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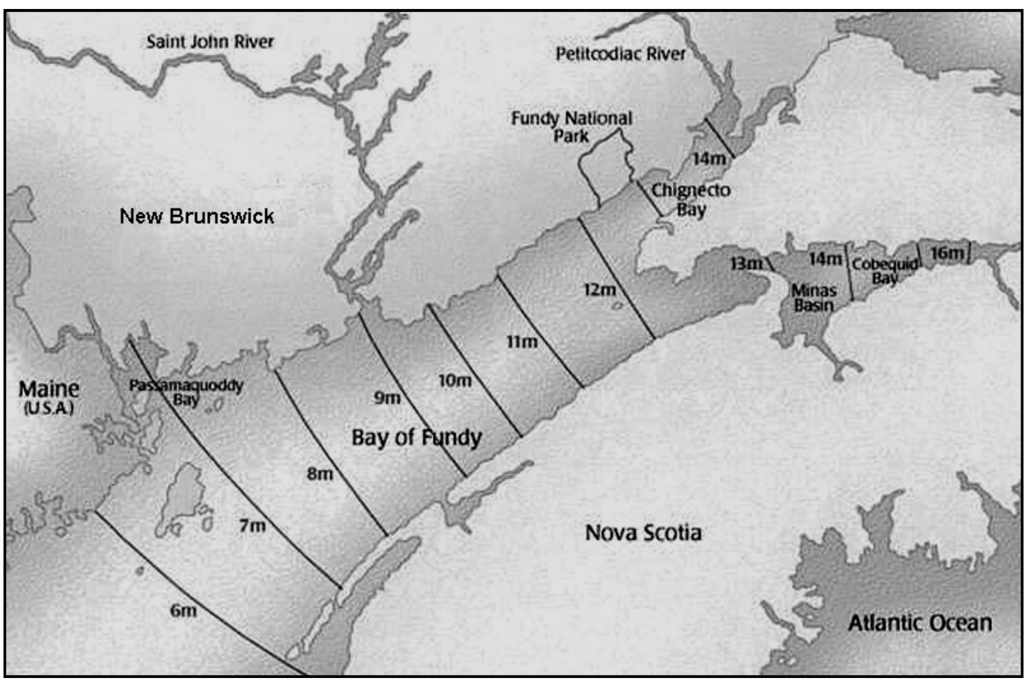
FUNDY ISSUES

Tweaking Tidal Technology:

Harnessing Fundy's Phenomenal Tides?

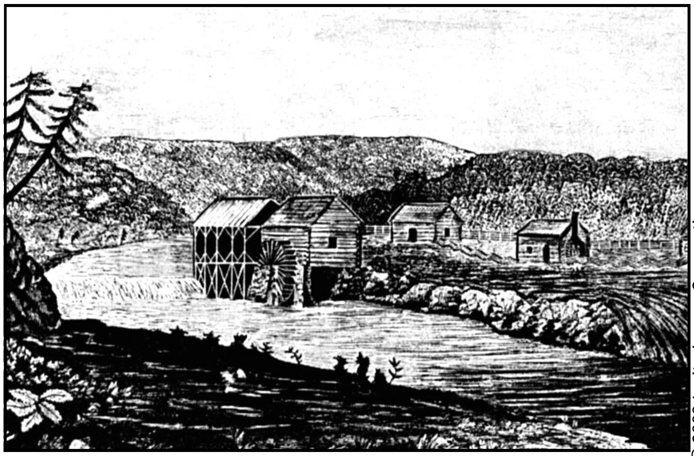
"The idea of harnessing some of the power of the tides of Fundy to carry out productive work has stirred men's minds for four centuries."

