and regional restaurants and specialty stores. Iceland has been using its geothermal energy resources since 1924 to heat greenhouses to grow various vegetables (See: Iceland National Energy Authority - http://www.nea.is/geothermal/direct-utilization/greenhouses/).

- Business/Start-Ups: Rural and remote communities may develop financial tax-based incentives to encourage and support the development of local businesses aligned with community assets and capital. Locally produced energy and agreements between power developers and local governments might provide opportunities for lower energy costs to support business development.

VIGNETTE: ANNAPOLIS TIDAL STATION

The Annapolis Tidal Station came online in 1984. This tidal energy generating station is based on a barrage model. In this model, the tidal Annapolis River is dammed and water is funneled through a tidal generating plant. The tidal station doubles as an interpretive centre and is a noted tourism attraction in the region. Visitation numbers suggest that people are interested in learning about innovative renewable energy opportunities like tidal energy.

8.5 - OWNERSHIP MODELS

The level, type, and disbursement of benefits from a renewable energy project are largely contingent on the project's ownership model. Table 8-7 presents three types of ownership models: local, shared/partnership, and developer ownership. Each ownership model is unique and will have its own benefits, costs, strategies, and governance models.

Tidal energy development may provide rural, island, and other remote communities with energy that may allow for development of local small-scale industries such as greenhouses, tourism-related activities/facilities, or small-scale manufacturing. Any ownership model can produce these types of opportunities. Choosing the model will depend on resources available, the mix of stakeholders, and the willingness to take on the risks associated with ownership.

Photo Credit: Leigh Melanson

Table 8-7: Pros and Cons of Different Ownership Models

MODEL	PROS	CONS	STRATEGIES FOR DEVELOPMENT	GOVERNANCE
Local Ownership	Lower energy costs and reliable supply either directly or indirectly Use of local business/services Local income generation Greater local/community acceptance of renewable energy project Greater local control of siting and overall project management Opportunities for empowerment Encourages socially responsible investing	Risk is solely with the community Experience may be limited Competition for funding can be high Community may be responsible for decommissioning costs Community members may experience "burnout"	**CEDIFs:** A Community Economic Development Investment Fund (CEDIF) can be created to support local ownership. The CEDIF committee must have at least six elected directors. Their role is to manage the CEDIF fund, which is created by a pool of capital raised through the selling of shares to members in a defined community. **Municipal Investment:** Municipalities may be able to invest directly in a renewable energy project like tidal energy. However, limits to direct municipal investment will be limited and based on legislated bylaws. **Bylaws/MPS:** It is necessary to develop the appropriate bylaws within a Municipal Planning Strategy (MPS) that support tidal energy development. Integrated Community Sustainability Plans (ICSP) may also provide an opportunity to develop strategies that enable tidal energy development.	The measures outlined below will support governance in locally owned energy projects. **Terms of Reference (TOR):** This document should outline a communication strategy, identify how benefits/costs will be shared, address how conflicts of interest might be managed, and outline other key management issues. The TOR must also include information regarding the election of officers/members of management committee. **Project 0 & M:** Key factors in Operations and Maintenance include administration, conduct of operations, equipment status, operator knowledge and performance, conduct of maintenance, and preventative maintenance. **Community updates:** How the community will be kept informed of the project, its status, and rates of return is another consideration. On-going community updates will be important and be accomplished through municipal website, flyer in the mail or with a local bill such as water, and public meetings. **Distribution of funds:** Terms of reference for the distribution of funds at the outset of the project is important and must be transparent. Rules and procedures for a periodic review and modification of distribution of funds to deal with arising community needs will be necessary.

MODEL	PROS	CONS	STRATEGIES FOR DEVELOPMENT	GOVERNANCE
Shared / Partnerships Ownership	Use of local business/services Financial strength and credit capacity Technical expertise Local recognition and acceptance Project development and technical experience Community sweat and financial equity	Investment risk to all partners Values may not be consistent among partners Reputation of partners is at risk if project fails Equitable decision-making among partners is challenging	The COMFIT program provides partnership opportunities if the community has a major share of ownership (> 50%). Other considerations include the need to: • Develop partnerships based on shared values • Determine the contribution of each partner • Determine majority and minority rights • Determine financing arrangements • Determine operational decision-making • Determine exit mechanism	Governance will require the development of a coordinating body. Coordinating structures could include: • Steering Committee • Task Force • Ad Hoc Committee • Standing Committee The coordinating body will be responsible for determining how: • decisions are made and by whom; • leaders are chosen; • members are chosen; • information is shared; • conflict is managed; • risk is managed; • day to day activities are carried out by the organization; and • staff are managed.
Developer Ownership	Use of local business/services Local share-holding opportunities Sharing of data on marine environment and other areas Developer sponsored community initiatives	Lack of local control over local marine resources Decommission risks Foreign ownership and/or rights to natural resources	Nova Scotia's Tidal Array Feed-in-Tariff (FIT) (http://nsrenewables.ca/tidal-array-feed-tariff) program for Independent Power Producers provides opportunities for developer ownership. The FIT applies to tidal devices in units greater than 0.5MW or set up in arrays. There are no limits on ownership.	Developer-owned projects will likely require: • Development agreements between project partners • MOUs (Memorandum of Understanding) between regional/provincial government and, in some cases, local government

8.6 - MOVING TOWARD ACHIEVING SOCIO-ECONOMIC BENEFITS

In order to better realize the socio-economic benefits related to tidal energy development, it is useful to incorporate the following elements into the planning of tidal energy projects.

BEING PROACTIVE - Local and regional governments must be proactive in order to maximize benefits and minimize costs associated with tidal energy development. Being proactive will involve becoming knowledgeable about renewable energy development. Participating in local, regional, and/or provincial renewable energy-related forums will provide this type of knowledge.

EDUCATION - Developing community buy-in across the stakeholder spectrum is essential in achieving socio-economic benefits. Opportunities for education should be developed and can include public open houses, newsletters, and school-based education initiatives.

PARTNERSHIPS/NETWORKING - Developing strategic partnerships and strong networks with government, local community organizations, and energy producers can support local and regional economic development.

VISIONING - Local/regional government and regional economic development authorities (RDAs) should establish a vision for their energy future supported by strategic planning. Many municipalities have already addressed this with Integrated Community Sustainability Plans (ICSP's).

8.7 - CHECKLIST FOR COMMUNITIES

The following is a checklist that will help a community consider whether it has skills, expertise, or services that could supply tidal energy projects. Ultimately, the checklist serves to help identify what type of strategy could be developed to participate in the tidal energy supply chain.

Checklist for Communities

1 Is there a task force, committee, or other network actively looking at tidal energy opportunities in your community?

2 Do you have a complete and up-to-date labour force profile (wages and benefits, supply and occupational categories, skills, latest employment data, employment forecasts)?

3 Do you have a complete and up-to-date list of education institutions (local or area) or others who are able to supply training relevant to tidal energy development?

4 Are necessary business support programs in place to assist new tidal energy companies to establish and to assist existing businesses to take full advantage of supply chain opportunities presented?

5 Are economic development and local officials joining networks and attending seminars and workshops to learn about current and future tidal energy development in your region?

6 What expertise could be brought into the community or attracted by nearby tidal energy development?

7 Does the Economic Development Coordinator/local RDA have a working knowledge of renewable energy and know where to get further information?

8 Does the community have an up-to-date community development strategy, an Integrated Community Sustainability Plan (ICSP), a strategic plan, or something similar?

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9 OPPORTUNITIES AND STRATEGIES FOR BUSINESSES

Businesses that get involved in tidal energy development now will gain experience and skills needed to serve the industry as it grows.

9 - OPPORTUNITIES AND STRATEGIES FOR BUSINESSES

WHAT DOES THIS MODULE COVER?

The natural resources available in Nova Scotia's tides provide an opportunity for businesses to start-up or expand service offerings to a new industry and perhaps relocate near the resource. This module describes the potential commercial opportunities in a new tidal energy industry and what businesses can do to take them up.

This module outlines the opportunities for businesses and strategies for taking advantage of them. Specifically, it covers the following:

• Activities that will be undertaken at each stage of tidal energy project development;

• Product and service suppliers, and the skilled and knowledge workers needed at each stage;

• Business development strategies for harnessing the benefits of tidal energy development; and

• Government and non-government organizations that play an important role in the development of the tidal energy.

This module is for anyone interested in how businesses can get involved in the tidal energy industry as it develops.

9.0 - SECTION 1: SUPPLY CHAIN DEVELOPMENT AND OPPORTUNITIES

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Multiple services, supplies, and expertise are required to support tidal energy projects through each project stage throughout its lifespan. This supply chain includes many different skillsets, tools, and service providers, including marine scientists and engineers, mechanical and electrical technicians, vessels, sensory instruments, divers, steel fabrication, manufacturing, and supporting expertise such as insurance, legal, transportation, and financial services.

The development of a supply chain for the tidal energy industry is important for a number of reasons. First, a robust supply chain will be integral to the growth and success of Nova Scotia's tidal energy industry. Without the expertise and supplies needed to service projects, tidal energy will not be able to progress efficiently. Second, the building of a supply chain presents a new economic opportunity for businesses, communities, and

Nova Scotians. Businesses that get involved in tidal energy development now will gain experience and skills needed to serve the industry as it grows. Lastly, growing a local supply chain for tidal energy in Nova Scotia and the region is important for ensuring that benefits from tidal energy development are experienced by local communities and businesses. Given that the sector is at an early stage throughout the world, there is also a potential opportunity for entities that get involved in tidal energy projects now to service the global market.

FOUNDATIONAL CONCEPT: WHAT IS A SUPPLY CHAIN?

A supply chain encompasses all aspects of how a product is delivered to an end user. It is a network of retailers, distributors, transporters, storage facilities, and suppliers that participate in the production, delivery, and sale of a product to the consumer. The supply chain is typically made up of multiple companies who coordinate activities to set themselves apart from the competition.

A supply chain has three key parts:

- Supply focuses on the raw materials supplied to manufacturing, including how, when, and from what location;
- Manufacturing focuses on converting these raw materials into finished products; and
- Distribution focuses on ensuring these products reach the consumers through an organized network of distributors, warehouses, and retailers.

9.1 - TIDAL ENERGY SUPPLY CHAIN DEVELOPMENT

The tidal energy supply chain is at a very early stage of development in Nova Scotia and globally, which is reflective of the current state of the industry as a whole. To date, tidal energy deployments have consisted primarily of one-off prototype devices that have been experimental in nature, and therefore, a supply chain capable of providing tens or hundreds of devices per year for commercial deployment has yet to be established. While this gap is a challenge to early projects, it can also be recognized as a window of opportunity for businesses that provide skills or services that can contribute to tidal project and industry development.

9.1.1 - CURRENT STATUS AND PROJECTED GROWTH

Tidal energy development in the near-term will be for the advancement of both small-scale (defined as less than 0.5 MW nameplate capacity) and large-scale in-stream tidal devices. In the mid-term, demand for in-stream tidal, as well as offshore wind components and service is projected to increase. Eventually, industrial approaches to support project development will be needed. There are presently gaps in capability and capacity regionally, as well as internationally.

There are few dedicated suppliers worldwide due to the relatively small scale of the industry, but suppliers in related applications may be able to contribute or modify existing products/services to supply the tidal energy sector. Currently, major components such as gearboxes, blades, and hydraulic generators are being manufactured as custom (one-off) units. This increases the cost of the project and expands lead times for prototypes since full design, development, and custom tooling/fabrication is often required. However, it is likely that as projects move into an array stage of development, using multiple devices, costs and time should both be reduced as supply chain capacity and capabilities grow.

As more tidal energy projects are developed and the industry matures, it is likely that volume can be expected to increase, attracting more suppliers, competition, and security of supply. Figure 9 1: Evolution of the Tidal Energy Supply Chain below illustrates an appropriate scenario for the continual development of the tidal energy supply chain.

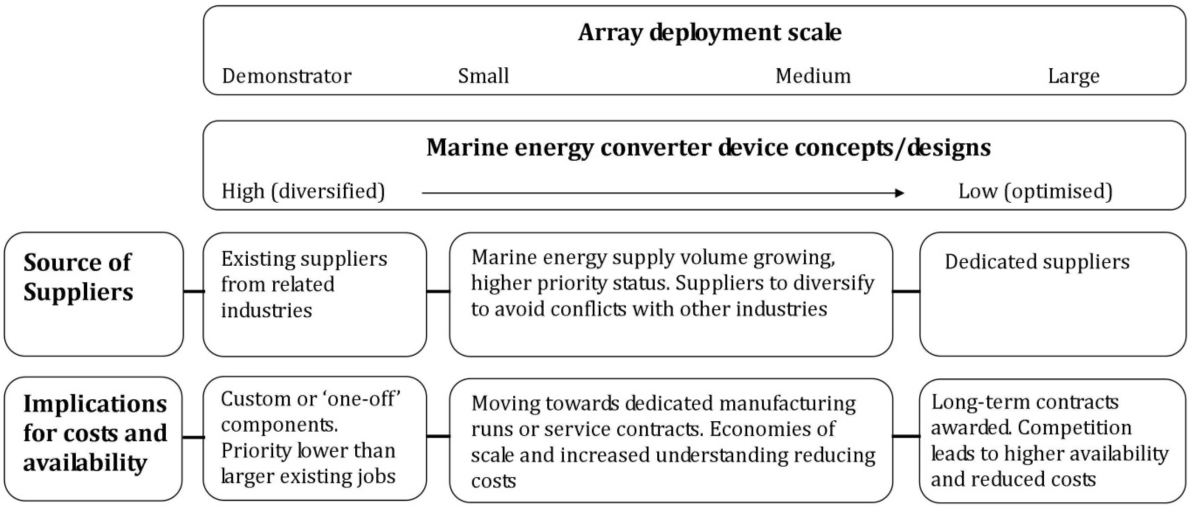

Figure 9-1: Evolution of the Tidal Energy Supply Chain

Source: (EquiMar, 2011)

9.1.2 - GAPS & CHALLENGES

Canada has several key areas where supply chain gaps and challenges have been identified. A 2011 study and report conducted by Natural Resources Canada engaged individuals representing various areas of the industry to provide insight on the status of the marine renewable energy industry and supply chain. The survey identified areas of strengths and perceived weaknesses of the current supply chain.

Table 9-1: MRE Supply Chain Strengths and Weaknesses

STRENGTHS	WEAKNESSES
Deep sea ports	Device manufacturing
Marine construction	Engineering construction
Resource monitoring and analysis	Foundations/anchoring
Environmental assessment	
Marine supplies	
Commercial diving	
Transport	

Source: Marine renewable energy supply chain strength/weaknesses (adapted from Natural Resources Canada, Canmet Energy Report, "The Marine Renewable Energy Sector Early-Stage Supply Chain", 2011)

A Nova Scotia-specific report commissioned by the Nova Scotia Department of Energy in 2011, The Marine Renewable Energy Infrastructure Assessment, identified the availability of appropriate infrastructure in a deep water port with close proximity to the resource, as well as the need for adaptive methods to service and/or deploy devices from shallow dry ports is as gaps that will need to be addressed to enable future development.

9.1.3 - PARTICIPATING IN NOVA SCOTIA'S TIDAL ENERGY SUPPLY CHAIN

The tidal energy supply chain consists of ten key segments. Various companies in Canada are providing services or products in each of these segments.

Table 9-2: Tidal Energy Supply Chain Segments

SUPPLY CHAIN SEGMENT	DESCRIPTION
Technology developers	Marine energy conversion device innovators, designers, and developers.
Manufacturers and suppliers	Manufacturers and component suppliers.
Project developers	Utilities and independent power producers.
Development services	Resource assessment/modelling, mapping, environmental impact assessment, sea floor environmental assessment and related marine safety supply consults, permitting, approvals planning, marine corrosion consulting.
Supporting technology providers	Tidal current resource measurement devices, environmental monitoring devices, buoys, underwater remote vehicle operators/owners, technical resource monitoring, and data collection.
Engineering and construction	Safety management, work platforms, underwater operators, cabling and electrical interconnect for marine operations/facilities, anchoring systems, engineering firms (electrical, civil, mechanical), on-site supervision, and management.
Operations and maintenance	Operational monitoring, transportation, port facilities and marine operators with related experience (including transport vessels and operators and certified diving teams) with the ability to do deployment/removal, emergency repair, mitigation strategies, and asset management.
Research and development	Academia, private, and public research centres and bodies.
Policy and industry support	Government policy development, industry associations, and non-governmental organizations.
Business services	Legal, financial, insurance, business communications, market research, and training activities.

Source: adapted from Natural Resources Canada, CanmetEnergy report, "The Marine Renewable Energy Sector Early-Stage Supply Chain", 2011

Many existing Nova Scotia and regional businesses are part of these segments and will have opportunities to participate in the tidal energy supply chain. Essentially, the gaps and challenges presented are opportunities for businesses to get involved early in project and industry development. Although Nova Scotia does not yet have a mature tidal energy supply chain, the province is well suited to engage in tidal energy development, given its long marine industry tradition—with significant experience in fishing, shipbuilding, and offshore oil and gas industries. Nova Scotia has the highest concentration of ocean technology companies in North America, with more than 200 businesses in operation. These companies have developed specialized expertise in marine environments all over the world and could service the tidal energy industry.

See Section 9.2 Project Stages for a detailed overview of tidal energy project requirements and Nova Scotia sectors with transferrable skills, expertise, and supplies.

DISCUSSION: STRATEGIES FOR SUPPLY CHAIN INVOLVEMENT

There are two potential strategies companies must consider when getting involved in the tidal energy supply chain:

1. Early-mover: Suppliers can put themselves in a position to supply goods and services in advance of demand. If a supplier already has a production capability for the required components, there is likely to be minimal risk or delay in supplying volume.

2. Late-mover: Suppliers can wait for when demand for goods and services are strong enough and move then to supply the industry.

Both routes involve an element of risk for both developers and suppliers. The early-mover can learn from mistakes, have ideas for improvement, and will have built relationships with developers/clients. The late-mover can learn from negative experiences of the early-mover and build their business model and strategies around that (if possible).

9.1.4 - TIDAL ENERGY SUPPLY CHAIN REQUIREMENTS

In order to learn how businesses, communities, and individuals can become involved in tidal energy development, it is important to first get an understanding of the supplies, services, and skills required for a tidal energy project. As noted earlier, at this stage in the tidal energy industry, there have only been a handful of one-off projects consisting of prototype devices. However, from these projects, it is possible to provide a general example and discussion of what service and supply provider requirements are likely to be involved with a single-device project.

This section will provide an overview of an in-stream tidal energy project, including a description of project stages, project activities, and potential supplies and services required.

9.1.4.1 - OVERVIEW OF AN IN-STREAM TIDAL ENERGY PROJECT

An in-stream tidal energy project will progress through a number of stages, each requiring an array of technical as well as supporting and enabling services. Service and supply provider requirements may differ from project to project due to the size of the device, location, and project scope. Device design, number of devices, and site location are some of the factors that may dictate requirements.

The following is a general description of each project stage, sub-stages, associated activities, and corresponding services and supplies required. Some activities and supplies/services required could be addressed by the project developer depending on in-house capability and capacity.

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

9.2 - PROJECT STAGES

Similar to other renewable energy resources, like wind and solar, there are several project stages of tidal energy development. This section will provide an overview of each stage to provide an understanding of the development process, associated activities, and supply chain opportunities.

1. RESEARCH AND DEVELOPMENT

The research and development stage (R&D) includes research and testing of tidal energy technologies to test and refine a prototype design that can be developed into a commercial-scale device. Typically, R&D activities are conducted by specialized centers belonging to companies, universities, or government entities.

RESEARCH AND DEVELOPMENT			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
• Energy conversion technology • Energy storage/usage • Prototype testing • Investment	• Universities • Government and industrial labs • Research granting agencies	• Tidal/wave tanks	• Technical expertise (technology choice assessment) • Electrical engineer • Research support • Financial services

Photo Credit: Leigh Melanson

2. SITE SCREENING AND PROJECT FEASIBILITY

The first stage of project development is aimed at identifying potential sites, learning characteristics of the sites, and determining feasibility of a project at those sites. After a potential site has been identified through a site screening, a site resource assessment is completed. The next step is to conduct various feasibility studies that consider the resource identified, resulting in detailed modeling of potential constraints to the project. If a tidal technology has already been selected, potential technical, physical, and environmental constraints influencing the site are assessed in relation to the technology's performance characteristics.

SITE SCREENING AND PROJECT FEASIBILITY			
ACTIVITIES	SUPPLIERS	EQUIPMENT & NSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
• Desktop screening exercise based on available data to identify sites • Early stage resource assessment • Constraints analysis including preliminary identification of First Nations interests, conservation areas, archaeological sites, infrastructure, and other marine environment users such as fishing, commercial transportation, recreational transportation, defence • Analysis of financial feasibility • Identification of high-level site-related health and safety hazards for future assessment and to inform design of Safety Plan • Identification of a suitable grid connection point and determination of availability • Logistics analysis – identification of suitable harbours, associated services, and infrastructure • Identification of marine renewable energy technology that will best fit the project objectives and identified sites	• Engineering and environmental consulting • Financial services • Universities • Government	• Desktop modeling tools • Acoustic Doppler Current Profiler (ADCP)	• Technical expertise (technology choice assessment) • Electrical engineer • Research support • Health & safety expertise • Financial services

3. PLANNING

During the planning stage, tidal energy developers engage in environmental and technical studies and activities to help inform project design and provide details necessary for determining what types of permits, licenses, and authorizations will be required to move forward with the project.