Once again, engineers, businessmen and politicians are looking at the powerful tidal currents in the Bay of Fundy as a vast, largely untapped, source of seemingly clean, "green", sustainable energy. They assure us that over the past decade new and improved marine energy technologies have reached the point where electricity can be generated efficiently, safely and with minimal environmental impact. There is indeed an impressive array of diverse marine energy devices now vying for a piece of the potentially lucrative market worldwide. Pilot and demonstration projects indicate that some of these devices show great promise. However, all of them are still largely unproven on a large, commercial scale, particularly with respect to their effects on the marine environment and its sea life. The governments of Nova Scotia and New Brunswick have been grappling with the question of how best to ensure that any proposed tidal power development in the Bay of Fundy is properly managed and regulated, carefully monitored, and cautiously introduced in an incremental, reversible manner. Before looking at how they are attempting to do this, we need to briefly consider earlier efforts at extracting power from Fundy's roiling waters in order to provide an historical context and a baseline against which to assess these newest endeavours.



From Electrical Power Research Institute Report 2006

Fundy's tides range from 6 m at the mouth to 16 m in Cobequid Bay.



Water mills on tidal rivers have long been a feature of Fundy landscapes.

A Venerable Vision

The idea of harnessing some of the power of the tides of Fundy to carry out productive work has stirred people's minds for four centuries. The first Europeans settling at Port Royal on the Annapolis Basin in Nova Scotia constructed a water-driven mill in 1607 to use the tidal surges in the nearby Lequille River (now Allains River) for grinding their grain. The mechanical power produced by such water-wheel and gear-train technology had to be used right at the site of generation. Thus, over the next three centuries, mechanical water mills for sawing lumber, carding wool, grinding grain and many other manufacturing activities sprung up on tidal sections of rivers, as well as further upstream, all around the Bay of Fundy.

The rapid evolution of electrical technology in the late 19th and early 20th centuries inspired new generations of engineers to dream of other ways of harnessing this seemingly "wasted" energy and then transmitting and using it far from the point of production. Many of these early dreams, such as one for building a transportation causeway across the Minas channel and installing turbines along its length, fortunately remained on the drawing board. However, a few made tentative steps towards realization. One such project was launched in 1916 under the auspices of the Cape Split Development Company (CSDC), which had close ties to Acadia University. George Cutten, President of Acadia, was also president of CSDC, while Acadia professor of engineering Ralph Clarkson was vice-president and managing director of the company. His invention, the Clarkson Current Motor, was the crucial piece of technology underpinning the grandiose scheme. Four of these motors, operating in adjacent bays and driven by the fierce tidal currents passing Cape Split, would be used to pump seawater to holding ponds at the top of the 350 foot cliff. This water would then be directed to surge back down large pipes to drive the turbines situated in a power house located at the base of the cliff. By thus storing the water temporarily, the maximum amount of electricity could be generated when the demand was greatest rather than when the tidal currents were at their peak, effectively "retiming" the power production. By selling shares, the company acquired about $13,000 in capital to launch its initial efforts, which included carrying out a feasibility assessment, obtaining an engineer's report, carrying out preliminary experiments and raising more funds to complete the ambitious project.

The project eventually failed, largely because it could not raise the additional capital ($2.5 million) needed, especially after an accidental fire destroyed the prototype Clarkson Current Motor in 1920. The company eventually sold its Cape Split property to Minas Basin Pulp and Paper in 1928, but retained the legal rights to power generation at the site until it finally turned these over to the Nova Scotia Power Commission in 1957. Interestingly,

Artist's conception of proposed tidal pumping station of Cape Split

Acadia University, Esther Clark Wright Archives. (2009). Cape Split Development Company. Retrieved August 31, 2009, from Vaughan Memorial Library web site: library.acadiau.ca/contentDM/csdc.html these companies, now named Minas Basin Pulp and Power and Nova Scotia Power, respectively, are both major players in the present efforts to test new tidal power technologies in the Bay of Fundy. In addition, Acadia University, whose library houses extensive records pertaining to the early tidal power developments, has been at the forefront of efforts over the years to study the possible environmental effects and other implications of tidal power development in the Bay of Fundy.

Building Barrages?

During subsequent decades, interest in Fundy tidal power waxed and waned but with little significant progress. However, by the 1960s, the Atlantic Tidal Power Programming Board began considering new proposals for tidal power projects in many places in the Bay of Fundy, including the Minas Basin. By the 1970s, attention had narrowed to a few promising sites, one of them involving a barrage across Cobequid Bay from Economy Point to Cape Tenny. The spectre of rising oil prices stimulated a surge of engineering and ecological research in the late 70s and early 80s. Although development of a large-scale Fundy tidal project was eventually shelved, it was decided to construct a pilot-scale prototype tidal power plant, to test turbine design and to study possible environmental impacts. In 1984, a small tidal power plant began operating on a rock causeway across the Annapolis River that had been built in 1960 to protect the upstream dykelands and support a highway. This plant produces electricity only on the ebb tide, as water trapped in an upstream head pond passes through a 4-bladed, 7.2 m diameter "low-head" turbine on its way back into the Annapolis Basin. With a capacity of 18-20 megawatts, the facility contributes enough electricity to the power grid to supply about 4,500 homes. While this constitutes only about 0.87% of Nova Scotia's total energy production, it accounts for a more impressive 7.3% of the province's energy production from renewable sources. The Annapolis tidal power plant, still the only one in North America, and an associated interpretation centre and regional tourist bureau, continues to attract some thirty five thousand visitors each year. Long-term studies of the environmental impacts of such barrage-based tidal technology *(discussed in Fundy Issues #9 - "Dykes, Dams and Dynamos: The Impacts of Coastal Structures"),* as well as the high capital cost, served to convince many that this wasn't an appropriate and sustainable way to harness Fundy's tidal energy and led to a pause in further tidal development for another two decades.

Going for "Green"

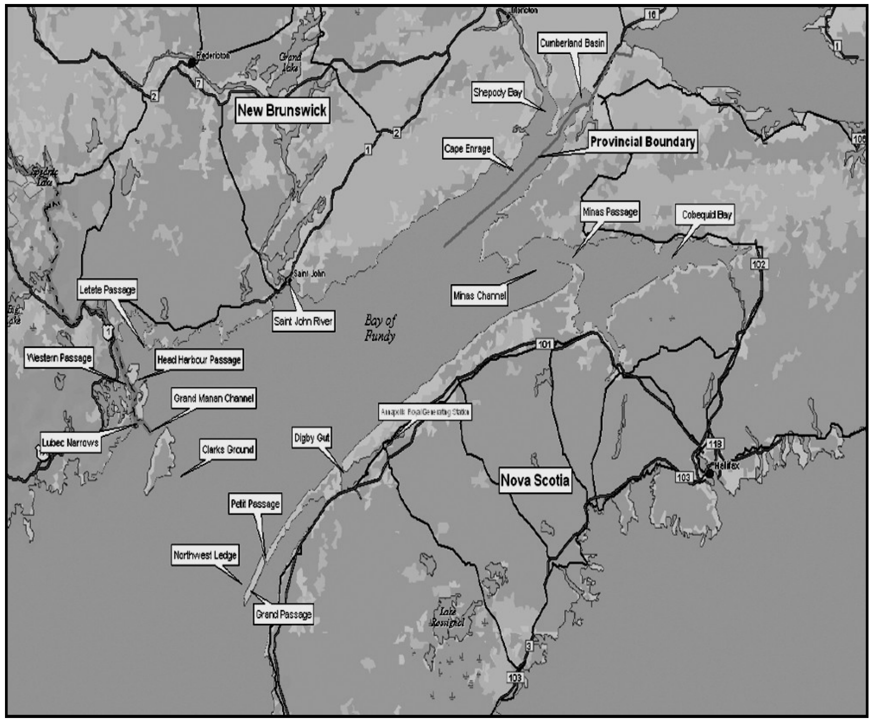
In the first decade of this century there has been a sea change in the prospects for renewable energy production from a variety of different sources, and lately, for tidal energy in particular. A number of factors triggered this resurgence in interest in the production of "clean", "green" energy in the Maritimes, the rest of Canada and indeed throughout the world. In particular, people increasingly recognize the threats to the world's climate posed by the rapidly rising levels of greenhouse gases, such as carbon dioxide, which trap heat in our atmosphere. The principal source of carbon dioxide, and other atmospheric pollutants, is the combustion of fossil fuels in our factories, homes, automobiles and electrical power plants. Furthermore, global political unrest has made nations wary of relying too much on fossil fuel imports to meet industrial and domestic needs. It is also clear that reserves of easily accessible oil will soon begin to diminish, resulting in shortages and rising prices.