PLANNING			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Environmental Scoping and Surveys Environmental surveys are used to assess whether a project could have an impact on a species that live in, use, or frequent the marine environment, both in the sea and air. Surveys address benthic species, fish, marine mammals, birds, and onshore species. • Planning for multiple surveys • Operation of vessels for use and management of survey equipment • Aerial surveying where coverage of larger area is required • Collection and evaluation of data to provide information on project development issues • Analysis and interpretation of survey data	• Technical/research consultancy • Universities/researchers • Offshore/marine survey vessel business	• Vessel (range of vessels can be used including local fishing crane, 30m long vessels, and specialist physical surveying vessels for environmental surveying) • Surveying, trawling, and imaging equipment • Aircraft (helicopter) for aerial survey	• Vessel operator •Helicopter/ aircraft operator • Marine biologist, ecologist, environmental scientist, and/or local knowledge from fishers, etc. (should have knowledge of local species)
Physical Surveys Coastal process surveys and seabed surveys are used to examine the subsea environment and potential impact of tidal energy projects, particularly on sedimentation and erosion. Existing bathymetry and seabed geomorphology (geophysical and geotechnical conditions) are investigated to further refine the location and extent of the deployment area, assess the fixing and mooring requirements, and outline a corridor for the cable route. The geomorphology of the seabed can also provide an indication of the likely benthic habitats in the area. Onshore geotechnical conditions should also be assessed in order to identify technical requirements for onshore works and cable installation. These use a mix of desktop studies and on-site investigations. • Planning for multiple surveys • Operation of vessels for installation and management of survey equipment • Collection and evaluation of data to provide information on project development issues	• Offshore/ marine survey vessel business • Technical/ research consultancy •Universities/ researchers	• Specialized vessel • Surveying, trawling, sonar and imaging equipment	• Vessel operator • Knowledge of sediment transfer • Geotechnical engineer

PLANNING			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Meteorological and Resource Assessment/Monitoring Measurement of meteorological and metocean conditions are necessary to enable detailed model of resource characteristics (wave heights, wave periods, tidal speeds, and direction of both waves and tides). Data collected is used alongside historical and modeled outputs to inform project design. The final resource assessment stage is completed once the technology is chosen and serves to determine the exact location of each device. • Planning for the deployment of instruments • Operation of vessels for installation and management of subsea deployment of acoustic profilers (ADCP) • Deployment and collection of ADCP measurements • Collection and analysis of weather patterns in the area • Collection and evaluation of acoustic data to provide information on project development issues	• Technical and research consultancy services to interpret and advise on modeling data (data analysis and resource modeling, site conditions and device suitability analysis)—metocean • Ocean technology supplier (instruments, ADCPs, etc.) • Offshore/ marine survey vessel business • Universities/ researchers	• Meteorological instruments and packaged instruments (ADCPs) • Dynamic positioning vessel • Remotely operated vehicles (ROV)	• Meteorology expertise • Vessel operator • ROV operator • Diver
Electrical Connection The availability of a suitable grid connection with sufficient capacity for the proposed project is integral for moving forward with the project. After identifying suitable grid connection points, a developer must begin discussions with the operator of the electrical grid. • Discussion with System Operator of the electrical grid • Identification of technical and contractual agreements for connection and associated costs	• Technical/ engineering consultancy • Legal services		• Electrical engineer • Technical expertise • Lawyer

4. PROJECT DESIGN & DEVELOPMENT

Tidal energy developers typically progress to the project design and development stage if the outcome of feasibility assessments meets the project objectives. During this stage, a developer typically performs activities necessary for gaining project approvals and permits, and as design progresses, technical information feeds into the regulatory process.

PROJECT DESIGN & DEVELOPMENT			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Public and Stakeholder Consultation Developers will engage with the local community throughout the life of the project. Extensive consultation with stakeholders, especially those more likely to be affected by the project, is typically undertaken during the preparation of an Environmental Assessment (EA). • Design of a consultation strategy and plan • Identification of potential stakeholders • Ongoing and formal engagement with First Nations • Production of materials for public consumption that provide project details and future development plans • Arrangements for public event/meetings • Collection of stakeholder input and analysis to inform project design, preparation of permit/approval applications, and EA	• Public relations firm/consultant • Consultants with existing EA expertise	• Meeting/conference space (local community centre or hotel)	• Consultant with knowledge of key local stakeholders and their relevant interests in a project may be required • Public Relations expertise
Mi'kmaq Ecological Knowledge Study (MEKS) There are sites in Nova Scotia that have particular cultural significance for the Mi'kmaq of Nova Scotia, who may use them to support traditional or current practices for food, social, or ceremonial purposes. A MEKS should be conducted to identify areas of historical and current use in the project area and to help to ensure that traditional knowledge informs project design and development. • Determine MEKS scope in consideration of project requirements and proposed site	• MEKS services	• Geographic Information Systems (GIS) technology • Geographical Positioning Systems technology.	• Mi'kmaq traditional knowledge experts

PROJECT DESIGN & DEVELOPMENT			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Environmental Assessment (EA) Although EAs have basic requirements and common elements, they should be project and site specific. They are informed by scoping and surveying conducted during the feasibility stage of project development. The EA considers the impacts of the project through the installation, operation, and decommissioning phases. Parameters assessed include: coastal and sedimentary processes, marine ecology (including benthic ecology and marine mammals), fish resources and commercial fisheries, marine navigation, cultural heritage and archaeology, ornithology, terrestrial ecology, landscape and visual impact, road traffic and access, tourism and recreation, water/sediment/soil quality, noise and air quality, and socio-economics. • Surveys and specialist investigations to provide a description of current environmental features (baselines) • Data gathering according to criteria defined by the previous surveying and scoping • Modeling and specialist studies to predict potential environmental impacts and evaluation, identification mitigation measures, identification of uncertainties, assessment of cumulative effects, and identification of monitoring requirements/plans • Input from stakeholders/consultees from continued dialogue on scope of surveys and studies, likely impacts, and mitigation measures • Design of potential monitoring program	• Consultants with existing EA and related specialist experience	• Physical and biological environmental monitoring and data processing equipment (e.g. ADCPs, hydrophones)	• Environmental/ resource management expertise (background in planning, environmental studies, biology, ecology, etc.)

PROJECT DESIGN & DEVELOPMENT			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Other Legal, Permitting, and Approval Requirements Project developers will need to prepare applications and documentation for all legal and permitting requirements including: land lease, power purchase agreement, regulatory approvals, financial agreements, and insurance. • Preparation of land lease document, permits/approvals applications • Preparation of application for negotiation of electrical grid connection conditions including modeling of device and array power quality output (if applicable), power project interconnection studies • Design of Safety Plan (addressing operational and occupational health and safety issues) • Determination of financing options and building of a financial team • Clarification of required insurance during the construction and operating phases covered by plant suppliers, construction, and installation contractors	• Detailed experience in the permitting and approval of projects within the marine environment • Legal services • Financial services • Insurance supplier • Health & safety consultant		• Legal expertise • Consulting services (health & safety expertise) • Electrical engineer • Technical expertise • Health & safety expertise • Legal expertise • Financial expertise
Project Design The project design is developed and refined in parallel to the EA. Findings from the environmental surveys and studies should feed back into the design and technical specification. This process should also set the basis for the preparation of suitable procurement and contract strategies. Technical specifications and drawings will assist in the drafting of the contract documents. • Evaluation of design options and outline of selected design using the following pre-set criteria: functionality, flexibility, operability, costs, proven performance, safety issues, environmental and socio-economic impacts, ease of installation, project risks, reliability, maintainability, and survivability. • Techno-economic analysis to determine the expected costs and revenues arising from the project to facilitate eventual financial investment decisions.	• Engineering consultant • Logistical support – marine architect		• Marine architect • Engineer

PROJECT DESIGN & DEVELOPMENT			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Development of a Procurement Strategy A strategy for the procurement of services and materials to serve project lifecycle needs will be developed. Strategies are designed to select suppliers that provide value for money over the expected life of the project while ensuring supplier competence and quality of service. Design of a strategy typically takes the following factors into consideration: • Analysis of current market status and projected market trends • Research and consideration of rules and procedures for procurement applicable to project development • Analysis of risk between parties involved and development of management techniques for uncertainty • Development of procurement process timescales and integration with overall project program	• Consultant may be required depending on the project developer's procurement and contract management experience.		• Financial, business administration expertise

PROJECT DESIGN & DEVELOPMENT			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Detailed Design A detailed design of the project will commence once a project receives the necessary approval from regulatory authorities and the predicted technical and commercial performance of the project remains feasible and in line with project objectives. Technical studies will be undertaken to refine project design. • Assessment and detailed design of electrical equipment and cables (subsea and onshore) • Detailed design of Supervisory Control and Data Acquisition (SCADA) System, communications, and control equipment • Detailed design of onshore facilities and auxiliary equipment • Development of generation profiles and quality of generation based on selected technology to inform grid connection studies • Grid connection feasibility study and integration with network • Specification of safety features, navigational marking, and lighting • Detailed review of the selected technology • Marine logistics studies to optimize installation methods, vessel, and port requirements • Failure Modes, Effects, and Criticality Analysis (FMECA) to ensure the integrity and survivability of the project infrastructure and to optimize its reliability, availability, and maintainability. • Review and refinement of cost estimates and program • Update of the design risk register • Preparation of a Quality Plan	• Logistical support (inform on marine safety and standards requirements) • Consultants –Engineering, technical, OHS, planning (deployment) • Financial services • Universities/ researchers		• Marine architect • Marine engineer • Subsea electrical expertise • Health & safety expertise • Technical knowledge in marine renewable energy or parallel sectors including pressurized vessels, marine equipment, and aquaculture. • Electrical engineer • Financial expertise

5. PROJECT FABRICATION

This stage focuses on the implementation of the selected procurement strategy for elements of the project that are to be contracted out. Device, project components, and infrastructure begin to be manufactured according to standards, timescales, and costs agreed to in the contract.

Main structural components

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

PROJECT FABRICATION			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Hydrodynamic System The hydrodynamic system is composed of the blades or hydrofoils and moves directly under the influence of forces applied by water. **Activities**: • Precision fabrication of blades and hydrofoils • Moulding and finishing of composite materials • Casting of metal structures used in providing buoyancy • Assembly of components with fasteners, welding, or other means • Design and production of pressure vessels for marine environment • Provision of coatings and treatments to control corrosion and marine growth • Workshop testing and verification	• Steel fabrication • Composites manufacturing	• Raw materials and parts: steel, composites	• Welders • Engineers

PROJECT FABRICATION			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Reaction System The reaction system keeps the device in position and provides a static reference point for oscillating devices (mooring arrangement, gravity base, foundation, or foundation fixed to sea bed via piles). **Activities:** • Design of dynamic structure in the marine environment under frequent waves • Procurement, fabrication, and handling of large scale steel and concrete structure of up to over 1000 tonnes • Design, manufacturing, and installation of wire ropes, chains, and anchors	• Steel fabrication • Manufacturer • Concrete supplier	• Raw materials: steel, concrete	• Engineers • Procurement specialist • Expertise in corrosion and marine growth prevention • Local knowledge of marine conditions
Power Take-Off System The power take-off system converts the motions of a device's hydrodynamic system into electrical energy. This can be done in two ways – 1) with hydraulic actuators or a linear electrical generator, or 2) constraining movement with speed-up gearboxes or direct drive electric generators. • Production of gearboxes, bearings, and power transmission components	• Engineering/ technical consultancy	• Subsea connectors from device to inter-array cabling with voltage rating of 11kV and above.	• Electrical engineer • Mechanical engineer • Technical expertise
Control System The control system provides both supervisory and closed-loop control. It also includes auxiliary systems. • Design and production for high reliability applications	• Engineering/ technical consultancy	• Specialist sensors and data collection systems related to the marine environment to indicate pressure, movement, electrical characteristics, or environmental conditions. • Hydraulic actuators, valves, or other equipment. • Bearings and actuation components for use in yawing or pitching	• Experience in design and use of supervisory control and data acquisition (SCADA) systems • Engineers

PROJECT FABRICATION			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Subsea Cabling and Connectors An electrical collector system is needed to connect individual devices to a common device interconnection point. There are two types of cables that are necessary for the operation of an in-stream tidal energy project. Array cables are required to connect strings of devices (if the project consists of an array) to an offshore substation and higher voltage cables are necessary to connect the substation to the onshore grid connection point. There is already very high demand for these types of cables from other industries and if manufacturing capacity does not increase, bottlenecks will likely occur. • Advise on selection of cable • Specify protection requirements	• Subsea cable supplier • Cable installer	• Large-scale and high precision cabling extrusion and assembly equipment • Cable armouring products to protect against extreme forces and ensure life of the conductor	• Electrical design knowledge • Mechanical engineer • Expertise in the production of insulation for cables to provide thermal and electrical protection
Electrical Equipment Transformers, switchgear, and other electrical equipment are likely to be based on conventional electrical power engineering products, but adapted to meet the needs of specific applications.	• Offshore electrical manufacturing		• Knowledge and understanding of design requirements of distributed generation and impacts of wave and tidal supply characteristics. • Electrical engineer
Foundations, Anchoring Systems, and Moorings In-stream tidal devices are anchored to the seabed. There are different types of systems for anchoring depending on device design. The following is a generalization of activities and supplies required to design and produce a foundation and anchoring system. • Production of large scale concrete structure • Fabrication of steel frame structure weighing up to over 500 tonnes • Assembly of various components	• Concrete supplier • Steel fabrication • Corrosion and marine growth prevention products	• Concrete • Cranes: lifting of various components into place for assembly and lifting assembly into barge for testing and deployment	• Marine engineer • Expertise in the design of dynamic structures for the marine environment • Technical expertise • Welders • Marine architect
Other Project Stage Service and Supply Requirements: • Insurance: protection of owner from accidental damage to the components during fabrication and assembly • Transportation of component parts to site for final assembly	• Insurance supplier • Transport company	• Trucks	• Truck drivers and machinery operators

6. CONSTRUCTION, INSTALLATION, AND COMMISSIONING

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

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

CONSTRUCTION, INSTALLATION, AND COMMISSIONING			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Procurement and Assembly Logistics • Identification of permitting requirements • Movement of materials procured from other jurisdictions	• Marine consultant • Customs broker for importing materials and guidance in obtaining proper permits for temporary use of barge		
Barge Requirements Supply vessels such as jack-up barges and crane barges will be required for lifting heavy loads. • Inspection of barge and associated equipment for compliance with regulations • Towing of barge through test program prior to deployment activities	• Marine consultant • Customs broker		

CONSTRUCTION, INSTALLATION, AND COMMISSIONING			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Deployment and Installation of Device • Preparation of device at port and float-out and install devices using general purpose vessels where possible • Marine logistics planning • Towing of barge and tidal assembly into place for deployment (and recovery) • Monitoring movement of marine life (lobster, fish, mammals, birds) during deployment for indication of change from normal behavior • Explore fish monitoring technologies at the turbine site (2-D and 3-D sonar) and follow fish patterns • Identification of acoustic signatures • Passive monitoring of acoustic noise from marine mammals to determine any effect or risk • View turbine in operation using side scan SONAR and camera on tether • Monitoring and analysis of anticipated wind and sea state during expected deployment/recovery window	• Engineering and environmental consultancy • Universities/ researchers • Diving services	• Fishing boats for transporting additional personnel and emergency response • Personal protective and safety equipment • Radios for communication between all parties involved in deployment • Instrumentation for communication with the assembly during deployment and recording of forces experienced on the assembly and other data to further understand environmental conditions and optimize design • Specialist tooling and ROVs • Marker buoys and navigational lighting	• Marine consultant for review and inspection and knowledge of local conditions and constraints • Electrical Engineer • Mechanical Engineer • System Engineers • Power Engineers • Certified welders (CWB Class 47.1) • Journeyman machinists • Customs broker to provide guidance in obtaining proper permits for temporary use of barge • Tugboat operator • Health and Safety/ Emergency Response preparedness • Marine biologist, ecologist • Divers
Installation of Foundations and Moorings In-stream tidal devices are anchored to the seabed. The method by which it is anchored depends on device design (pin-piled, concrete gravity, multipoint mooring). • Offshore installation and assembly of various components	• Diving services	• Cranes • Specialist tooling • ROV • Support vessels • Specialist vessels (installation) • Drilling and piling operations	• Vessel operators • Divers • Marine drilling • Marine construction • Environmental monitoring • Construction supervision • ROV and tooling operator

CONSTRUCTION, INSTALLATION, AND COMMISSIONING			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Installation of Offshore Electrical Systems (including Cable Installation) • Grid connection upgrades • Procurement of cabling/electrical contractors and storage/testing of cables • Procurement of bespoke winches and drums for cable • Draw-through and installation of several kilometers of subsea cabling to avoid geohazards • Cable protection and securing using rock dumping (and potentially ROVs for pinning and active positioning around seabed features) • Directionally drilled pipelines from shore out to the location of devices • Installation and connection of the offshore substation and array cabling between devices (if applicable)	• Cabling/electrical contractors • Drilling contractor	• Power conditioning equipment (converters, generators) • Underwater substation pod—(transformers, switchgear) • Bespoke winches and drums for cable • Cable laying vessel • Special drilling equipment (carbon steel pipeline, fabricated-coated-assembled-welded) • ROV (optional)	• Electrical engineer • Technical expertise • LV Dynamic cable and MV Static Cable (with fibre optics) • Geotechnical knowledge • ROV operator • • Subsea cable armouring/burial vessels and skills
Onshore Structures (if needed) Projects will likely include an onshore substation and control building. This could also be built to house some essential operations and maintenance staff. Given the remote location of some of these projects, it is also possible that a road may need to be built to provide for site accessibility. • Construction of building • Preparation of applications for any planning permits or approvals required by regulatory authorities	• Building contractor • Concrete supplier • Electrical contractor • Window installation • Telecommunications • Metalworks • Plumber	• Concrete • Building supplies • Windows • Plumbing supplies • Electrical equipment	• Carpentry • Building design and construction • Electrician • Metal works • Plumbing • Telecommunications
Other Project Stage Service and Supply Requirements: • Insurance: protection of owner from accidental damage to the components during fabrication and assembly • Project certification	• Insurance supplier		• Certification – permitting requirements

7. OPERATIONS AND MAINTENANCE

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

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

OPERATIONS & MAINTENANCE (O&M)			
ACTIVITIES	SUPPLIERS	EQUIPMENT & INSTRUMENTS	SKILLED WORKERS & KNOWLEDGE WORKERS
Operations • Review, monitoring, auditing, and managing environmental performance to ensure compliance with permit/approval conditions • Provision of information on environmental impact to stakeholders and regulatory authorities • Monitoring performance • Inspection of operations and activities • Planning and management of maintenance activities • Administrative activities related to customer, regulatory, and legal requirements	• Diving services • Consultants—engineering, technical, environmental • Administrative services • Port services and facility	• Computing systems • Navigation systems and data	• Dedicated operations staff and control centre • Marine engineer (class 4 or higher) for offshore and onshore maintenance work • Power Engineer (Class 1 and Class 4) • GIS services • Subcontractor support services • Vessels for ongoing environmental monitoring activities and inspection • Ecologists and marine biologists • Mechanical technicians • Electrical technicians • Health & Safety/Emergency Response • Business administration

OPERATIONS & MAINTENANCE (O&M)			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Maintenance • Planned maintenance including retrievals using tugs and workboats • • Management of unplanned maintenance	• Port facility • Consultants – engineering, technical	• Support vessels including tug boats and workboats • Portside lifting capability to lift the device to shore if needed (crane) • Local workshop facilities to allow for strip-down, refurbishment, re-assembly, and testing of devices. • Storage for replacement parts/ PTO systems	• Dedicated maintenance staff and control centre • Mechanical technicians • Electrical technicians • Marine engineer (class 4 or higher) for offshore and onshore maintenance work • Welding and machining • Health & Safety/Emergency Response

8. DECOMMISSIONING

Once a project reaches the end of its operating life, it will be decommissioned and the associated infrastructure removed in a safe and environmentally sustainable manner and in accordance with regulatory requirements.

Many of the physical activities and supply requirements under decommissioning will be similar to the installation and O&M stages and therefore several steps have not been repeated in this section. Please see stages 6 and 7 for a list of those activities and requirements.

DECOMMISSIONING			
ACTIVITIES	**SUPPLIERS**	**EQUIPMENT & INSTRUMENTS**	**SKILLED WORKERS & KNOWLEDGE WORKERS**
Decommissioning Plan • Prepared as part of the permitting conditions and revised over the life of the project • Consultation with regulatory authorities and stakeholders to determine decommissioning methodology and potential mitigation needs • Consideration of potential environmental impacts • Contains provisions for safe removal of the project infrastructure and disposal of removed equipment • Preparation of a suitable procurement strategy for the elements of the decommissioning work to be outsourced • Site surveys pre- and post-decommissioning	• Engineering and environmental consulting • Government		• Technical expertise • Engineers • Research support • Health & Safety expertise • Financial services
Decommissioning Fund • Fund set aside over life of the project to ensure that decommissioning and other costs will be covered	• Financial services		

CASE STUDY: NOVA SCOTIA POWER AND OPEN HYDRO AT FORCE*

In 2009, Nova Scotia Power and Open Hydro deployed a 1 MW Open Hydro device at FORCE. The following is an account of services, supplies, and activities involved in the project provided by Nova Scotia Power Inc. (NSPI). It is the only information available based upon actual experience of deploying a turbine in the Bay of Fundy.

The types of services, materials and skill sets that were solicited outside of the berth holder (NSPI) and technology developer's (OpenHydro's) organization during the fabrication, deployment, and recovery of the OpenHydro In-Stream Tidal Turbine in the FORCE site in the Bay of Fundy are identified below. The information is divided into three sections: Design, Fabrication, and Deployment and Recovery.