"Three quarters of Nova Scotia's electricity is presently generated by burning coal, most of which is imported."

In an unprecedented effort to reduce the volume of carbon dioxide production globally and slow the rate of atmospheric warming, most nations including Canada signed an international treaty, the Kyoto Protocol, in 1996. This agreement requires Canada, in concert with its provinces, to reduce the production of greenhouse gases by at least 6% from 1990 levels by the year 2012. Nova Scotia is expected to do its part to achieve this modest objective. It can do this partly by reducing its overall energy consumption, by using it more efficiently (fuel efficient cars and domestic furnaces), and conserving it where possible (better insulated homes and use of public transportation). But it must also cut its release of greenhouse gases by reducing the use of fossil fuels in favour of cleaner, non-fossil fuel ways of generating electricity. This is clearly important, given that almost half (48%) of the greenhouse gases produced in the province result from generating electricity.

Power Provider

The bulk (97%) of the electrical power distributed and used throughout Nova Scotia is generated by Nova Scotia Power (NSP), now a subsidiary of Emera Inc. It operates 33 hydroelectric plants, 9 plants that burn fossil fuels (5 thermal and 4 combustion turbines), the tidal power plant at Annapolis Royal and 2 wind turbine farms. The various plants provide some 2,300 megawatts of generating capacity, and produce 13,000 gigawatt hours of electricity annually for distribution to almost half a million residential, commercial and industrial users. Three quarters of Nova Scotia's electricity is presently generated by burning coal, most of which is imported.



From Final Background Report for the Fundy Tidal Energy SEA

Possible tidal power sites in NS and NB

The Nova Scotia government has legislated "Renewable Energy Standards" regulations as part of the province's Energy Act, requiring NSP to generate at least 20% of its electricity from renewable sources by 2013. Recently, a government policy to close all fossil-fuel based power plants by 2020 has also been tabled. The effort to control the manner of production of electricity is termed "supply side management". One renewable source, hydro power, whereby electricity is generated by damming rivers and directing the flow through turbines, has already tapped most of the available sources and offers little scope for further expansion. Extracting energy from the wind using bladed turbines atop tall towers is a proven technology that already has a solid foothold in the province. The number of wind farms is likely to grow steadily over the next few years and contribute significantly to achieving the legislated renewable energy standard. However, the NIMBY (not in my backyard) attitude poses problems for locating the turbines on land. Perhaps offshore wind farms, similar to those off Denmark and Britain, could be used to harness the very strong winds blowing over the Bay of Fundy. Currently, solar energy is best suited to localized, small-scale, domestic energy needs, but could become more important as solar technologies evolve and solar panel prices fall. Biomass energy, produced by burning vege-

EPRI Report Estimates of Extractable Power (EP) at possible tidal power sites in NS and NB

Location	EP (MW)
Nova Scotia	**(330)**
Cumberland Basin	6.5
Minas Channel	131
Minas Passage	166
Cobequid Bay	6.3
Digby Gut	4.9
Petit Passage	9.2
Grand Passage	6.6
New Brunswick	**(89.9)**
Lubec Narrows	1.2
Western Passage	10.8
Head Harbour Passage	14.0
Letete Passage	4.2
Cape Enrage	30.0
Shepody Bay	13.0
Cumberland Basin	16.7
Saint John River	?