DESIGN

Research Support

- Collection of bathymetry data to aid in selecting the most ideal location for deployment of the device

Deployment

- Collection of Acoustic Doppler Current Profiler (ADCP) measurements at the deployment location so that design of the assembly could be optimized
- Analysis of the weather patterns in the area and the tidal profile so that the design could be optimized
- Collection and evaluation of acoustic data to quantify the acoustic signature of the area before and after deployment

Engineering Consultants

- Assistance in the preparation of applications for funding support
- Assistance in evaluation of possible technologies for deployment

Marine Architect

- Evaluated the subsea base design
- Provided logistical support during final design, testing, and deployment
- Informed on Nova Scotia marine safety and standards requirements

FABRICATION

Steel Fabrication

- Fabrication of the subsea base in Nova Scotia (closer to the deployment location than the technology developer's shop in Ireland)
- Inspection of the subsea base during fabrication

Concrete Supplier

- Ballasting the subsea base for stable deployment in the Bay of Fundy

Cranes

- Lifting the various components into place and allowing for assembly
- Lifting the assembly into the OpenHydro Installer barge (the "barge") for testing and deployment

Diving Services

- Assistance with removal of subsea base ballast fill pipes

Insurance

- Protection of the owner from accidental damage to the components during fabrication and assembly

Instrumentation

- Provision of communication with the assembly during deployment
- Recording of forces experienced on the assembly and other data to further understand conditions in the Bay of Fundy and optimize the design

Marine Consultant

- Inspection of the barge and associated equipment for compliance with regulations
- Provision of warranty surveyor services and preparation of tow certificate
- Evaluation and summary of available underwater electronic data collection and communication technologies

Research Support

- Assessment of seabed conditions to aid in design of sea trials / testing of assembly

DEPLOYMENT AND RECOVERY

Marine Consultants

- Review and evaluate the OpenHydro Installer barge (the "barge")
- Assist in identification of permitting requirements

Customs Broker

- Assistance in movement of materials from the UK to Nova Scotia as required
- Guidance in obtaining proper permits for temporary use of the OpenHydro Installer barge

Personal Protective Equipment

- Ensuring personnel involved with deployment and recovery operations had all available precautions in place to ensure their safety

Radios

- Ensuring efficient and effective communication between all parties involved in deployment and recovery operations

Fishing boats

- Accompaniment for the barge and tugboats during deployment and recovery operations to carry additional personnel that could not be on the tugboats

- Providing quick response in case of emergency.

Tugboats

- Towing the OpenHydro Installer barge (the "barge") through a test program prior to initiating deployment activities in the Bay of Fundy

- Towing the barge and tidal assembly into place for deployment, and towing the barge into place for recovery of the assembly.

Research Support

- Monitoring the movement of lobster during deployment for indication of change from normal behaviour

- Viewing the turbine in operation using side scan SONAR

- Viewing the turbine in operation using a camera on a tether

- Studying the anticipated wind and sea state during expected recovery window

- Monitoring biomass (schools of fish) and their movements in the upper Bay of Fundy through echo sounding and netting

- Monitoring bird and mammal behaviour in the area of the turbine for changes

- Passive monitoring of acoustic noise from marine mammals and determining if they are affected or at risk from the turbine.

- Exploring fish monitoring technologies at the turbine site (e.g. 2-D and 3-D sonar), and following fishing patterns at shoreline herring weirs in the area.

- Identifying acoustic signatures to the turbine and determining the effects locally

- Determining deployment effects scour on benthic habitat

Insurance

- Protection of the owner from accidental damage to the components during deployment and recovery operations

Public Relations

- Provision of professional media coverage of milestone events such as assembly and deployment

Cranes

- Lifting for dismantling of the assembly to allow for evaluation of performance

Diving Services

- Observation of the subsea base to evaluate biological growth and overall condition

Looking forward, there are a number of services and technologies that may be valuable for further deployments of in-stream tidal turbines in the Bay of Fundy.

- Dynamic Positioning (DP) Vessel – This type of vessel was not required for the deployment or recovery of the OpenHydro turbine. However, this type of vessel may be valuable for the deployment of other technologies or larger turbines as they approach commercialization. In addition, cable repairs or cable splicing for any reason "on sea" may require a constant position, which may be facilitated by this type of vessel.

- Remote-Operated Vehicle (ROV) – ROVs were not used in the deployment or monitoring of the OpenHydro turbine. However, all technology developers recognize the benefit of using an ROV to monitor deployment, perform visual surveys of the cable or turbine, and complete work under water. It is unknown if ROVs that can be manipulated accurately in the Bay of Fundy are available.

- Core sampling – Core sampling was not performed when evaluating the deployment site for the OpenHydro turbine. Accurate characterization of the floor of the Bay of Fundy, particularly at the deployment site, may be valuable information for technology developers. The ability to do this type of work in a cost effective manner in the Bay of Fundy is unknown.

- Piling etc. – Some technology developers may be planning to anchor their turbines directly to the floor of the Bay of Fundy (vs. the subsea gravity base used by OpenHydro). This may also prove to be a challenge in the Bay of Fundy.

** Please note that information in this case study was solicited by Maritime Tidal Energy Corporation in its preparation of the "Marine Renewable Energy Infrastructure Assessment" and was originally published as part of that assessment.*

Nova Scotia and the Atlantic region have a unique opportunity to capture the benefits of this new sector through the entire supply chain—from research and development through to engineering, manufacturing, installation, operation and maintenance.

9.3 - BUILDING THE TIDAL ENERGY SUPPLY CHAIN

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

9.3.1 - RELATED SECTORS WITH SUPPLY CHAIN POTENTIAL

Businesses and organizations with a track record in working in the marine environment, perhaps gained from industries such as offshore oil and gas, ocean technology, fishing, or marine aggregates extraction, may be well suited to undertake this work. This embedded workforce can serve to transfer skills across to the developing tidal energy sector, creating a new supply chain.

This section aims to provide an overview of the major ocean-industry related sectors that could feed into the tidal energy supply chain to develop some of the major components needed to support the industry and decrease the costs of project development. It also provides some strategies for supply chain development.

9.3.1.1 - OFFSHORE PETROLEUM

Canada has internationally recognized expertise in extraction equipment, drilling technologies, and maintenance systems for the offshore oil and gas industry—expertise that has already been engaged in some aspect of early tidal energy prototyping. Businesses, technical skills, and resources that are already involved in the offshore petroleum sector can be aligned with tidal energy projects to support the installation, operation, and maintenance of devices.

9.3.1.2 - WIND ENERGY

Similar to offshore oil and gas, the wind energy sector includes some skill sets and expertise that could be transferrable to the tidal energy sector. However, some experts have noted that the transfer of skills between industrial sectors is not seamless and careful planning and effort need to be made to develop knowledge transfer strategies.

9.3.1.3 - OCEAN TECHNOLOGY

Ocean technology is a growing sector in Nova Scotia, generating $5 billion in revenue and employing 14% of the province's workforce. The sector is a mix of primarily small and medium-sized enterprises with a few large multi-national corporations (Government of Nova Scotia, 2011). Local companies have been pioneers in underwater acoustics and imaging, marine communications, navigation, ocean monitoring, a wide variety of enhanced engineering and environmental services, and the production of innovative equipment to operate in harsh marine environments. Many ocean technology firms also have a breadth of experience in the offshore oil and gas industry, having provided much of the engineering, seismic survey, modeling, forecasting, production, and processing underwater intervention support during the Sable Offshore Energy project and Deep Panuke Project.

Key sub-sectors existing in Nova Scotia's ocean technology sector that could become involved with marine renewable energy development include:

- acoustics, sensors, and instrumentation;
- data, information, and communications systems;
- marine geomatics;
- unmanned surface and underwater vehicles; and
- naval architecture.

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

With 450 PhDs in ocean-related disciplines and the world's highest concentration of researchers in the sector, Nova Scotia has many knowledge workers that can access opportunities presented by tidal energy development.

9.3.2 - RESEARCH AND ACADEMIC INSTITUTIONS

Tidal energy project development will require access to R&D facilities, skilled workers, and research expertise in a number of disciplines. With 450 PhDs in ocean-related disciplines and the world's highest concentration of researchers in the sector, Nova Scotia has many knowledge workers that can access opportunities presented by tidal energy development. Nova Scotia is home to eleven universities and a community college system, which together have marine, science, engineering, marine geomatics, geological oceanographic studies, technology programs, courses, and potential research activities that have and/or will likely contribute to support tidal energy development. Strategic research initiatives among key organizations can help answer key research questions and gather supporting data.

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

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

Academic institutions could serve to support future training and skills in marine renewable energy development by establishing programs and courses that cater to the needs of the sector. They also may have research facilities, resources, and expertise that could be applied to future project development. Collaborative activities and projects among local research institutions and industry could serve to accelerate marine renewable energy industry development through applied research projects, business incubation, and university placements.

9.3.3 - MARINE STRUCTURE FABRICATION AND MARINE TRANSPORTATION

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

9.3.4 - PORT FACILITIES

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

Infrastructure requirements vary according to the type and size of technology used and life cycle stage. The Marine Renewable Energy Infrastructure Assessment (2011) identified that multiple ports in Nova Scotia could support aspects of project development given the broad requirements of developers at this early stage. The assessment concluded that current infrastructure was sufficient in these early stages, but major infrastructure would be required to support the tidal energy industry beyond the capacity of 64 MW at FORCE.

Ports within the region that have been used or have been identified as having future potential and their respective assets are shown in Table 9-3.

Table 9-3: Assets of Nova Scotia Ports Identified for Tidal Energy

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

Source: Marine Renewable Energy Infrastructure Assessment, 2011

9.3.5 - PROFESSIONAL AND SUPPORTING SERVICES

Various support services will also be required by tidal energy projects, including legal, financial, insurance, logistics and management support, consultants (environmental, engineering, technical), planning, transportation, construction (onshore), and communications. These services are readily available in Nova Scotia and the region and as the industry advances, it is likely that there will be greater opportunities for these businesses to participate. It is also likely that many new opportunities could also emerge. For example, the creation of innovative businesses such as a turn-key management service, providing planning and implementation of the installation process, could be attractive to project developers.

CASE STUDY: NEW COMPANIES EMERGING TO SERVICE WAVE AND TIDAL ENERGY

There are several examples of innovative companies and partnerships being established to service marine renewable energy projects—with companies from different sectors bringing expertise to the tidal energy industry.

Recently, Swedish utility, Vattenfall joined forces with the UK's Babcock and Spanish renewables specialist Abengoa, to launch a new engineering services company, Nautimus, which will focus on wave and tidal energy. Nautimus will provide technology-neutral engineering, procurement, and construction (EPC) services for project developers. The partnership was established to address the absence of EPC services players in the marine renewable energy sector capable of handling the wide ranging challenges associated with constructing projects with new technology in the marine environment. If unfilled, this gap would pose a significant problem for the sector in the UK if industrial development proceeds as it is projected.

Nautimus is the world's first engineering firm dedicated to marine renewable energy and signals the momentum and opportunity presented by the sector as it grows towards larger projects and increased industrial activity.

For more information on Nautimus, please visit: http://www.abengoa.es/corp/web/en/noticias_y_publicaciones/noticias/historico/2012/05_mayo/abg_20120507.html for the news release or www.vattenfall.com.

KEY DOCUMENTS

The following documents and links provide further information on tidal energy supply chain development, opportunities in Nova Scotia, and the global status of the tidal energy industry. Data to inform project supply chain requirements at each tidal energy project stage was gathered from the following documents:

- Wave and tidal energy in the Pentland Firth and Orkney waters: How the projects could be built, BVG Associates for The Crown Estate, 2011 http://www.thecrownestate.co.uk/media/71431/pentland_firth_how_the_projects_could_be_built.pdf
- Nova Scotia Tidal Symposium Supply Chain Presentations, July 2011. Government of Nova Scotia www.nsrenewables.ca
- Marine Renewable Energy Infrastructure Assessment Report, Nova Scotia Department of Energy, 2011http://www.gov.ns.ca/energy/resources/EM/renewable/Marine-Renewable-Energy-Infrastructure-Assessment.pdf
- The Marine Renewable Energy Sector Early-Stage Supply Chain, Natural Resources Canada, Canmet Energy, 2011 http://www.oreg.ca/web_documents/marine_renewable_energy_supply_chain_en.pdf
- Guidelines for Project Development in the Marine Energy Industry www.emec.org.uk.

ORGANIZATIONS

SUPPLY CHAIN-SPECIFIC LINKS

- Offshore Renewables Supply Chain Directory (Scotland) http://www.scottish-enterprise.com/your-sector/energy/offshore-wind/CompanySearch.aspx

OTHER ASSOCIATIONS AND ORGANIZATIONS

Nova Scotia

- Ocean Technology Council of Nova Scotia http://otcns.ca/

International

- Scottish Development International http://www.sdi.co.uk
- Marine Renewables Industry Association (Ireland) http://www.mria.ie/links.php
- Aotearoa Wave and Tidal Association (AWATEA) -- established in 2006 to promote the uptake of marine energy in New Zealand www.awatea.org.nz
- RenewableUK -- the trade and professional body for the UK wind and marine renewables industries www.bwea.com
- Scottish Renewables -- Scotland's trade association for renewable energy, including wave and tidal www.scottishrenewables.com/
- European Ocean Energy Association (EU-OEA) -- unites the broad interests of the European ocean energy industry into a single, focused and independent voice www.eu-oea.com

9.4 - SECTION 2: STRATEGIES FOR BUSINESSES

Author: Dr. Shelley MacDougall

There is much work to be done. The challenges and opportunities of sustainably developing tidal energy call for the participation of a wide array of businesses. This section describes the concept of industry clusters and the idea of "cluster thinking" to propel the region to the forefront of technology and process expertise. Advice is given on how businesses can get involved, and the government departments and non-governmental organizations in Nova Scotia that play a role in the development of the industry are identified.

9.4.1 - INDUSTRY CLUSTERS

An industry cluster is a geographic concentration of companies (suppliers of goods and services, their customers, and related companies) and organizations (research labs, universities, industry associations, standards associations) in the same industry. Companies in the cluster share common needs, opportunities, constraints, and obstacles to productivity (Porter, 2000, p. 18). They both compete with one another and cooperate. One of the most famous of industry clusters is Silicon Valley in California. There are many others: the Italian shoe industry, New York City's garment district, banking and theatre industries, the US auto industry, California's filmmaking and wine industries, the Alberta oil industry, and Boston's Route 128 biotech industry, to name a few.

9.4.1.1 - HOW DOES A CLUSTER FORM?

Researchers have studied many clusters over the years, but it is difficult to generalize about how they form. However, clusters have often formed near a particular resource, such as a natural resource, or skilled or inexpensive labour; near a market, for easier access to customers; near customers and suppliers, for reduced costs of doing business; or near a strategic asset (Seeley, 2007). In the case of Nova Scotia, tidal resources are a draw for businesses, but so too is the developing knowledge of TEC devices, monitoring and communications technologies, processes, practices, and standards. These constitute strategic assets. Clusters also form around a university with breakthrough technologies (such as in Kitchener-Waterloo), and government contracts (such as the Canadian Government's shipbuilding contract, awarded to Irving Shipbuilding). In Nova Scotia, NSPI's renewable energy requirements and the Clean Energy Act lend support to the development of a tidal energy industry.

As an industry develops in an area, other companies are attracted to it to supply products and services, so they locate or start up nearby. This is especially the case in an industry that is new and the products and services are still undefined. Being close to customers and suppliers allows for ease of communication, collaboration, and sharing of tacit knowledge (Seeley, 2007).

FOUNDATIONAL CONCEPT: TACIT AND EXPLICIT KNOWLEDGE

"Knowledge is defined as a fluid mix of experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Human knowledge exists in different forms that can be articulated explicitly (explicit knowledge) or manifested implicitly (tacit knowledge).

Individuals bring specialized knowledge and expertise into an organization. Once shared or learned, knowledge can be held collectively. The building of collective knowledge eventually contributes to the organization's intellectual capital.

Collective knowledge can be either explicit or tacit. Explicit collective knowledge is present in organizational operating procedures, documentation, information systems, and rules. Some of this knowledge is public domain knowledge shared by many professionals and organizations. Collective tacit knowledge is manifest in such things as habits, skills, and abstract understanding among organization members. It is an overarching and collective form of shared knowledge that is neither readily observed nor easily and quickly learned. Those who gain access to and acquire collective tacit knowledge can leave with it, but it simultaneously remains in the organization" (MacDougall & Hurst, 2007, p. 185).

9.4.1.2 - HOW BIG IS THE GEOGRAPHIC REGION OF A CLUSTER?

The geographic region ranges from a few city blocks to multiple provinces (Alberta, Saskatchewan oil industry) or states (US auto industry). Medicon Valley, a biotech and pharmaceuticals cluster, spans the water between Denmark and Sweden (Lundquist & Power, 2002). Clusters have been described in various configurations, such as district, valley, triangle, route, and region. In Nova Scotia, the tidal energy region is yet to be defined; it could be in one municipality, a county, the province, or a multi-provincial, even international region, such as the Fundy region.

9.4.1.3 - WHAT ARE KEY ELEMENTS IN A CLUSTER?

Key elements in an industry cluster include availability of skilled and knowledge workers, access and engagement of researchers and university labs, support for research and development, and startup financing for developers of technologies.

An industry association is integral to an industry cluster. The industry can be a forum in which otherwise competing companies can collaborate to share non-proprietary knowledge; engage in public education; communicate needs to government (such as what infrastructure is needed); share costs of specialized equipment; promote the industry brand (e.g. Nova Scotia Wines); advise schools, colleges, and universities of the skills and expertise needed by the industry to develop the competence base; host networking events, workshops, and seminars; and collaborate on standards setting.

The Fundy Ocean Research Centre for Energy (FORCE) is an example of the collaborative efforts of companies in the tidal energy industry, regulators, and researchers who have joined together to share costs and knowledge for the advancement of the industry. This test facility for large-scale tidal energy devices is important to the development of an industry cluster. Also important in the development is the existence of business incubators, such as the Acadia Centre for Rural Innovation and research institutes, such as the Acadia Tidal Energy Institute.

9.4.1.4 - WHAT ARE THE ADVANTAGES?

One of the advantages of an industry cluster is strength in numbers. Regional wine industries are a good example: wineries and grape growers are generally small organizations. Individually, they do not have sufficient clout to influence public policy or have commercial bargaining power. Collectively, though, through the formation of a wine and grape growers association, they are able to lobby government; promote the wine region and its wines; share costs of equipment, supplies, and consultancy services; engage with university and government researchers on common problems; and raise money for local initiatives.

Another advantage is the proximity to suppliers and customers, which facilitates the development of new technologies and processes by virtue of the ability to meet regularly, face-to-face. The rate of innovation in clusters tends to be greater than outside clusters, at least during the growth stage. As they mature, this can change. Clusters may become too inward looking and, over time, find themselves no longer competitive globally (Seeley, 2007).

While the construction and deployment of the tidal energy devices in local waters themselves may not become a large economic driver in Nova Scotia, the development of technologies and expertise associated with them will be in demand worldwide.

9.4.1.5 - HOW CAN THIS WORK FOR NOVA SCOTIA TIDAL ENERGY INDUSTRY?

First of all, “cluster thinking” is needed: an orientation toward groups of organizations, rather than individual firms (Courtright, 2006). Many of the pieces are in place for the Nova Scotia tidal energy industry to develop as a cluster. Table 9.5: Key Organizations Supporting Tidal Energy Development for Nova Scotia identifies many of key organizations that are in place. While the construction and deployment of the tidal energy devices in local waters themselves may not become a large economic driver in Nova Scotia, the development of technologies and expertise associated with them will be in demand worldwide. Developing and exporting innovative products and process expertise will generate local economic benefits.

As noted above (Related Sectors with Supply Chain Potential), much of the skill and expertise needed to serve the nascent tidal energy industry is available in Nova Scotia in other maritime industries. As the prospects for tidal energy develop, many of these organizations can make the investment necessary to also serve the tidal energy industry. This will help build an industry cluster.

9.4.1.6 - CAN GOVERNMENT POLICY ENCOURAGE THE DEVELOPMENT OF A TIDAL ENERGY INDUSTRY CLUSTER?

“Most clusters arise without the help of governments and many die despite it” (Seeley, 2007, p. 64). Still, governments can play a role. They can help though promotion of the region as being an area where world-class expertise and tidal resources exist (i.e. The Fundy Standard), maintaining favorable policies toward innovation (i.e. COMFIT and FIT), encouraging entrepreneurship, supporting research and development through funding university, government and private research and laboratories, and a supporting a good education system (Seeley, 2007). It is important for government to not “pick winners” or prop up a failing business; rather, government should let market forces stimulate the drive toward innovation (Craig, 2000). The government can also keep the industry informed, convening cluster members to share information, working with the industry association, and supporting access to capital.

VIGNETTE: MAINE TIDAL ENERGY AS AN INDUSTRY CLUSTER

“Maine has the unique opportunity to create a world-class marine tidal energy cluster that encompasses multiple industries and organizations. This cluster would feature research and development (R&D) excellence at both the University of Maine and Maine Maritime Academy, fostering high-tech manufacturing facilities for marine composite structures, a resurgence of marine services activity at working waterfronts, and enhanced understanding of the Gulf of Maine ecosystem.

This collective approach to sensible development of Maine’s tidal energy resource will have significant economic, educational, and social impacts. Tidal energy development will be as defining to the Maine coast in the 21st century as forest harvesting, fishing, boat building and tourism have been. It has the potential to provide long-term benefits that could positively affect future generations” (Ferland, 2008, p. 111).

VIGNETTE: ORKNEY RENEWABLE ENERGY CLUSTER

“Given that Orkney is rich in renewable energy sources of wind, wave and tide, there is clearly scope for Orkney to be a major renewable energy producer in the future. Developing local natural resources has always been the key pathway to economic development in the islands, enabling the development of industries which export to markets outside the islands, so earning revenues to pay for goods and services imported to the County. Rather than self-sufficiency, the traditional goal has been to maximise production and profit, selling into export markets in the UK and beyond.

Developing Orkney’s renewable energy resources will benefit the islands economically, and indeed the development that has already taken place has brought jobs (OREF calculate of the order of 150), skills and expertise that can be used locally and exported, and income for landowners and for community groups that have an involvement. The European Marine Energy Centre, which tests marine energy devices, and the International Centre for Island Technology (Heriot Watt’s Orkney campus and the base for its postgraduate renewable energy courses), are part of a marine renewables cluster. This cluster also encompasses a number of private sector firms which have developed considerable renewables expertise, and which are attracting funds to Orkney and selling their expertise abroad” (Orkney Islands Council, 2009, p. 4).