tative matter (such as forestry or agricultural wastes), is controversial option being implemented on a small scale. Biogas energy, generated by burning methane from landfills, and agrifuels, made by fermenting high sugar crops to ethanol or extracting vegetable oils for use in diesel engines, are unlikely to be major energy sources in the province in the near future. Nuclear power, available in New Brunswick, is not even on the energy table in Nova Scotia.

"With recent advances in turbine technology, attention is turning again to the possibility of harnessing Fundy's tides."

Focus on Fundy

There is another source of renewable energy that may contribute to efforts to reduce our dependence on fossil fuels for generating electricity. With recent advances in marine turbine technology, attention is turning again to the possibility of harnessing Fundy's tides. Tidal power offers two major advantages over wind power. The wind is variable and highly unpredictable, while tidal flows are as monotonously regular as clockwork and can be accurately predicted far into the future. Also, finding places to build wind generators has long been a contentious issue, on aesthetic grounds because they are highly visible and intrusive in scenic landscapes, as well as on medical grounds because of ongoing concerns about their effects on the health of nearby people and livestock. Tidal energy devices, in contrast, are mostly submerged, invisible and far away from areas frequented by humans and livestock. But, as we shall see, avoiding one set of thorny issues on land may just be opening another Pandora's Box of potential problems in the coastal environment.

While it has long been known that Fundy's tidal currents are strong enough to generate large amounts of electricity, it has not been clear exactly how much power can be extracted in a sustainable manner, that is, without measurably altering the Bay's marine environment and living resources over the longer term. To obtain this information, a study was undertaken in 2005 to make firm energy production estimates for the most promising sites around the Bay. Nova Scotia and New Brunswick and the states of Maine, Massachusetts, Alaska, Washington and California jointly funded the US$425,000 study by the California-based Electric Power Research Institute (EPRI). This study also revealed how Fundy compares with other possible tidal power sites scattered around North America. One of the final reports, entitled "Nova Scotia Tidal In-Stream Energy Conversion (TISEC): Survey and Characterization of Potential Project Sites", released in October 2006, identified seven sites in Nova Scotia that showed considerable promise for tidal power development (*see table opposite*). By assuming that about 15% of the maximum possible current energy could be extracted without significantly disrupting water circulation the report concluded that up to 330 MW of electricity could be generated. A comparable report focusing on New Brunswick identified an additional 7 promising sites with a total of 90 MW of extractable energy (*see table opposite*).

"there is little reliable information about the performance and environmental impacts of many of the newer designs...[and] limited operational experience … to draw upon in developing policies for regulating their location, installation and operation".

A SEA Story

Because the technology for extracting tidal energy has been rapidly evolving in recent years, there is little reliable information about the performance and environmental impacts of many of the newer designs. Furthermore, there is only limited operational experience with the devices to draw upon in developing policies for regulating their location, installation and operation. Therefore, the Nova Scotia and New Brunswick governments decided to move cautiously and incrementally in considering whether or not tidal power development would be permitted in Fundy's waters. To this end, a Strategic Environmental Assessment (SEA) Process was launched as a framework for deciding whether demonstration or commercial tidal power devices could be safely and economically operated in the Bay, and if so, how their deployment could be effectively studied, managed and regulated. The word Strategic in the acronym SEA means "pertaining to a strategy", and the process is essentially about devising an overall strategy for addressing the challenge of using the Bay's energy to generate electricity without causing harm. Unlike a typical Environmental Impact Assessment (EIA), the SEA does not focus on a specific type of development project at a particular geographic site. It attempts a much broader overview of the problem, in the form of a scoping exercise that examines likely development scenarios at promising sites throughout the region. It is an opportunity to explore the big picture and also a chance for all those with a vested or other interest in, or likely to be affected by, the development to make their views heard before any substantive decisions are made. It assesses the benefits of such developments and also identifies any potential problems, concerns or uncertainties. If at the end of the SEA process it is decided to proceed in principle with tidal power development, then each proposal submitted for placing particular generating devices at specific locations should still have to undergo a detailed EIA and further public scrutiny.