FOUNDATIONAL CONCEPT: SEVEN SECRETS OF FAILURE

John Craig summarized the "Seven Secrets of Failure" in developing an industry cluster and provides alternative approaches. Paraphrasing Craig, the alternative approaches are as follows:

1. Rather than focusing on real estate (providing industrial land and enticing companies to locate there), focus on where the organizations with knowledge and skills relevant to the cluster are located.

2. Rather than concentrating on attracting outside investment, build on the "embryo of the industry cluster that already exists. Gather and digest information about the world-wide market and technological opportunities relevant to the cluster. Development of a learning cluster starts as a learning process, rather than an investment process."

3. Rather than politically push for the creation of businesses in the cluster, allow the cluster to grow in response to the pull of the market.

4. Rather than providing strong political leadership, allow companies to respond what customers want. Also, do not allow those with the strongest established positions to control the cluster's development.

5. Do not pick winners – do not provide government assistance where market failures are identified.

6. Do not plan the development of the cluster or provide special government supports. Rather, help make information about opportunities more readily available.

7. Do not be secretive, rather, make information widely available.

Craig, J. (2000) The Seven Secrets of Failure. Centre for Policy and Development Systems, Queensland, Australia. Accessed July 2012 at: http://cpds.apana.org.au/Documents/Cluster/developing_industry_cluster.htm# .

9.5 - CHECKLIST FOR BUSINESSES

Author: Elisa Obermann

The following is a checklist that will help companies and business owners determine whether they have skills and expertise to service tidal energy projects and identify the appropriate strategy for engaging in the tidal energy industry.

Table 9-4: Checklist for Businesses Interested in Tidal Energy

CHECKLIST FOR BUSINESSES
What skills, services, and/or supplies do you currently offer that could be applied to a tidal energy project? What needs to be brought in?
What is your capacity to serve tidal energy projects (1, 2, or multiple projects and at what activity level)?
Are resources available to make tidal energy a priority and work to be an early-mover?
Have you made connections with any potential business partners or project developers?
Have you considered potential risks involved with working in an emerging sector like tidal energy?

9.5.1 - KEEPING INFORMED OF OPPORTUNITIES

There are several ways for businesses and communities to learn more about tidal energy development and keep informed of associated supply chain opportunities. Many organizations provide information about the industry and projects through websites, organizing and hosting networking events (conferences, workshops, trade missions), and posting supply chain specific opportunities. Networking events and conferences are valuable opportunities to meet project developers and other industry players. Table 9-5 lists links to organizations, key documents, and literature that provide background and up-to-date information on supply chain opportunities.

Marine Renewables Canada (formerly the Ocean Renewable Energy Group (OREG)) provides a list of worldwide events, conferences, and workshops of interest to the marine renewable energy industry: http://www.oreg.ca/index.php?p=1_6_Events.

9.6 - KEY ORGANIZATIONS

There are several organizations in Nova Scotia, regionally and at the national level, that are very involved in tidal energy development and serve as valuable resources for information on current industry progress, new project initiatives, and supply and service opportunities. These are identified in Table 9-5.

Table 9-5: Key Organizations Supporting Tidal Energy Development for Nova Scotia

KEY ORGANIZATIONS			
ORGANIZATION	ABOUT	LINK	SUPPLY CHAIN ACTIVITIES/ SUPPORT
Nova Scotia Department of Energy	Provincial government department leading tidal energy policy and regulatory development.	www.gov.ns.ca/energy	• Notice of new industry development initiatives, projects, and supportive policy/regulations • Hosts workshops and stakeholder consultations
Nova Scotia Department of Economic, Rural Development, & Tourism	Provincial government department leading community and rural development initiatives.	www.novascotia.ca/econ/	• Implementation of the JobsHere plan: http://novascotia.ca/jobshere/
Atlantic Canada Opportunities Agency	Federal department working to create opportunities for economic growth in Atlantic Canada by helping businesses become more competitive, innovative, and productive.	http://www.acoa-apeca.gc.ca/Eng/Pages/Home.aspx	• Oversees and administers business development programs
Fundy Ocean Research Center for Energy	Canada's leading research centre for in-stream tidal energy, located in the Bay of Fundy, Nova Scotia.	www.fundyforce.ca	• Currently has 4 berths for tidal technology project development, with different technologies/project developers • Posts opportunities for contractors, subcontractors, etc. here: http://fundyforce.ca/media-center/opportunities/

KEY ORGANIZATIONS			
ORGANIZATION	ABOUT	LINK	SUPPLY CHAIN ACTIVITIES/ SUPPORT
Offshore Energy Research Association	Funds offshore energy environmental and geoscience research and development.	www.offshoreenergyresearch.ca	• Issues requests for proposals for R&D work • Hosts bi-annual R&D conference and research events/workshops
Marine Renewables Canada (formerly Ocean Renewable Energy Group – OREG)	National marine renewable energy (tidal, wave, in-stream river) industry association supporting the development of the sector	www.marinerenewables.ca	• Hosts networking events, an annual conference, and trade missions • Conferences provide opportunities to learn about industry progress and players involved • Posts opportunities specific to tidal energy development
The Maritimes Energy Association	Industry organization for Eastern Canada's energy industry focused on supporting the maximization of Atlantic Canadian participation in the supply of both goods and services to meet the needs of the energy industry.	http://www.maritimesenergy.com/	• Hosts networking events, an annual conference, and trade missions • Posts opportunities for energy and marine supplies and services
Acadia Tidal Energy Institute	Focused on assessing tidal energy resources and the associated environmental challenges and socio-economic opportunities.	http://tidalenergy.acadiau.ca/	• Conducts multidisciplinary research projects on tidal energy resource assessment, environmental monitoring and impacts, socioeconomic growth, and sustainable communities • Leads development and delivery of tidal energy educational programs and other support materials • Facilitates capacity building and understanding of available tidal energy resources, environmental effects, and socioeconomic opportunities, particularly in local rural communities
Fundy Energy Research Network	Coordinates and fosters research collaborations, capacity-building, and information exchange to understand the environmental, engineering, & socio-economic factors associated with tidal energy development in the Bay of Fundy.	www.fern.acadiau.ca	• Core focus is socio-economic issues (including supply chain development) • Coordinates and supports tidal energy research projects, activities, and events

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10 FINANCING, GOVERNMENT SUPPORTS, AND MANAGING RISK

10 - FINANCING, GOVERNMENT SUPPORTS, AND MANAGING RISK

Author: Dr. Shelley MacDougall

WHAT DOES THIS MODULE COVER?

Developers, lenders, and investors will require some level of assurance the tidal energy project is likely to be profitable over time. This section identifies sources of financing, government supports, risks, and methods of reducing or spreading the risks of in-stream tidal energy project development.

This module outlines the financial considerations of developing a tidal energy resource:

- What financing can be accessed at various stages of the project?
- What are the risks at the various stages of development, such as technological, delivery, labour, policy, price volatility (materials, production costs), and weather?
- By what means can these risks be mitigated or shared to reduce the exposure of any one party to the risks that would otherwise deter investment?

IS THIS MODULE FOR YOU?

This module is for anyone concerned with the financial viability and risks of tidal energy projects, such as developers, policy makers, insurers, equity investors, and lenders.

10.0 - FINANCING IN THE STAGES OF TECHNOLOGY AND PROJECT DEVELOPMENT

Beyond the engineering challenges and environmental and societal hurdles, a significant barrier to commercializing tidal energy is financing. Through the stages of development of new technology, there are times when financing is scarce. Exacerbating this is competition for funding from other renewable technologies as well as mature technologies that generate electricity from fossil fuels and the absence of a price on carbon dioxide emissions. This section briefly describes the financing typically found at the various stages of development as they apply to tidal energy.

10.0.1 - STAGES OF TECHNOLOGY DEVELOPMENT, PROJECT DEVELOPMENT, AND COMMERCIALIZATION

The stages of technology and project development are defined differently in various reports, studies, and articles. In an attempt to reconcile some of the categorizations and familiarize the reader with various terms used in the industry, Table 10-1 lists the activities undertaken to develop and commercialize new technology and includes two common groupings of the activities. The table also includes types of financing commonly used for these stages of technology development, as well as suitable government supports that provide incentives or assistance to developers or assurances to lenders and equity investors. These sources and supports will be discussed further in subsequent sections.

The process begins with research and development of the technology. The stages of technology development and "Technology Readiness Levels" will be described in a later section.

Following the technology development stage are pre-commercialization activities: feasibility assessments, planning, permitting, community consultation, and project design. All of these activities require financing, which generally comes from the developer's own resources, venture capital, and government supports in the form of loan guarantees, incubators, and tax incentives.

Table 10-1: Stages of Technology and Project Development, Sources of Financing, Government Supports and Incentives

STAGE	ACTIVITIES	ORECCA* STAGES	ECOFYS** STAGES	SUITABLE SOURCES OF FINANCING	SUITABLE GOV SUPPORTS & INCENTIVES
Research & Development (technology)	Energy Conversion technology Energy Storage/ Usage Prototype testing Investment	Pre-feasibility	R&D	Balance sheet financing, angel investment	R&D grants, university funding, government labs, incubators, R&D tax incentives
Feasibility Assessment (project)	Geophysical Oceanographic Heritage Environmental Competing use Financial Feasibility Community consultation		Pre-commercialization	Balance sheet financing, venture capital, private equity	Guarantees, public-private venture capital, soft and convertible loans
Planning	Project planning Permits Insurance Finance Legal Power purchase agreement Community consultation	Design and Development			
Design	Project design Offshore design Mechanical design Hydrodynamic design Electrical system design Civil (onshore design) Control system design				

STAGE	ACTIVITIES	ORECCA* STAGES	ECOFYS** STAGES	SUITABLE SOURCES OF FINANCING	SUITABLE GOV SUPPORTS & INCENTIVES
Manufacture	Moorings Offshore floating structure Energy coupling system Power generation equipment Power transmission equipment Navigation/Common equipment Control equipment Energy storage systems Onshore structures construction Resource assessment equipment Component testing Component verification	Construction	Commercialization	Private equity, bank senior debt, mezzanine (subordinate) debt, project financing	Loan guarantees, contingent grants, stable/long term government policies
Installation	Onshore assembly Cable laying Transportation Offshore construction Civil (onshore engineering) Environmental monitoring				
Operation & Maintenance	Integrity management Performance evaluation Recovery and repair Reliability management Structural monitoring Environmental monitoring	Operation			Feed-in tariffs, renewable energy credits, power purchase agreements

STAGE	ACTIVITIES	ORECCA* STAGES	ECOFYS** STAGES	SUITABLE SOURCES OF FINANCING	SUITABLE GOV SUPPORTS & INCENTIVES
Decommissioning	Offshore disassembly Transportation Recycling/ waste disposal Refurbishment Environmental compliance	Decommissioning	Decommissioning		

*Offshore Renewable Energy Conversion Platform Coordination Action
**Ecofys Investments B.V., headquartered in the Netherlands.
Sources: ORECCA 2011, p51-54; EcoFYS 2011, p.100.

Once the pre-commercialization activities are complete, the go/no go decision is made. Large amounts of capital are required with the decision to proceed. For some projects to be financially feasible, they need to be built in arrays (multiple TEC devices) to benefit from economies of scale. The large amounts of capital and duration of the project put the project beyond the capability of venture capitalists and usually beyond the capability of the developer to go it alone. Equity investors and bank financing are needed. If the project goes ahead (commercialization), the cable is laid, and devices are manufactured and installed. Operations and maintenance are then ongoing for the life of the project, after which time, the equipment is decommissioned (or repowered).

10.1 - METHODS OF FINANCING

This section describes methods of financing that are suitable at the various stages of development and commercialization. In subsequent sections, methods of financing and government supports available in Nova Scotia will be described.

10.1.1 - BALANCE SHEET FINANCING

Balance sheet financing, also known as corporate financing, is simply the project developer investing in the renewable energy project from its own cash, financed either from existing or new equity and debt. The loans are secured by the developer's general assets. This is often the only financing option for technologies without a track record in the R&D and pre-commercialization stages.

Advantages of balance sheet financing include:

- The interest rate on the corporate debt raised is cheaper than it would be on debt raised specifically for the new technology project since it reflects the general credit risk of the developer and its own debt/equity ratio, rather than the risk of the stand-alone project.

- Without involving other investors, balance sheet financing involves fewer parties, so the developer has more control over the project.

- There are no additional loan covenants, only the ones the company must usually adhere to.

FOUNDATIONAL CONCEPT: STAGES OF DEVELOPMENT

For more information on financing at the various stages of development, refer to Weiser & Pickle (1998); Ecofys (2011); ORRECA (2011), www.renewableenergyworld.com, www.windenergythefacts.com.

FOUNDATIONAL CONCEPT: WHAT IS VENTURE CAPITAL?

Venture capital is a subset of private equity capital. Venture capital is provided by a company that acts as a financial intermediary, pooling investors' capital and investing in a portfolio of private companies (i.e. companies whose shares are not traded in the public equity markets). The venture capital organization, or "VC," takes an active role in monitoring and overseeing management activities. The VC takes an equity stake in high-growth potential companies with the expectation of cashing out through either a buyout or initial public offering (IPO) in the public equity market within 4 to 7 years.

Disadvantages include:

- The developer has full exposure to the project risk.
- Many developers do not have sufficient capital to go it alone on the project.
- Many developers do not have a strong track record for large projects (Weiser & Pickle, 1998).

While balance sheet financing is the most common form of financing the early stages of new technology, many developers are simply not large enough nor have sufficient cash flow to carry out all the steps to completion.

10.1.2 - VENTURE CAPITAL

Venture capital organizations (VCs) raise capital from a variety of investors, all of whom have a high risk tolerance, and include insurance companies, pension funds, mutual funds, and high net worth individuals (Ecofys, 2011, p. 231). There are also examples of government-funded venture capital and public-private venture capital.

VCs invest in new technologies or new markets in the early stages. In the case of new technologies, venture capital comes into play at the R&D or pre-commercialization stages (Ecofys, 2011). However, commercializing tidal energy is very capital intensive and involves long investment horizons; most developers and venture capitalists do not have sufficient resources to finance that stage of the project. This is a significant barrier to advancing the development of new technologies such as TEC. For more mature technologies, project financing is an option, but for nascent technologies, it remains hard to get.

10.1.3 - PROJECT FINANCING

For mature technologies, such as wind power, project financing is available. Building a commercial-scale wind energy farm requires very large amounts of capital, well beyond what the developers can finance. Bank loans are needed and project financing is a common arrangement for acquiring debt financing.

Project finance is typically a late-stage means of financing. Banks have little-to-no tolerance for technology risk, so project financing is generally not available for projects until the technology is proven. As well, power purchase agreements, feed-in tariffs and renewable obligation standards usually need to be in place since repayment of the loans depends on the cash flows of the project.

VIGNETTE: ALSTOM HYDRO AND BALANCE SHEET FINANCING

Author: Brandon Greer

In 2009, worldwide hydro power leader, Alstom Hydro, signed a deal with the British Columbia-based Clean Current Energy, a private company specializing in the design and testing of tidal energy technology. The deal gave Alstom an international license for ocean and tidal stream applications for one of Clean Current's patented technologies. The technology is a horizontal-axis ducted turbine with a direct-drive, variable-speed permanent magnet generator, designed to be equally effective in both directions, so as to fully utilize two-way tidal currents. In December 2010, Alstom revealed the characteristics of BELUGA-9, its first tidal energy-generating turbine, to be tested at the FORCE site in the Bay of Fundy.

As a larger company with more resources and access to capital markets, Alstom's support allowed Clean Current, the smaller technology organization, to further develop its technology. While the project received some financial support from Sustainable Technology Development Canada, the majority of the project has been funded from Alstom's balance sheet.

Sources:

Alstom Press Release, 2009. "Alstom enters the Ocean Energy market, reinforcing its renewable energy portfolio," (http://www.cleancurrent.com/media/pressreleasealstom.htm)

Alstom Press Release, 2010. (http://www.cleancurrent.com/media/Alstom%20announcement/Alstom%20Press%20Release%20Dec%203%202010.pdf)

The project developer and equity investors will be looking for as high a debt/equity ratio as possible since the cost of debt is cheaper than equity and is tax deductible. The amount of the loan provided will depend on the estimated energy production and banks will be conservative about the assumed energy projections.

Project financing is generally negotiated as two loans. First is a construction loan. Once construction is completed, the construction loan and interest owing on it is converted to a mortgage-style term loan. There are many more risks during the construction phase (construction risks, supply chain constraints, weather risk, and coordination issues inherent in working with multiple contractors, etc.), so the rate of interest is higher than for the subsequent term loan. It is disbursed in installments as project milestones are met.

NOVA SCOTIA IN CONTEXT: INNOVACORP

Innovacorp is Nova Scotia's early-stage venture capital organization. Its goal is to help emerging Nova Scotia knowledge-based companies commercialize their technologies and succeed in the global marketplace. They are especially interested in the information technology, life sciences, and clean technology industries. Early-stage investment is at the core of their business model, but their team is about more than just money. They provide hands-on business advisory services, tailored to meet the unique – and evolving – needs of each of the promising technology companies in their portfolio. They also give entrepreneurs access to world-class incubation facilities and an international network of expert advisors (Dawn House, Innovacorp).

FOUNDATIONAL CONCEPT: WHAT IS PROJECT FINANCING?

Project Financing is a method by which the renewable energy project is legally set up as separate, stand-alone company. Equity investors and lenders finance the project company. The equity investors, also known as sponsors, include the developer and other investors taking an ownership stake. The lender(s) is a bank or syndicate (group) of banks that provide approximately 60-80% of the financing through a loan. The loan is considered non-recourse: it is secured by the project assets and the interest and principal is paid from the project's cash flows. The lender does not have recourse to the equity investors/ developer if the project fails. If the project is unable to service the debt, the lender can seize the assets and either operate the project or sell it to repay the debt. For large projects, the debt can be raised by issuing bonds to institutional investors. The bonds, however, must be rated as investment grade (Baa3/BBB- or better*). The project company can be structured as a corporation, general partnership, or limited partnership, with the sponsors investing and receiving benefits accordingly (dividends, tax credits, cash flow).

*For a description of bond ratings, go to: http://www.bondsonline.com/Bond_Ratings_Definitions.php).

The advantages of project financing include:

- The amount of equity capital needed from the project developer/sponsor is less than with balance sheet financing.
- The loan is non-recourse, thereby limiting the losses the developer/project sponsor must absorb if the project fails.
- Though it is usually more expensive than balance sheet financing, developers consider the reduced risk exposure worth the extra cost.
- The project does not have a substantial impact on the developer's balance sheet or credit worthiness.
- Small- to medium-sized developers can pursue several projects simultaneously.
- Higher debt/equity ratios are possible, allowing for more use of cheaper, tax-deductible debt.

The disadvantages include:

- The interest rates on project finance debt are higher than for balance sheet financing, due to the risk of the project versus the general credit risk of the sponsor.
- Project financing is difficult to arrange due to the number of parties involved and due diligence required. There are large transaction costs of arranging various contracts, such as legal fees (Weiser & Pickle, 1998).
- Availability of project financing has been less in recent years, due to the global credit crisis.

Tidal energy is still at the pre-commercial stage and still has significant technology risk, forcing balance sheet financing by project developers. This is the point at which there is a financing gap, often called the "technology valley of death." Venture capitalists are willing to take on the risk at this stage of technology commercialization, but they usually do not have sufficient funds to undertake such a large project. They also require a quicker return of their capital than the typical renewable energy power project (Bloomberg, 2010). Banks are not willing to take on technology risk, so pre-commercial technologies are not able to obtain project financing until the technology has an established track record. Wave energy is also facing this financing gap, whereas onshore and offshore wind energy have sufficient track records to be able to get project financing.

10.2 - GOVERNMENT FINANCING AND SUPPORTS IN NOVA SCOTIA[1]

In the province of Nova Scotia, there are a number of programs that will support the development of TEC technology and tidal energy projects. They include research and development grants, post-doctoral fellowships, feed-in tariffs, a public-private venture capital fund and investment tax credits. Some are provided by the Government of Canada, and some by the Government of Nova Scotia. Creating the impetus for companies and universities to embrace these, however, was the Environmental Goals and Sustainability Act, which set aggressive targets in Nova Scotia for generating electricity from renewable sources.

The Province of Nova Scotia, through its 2007 Environmental Goals and Sustainability Act and its 2010 Renewable Energy Plan, has committed to deriving more electricity from renewable sources. This renewables obligation is to derive 25% of its electricity from renewable sources by 2015 and 40% by 2020. This legislation obliges Nova Scotia Power, Inc. to both invest in renewable energy production and purchase energy from independent producers to achieve these targets. The renewables obligation provides an important backdrop for other initiatives and incentives and resolves some amount of uncertainty for investors. Government supports available in Nova Scotia from the governments of Canada and Nova Scotia are summarized below.

10.2.1 - COMMUNITY ECONOMIC DEVELOPMENT INVESTMENT FUNDS (CEDIF) – PROVINCE OF NOVA SCOTIA

Community Economic Development Investment Funds (CEDIFs) support economic development in Nova Scotia by retaining investment capital in the region and returning financial benefits to the local community. Though not designed for renewable energy specifically, CEDIFs have been used to develop community-owned wind energy projects in Nova Scotia and are applicable to small-scale tidal energy projects.

A CEDIF is an investment fund, created by selling units to members of a defined community for the purpose of developing local, for-profit corporations or co-operatives. Investors receive a 30% tax credit from the Nova Scotia government in the tax year the investment is made. The investments are also RRSP-eligible. Investors are required to hold their shares for five years (an earlier disposition of the units would require the investor to pay some of the tax credit back to the province). Eligible CEDIFs may generate subsequent tax credits for investors who hold their shares for longer than five years. As shareholders, investors may also receive dividends and capital gains.