"the SEA does not focus on a specific type of development project at a particular geographic site. It attempts a much broader overview of the problem, in the form of a scoping exercise".

In 2007, the Nova Scotia Department of Energy engaged the Offshore Energy Environmental Research (OEER) Association to implement the SEA process, asking it to "provide advice on whether, when and under what conditions tidal energy demonstration and commercial projects should be allowed in the Bay of Fundy." OEER, a not-for-profit partnership incorporated in 2006, includes as its members, Acadia, Cape Breton, and St. Francis Xavier Universities as well as the NS Department of Energy. It was originally set up to promote environmental research and development pertaining to offshore energy, particularly sub-sea drilling, but has since expanded its mandate to include a consideration of renewable energy projects and their environmental implications. OEER in turn created a small Technical Advisory Group (TAG) to oversee the project as well as a 24 member Stakeholder Roundtable to provide ongoing input from the principal interest groups. Broader input to the process was encouraged by a series of community forums and workshops as well as by a request for written submissions. For the tidal power issue, OEER has also formed a joint Tidal Area Sub-committee with the Ocean Energy Technical Research Association (OETR) (which focuses on offshore oil and gas and carbon sequestration research) to oversee and advise on research issues.

To provide a solid base of information to guide the discussions, OEER contracted a consulting firm to carry out a comprehensive background review of all aspects of marine energy development in the Bay of Fundy. It began by reviewing the current and anticipated energy needs of Nova Scotia and New Brunswick as well as the provinces' existing policies and regulations with regard to energy supply and the role of renewable energy in their planning. The study then surveyed the wide variety of marine energy technologies currently available (such as wave energy, offshore windfarms, tidal lagoons, etc.), with its principal focus on Tidal In-Stream Energy Conversion (TiSEC) devices. Suggestions were made as to which of these approaches might be worth considering for use in Fundy coastal waters. The report also summarized a great deal of available information about the geology (*e.g.* bottom topography and sediment movements), oceanography (*e.g.* waves, tides and currents), climatology (*e.g.* wind and weather), biology and ecology (*e.g.* plants and animals and their interactions), economics (fisheries, jobs etc.) and the social structure of the Fundy coastal communities. As well, it considered the possible consequences of tidal power development on the marine environment and living resources and also speculated about the possible benefits and threats to the well-being of coastal communities around the Bay. It also offered possible scenarios about how initial pilot-scale and eventual commercial-scale developments might occur. Equally importantly, the report identified areas where critical data were lacking and suggested how to go about acquiring the information needed for sound decision-making. This background report provided a wealth of baseline information as grist for the subsequent phases of the SEA process.

The OEER Technical Advisory Group and the larger Stakeholder Round Table group met together on seven occasions for daylong meetings, during which they carefully reviewed the background report. They also participated in six community forums held at various locations in Nova Scotia, a number of other workshops and also received written submissions from many individuals and groups. OEER also invited proposals for *"SEA Participant Support Funds"* that allowed six interested groups to carry out research projects or prepare reports on aspects of tidal power development that might otherwise have been neglected. For example, the Nova Scotia Environmental Network received funding to hold a day long workshop to obtain input from 45 of its member organizations, a consultant completed a study on submerged floating ice in the upper Bay that might pose a hazard to marine turbines, and the Atlantic Policy Congress of First Nations Chiefs submitted a report on the scope and nature of fishing activities by First Nations groups in the Bay of Fundy.