CEDIFs play a particularly important role in tidal energy development with the introduction of the Community Feed-in Tariff (COMFIT), announced by the Government of Nova Scotia in 2010.

10.2.2 - FLOW-THROUGH SHARES

Flow-through shares, which have similar attributes to common shares, can help a developer finance a tidal energy project by providing tax savings to flow-through share owners.

Flow-through shares are newly issued shares of an incorporated company whose principal business is, in this case, developing renewable energy. The company is called a principal-business corporation (PBC). A flow-through share is a share of capital stock of the principal business corporation, issued under a flow-through share agreement. Flow-through share owners can be individuals or corporations.

[1] Note: Supports listed here are largely dependent on government policy and as such are subject to change. The information here reflects information available as of January, 2013.

In a flow-through share agreement, the PBC agrees to pass on, or “renounce,” its eligible expenses, along with their associated tax deductions, directly to the investors. Of particular interest are the Canadian Renewable and Conservation Expenses (CRCE). These capital expenditures (Capital Cost Allowance Class 43.1 or 43.2) are subject to accelerated depreciation for tax purposes, as will be discussed later. Whereas the PBC may not have income against which to deduct these expenses, the flow-through share owner can then claim the expenses against his/her/its own income and reduce taxes payable.

For more information on flow-through shares, go to http://www.cra-arc.gc.ca/tx/bsnss/tpcs/fts-paa/menu-eng.html.

10.2.3 - FEED-IN TARIFFS – PROVINCE OF NOVA SCOTIA

A feed-in tariff is a guaranteed rate paid per kilowatt hour for energy to producers whose energy is delivered to the provincial electricity grid. The tariffs are guaranteed for a fixed period of time, thereby reducing price uncertainty for energy project developers and their investors. In 2011, the Nova Scotia government announced the feed-in tariffs for community-owned renewable energy projects. Feed-in tariffs for larger, commercial-scale tidal projects are to be announced in 2013.

The community feed-in tariff (COMFIT) applies to projects being developed by municipalities, First Nations, co-operatives, universities, CEDIFs, and not-for-profit groups. The rates to be paid (tariffs), announced by the Nova Scotia Utility and Review Board in 2011, were established based on estimates of the cost of producing the renewable energy, plus a 15% rate return on investment to compensate investors for the risk. For the development stage of small-scale, in-stream tidal energy projects (generating up to 0.5MW), the COMFIT rate is 65.2 cents per kWh (http://ns.renewables.ca/comfit-communities). This rate will be revisited by the Utility and Review Board in 2014.

The COMFIT program began accepting applications in September 2011 and the first round of project approvals was announced in December 2011. Once a community project is approved for a community feed-in-tariff, the proponents have to complete various feasibility assessments and planning and design activities, engage with affected communities, and arrange financing. To take up the COMFIT, the proponents of small-scale in-stream tidal projects must be delivering electricity to the grid within five years of COMFIT approval.

Information about Nova Scotia Feed-in Tariffs can be found at http://ns.rewnewables.ca . A comprehensive COMFIT guide is available at: http://nsrenewables.ca/sites/default/files/ns_comfit_guide_sept_19_2.pdf.

10.2.4 - MI’KMAQ PARTNERSHIPS AND ACCESS TO CAPITAL

(Co-authored with Eric Christmas, Mi’kmaq Energy Advisor)

The Mi’kmaq of Nova Scotia have been active participants in the renewable energy sector on many fronts. Most significant are the development of policies regarding the creation of Mi’kmaq partnerships and the availability of Mi’kmaq lands that would qualify under the COMFIT program.

The Mi’kmaq Renewable Energy Strategy was developed in 2011 to complement the provincial strategy. It was written to not only enlighten the communities and leadership of the potential renewable energy technologies available (including tidal), but also identify the potential for long-term financial benefits arising from project developments, both on and off Mi’kmaq lands.

The Assembly of Mi’kmaq Chiefs’ work with various levels of government and the corporate sector has secured access to investment capital. Planning is underway for The Mi’kmaq Renewable Energy Development (MRED) fund. The Assembly is also negotiating with government for access to affordable, below-market rate, long-term financing. Information about the Mi'kmaq Renewable Energy Strategy can found at www.mikmaqrights.com.

10.2.5 - CLEAN TECHNOLOGY FUND (VENTURE CAPITAL) – PROVINCE OF NOVA SCOTIA

In 2011, the Nova Scotia government announced a new $24 million Clean Technology Fund for early stage companies developing a "diverse range of products and services intended to provide superior performance at lower costs, while minimizing negative ecological impact and using natural resources responsibly" (Premier D. Dexter, September 2011). The fund is managed by Innovacorp and is targeted at companies that focus on alternative and renewable energy, energy savings, greenhouse gas reduction, capture and storage, environmental remediation, and air quality and emissions management (http://innovacorp.ca/news/news/nova-scotia-clean-technology-start-wins-international-competition, accessed May 22, 2012).

As noted earlier, the financing needed by project developers of tidal energy generally does not fit with the scope and scale of venture capital, due to the large dollar amount needed and the investment horizon.

10.2.6 - SD TECH FUND - SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA

Sustainable Development Technology Canada (SDTC) recognized the funding gap in the innovation cycle and developed a fund to bridge the gap. The SD Tech Fund contributes to late-stage technology development and pre-commercial demonstration of clean technology. SDTC's aim is to reduce the risk of investing in clean technologies by providing funding and assistance to the point in the innovation process when venture capital or industry will invest. SDTC does not take an equity stake, hold the intellectual property, or require repayment (for more information, please go to: www.SDTC.ca).

10.2.7 - NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL OF CANADA

The Natural Sciences and Engineering Research Council of Canada provides technology R&D support through partnership grants and student funding programs. These are described briefly below.

10.2.7.1 - PARTNERSHIP GRANTS

NSERC Partnership Grants fund collaborations between companies and university researchers to conduct technology research and development activities. The various grants under this category are:

Interaction Grants – The maximum Interaction Grant is $5,000 for researchers' travel to meet with Canadian-based companies to identify a company-specific problem solvable through collaborative research.

Engage Grants - NSERC contributes up to $25,000 for 6 months to fund direct research costs for specific, short-term industrial R&D challenges.

Collaborative Research & Development Grants – This grant covers up to half the costs of R&D projects that provide the company access to specialized facilities, knowledge, and students. The company contributes the remaining funds.

Strategic Project Grants – This program pertains to areas of strategic importance to the country. NSERC contributes a substantial portion of direct costs for the development of strategic knowledge. At the time of writing, areas of strategic interest are: Environmental Science and Technologies, Information and Communications Technologies, Manufacturing, and Natural Resources and Energy (http://www.nserc-crsng.gc.ca/Professors-Professeurs/RPP-PP/SPG-SPS_eng.asp, accessed May 22, 2012).

10.2.7.2 - NSERC STUDENT FUNDING PROGRAMS

NSERC provides funds to hire students and post-doctoral fellows.

Industrial R&D Fellowships Program – NSERC contributes up to $30,000 per year for up to two years to hire doctoral graduates to conduct a research project at the host company's facilities. The host company must contribute at least $10,000 per year.

Industrial Post-Graduate Scholarship Program – NSERC contributes up to $15,000 per year so a company can hire a masters- or doctoral-level science and/or engineering student to conduct research at the company's research facilities. The host company must contribute at least $6,000 and supervise the student's research for at least one day per week.

Industrial Undergraduate Student Research Awards Program – NSERC contributes $4,500 for a 16-week term so a company can hire an undergraduate student to assist with a research and development project.

For more information on NSERC partnership grants, go to www.nsercpartnerships.ca.

10.2.8 - NATURAL RESOURCES CANADA ECOENERGY INNOVATION INITIATIVE (ECOEII)

The ecoENERGY Innovation Initiative program is focused on research projects for government, academic, and private sector projects with external public and private stakeholders. There are five strategic priority areas: Energy Efficiency, Clean Electricity and Renewables, Bioenergy, Electrification of Transportation, and Unconventional Oil and Gas. Both research and development and demonstration projects are funded. Two calls for proposals were made, in 2011 and 2012, with no others announced at the time of this writing (http://www.nrcan.gc.ca/energy/science/2003, accessed June 3, 2012).

10.2.8.1 - PRODUCTIVITY AND INNOVATION VOUCHER PROGRAM (P&I) – NOVA SCOTIA DEPARTMENT OF ECONOMIC AND RURAL DEVELOPMENT AND TOURISM

The Productivity and Innovation Voucher Program (P&I), offered by the Nova Scotia Department for Economic and Rural Development and Tourism, provides small- and medium-sized businesses with "credits" to pay university researchers for their expertise. There are two types of P&I vouchers: Tier 1 vouchers (maximum $15,000); and for previous voucher recipients, Accelerated Program vouchers (maximum $25,000). Recent P&I vouchers have been used for feasibility studies, industrial/process engineering services, applied research, prototyping, product design, eco-efficiency audits, and scientific/technology-related advice and support (http://www.gov.ns.ca/econ/pnivouchers/, accessed Jan. 18, 2013).

Eligible businesses are those registered and operating in Nova Scotia with fewer than 100 employees, part or all of whom reside in the province. Proposals are accepted for review by the Department of Economic and Rural Development and Tourism each September.

10.2.9 - MITACS

Mitacs offers programs that give Canadian companies access to research expertise. The Mitacs-Accelerate program contributes $7,500 toward the cost of hiring a graduate student or postdoctoral fellow for four months to work on a business research project. The Mitacs-Elevate program, presently being piloted in Ontario and British Columbia, co-funds post-doctoral fellowships for work on major industrial research projects. For more information, go to www.mitacs.ca/resources-companies.

10.2.10 - INDUSTRIAL RESEARCH ASSISTANCE PROGRAM - NATIONAL RESEARCH COUNCIL OF CANADA (NRC-IRAP)

The NRC-IRAP provides technical and financial assistance to small- and medium-sized businesses to develop and commercialize technologies. Their services include technical and business advisory services, financial assistance, and networking with industry experts and potential business partners. The IRAP cost-shares salary and contractor costs for an eligible/approved research and development project. For more information on NRC-IRAP, go to http://www.nrc-cnrc.gc.ca/eng/ibp/irap.html.

10.2.11 - PRODUCTIVITY INVESTMENT PROGRAM (PIP) – NOVA SCOTIA DEPARTMENT OF ECONOMIC AND RURAL DEVELOPMENT AND TOURISM

The Productivity and Investment Program (PIP) is designed to help Nova Scotia businesses and workers become more productive and innovative, with the goal of improving global competitiveness. The PIP has two incentives suitable for tidal energy development projects: the Capital Investment Incentive (CII) and the Workplace Innovation and Productivity Skills Incentive (WIPSI). Each of these is described below. More information on these incentives can be found at http://www.gov.ns.ca/econ/pip/.

10.2.11.1 - CAPITAL INVESTMENT INCENTIVE (CII)

The Capital Investment Incentive is designed to assist with the cost of "technologically-advanced machinery, clean technology, equipment, software and hardware" and will contribute 20% toward the cost. "Preference is given to corporations that export out of Nova Scotia, but consideration will be given to non-exporting corporations if a compelling case can be presented." Eligible industries include those undertaking the development of non-traditional sources of energy. http://www.gov.ns.ca/econ/pip/cii/

10.2.11.2 - WORKPLACE INNOVATION AND PRODUCTIVITY SKILLS INCENTIVE (WIPSI)

The Workplace Innovation and Productivity Skills Incentive can be used by businesses and industry associations to support the costs of training employees for new technology and innovative processes. It is cost-shared (50%) for industry associations and larger businesses, and fully funded for small businesses for the first $10,000, and cost-shared beyond that amount. http://www.gov.ns.ca/econ/pip/wipsi/

10.2.12 - TAX INCENTIVES – CANADA REVENUE AGENCY, PROVINCE OF NOVA SCOTIA

Several tax incentives are in place to support scientific research and development and for clean technology investment. These include investment tax credits and accelerated depreciation for tax purposes. These are each discussed below.

10.2.12.1 - SCIENTIFIC RESEARCH AND EXPERIMENTAL DEVELOPMENT (SR&ED) INCENTIVE

The SR&ED is a federal tax incentive program to support activities to achieve technological advancement or to advance scientific knowledge. It is an investment tax credit, made available to businesses doing research and development in Canada, whether basic or applied, for new or improved materials, devices, products, or processes. The incentive can be in the form of a refundable investment tax credit, which reduces taxes payable. It can reduce the company's current year tax liability, be carried back three years, or carried forward 20 years.

The SR&ED is available to Canadian controlled private corporations, non-Canadian controlled corporations and proprietorships, partnerships, and trusts. The ITC rate for the latter two is 20% of qualified SR&ED expenditures. For Canadian controlled private corporations, the ITC rate is 35% of the company's "calculated expenditure limit" and 20% of expenditures beyond the calculated expenditure limit. The expenditure limit is based on the firm's previous year taxable income and taxable capital. See www.cra.gc.ca/sred for this calculation.

Qualifying SR&ED expenditures are costs of experimental development, applied and basic research and can include salaries and wages, materials, SR&ED contracts, lease costs of equipment, overhead, third party payments, and capital expenditures. Also eligible are the costs of work directly in support of these activities such as engineering, design operations research, mathematical analysis, computer programming, data collection, testing, and psychological research.

To make a SR&ED claim, forms T661 Scientific Research and Experimental Development Expenditures Claim and T2SCH31 (Investment Tax Credit-Corporations) or T2038 (IND) (Investment Tax Credit – Individuals) must be submitted with the year's federal income tax return. See www.cra.gc.ca/sred for these forms. These claims are subject to a technical and financial review by the CRA, conducted by CRA staff. Technical review evaluates the work to ensure it meets the SR&ED eligibility criteria. A financial review looks at the costs to make sure they are eligible expenditures. These reviews may require site visits (Overview of the Scientific Research and Experimental Development (SR&ED) Tax Incentive Program, Canada Revenue Agency, www.cra.gc.ca/sred, accessed May 18, 2012).

10.2.12.2 - NOVA SCOTIA RESEARCH AND DEVELOPMENT TAX CREDIT

The Nova Scotia R&D tax credit is applicable to SR&ED-eligible expenditures. The rate is 15% and is refundable if the amount of the credit exceeds the Nova Scotia taxes payable. The credit is claimed on Schedule 340 of the NS T2 form and is administered by the Canada Revenue Agency. (http://www.novascotia.ca/finance/en/home/taxation/businesstax/corporateincometax/researchanddevelopmenttax.print.aspx, accessed May 18, 2012).

10.2.12.3 - ACCELERATED CAPITAL COST ALLOWANCE FOR CLEAN ENERGY GENERATION

Capital investment expenditures made in tidal power equipment are eligible for accelerated capital cost allowance, or amortization for tax purposes. The CCA rate for this class of equipment (Class 43.2) is 50% per year, on a declining balance basis. This has the effect of deferring some taxes to later in the project's life.

In addition, "certain intangible project start-up expenses (for example, engineering and design work and feasibility studies) are treated as Canadian Renewable and Conservation Expenses. These expenses may be deducted in full in the year incurred, carried forward indefinitely for use in future years, or transferred to investors using flow-through shares" http://www.budget.gc.ca/2010/plan/anx5-eng.html#a27.

10.3 - RISK AND RISK MITIGATION

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There are numerous risks associated with tidal energy projects. The risks vary by the stage of the project and affect its financial viability. Although complete removal of all of the risks is unachievable, mitigation measures can be taken to reduce exposure to the risks to an acceptable level. The appropriate mitigation methods will vary according to the stage of the project and type of risk.

Throughout a tidal energy project, decisions are made that expose the project developer and its investors to risk. The higher the risk associated with a project, the more hesitant investors are about financing it. Since tidal energy is at an early stage of development, the level of risk is a considerable barrier to obtaining financing. Financers want to have answers to questions such as: what can go wrong, what kind of additional costs and delays would result, and who takes the risk (Hamilton, 2006)? To increase investors' confidence, it is important to identify risks and attempt to mitigate and reduce them as much as possible (Drake & Howell, 2011). This section will describe the risks inherent in building, installing, and operating tidal energy devices and ways to mitigate or manage these risks.

10.4 - TYPES OF RISKS

To analyze and mitigate the risks inherent in tidal energy, they must first be identified. Some are related to the technology itself (design), others depend on the maturity of the supply chain (equipment accessibility, cost overruns, damage to property, availability of a capable operator), while still other external risks are beyond the control of the project developer (weather, market risk, political/regulatory risk). Furthermore, there is risk of damage to the environment and risk of damage to the equipment by the elements in the environment.

The various types of risks noted are discussed in this section. Once the specific risks of the project are identified, the appropriate risk mitigation methods can be explored to manage and minimize negative outcomes.

DISCUSSION: RISK MITIGATION

The four methods for mitigating or managing risks are as follows:

- Risk transference,
- Risk minimization,
- Risk avoidance, and
- Risk acceptance.

Risk Transference -- Risk transference is the spreading or sharing of risk. This transference involves passing some or all of the risk to another party to reduce the exposure to an acceptable level.

One way to transfer risk is through insurance. Insurance can give financial protection from damage or delays during the fabrication, transport, construction, and operational stages of the tidal energy project. Insurance can lower the cost of capital by reducing the financial impact of potential setbacks. The damage or delays can be caused by human error, technological reasons, or from the environment. The traditional products insurers cover are contractors' risks, property damage, machinery breakdown, delays in start-up, business interruption, errors and omissions, legal liability, political risks, and some financial risks such as default or currency convertibility (United Nations Environment Programme, 2004).

For an insurance company to take on risk, it must be provided with enough information to predict the likelihood and severity of the losses so it can set a premium (United Nations Environment Programme, 2004). The main criteria for the insurability of risk are: probability of an event occurring, its potential maximum total loss, average total loss, the average time span between two events, the level of insurance premium required, the degree to which the insured can manipulate the risk, legal limitations, and insurance coverage limitations such as deductibles and liability limits. Depending on frequency and severity, the risks may not be insurable. Insurance is determined on a case-by-case basis and usually has a higher price and more terms and conditions for renewable energy projects than conventional energy projects (Marsh & MacLennan Companies, 2004).

There have been challenges with underwriting renewable energy projects. These challenges stem from the newness of the technologies, limited underwriting expertise, lack of actuarial information, lack of suitable risk transfer mechanisms, low transaction sizes, poor loss histories, and location in harsh conditions. Underwriters often see different hazards in different stages and, as a result, tidal energy will demand a stage-by-stage rating approach (Marsh & MacLennan Companies, 2004). Based on a report published in February 2011, there were no insurers at that time who were prepared to underwrite such risks (IEA-RETD, 2011). As tidal energy becomes more established, energy executives are expecting wider availability of more-standardised products, notably insurance and hedging contracts (Economist Intelligence Unit, 2011).

In addition to insurance, there are other methods available to transfer the risk. The risk transference methods include requiring some risks be borne by the relevant sub-contractors, joint venturing, and market hedges (Rodenhuis, 2008).

Sub-contracting is a process whereby the project developer employs a business or person outside of the company to complete work for a larger project. Sub-contracting transfers risk as these business functions are not retained within the company. The sub-contractor may be better able to mitigate the risk or be willing to take on some of the risk in exchange for a higher contract price. For instance, a technology developer can provide a warranty on the technology, or the construction company can provide guarantees the work will be done on time and according to specifications.

A joint venture is a new entity created by two or more parties (usually companies) who have a contractual agreement to achieve specific objectives. They contribute their equity for a certain amount of time, creating a temporary partnership. This helps share the risk between the companies as they will be sharing all revenues, expenses, assets, and risks.

A hedge is an offsetting investment made to neutralize the risk of adverse price movements. Hedging can be used to protect against the uncertainty of currency exchange rates and commodity prices.

Risk Minimization (Reduction) -- The second method of managing risk is minimization. Minimization is reducing or controlling the risk by changing or implementing procedures or changing characteristics of a project to reduce the likelihood of unforeseen events occurring. The risk minimization process typically incurs additional costs.

Methods of risk minimization include pre-feasibility studies and applying research findings and lessons learned from other industries to the tidal energy industry. Such measures can help reduce the risk to an acceptable level to attract investors (Ercoli, Julien, Kristine & Salvtore, 2011).

Deepening industry collaboration is another way to reduce the risk; pooling maintenance equipment and spare parts can help minimize the risk inherent in tidal energy projects. As projects get more complex, such industry partnerships may become essential (Economist Intelligence Unit, 2011).

Risk Avoidance -- The third option for managing risks involves risk avoidance. Avoidance is done by designing risk out of the equipment and processes, or choosing not to accept the risk. Designing the risk out can be achieved by studying and applying lessons from other industries with similar experiences. It may include avoiding a particular activity that carries the risk. The company needs to conduct a cost-benefit analysis to ensure that avoiding the risk is worth the cost.

Risk Acceptance -- The fourth method of managing risk is risk acceptance. Acceptance occurs when it is decided the risk to the organization is within acceptable limits. If the risk is accepted, it is very important to monitor it. Monitoring can be done by setting performance indicators and watching trends that could indicate variances from what was expected.

One reason for accepting risk is information asymmetry. When the insurer perceives the risk of a particular project to be higher than the developer does, risk acceptance becomes more cost-effective than insurance (Economist Intelligence Unit, 2011).

Political and regulatory risks, for example, are generally accepted by developers since limited options are available for transferring them (Economist Intelligence Unit, 2011). A company's risk acceptance decision is the part of the risk management process that establishes what the risks are and to what extent the company should tolerate them as a part of its normal business. The standard approach is to control all the risks management believes it can control within its available resources and accept the remainder (Marsh & McLennan Companies, 2004).

10.4.1 - TECHNOLOGY RISK

Technology risk essentially revolves around two questions: will the device work and will it continue to work? The preferred mitigant to these risks is operational experience. With tidal energy being an emerging sector and owners wanting to benefit from the latest technologies, this may not be possible for some time (IEA-RETD, 2011).

Technology risk is one of the highest risks for tidal energy at present. Various technologies have been tested in tanks, and prototype and full-scale devices have been deployed in the EMEC test facility in Orkney, Scotland. Testing in a range of resource settings helps to determine device reliability and susceptibility to accidents and damage (Resolve Inc. & Schwartz, 2006, p. 17). As more is learned about the technology, the more likely the owner will be able to transfer the risk to an insurer.

Both insurers and financers penalize new or poorly understood technologies and processes with prohibitive premiums and terms (United Nations Environment Programme, 2004). As it is unknown how well the tidal energy technology will endure the natural elements over time, it will take insurers a while to increase their confidence to the level they have with tested and known technologies. Until there is an operating history for tidal turbines, insurers will likely only cover damage that could result from the workers or from defective parts (Marsh & McLennan Companies, 2004, p. 73).

VIGNETTE: TECHNOLOGY RISK IN TIDAL ENERGY – INVESTOR PERSPECTIVES

When asked about investing in tidal energy in the DECC Wave & Tidal Investor survey (2010), a spokesperson at a bank responded, “Technology is probably the biggest issue and funding hot on its heels. Can you prove it will work, and how reliable will it be, that’s clearly the biggest issue for any financier” (DECC, 2010).

As an angel investor stated in the DECC Wave & Tidal investor survey, “We need to build machines that will demonstrate adequately that reliable and consistent electricity can be produced” (DECC, 2010).

10.4.2 - SUPPLY CHAIN RISKS

Beyond the uncertainty associated with new technology is that of the supply chain to manufacture, assemble, deliver, install, and operate the equipment on time and on budget. A nascent supply chain adds a significant amount of risk during the construction stage of a project.

BEST PRACTICES: TECHNOLOGY READINESS LEVELS (TRL)

The National Aeronautics and Space Administration (NASA) developed a scale for technology development that has been adopted by many government departments and businesses. Ranging on a scale from 1 to 9, the technology readiness level indicates the stages of development and testing a new technology has passed through. Originally developed in the 1980s, it is now a fairly standardized system that communicates the technology risk still latent in the project. A version of the TRL levels is provided in the Table 10-2. For more information, go to: http://www.em.doe.gov/pdfs/TRA%20Guide%20Draft%20w%20EM-60%20Comment2.pdf.

10.4.2.1 - EQUIPMENT AND MANUFACTURING ACCESSIBILITY

The large turbines, bases, and cables will require large and costly construction facilities and installation equipment. Before the supply chain is established, there will be a small quantity available. Key equipment includes lifting equipment, piling hammers, and sea-going vessels. If a key piece of equipment breaks prior to, or during, project implementation, the project may be delayed (IEA-RETD, 2011). Even if there are units nearby, those could be committed to other projects for a significant amount of time. In the early days of the tidal energy industry, key equipment may be largely committed to other industries such as offshore oil and gas. These problems can not only result in long delays for building new capacity, they can also cause developers to withdraw from projects entirely (Greenacre, Gross, & Heptonstall, 2010).

The developer can transfer some of this risk by having the risk of construction delays remain with the contractor. A provision for a contingency allowance should also be part of the contract (IEA-RETD, 2011). To minimize the risk, engineers should validate the requirements for spare parts, vessels, and cranes. These requirements should also be a part of defined, long-term operational procedures (Guillet, 2007).

Since tidal energy is a new and developing industry, it cannot be guaranteed the tidal turbine manufacturers will be around in years to come. The turbines may become obsolete. There is also the risk that some designs of tidal turbines could be withdrawn. As a mitigant to these risks, the owners should ensure they will always have access to the components’ designs. This way, if the tidal turbine manufacturer is no longer available, it may be possible to have the components manufactured by another company (IEA-RETD, 2011).

10.4.2.2 - COST OVERRUNS

Often, projects fail to be completed on time and on budget. It is important for the tidal energy companies to analyze the factors that may cause time and cost over-runs and find measures to mitigate these risks.

Cost overruns occur in many projects. However, the more contractors there are involved in the construction and supply, the more potential there is for cost overruns, due to the greater number of interfaces (IED-RETD, 2011). As tidal energy is an offshore project, it is especially complex and will require more coordination and management than onshore projects (Guillet, 2007). Delays or deficiencies by one contractor can affect the entire project's schedule.

The impact of these setbacks on the budget and schedule of the entire project should be assessed by the project developer. A contingency analysis includes identifying what would occur if a particular contractor's work is delayed or not performed. A risk minimization measure for the project developer is to employ an independent expert to evaluate these situations and determine the costs associated with the downside scenarios. In order to properly transfer risk to the appropriate contractors and suppliers, thoroughness must be maintained when negotiating and writing contracts. It is also important to have strong project management, in particular at the interfaces, and to set a contingency budget to provide a buffer for delays and cost overruns (IEA-RETD, 2011).

A turnkey contract can be used to mitigate the risk of cost overruns (Rodenhuis, 2008). Cost savings and quicker delivery times may be achieved, but there is a loss of control over decisions throughout the construction process.

Including performance incentives for contractors is an additional way to mitigate the risk of time and cost overruns. An example of a performance incentive is an additional payment if work is finished before the deadline. Alternatively, penalties for missed deadlines could be used as a deterrent (Rodenhuis, 2008).

Certain delay risks may have insurance available (Rodenhuis, 2008). For financing, banks will require responsibility for the risks to be clearly allocated. This includes clearly defining the hand-over procedure between the contractors at each interface. The procedure should be clearly stated in the contract for every contractor (Guillet, 2007).

The greater the distance the installation is from shore, the further the sea-going vessels have to travel during the trips to install equipment, the more complex the foundations, and the longer the cabling required. These increase the potential for cost overruns. A harsher environment and rough water will also complicate the process (Greenacre et al., 2010; IEA-RETD, 2011). As the distance and depth increase, so too do the risks associated with project development, installation, and maintenance. As a result, a higher contingency budget will be needed (IEA-RETD, 2011).

FOUNDATIONAL CONCEPT: TURNKEY CONTRACT

A turnkey contract is an agreement in which the contractor finishes the entire project and delivers the product in a completed state, rather than in stages. With this contract, the contractor owns the project until it is finished. This provides the contractor with the incentive to finish the project on time and on budget.

10.4.3- DAMAGE TO PROPERTY AND EQUIPMENT

Construction can cause damage to private property, to public wharves, and to underwater transmission cabling. Beneath the water, the interconnection cable may cross other cables and pipes in the water. It is essential to get the details on existing cables and pipes through investigations and discussions with other service owners and the authorities. During the project planning stage, the construction contractor should be held responsible for completing a final survey of the area before starting to dredge and install the cables. If possible, an agreement should be made that if any damages occur to the existing property, remediation is the contractor's responsibility (IEA-RETD, 2011).

VIGNETTE: INCENTIVES TO DEVELOP FURTHER OFFSHORE

In some countries, a higher remuneration is established for contract work that is further offshore, which provides an incentive to develop these projects. For an example, refer to 'Case Study: Water Depth and Impact on Overall Cost Structure and Revenues' on page 63 in IEA-RETD, 2011 (noted in the references at the end of this module). This case study specifically looks at the tariff structure used in Germany as a remuneration technique.

10.4.4 - LACK OF CAPABLE OPERATOR

The capability of the power plant operator is important and needs to be attended to during the planning process. As tidal energy is a new energy sector, there will be few companies, if any, with a track record. As the personnel will not have experience working directly in tidal energy, the developer should determine the suitability of the personnel and operational plans (IEA-RETD, 2011). There will likely be a shortage of skills, as there will be a worldwide competition for service crews from the oil and gas industries and other offshore activities (Greenacre et al., 2010).

Means of mitigating this include performance incentives such as bonuses or equity participation. Alternatively, there can be penalties in the event of poor performance (IEA-RETD, 2011).

10.4.5 - EXTERNAL RISKS

External risks are largely out of the control of the project developer, though there are techniques for mitigating the impact of some. External risks include political and regulatory uncertainty, uncertainty over costs of various factors of production, foreign exchange rates, and weather risks. Each of these is discussed below.

10.4.5.1 - POLITICAL/REGULATORY RISK

Long-term government support mechanisms are generally needed to sustain renewable energy projects. This is a very important way to mitigate real and perceived risks that concern investors in tidal energy. Due to frequently changing national and international policies, investors lack confidence in regulatory policies (United Nations Environment Programme, 2004). New policies and budget changes can arise when a new party is elected to government. While tidal energy is in the early stages and dependent on government support, this adds a great deal of uncertainty.

Regulatory changes, such as to environmental regulations, also present a risk for tidal energy projects. The tidal turbines are sited in public environments and are tapping energy from a natural resource. Consequently, developers face uncertainty about siting and environmental permitting (Milford, Morey, & Tyler, 2011).

Banks accept some amount of regulatory change risk, although to finance a project, the regulatory structure must be completely understood. The banks will require a regulatory framework that makes the projects feasible at the outset (Guillet, 2007). The willingness and capability of provincial and federal authorities to handle the permits and licences will affect the perceived regulatory risks.

Many renewable energy executives say they retain, and thus accept, regulatory risk because they are unable to see any worthwhile alternatives (Economist Intelligence Unit, 2011). Though the executives are retaining the risks, they also want to find ways to minimize them. One way developers can mitigate political and regulatory risk is to strengthen communications with regulators and policymakers (Economist Intelligence Unit, 2011). Strengthening communications can be viewed as risk minimization through increased industry collaboration. Proper confirmation by legal advisors that all permits, licenses, etc. are in place is also important.

10.4.5.2 - WEATHER RISKS

The weather, storm surges, and strong tidal currents add uncertainty for the installation and maintenance of the TEC devices. The tides themselves limit the times when work can be done on site. The weather and water conditions can cause expensive delays, so installation and operating costs will be uncertain, particularly when there is a need for specialized vessels. Choppy waters further increase risk when installing the turbines and pose a threat to the safety of the workers.

To mitigate weather risks, the contract between the developer and contractors should state the agreements regarding weather risks. Sharing weather risk is typical for these two parties. A usual agreement may have the contractor responsible for “average” weather. It must be defined exactly what falls under “average” weather. Typically, the contractor would get relief from the planned schedule, but would not add the cost of weather days (IEA-RETD, 2011).

In addition, bad weather causing extremely rough waters and storm surges may harm installed turbines. To mitigate these risks, the turbines should be tested in extreme conditions to determine whether they will survive or break apart and become a hazard themselves (Ingram, 2011).

DISCUSSION: POLITICAL RISK

All over the world, government support has been crucial to the development of new renewable energy industries (Esteban & Leary, 2009). In 2010, it was observed that as worldwide support in renewable technologies grew, investment decreased significantly in the countries where the government support declined (Economist Intelligence Unit, 2011).

Government policy can help the tidal energy industry achieve returns and reduce risks through incentive mechanisms such as feed-in tariffs and green certificates (Guillet, 2007). To mitigate the risk of funding being removed when the government changes, the support for tidal energy should be designed to be long term, regardless of political changes.

BEST PRACTICES: HEALTH AND SAFETY

When mitigating the risk, it is important to exert additional effort above simply satisfying the local legislation regarding the health and safety of all parties involved. Particular effort should be applied in planning health and safety by ensuring detailed policies and plans for all stages of the project from construction to operation. It is important to regularly audit and provide feedback on these safety procedures and actions (IEA-RETD, 2011).

10.4.5.3 - DAMAGE TO EQUIPMENT BY THE ENVIRONMENT AND OTHER USERS OF THE WATER

Damage to property could occur due to various hazards: biofouling, third party interference, larger than expected currents, or damage due to logs and submerged ice, etc. The damage could occur on the new tidal energy equipment or existing sub-sea equipment. Managing offshore activities is the starting point in mitigating this risk, although insurance is apt to be the key mitigant (IEA-RETD, 2011).

The accumulation of microorganisms, plants, algae, or animals on wetted structures is known as biofouling. As the turbines and transmission cables are in the water, biofouling could damage the equipment. There are many different organisms that can cause biofouling, many surfaces affected by it, and many different solutions to the problem. Anti-fouling is the method of either removing or preventing this accumulation, and can include the use of biocides or non-toxic coatings. To mitigate the risk posed by biofouling, research needs to be done into the best solution, or anti-fouling process, for tidal energy before installation of the turbines (Stanczak, 2004). This research would include examining the toxicity of the paints, hydraulic fluids, and chemicals used to control biofouling (Resolve, Inc. & Schwartz, 2006).

Damage could likewise be caused by a third party, for example, by anchoring in a prohibited area and damaging subsea cables. Again, the mitigant most appropriate for this situation would be insurance (IEA-RETD, 2011).

Damage due to submerged, sediment-laden ice has been a concern but is currently considered a low risk for tidal energy developments in the Upper Bay of Fundy (Sanderson, Redden, & Broome, 2012). Direct observations of ice movements near turbines in Minas Passage would help to determine the likelihood of interaction between submerged ice and bottom mounted turbines. Any collision involving a turbine and submerged debris (e.g. logs, fishing gear) or a large marine vertebrate (e.g. whale) could damage the tidal device. To mitigate such risks, there should be monitoring for large submarine hazards at all tidal device deployment sites. For the long-term, risk mitigation would include engineering the tidal devices to withstand contact with those hazards that would be difficult to completely prevent (Baddour, Byers, & Saunders, 2008).

10.4.5.4 - MARKET RISK

The market creates uncertainty in the cost and price of the inputs for tidal energy and the tidal energy output. There is uncertainty in the costs of commodities and other inputs, as well as in the price paid for electricity (Economist Intelligence Unit, 2011).

The cost of tidal energy is sensitive to currency exchange, commodity, equipment, and labour price changes. The cost of raw materials for tidal energy projects are directly affected by commodity prices. Steel is a major component of the tidal turbines, so steel price volatility makes estimating the costs of the turbines and bases challenging. Accordingly, it is too risky for steel buyers or sellers to lock themselves into fixed price contracts. It is valuable to monitor the price of these inputs to help mitigate the risk of the price changes and hedge when possible (Greenacre et al., 2010).

10.4.5.5 - ENVIRONMENTAL RISK

With the installation of devices in the water, there is potential for damage to the environment. It is important to look at these risks as well as the liability that could result (Economist Intelligence Unit, 2011).

Environmental damage has the potential to occur in a variety of areas. The damage could occur from the turbines in the water or from activities onshore. It is important to study these risks and have appropriate procedures to monitor the environmental conditions. If environmental damage does occur, the project owner could be liable and thus it is imperative to have planned mitigation procedures already in place (IEA-RETD, 2011).

There are several measures companies are currently taking to mitigate environmental risks with renewable energy projects. The most prevalent measure is improving environmental audits. Another measure frequently used is implementing strict environmental standards. Other planned mitigation procedures include staged development, more frequent communication with consumers and environmental groups, and closely monitoring subcontractors' environmental practices (Economist Intelligence Unit, 2011).

Two risk transference methods currently used for environmental risks include insurance and catastrophe bonds. Catastrophe bonds transfer certain risks (usually from an insurer) to investors. Investors will buy these bonds because they generally pay higher interest rates. A smaller group of companies also use self-insurance pools (Economist Intelligence Unit, 2011). This is a method where a calculated amount of money is set aside by the company to compensate for the loss, if incurred.

IN NOVA SCOTIA: REDUCING MARKET RISK FOR TIDAL ENERGY

Legislation in Nova Scotia has helped to reduce market risk for selling electricity generated from the tides. The commitment to generating electricity from renewables (25% by 2015; 40% by 2020) assures demand. Feed-in tariffs for tidal energy provide greater certainty of price for producers. Both are subject to power purchase agreements.

10.6 - SUMMARY

Much work has been done on the development and testing of prototypes and and full-scale devices in tanks and test sites, such as at European Marine Energy Centre (EMEC) in Orkney, Scotland. However, there is not a lot of experience with the commercialization of in-stream tidal energy as yet. Ocean Renewable Power Company (ORPC) in Maine, USA installed turbines and cables in Cobscook Bay in 2012 and is currently delivering electricity to the grid. This was the first commercial in-stream tidal energy project in North America.

Arrays of turbines are needed to achieve sufficient economies of scale to make commercializing tidal energy technologies feasible. However, arrays require very large amounts of capital and very long investment horizons. Device and project developers and government departments are discussing ideas on the needed supports and risk mitigation measures to move the technology beyond the "technology valley of death." The absence of financing, due largely to the inherent risks, size of investment and investment horizons, is a significant obstacle to the progress of the industry around the world.

Tabel 10-2: Technology Readiness Levels (U.S. Department of Energy)

RELATIVE LEVEL OF TECHNOLOGY DEVELOPMENT	LEVEL	TRL DEFINITION	DESCRIPTION
System Operations	TRL 9	Actual system operated over the full range of expected conditions.	The technology is in its final form and operated under the full range of operating conditions. Examples include using the actual system with the full range of wastes in hot operations.
System Commissioning	TRL 8	Actual system completed and qualified through test and demonstration.	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning. Supporting information includes operational procedures that are virtually complete. An ORR has been successfully completed prior to the start of hot testing.
	TRL 7	Full-scale, similar (prototypical) system demonstrated in relevant environment.	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning. Supporting information includes results from the full-scale testing and analysis of the differences between the test environments, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete.
Technology Demonstration	TRL 6	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment.	Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering scale prototypical system with a range of simulants. Supporting information includes results from the engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for the testing should closely represent the actual operating environment.

RELATIVE LEVEL OF TECHNOLOGY DEVELOPMENT	LEVEL	TRL DEFINITION	DESCRIPTION
Technology Development	TRL 5	Laboratory scale, similar system validation in relevant environment.	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants1 and actual waste. Supporting information includes results from the laboratory scale testing, analysis of the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.
Technology Development	TRL 4	Component and/or system validation in laboratory environment.	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste. Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4-6 represent the bridge from scientific research to engineering. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system will probably be a mix of on hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function.

RELATIVE LEVEL OF TECHNOLOGY DEVELOPMENT	LEVEL	TRL DEFINITION	DESCRIPTION
Research to Prove Feasibility	TRL 3	Analytical and experimental critical function and/or characteristic proof of concept.	Active research and development (R&D) is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants. Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. At TRL 3, the work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments.
Research to Prove Feasibility	TRL 2	Technology concept and/or application formulated.	Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from TRL 1 to TRL 2 moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.
Basic Technology Research	TRL 1	Basic principles observed and reported.	This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world. Supporting Information includes published research or other references that identify the principles that underlie the technology.

Source: Technology Readiness Assessment (TRA) / Technology Maturation Plan (TMP) Process Guide, Office of Environmental Management, U.S. Department of Energy, March 2008, p. 6. Available at: http://energy.gov/sites/prod/files/em/TRAGuideDraftwEM-60Comment2.pdf.

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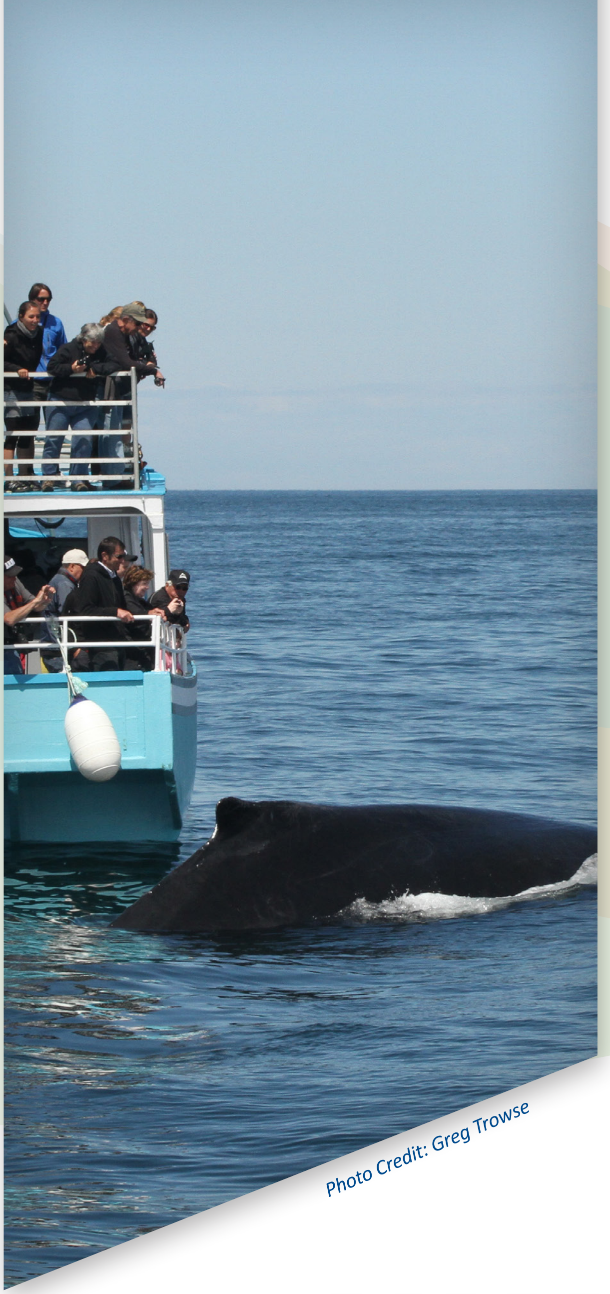

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11 ASSESSING THE POTENTIAL ECONOMIC IMPACTS OF A FIVE MEGAWATT TIDAL ENERGY DEVELOPMENT IN THE DIGBY AREA OF THE BAY OF FUNDY

11 - ASSESSING THE POTENTIAL ECONOMIC IMPACTS OF A FIVE MEGAWATT TIDAL ENERGY DEVELOPMENT IN THE DIGBY AREA OF THE BAY OF FUNDY

Author: Dr. Brian Vanblarcom

WHAT DOES THIS MODULE COVER?

The economic impacts from tidal energy development are largely unknown due to two primary factors: a) a very small number of deployments, with only a handful at the commercial stage, and b) limited analysis using econometric modeling. This section seeks to narrow this gap in knowledge by providing an input-output analysis of the economic impacts of a 5MW tidal facility in the Digby area of Nova Scotia.

This module provides an estimate of the inter-industry impacts of a 5MW tidal facility in the Digby area of Nova Scotia. The module provides summary tables on the following:

- Table 11-1: Capital Cost for a 5MW tidal facility,
- Table 11-2: Total Costs (inputs & outputs) by Economic Sector for Constructing a Commercial Facility,
- Table 11-3: : Annualized Cost Inputs and Outputs by Economic Sector for Constructing a Commercial Facility,
- Table 11-4: Costs by Category of Operating a Commercial Facility, and
- Table 11-5 : Cost Inputs and Outputs by Economic Sector for Operating a 5MW Facility.

KEY IMPACT ESTIMATES INCLUDE:

- Total (multiplied) spending from the development/construction phase of $46 million, with total income creation of $14.3 million.
- 240 person years of employment, or 48 jobs per year over each of the five years of the development/construction phase.
- Annual operational total spending generation of $344,000; annual income creation of $124,000.
- Annual operation creates two full-time job equivalents.

WHO SHOULD READ THIS MODULE?

This module is for anyone interested in the potential economic impact of developing a 5MW tidal energy project in the Digby area, including potential spending across industries in Digby and estimated number of jobs. These estimates are based on a hypothetical case; actual spending and economic impacts would differ from project to project.

CONCEPT:
PRINCIPLES OF INPUT OUTPUT ANALYSIS

An input-output (I/O) model is a mechanism that allows analysis of inter-industry relationships of an economy.

An I/O model attempts to quantify, at a point in time, the economic interdependencies of an economy. I/O accounting is a framework that explicitly recognizes interdependencies among productive industries of the economy and the elements of final demand. Final demand is the demand for goods and services consumed directly by ultimate consumers. Final goods and services are referred to as final because they are not put back into the production process to make some other good. The interdependencies are characterized by the inter-industry structure, which shows the inputs that are combined to produce output. The I/O analysis framework is similar to a financial accounting framework that tracks purchases and expenditures on goods and services in dollars. The I/O framework traces the dollar flows between businesses, as well as between businesses and consumers in an economy. The input-output model is summarized below in matrix form. Details of the model used here follow.

X* = (1-A*)-1 F*

Where: X* = the vector of total output

(1-A*)-1 = the closed model total requirements matrix (Leontief inverse)

F* = vector of final demand changes associated with tidal power development

The Nova Scotia input-output (I/O) model forms the basis of the Digby County I/O model. The provincial I/O model for Nova Scotia is based on Statistics Canada data. The provincial I/O direct requirements matrix is adjusted

Continued on next page ...

11.0 - INTRODUCTION

This section estimates the potential economic impacts emanating from a 5MW tidal development (generation device and land-based components), as described in Nova Scotia Utility and Review Board in the matter of a hearing to determine Renewable Energy Community Tariffs, March 2, 2011 [Synapse Exhibit M]. The purpose is to quantify the economic significance of tidal energy development. More specifically, this section will examine a hypothetical case study of a 5 MW community-based tidal project in the Digby area of the Bay of Fundy. Digby was chosen for analysis based on a number of potential sites being identified in that area. Fundy Tidal Inc. has received regulatory approval for a 1.95 megawatt tidal power project in Digby County. Small scale tidal developments will be the focus for the case study since the applicable technology/costs/degree of local inputs, etc. for larger (150 MW range) developments are significantly less precise at this point in time.

The study area for the case study is Digby County. In order to estimate the potential economic impacts, an input-output (I/O) model for Digby County was developed. The box to the right of the page contains an overview of I/O analysis.

A key goal of the analysis is to measure the degree to which the expenditures related to tidal energy production generate economic activity in the local economy. The study area input-output model captures both the direct and spin-off (indirect and induced) effects of these expenditures.

The expenditure (cost) inputs that generate the economic impacts are based on cost figures appearing in the publication entitled, *In the Matter of the Electricity Act and In the Matter of a Hearing to Determine the Renewable Energy Community Feed-On Tariffs, by* Nova Scotia Utility and Review Board, published in March 2, 2011. The outputs (impacts) are measured in terms of total sales and income generated locally from initial expenditures related to tidal energy development. The degree to which the expenditure (cost) inputs and the economic impacts (outputs) will be generated/captured locally is unknown at this point in time. The analysis conducted here should be considered a simulation in that the I/O model is based on the structure of the local economy as of the 2006 census, and more importantly, the resulting impacts (outputs) will change in proportion to which the actual expenditures (cost) differ from the current estimates.

It is assumed that 70 percent of the capital costs will be services provided by local firms (*Final Report Renewable Energy Opportunities and Competitiveness Assessment Study,* Nova Scotia Department of Energy, SLR Consulting Ltd., *SLR Project No. 210.05753.00,* September 23, 2010, p. 40). This assumption is critical to the analysis, in that tidal power development expenditures going to non-local firms "leak out of the local economy" and hence reduce the direct/indirect/induced impacts. It is further assumed that all developmental expenditures related to tidal energy are incremental to the study region. In other words, the tidal energy-related spending, outlined in this analysis, occurs in addition to existing levels of economic activity. It is also assumed that the resulting spin-off benefits (for example, additional spending, jobs, and income) are captured in the Digby area economy.

Continued from previous page ... via employment based location quotients (LQs) to approximate the Digby economy. The location quotient, in this case, is a measure comparing the concentration of an industry in Digby County and its concentration in the province of Nova Scotia, as a whole.

The closed model allows the direct, indirect and induced effects of an exogenous change to be captured. Direct effects occur when firms involved in tidal power development buy goods/services from local firms. Indirect effects occur when local firms buy local inputs (goods/services) as a result of the direct impact. The economic activity resulting from the re-spending of income generated by the direct and indirect effects is known as the induced effect. The induced impacts are additional expenditures resulting from increased income brought about by increases in final demand.

There are a few key assumptions related to I/O analysis that should be noted. Firstly, the level of input purchased by an industry is exclusively determined by the level of this industry's output and that there exists no input substitution or economies of scale in the production. Secondly, there are no constraints on industry capacity. Whatever is demanded by industries as inputs can be supplied at current prices. Thirdly, inherent in the induced effects, is that household income flows to residents and residents spend their new income following the existing pattern of expenditures.

Given the assumed leakages from the local economy (related to production of goods/industry profits), the closed model is most applicable due to its ability to capture the induced effects associated with re-spending of income created via the direct and indirect effects. An I/O model framework therefore, provides the ability to answer "what if" questions. For example, what will happen in the economy if final demand due to tidal energy development was to increase by 50 million dollars?

The total economic impact (direct/ indirect /induced) on spending across all industries in the Digby County economy from the construction phase is estimated to be $46 million, with total income creation of $14.3 million.

11.1 - DEVELOPMENT PHASE

The case study reflects the economic activity generated from creating a 5 MW facility near Digby. The analysis is based on the construction and operation of the 5 MW facility. Total capital costs are estimated at $10 million per MW (Nova Scotia Utility and Review Board, 2011). The costs for construction of a 5 MW facility are estimated in Table 11-1.

Table 11-1: Capital Cost for a 5MW Tidal Facility

COST CATEGORY	COST FOR 5 MW FACILITY
Development	$9,500,000
Equipment & Installation	$33,350,000
Interconnection	$2,600,000
Reserves (upfront maintenance/working capital)	$1,130,180
Financing (closing costs/interest)	$3,813,500
Total	**$50,393,680**

Source: *Nova Scotia Utility and Review Board in the matter of a hearing to determine Renewable Energy Community Tariffs, March 2, 2011 (Synapse Exhibit M). http://www.nsuarb.ca/images/stories/pdf/electricity/july2011/comfit.pdf*

In order to assess the total direct/indirect/induced effects (multiplied) of the capital spending on the Digby County economy, the expenditures in Table 11-1 are reduced by 30% (as noted, 70% of inputs are assumed to be supplied locally) and delineated into North American Industrial Classification (NAIC) input categories, as shown in Table 11-2. Development costs were apportioned to Business Services, and equipment/installation costs split on a 50/50 basis with the Manufacturing and Construction sectors. Interconnection costs were considered to be in the Construction industry and Financing and Reserves costs allocated to the Finance Insurance and Real Estate (FIRE) sector. Given that all expenditures took place in a single year, the total expenditure and income effects of the capital expenditures (as derived from the Digby County input-output model), are also shown in Table 11-2. The total economic impact (direct/indirect /induced) on spending across all industries in the Digby County economy from the construction phase is estimated to be $46 million, with total income creation of $14.3 million. As would be expected, the total expenditure impacts are concentrated in the Construction and Manufacturing industries, with (direct/indirect /induced) spending of $13.7 million and $13.1 million, respectively. Other industries generating significant spending effects are Business Services ($7.3million), Finance, Insurance and Real Estate (FIRE), with $7.1 million, and Retail Trade ($1.4 million).

The combined development/commercial installation time frame for tidal power, however, has been shown to be considerably longer than one year. In absence of a definitive time frame for which the development and construction expenditures shown in Table 11-2 will actually occur, it is assumed that they will take place proportionately in each year, over a five year period. (Please note, no discounting reflecting the time value of money has been applied). The annualized costs would therefore represent one fifth of the total, with annual total direct expenditures of approximately $10 million per year,

$7.0 million occurring locally. The resulting impacts are shown in Table 11-3. On an annualized basis (over a five year time frame, with no discounting), total expenditures across all industries are $9.2 million. Construction and Manufacturing industries see expenditures of $2.8 million and $2.6 million, respectively, followed by Business Services ($1.5 million), Finance, Insurance and Real Estate (FIRE), with $1.4 million, and Retail Trade ($282 thousand). Annualized total income creation across all industries is estimated to be $2.9 million. Using the Oregon Wave Energy Trust, Economic Impacts of Wave Energy to Oregon's Economy, OWET (2009) income-to-employment ratio of $60,000 per year, the construction phase would be expected to generate 240 person years of employment, or 48 jobs per year over each of the five years of the development/construction phase.

Table 11-2: Total Costs (inputs & outputs) by Economic Sector for Constructing a Commercial Facility (Assumes 70% accrues to local firms.)

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Agriculture	$0	$122,791
Forestry and Logging	$0	$60,971
Fishing, Hunting, and Trapping	$0	$9,305
Support Activities for Agriculture and Forestry	$0	$18,398
Mining	$0	$95,005
Utilities	$0	$383,309
Construction	$13,492,500	$13,873,692
Food Manufacturing	$0	$306,593
Other Manufacturing	$11,672,500	$13,136,669
Wholesale Trade	$0	$775,736
Retail Trade	$0	$1,408,566
Transportation	$0	$69,744
Finance, Insurance, Real Estate	$3,460,576	$7,109,756
Business Services	$6,650,000	$7,305,038
Accommodation and Food Services	$0	$451,167
Other Services	$0	$341,087
Hospitals/Health Care	$0	$196,700

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Education	$0	$197,312
Government (Federal/Provincial/Municipal)	$0	$65,869
Households (income from wages and profits)	$0	$14,311,918
Total Output (excludes Households Income)	**$35,275,576**	**$45,927,709**

Table 11-3: Annualized Cost Inputs and Outputs by Economic Sector for Constructing a Commercial Facility (Assumes a five-year time frame.)

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Agriculture	$0	$24,558
Forestry and Logging	$0	$21,194
Fishing, Hunting, and Trapping	$0	$1,861
Support Activities for Agriculture and Forestry	$0	$3,680
Mining	$0	$19,001
Utilities	$0	$76,662
Construction	$2,698,500	$2,774,738
Food Manufacturing	$0	$61,319
Other Manufacturing	$2,334,500	$2,627,334
Wholesale Trade	$0	$155,147
Retail Trade	$0	$281,713
Transportation	$0	$13,949
Finance, Insurance, Real Estate	$692,115	$1,421,951
Business Services	$1,330,000	$1,461,008

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Accommodation and Food Services	$0	$90,233
Other Services	$0	$68,217
Hospitals Health Care	$0	$39,340
Education	$0	$39,462
Government (Federal/Provincial/Municipal)	$0	$13,174
Households (income from wages and profits)	$0	$2,862,384
Total Output (excludes Households Income)	**$7,055,115**	**$9,185,542**

11.2 - OPERATIONAL PHASE

The costs for the annual operation of the 5 MW facility are categorized in Table 11-4. The figures in Table 11- 4 are based on those outlined in Nova Scotia Utility and Review Board, In the Matter of the Electricity Act and In the Matter of a Hearing to Determine the Renewable Energy Community Feed-On Tariff, March 2, 2011. Overhaul costs are annualized based on a major overhaul every six years. Total annual operating expenditures are estimated at $255,000, all accruing locally.

Table 11-4: Costs by Category of Operating a Commercial Facility

COST CATEGORY	COST FOR 5 MW FACILITY
Annualized portion of overhaul (one-sixth of six-year overhaul)	$100,000
Annual Operations and Maintenance Labour	$75,000
Annual Other (Administrative, Insurance/Land Lease)	$80,000
Annual Total	**$255,000**

Source: *Nova Scotia Utility and Review Board in the Matter of a Hearing to Determine the Renewable Energy Community Tariffs, March 2, 2011 (Synapse Exhibit M)* http://www.nsuarb.ca/images/stories/pdf/electricity/july2011/comfit.pdf

The costs from Table 11-4 are divided into economic sectors and inserted in the Digby County I/O model to estimate the total (direct/indirectly/induced) annualized expenditure impacts of the spending attributable to operation of a 5 MW tidal turbine. This is shown in Table 11-5. Finance, Insurance and Real Estate sector will see annual spending impacts of $113,000, Construction ($105,000), Business Services ($80,000), Retail Trade ($12,000), and Manufacturing ($9,000). The annual total spending impact across all industries generated is estimated to be approximately $344,000 per year, with total income creation of $124,000. The income creation approximates two full time job equivalents.

Table 11-5: Cost Inputs and Outputs by Economic Sector for Operating a 5MW Facility

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Agriculture	$0	$975
Forestry and Logging	$0	$478
Fishing, Hunting, and Trapping	$0	$80
Support Activities for Agriculture and Forestry	$0	$147
Mining	$0	$415
Utilities	$0	$2,879
Construction	$100,000	$105,313
Food Manufacturing	$0	$2,506
Other Manufacturing	$0	$9,524
Wholesale Trade	$0	$5,354
Retail Trade	$0	$12,006
Transportation	$0	$595
Finance, Insurance, Real Estate	$80,000	$113,252
Business Services	$75,000	$80,103
Accommodation and Food Services	$0	$3,919
Other Services	$0	$2,668
Hospitals/Health Care	$0	$1,706
Education	$0	$1,737
Government (Federal/Provincial/Municipal)	$0	$562
Households (income from wages and profits)	$0	$124,174
Total Output (excludes Households Income)	**$255,000**	**$344,219**

11.3 - SUMMARY

This section estimated the potential economic impacts emanating from a 5MW tidal facility in the Digby area of the Bay of Fundy. In order to estimate the potential economic impacts, an input-output (I/O) model for Digby County was developed. Project costs are based on The Renewable Energy Community Feed-In Tariffs (Nova Scotia Utility and Review Board, 2011). It is assumed that 70% of the capital and all service costs will go to local firms (SLR Consulting Ltd., SLR Project No. 210.05753.00, 2010).

The development costs are projected at approximately $10 million per megawatt, meaning $50 million for the 5MW hypothetical case study. The total economic impact (direct/indirect/induced) on spending across all industries in the Digby County economy from the development/construction phase is estimated to be $46 million, with total income creation of $14.3 million. The total expenditure impacts are concentrated in the Construction and Manufacturing industries, with spending of $13.7 million and $13.1 million, respectively.

On an annualized basis, over a five-year time frame, the resulting development phase impact of expenditures, across all industries, is $9.2 million, with Construction and Manufacturing industries seeing expenditures of $2.8 million and $2.6 million respectively, followed by Business Services ($1.5 million), Finance, Insurance and Real Estate (FIRE), with $1.4 million and Retail Trade ($282 thousand). Annualized total income creation across all industries is estimated at $2.9 million. The development/construction phase would be expected to generate 240 person years of employment or 48 jobs per year over each of five years. Employment creation of forty-eight jobs per year is equivalent to approximately one percent (0.7%) of Digby County's total employment of 7,215 (Services Canada, 2002). A critical element in the economic impact of this phase is dependent upon whether the tidal power generation devices are manufactured locally or imported. Furthermore, if the development phase were to generate a successful exporting industry, the economic impacts could be significantly larger than the case study estimates and for an indefinitely longer period of time.

The annual operational phase expenditures are much smaller than the development phase but are ongoing. The yearly total spending impact (direct/indirect/induced) across all industries generated by the operation of the 5 MW tidal device is estimated to be approximate $344,000 per year, concentrated in Finance, Insurance and Real Estate ($113,000), Construction ($105,000), and Business Services ($80,000). Annual income creation is estimated at $124,000. The income creation approximates two full-time job equivalents.

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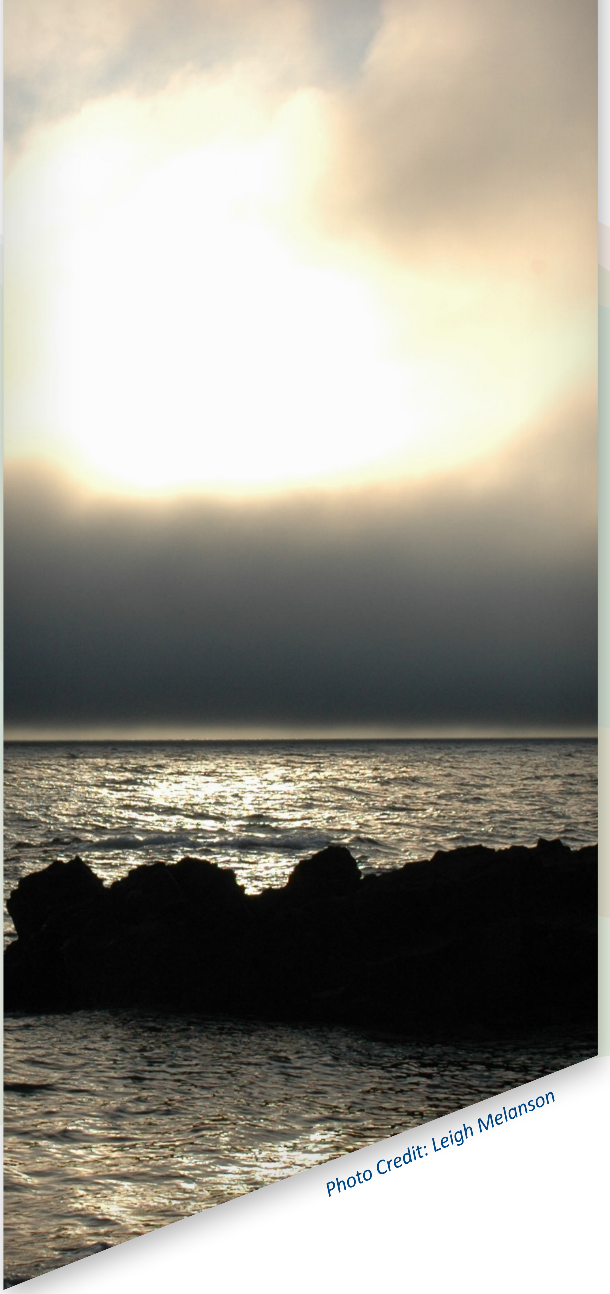


APPENDICES

APPENDIX A: EUROPEAN MARINE ENERGY CENTRE: CASE STUDY

CASE STUDY: PENTLAND FIRTH AND ORKNEY WATERS MARINE RENEWABLE ENERGY

Author: Dr. John Colton

Introduction

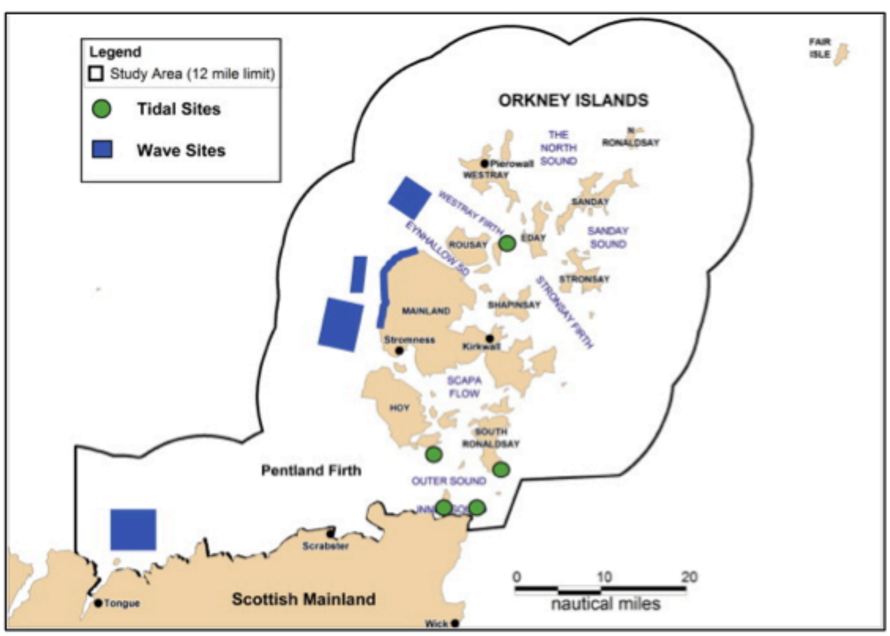
The Orkney Islands, situated off the north east coast of mainland Scotland, have become an international centre for marine renewable energy research and development in wave and tidal energy. Given that the Orkney waters boast 50% of the UK's and 25% of Europe's tidal resources, it was ideally situated to host the European Marine Energy Centre (EMEC). This case study provides a snapshot and high-level overview of the development of Orkney as a centre for marine renewable energy research and development.

The Orkney Islands

The history of Orkney is rich and varied and spans almost 9,000 years. In the 1850s, the retreating seas uncovered Skara Brae (a UNESCO World Heritage site), an early Neolithic community. Vikings based their raids from the Orkney Islands against Scottish and Norwegian settlements, ending in 875 with formal Norwegian rule. Scottish rule of the Orkney Islands emerged in 1468 as a dowry from the King of Norway. The Orkney Islands came under British rule soon after and is now part of the United Kingdom. During the Word War I and World War II, the Orkney Islands, in particular Scappa Flow, served as an important naval centre.

The people of the Orkney Islands have been opportunistic, basing their lives on a close relationship to the sea and its resources. Shipbuilding and fishing historically supported local economies and more recently farming, offshore oil and gas, and tourism. With the advent of marine renewable energy research and development, the Orkney Islands were a likely choice for this type of development. Covering an area of 975 km^2 comprised of 70 islands, the population is approximately 20,000 inhabitants, situated on 17 of the Orkney Islands. This number swells to 127,000 as visitors travel to these islands seasonally.

Marine Resources and EMEC



The Orkney Islands have some of the best-known marine resources in Europe and it's estimated that up to 18,000 GWh of renewable energy could be generated annually. Renewable energy resources, if fully developed on the Orkney Islands, could contribute more than the 40% that is required for the Scottish government to meet its renewable energy targets by 2020. Given the Orkney Islands abundant marine energy resources, it was the ideal location for the

European Marine Energy Centre (EMEC). Established in 2003 in Stromness, EMEC provides both research and testing of wave and tidal energy converters, including deployment methodologies and procedures. Heriot Watt International Centre for Islands and Technology (ICIT), also located in Stromness, provides research and technical expertise to the growing marine renewable energy sector. Collectively, both EMEC and ICIT have positioned the Orkney Islands as a centre of excellence in technical expertise and knowledge related to marine renewable energy. In addition to the 14 full-scale berth sites for tidal and wave-testing devices, there are two scale test sites where tidal and wave energy converters in early stages of design can be tested. EMEC also provides other services that include independently verified performance assessments as well as research and consultancy.

The straits separating the Orkney Islands from mainland Scotland are known as the Pentland Firth. It is here that EMEC has the majority of its tidal berth sites, where tidal currents can range up to 4.5 m/s. Tidal clients include, for example, Open Hydro, Atlantis Resources Corporation, Bluewater Energy Services, Scotrenewables, and Voith Hydro. Currently, EMEC has eight grid-connected tidal berth sites, with plans for expansion.

Economic Development

- Marine renewable energy has stimulated economic growth in the Orkney Islands particularly in the communities of Stromness and Kirkwall. Approximately 250 jobs have been created as a direct result of marine renewable energy development since the creation of EMEC ten years ago. These jobs span the supply chain and include, for example, engineers, metal fabricators, tidal device developers, and shipyard and quay services. The net economic impact has been significant supporting local economies significantly.

- Key to the development of the marine renewable energy sector was consultation and collaboration with ocean energy device manufacturers to determine the needs of industry. Needs included 24-hour access to ports for construction purposes, long quays, skilled labour, and a small area of land with long-term availability in the port facility. Given the momentum in marine renewable energy development, EMEC's and ICIT's positioning of Orkney as a place to do research and business, and significant investment by the Orkney Islands Council and Scottish Government, the Pentland Firth and Orkney Waters Marine Energy Park was recently established. Scotland's Energy and Climate Minister noted *"the designation as a marine energy park further promotes the Highlands and Islands of Scotland as a marine energy hub, and will accelerate investment and the industry's ambition for commercialization of the technologies being tested here."*

- Supply chain development, especially technical expertise, has been fuelled by the growth of the marine energy sector. Energy North, a trade association, has developed a supply chain matrix in consultation with its members in order to demonstrate its reach and capabilities in the marine renewables sector.

Planning

The Crown Estate manages Crown properties throughout the United Kingdom and is responsible for developing leases with developers for tidal and wave devices. Recent leases in the Pentland Firth and Orkney waters to tidal and wave device developers have the potential capacity of up to 1,600 MW. Collectively, the projects are thought to be the largest development of its kind worldwide. Gaining community support for this type of development consisted of one-week of events called Information Days. Attracting over 700 people to these events, 90% of the feedback indicated support for marine renewable energy development.

In order to accelerate and de-risk project development, the Crown Estate invested approximately $9 million in enabling actions. A developer's forum, comprised of the developers in the Pentland Firth and Orkney waters and the Crown Estate, determined these actions. Regulatory bodies and interactions with other stakeholders provide the Crown Estate with guidance in the application of these enabling actions.

Marine spatial planning (MSP) of the Pentland Firth and Orkney waters began in 2012 and an advisory group was established in 2013. A working group, developed by Marine Scotland, the Highland Council, and the Orkney Islands Council, is tasked with the development of the pilot non-statutory Pentland Firth and Orkney Waters Marine Spatial Plan. The aim of this strategic plan is to develop a decision-making framework for licensing and other consent applications in the marine area. To achieve this goal, it will be necessary to consult with stakeholders and "reconcile the aspirations" of the multiple users of the marine environment that includes inshore fisheries, shipping and navigation, aquaculture, oil and gas, recreation, tourism, and the marine renewable sector. The ultimate purpose of the plan is to support sustainable economic growth and management of the Pentland Firth and Orkney waters.

The Local Development Plan for Orkney addresses a broad range of community planning issues that include policies on coastal development. Current designations for coastal areas are: developed, undeveloped and isolated coast. Development will not be allowed in areas at risk such as those with coastal erosion. The plan notes that partnerships are required to implement many of the actions. The Orkney Renewable Energy Forum, working in partnership with the Orkney Islands Council, has provided leadership in the ongoing discussion and debate regarding Orkney's future with renewable energy and its role in marine renewable energy.

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APPENDIX B: OCEAN RENEWABLE POWER COMPANY (ORPC): CASE STUDY

CASE STUDY: OCEAN RENEWABLE POWER COMPANY

Author: Dr. John Colton

Company Profile and Values

Strong environmental and community values have fueled ORPC's vision of developing environmentally friendly projects that harness the power of the tides and currents of North America's coasts and rivers. ORPC has quickly emerged as a leader in marine renewable energy development and is one of the few companies in the world to have harnessed power from the water without a dam or impoundment. While the primary focus of ORPC has been on its Cobscook Bay Tidal Energy Project adjacent to the City of Eastport and Town of Lubec, Maine, it is also developing projects in Cook Inlet, Alaska and Brier Island, Nova Scotia.

Taking advantage of the 100 billion tons of water flowing in and out of the Bay of Fundy and tidal ranges reaching up to 55 feet, the City of Eastport and Town of Lubec, Maine at the mouth of the Bay of Fundy, were likely choices for tidal energy research and development by ORPC. In 2012, ORPC's tidal energy converter, called TidGen delivered power to the Bangor Hydro Electric power grid from ORPC's Cobscook Bay Tidal Energy Project. This made ORPC the first marine renewable energy company to deliver tidal energy to the grid in North America. The innovative design of TidGen, coupled with ORPC's reputation as a strong community partner, has demonstrated that marine renewable energy is not only feasible but can be done with a meaningful foundation of community engagement and a strong network of partners.

Engaging Community and Partners

Founder and CEO of ORPC, Christopher Sauer, started his company in Florida with designs to develop marine renewable energy off Florida's eastern coast. Given the distance to the resource and the high costs associated with development, Chris moved his company to Portland, Maine, where he explored other areas for tidal energy development. He was familiar with Maine, as he had a cabin he had been visiting for years. With ORPC established in Maine, the company focused its research and development on the resources in Cobscook Bay, adjacent to the City of Eastport and Town of Lubec.

ORPC takes an incremental approach to growth and this philosophy was put into practice with the Cobscook Bay Tidal Energy Project. At the outset, ORPC implanted themselves in the community by opening a local office. Engaging the community early was crucial to help overcome local skepticism. People in the City of Eastport and Town of Lubec had heard before from other developers of projects that never materialized, such as oil refineries, tidal dams, and fish farms. ORPC overcame the skepticism by working hard to become part of the community.

It was important for ORPC to do it right, get the lay of the land, and establish a good track record with the communities and other stakeholders of interest as it moved toward establishing its first project. Rather than approaching the communities and detailing its needs, ORPC noted the available opportunities with respect to tidal energy and asked how they could work together as partners in pursuing this type of development. Part of this involved developing an informal MOU with the City of Eastport. The MOU outlined how data collected by ORPC and its partners would be shared. Some of this data included information related to environmental monitoring of benthic habitats.

Key to community engagement for ORPC is thinking long-term engagement. The company has 5 five full-time staff in the City of Eastport. These people are well connected and have networked with the Cobscook Bay Resource Center, the Eastport Port Authority, Sunrise County Economic Council, the Cobscook Bay Fisherman's Association and area fishermen, local harbor pilots, The Boat School, and public and other local organizations. While ORPC has conducted open houses and hosted other public forums on tidal energy development, what has been most successful has been the time it has taken to develop one-on-one relationships with its stakeholders.

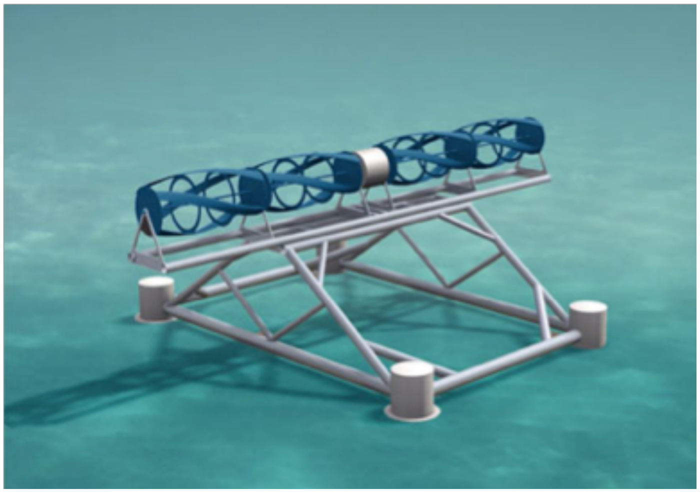
Coupled with its community efforts has been its relationship with Calypso, an innovative marketing firm that has helped ORPC craft its message. "The messaging equipped ORPC with consistent language that effectively supported and exemplified the company's leadership position" nationally and internationally. Positive press in targeted trade and professional publications as well as the popular press has positioned ORPC as a world leader in marine renewable energy technology. This type of attention is important in attracting future investment. ORPC's deep community engagement and its innovative technologies provided Calypso with a good story to tell.

Economic and Environmental Impacts

To date, the Cobscook Bay Tidal Energy Project has injected $14 million into the local economy, $4.7 million in the local community since 2007. ORPC, as well as having engaged 40 local contractors, have created five full-time local jobs and supported 100 supply chain jobs. This level of investment is significant and was leveraged largely through a $10 million investment by the U.S. Department of Energy to bring ORPC TidGen from the laboratory to commercial deployment. Power generated from the Cobscook Bay Tidal Energy Project will be enough to power 75 to 100 homes. Future expansion plans will provide 5 megawatts of power, enough energy to supply power to over 1,200 homes and businesses in Maine.

ORPC is diligent in their approach to evaluating the effects of their devices on marine life. Tidal turbine devices have been monitored with cameras and other equipment to better understand the impacts on fish and sea mammals. This has been done in collaboration with universities and environmental groups. Research has shown minimal negative impacts to marine life, as it is believed fish and sea mammals tend to avoid the slow-moving turbine foils of the TidGen device. With a $600,000 grant from the U.S. Department of Energy in 2009, ORPC has been able to monitor beluga whales in its Cook Inlet site in Alaska in order to track the consequences of the deployment of its devices.

Computer image of TidGen



ORPC Technology

The TidGen is developed to operate in depths of water from 15-30 metres, allowing it to be used in shallow tidal sites. TidGen was engineered based on principles of modularity, the use of strong materials suited for marine environments, minimal benthic impact, and low revolutions per minute (RPM). The TidGen power system "produces electricity from water currents using dual advanced design cross flow (ADCF) turbines that drive an underwater permanent magnetic generator mounted between the turbines on a common shaft. The technology features a limited number of moving parts that do not use gears or petroleum-based lubricating fluids."

The TidGen, deployed at Cobscook Bay, Maine, has a maximum capacity of 180 kW but will operate at 60 kW as tidal currents reach a maximum of 2.65 m/s. Electrical components will vary at other sites based on site characteristics. Once deployed, the device is fully submerged with no visual impact and only limited effect on local marine traffic. The TidGen is approximately 27 m long by 3 m wide by 3 m high, and the bottom support frame is approximately 20 m long by 14 m wide by 6 m high. It is connected to shore using underwater power and data cables.

Strategic Partnerships

In addition to the Cobscook Bay Tidal Energy Project, ORPC has research and development projects underway in Cook Inlet, Alaska and Brier Island, Nova Scotia. In Nova Scotia, ORPC has formed a partnership with Fundy Tidal Inc., a community-based and community-shareholder owned Canadian power company. Like the project across the Bay of Fundy in Maine, FTI and ORPC have plans to do something in the Digby Gut. As these projects come online, they will have the combined potential to generate more than 300 megawatts of electricity.

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Personal Communication December 6, 2012:
Susy Kist, Marketing and Communications Manager, ORPC
Tuck O'Brien, Project Development Manager, ORPC

GLOSSARY

• **Acoustic Doppler Current Profiler (ADCP)** - The Acoustic Doppler Current Profiler (ADCP) measures the speed and direction of ocean currents using the Doppler effect of sound waves scattered back from particles within the water column.

• **Annual Energy Production** - The total power produced in a year, usually measured in TWh. It can be calculated by multiplying the mean power by the number of hours in a year.

• **Array** – A tidal array refers to a series of tidal energy convertors deployed in a single location to capture energy. Arrays can appear as a single line or staggered rows; orientation and placement depends on the local conditions.

• **Asset Mapping** – An approach used in community development for multiple purposes (economic, social, environment, health). The process usually entails collecting information about positive aspects of a community into an inventory. This information is then used to strategically think about how to build on these assets to achieve a desired goal.

• **Balance Sheet Financing** - Also known as corporate financing, is simply the project developer investing in a project from its own cash, financed either from existing or new equity and debt.

• **Biofouling** – The accumulation of microorganisms, plants, algae, or animals on wetted surfaces, which may or may not interfere with the normal operating of a device placed underwater.

• **CAPEX- Capital Expenditure** refers to the costs incurred when a company spends money on acquiring/building a fixed asset. Typically, this involves acquiring or upgrading physical assets such as equipment, property, or industrial buildings.

• **Community Economic Development Investment Fund (CEDIF)** - A CEDIF is a pool of capital, formed through the sale of shares (or units), to persons within a defined community, created to operate or invest in local business. It cannot be charitable, non-taxable, or not-for-profit, and must have at least six directors elected from their defined community. (For more information see: **http://www.gov.ns.ca/econ/cedif/**).

• **Community Feed-in Tariff (COMFIT)**– Developed by the Government of Nova Scotia, this program provides an opportunity for communities and other organizations to be paid a guaranteed price for renewable energy to support economic and sustainable development. (See Feed-in Tariff.)

• **Decommissioning** – This refers to the process of taking a device (e.g. tidal turbine) offline (i.e. no longer producing energy) and likely removing it from the water.

• **Dynamic Positioning vessels** – This refers to vessels that can maintain a constant position in the water.

• **Economic Impacts (Direct, Indirect, Induced)** – The economic benefits of a project are often measured in terms of their direct, indirect and induced economic impacts. Direct impacts refer to the employment and revenues attributable to a project. Indirect impacts refer to the purchase of goods and services to support a project from other firms, in terms of the employment and revenues related to the incremental business activities resulting from their operations. Induced impacts refer to household spending due to the increase in income due to the direct and indirect impacts of a project.

• **Electromagnetic fields** - Electric fields are created by differences in voltage: the higher the voltage, the stronger will be the resultant field. Magnetic fields are created when electric current flows: the greater the current, the stronger the magnetic field. An electric field will exist even when there is no current flowing. If current does flow, the strength of the magnetic field will vary with power consumption but the electric field strength will be constant.

• **Energy Resource: Theoretical** -This refers to the power contained in the entire resource.

• **Energy Resource: Technical** - This is the proportion of the theoretical resource that can be captured using existing technology.

• **Energy Resource: Practical** - This is the proportion of the technical resource that is available after consideration of external constraints – for example, environmental impacts.

• **Energy Resource: Economic** - This is the proportion of the practical resource that can be economically captured.

• **Energy security** – refers to the ideal state of having long term certainty on the cost and availability of energy for the individual consumer and energy inputs (fuels) for energy producers or utilities.

• **Exclusion zones** – Refer to zones where development and certain types of activity may be limited or prohibited in order to reduce conflict between marine area users.

• **Feed-in Tariff (FIT)-** This is a policy mechanism designed to accelerate investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology.

• **Generator** – The generator is the portion of a turbine in which electricity is generated. In many horizontal axis turbines the generator is housed in the central part of the device (the 'bulb'), surrounded by the moving blades; in some horizontal axis designs, the generator has been moved outside the blades in the surrounding frame; these are sometimes called 'rim generators'. In many vertical axis designs, the generator may be connected to the spinning blades by a long shaft, enabling the generator to sit above the water level.

• **Gravity base** – A mooring system that keeps a tidal device on the seafloor using gravity by attaching the device to a heavy base.

• **High Conservation Concern (HCC)**- A habitat or species of HCC are ecosystem components that are considered to be of ecological, economic, or cultural concern or are sensitive to disturbance. Valued Ecosystem Components (VEC) is the more commonly used term in environmental assessment to signify this type of habitat or species.

• **Installed capacity** - This is the maximum power generation capacity of a given turbine array. For example, an array of 10 turbines rated to produce 1.2 MW would have an installed capacity of 12 MW.

• **Intertidal zone** - This is the area that is above water at low tide and under water at high tide.

• **Levelized Cost of Energy** - This is the metric used to evaluate a project's financial feasibility. The cost of energy evaluation includes both physical (electrical infrastructure and devices) and knowledge inputs (assessments, legal fees, etc.).

• **Maximum extractable power** - It is the maximum in-stream power that can be extracted from a given tidal resource while accounting for the resulting reduction in the flow speed.

• **Mean Power** - The average power produced, usually measured in Megawatts (MW).

• **Near- and far-field effects** – This refers to the spatial and temporal effects of changes in the marine environment. Some effects will occur close to the location of tidal devices, while other may occur kilometers away.

• **NIMBY – Not In My Back Yard** – Refers to attitudes around decisions to build or locate different types of structures or industries – such as wind turbines – where in principle there is support. However, the same supporters object to the development near where they live, go to school, or work.

• **OPEX – Operating Expenditure** - Refers to an ongoing cost for running a product, business, or system. Examples include wages, maintenance and repair of machinery, utilities and rent expenses.

• **Power conditioning equipment** – Equipment that assists in the regulation of voltage.

• **Power Density** – This is the power of the flow of water – the power per unit of cross-sectional area.

• **Project Financing** – Refers to a financing method where a project is legally set up as a separate, stand-alone company. Equity investors and lenders finance the project company. The equity investors, also known as sponsors, include the developer and other investors taking an ownership stake. The lender(s) is a bank or syndicate (group) of banks that provide approximately 60-80% of the financing through a loan. The loan is considered non-recourse: it is secured by the project assets and the interest and principal is paid from the project's own cash flows.

• **Rated Power/Nameplate Capacity** - The "rated power" or "nameplate power" of the device is how much power it can generate when running at its full capacity.

• **Spring/Neap/Slack Tides** – Refers to the different aspects of the tidal cycle. Spring tides are when tides are higher than average, neap tides are lower than average and slack tides refer to the point at which the water is neither ebbing (out to the ocean) nor flowing (towards shore) and the direction of the tide is about to change.

• **Stakeholder**- Refers to individuals or groups that have an interest in or may be impacted by a project, plan, or policy decision.

• **Strategic Environmental Assessment** - A Strategic Environmental Assessment is a systematic process for evaluating the environmental consequences of a proposed policy, programme or development so that environmental implications can be incorporated into strategic planning and decision-making.

• **Supervisory Control And Data Acquisition (SCADA)** - Refers to computer controlled systems that monitor and control industrial processes that exist in the physical world, typically over long distances with multiple sites, a key example being energy production.

• **Supply Chain** – A supply chain consists of all the steps and stages and processes needed to develop a product and get it to its point of final sale (i.e. the consumer). The supply chain includes the extraction of raw materials, (e.g. iron ore, timber) to manufacturing (e.g. welding) to distribution (e.g. freight carriers) to sales and final disposal.

• **Tidal Energy Convertor (TEC)** – Refers to a generic term to describe devices that convert energy from the tides into electrical energy. Also referred to as TISEC.

• **Tidal Head** - Refers to the vertical difference in water levels in two parts of the same system, such as on either side of a barrage or from one end of a channel to another. It is the difference in height that causes the water to flow, and thus give the power.

• **Turbine** – A generating device with moving blades that converts the energy of moving air or water into electricity.

• **Watt: Unit of Energy - Kilowatt, Megawatt, Gigawatt, Terawatt**

o The watt is a derived unit of power in the International System of Units (SI). The unit is defined as one joule per second and measures the rate of energy conversion or transfer.

o The kilowatt is equal to one thousand (10^3) watts. This unit is typically used to measure household appliances and the output of engines.

o The megawatt is equal to one million (10^6) watts. Usually used in reference to measure larger consumers and producers of energy such as data centres or windmills.

o The gigawatt is equal to one billion (10^9) watts. Typically used in reference to large power producers or in reference to usage within an electrical grid.

o The terawatt is equal to one trillion (10^{12}) watts. The total energy usage on Earth is measured in terawatts.