Proceeding Prudently

In April 2008, after carefully reviewing the background report, the results of participant funding projects, summaries of workshops and community meetings, written submissions and a wide range of other information about tidal energy development, OEER released a comprehensive 83 page report entitled *"Fundy Tidal Energy Strategic Environmental Assessment".* It presented 29 recommendations as to how, and under what conditions, tidal energy development might be permitted to proceed in the Bay of Fundy. The first recommendation laid the groundwork for those following by calling upon the government to use ten fundamental "sustainability principles" in developing its approach to renewable marine energy development in the Bay. The first of these are oriented primarily towards protecting the environment. They include concepts such as: public, rather than private, management and control of marine energy; using the energy produced from tides to reduce the province's greenhouse gas production, rather than simply export it; work with both the Federal and New Brunswick governments to protect the environment and resources; testing and development should proceed at a measured pace and only so long as no deleterious environmental effects are encountered. The remaining principles are more socio-economic in nature. They require that existing fisheries be protected or at least compensated, that there should be lasting benefits for present and future generations, that the economies of coastal communities be enhanced by nearby developments, that development be integrated with a broader coastal zone management plan that allows all those affected to have an effective voice in decision making, and that the entire process be open to public scrutiny and review. The remaining 28 recommendations largely elaborated and expanded on these principles in considerable detail. One important recommendation, pertaining to the concept of a gradual incremental, reversible approach to tidal energy development, was that a small scale pilot or demonstration facility be established to carefully test and evaluate some of the more promising tidal power technologies in the demanding Fundy environment before committing to any commercial development.

"that a ... demonstration facility be established to carefully test and evaluate some of the more promising tidal power technologies in the demanding Fundy environment before committing to any commercial development".

In 2008, the Nova Scotia Department of Energy released a 36 page response to the Strategic Environmental Assessment Report in which it laid out its overall vision for tidal power development and its view on each of the 29 recommendations. In general, it accepted *"both the direction and objectives of the SEA",* noting that some recommendations can be acted on immediately while others may come into play later depending how tidal power development evolves and expands in the future. More concretely, the government committed to giving OEER up to $2 million for further research into tidal energy, making available $4.7 million towards a test facility for tidal energy devices if it passes an environmental impact assessment, and contributing $300,000 towards associated environmental research and monitoring. While supporting the emphasis on moving forward with the testing of TiSEC devices, the province also left the door open to further experimentation with tidal lagoon technology, providing it passes a federal environmental impact assessment review.

Because a number of different federal and provincial departments have interests or roles in the development and regulation of tidal power, the two governments created a "One Window" Committee to coordinate their participation in the management processes associated with creating and operating tidal power demonstration projects in the Bay. The committee includes representatives from Environment Canada, Natural Resources Canada, Fisheries and Oceans, Canadian Environmental Assessment Agency and Transport Canada, along with representatives from the provincial departments of Energy, Environment, Labour, Fisheries and Aquaculture, and Natural Resources.

Trendy Tidal Technologies

The renewed interest in Fundy's energy potential coincided with substantial advances in tidal energy technology. Earlier approaches that relied on building massive barrages to impound rising tidewater and then release it to generate electricity on the falling tide proved both environmentally damaging and costly. However, since the 1970's, a new generation of devices has been developed that relies on turbines deployed directly in the tidal currents and generates electricity on both the incoming and outgoing tides. These Tidal in-stream Energy Conversion (TiSEC) devices promise cost-efficient electricity production with presumed less impact on the environment and living marine resources. The OEER Background Report describes 41 of these devices that are presently being developed or are already commercially available. The majority are horizontal axis turbines comparable to submarine windmills, while others rotate around a vertical axis, have oscillating hydrofoils, or depend on the venturi principle. Several of these devices are already deployed at test facilities or demonstration projects around the world, including England, Italy, Norway and Canada (British Columbia). A number of companies would like to deploy and test their devices in the Bay of Fundy because of the harsh operating conditions. Most of the turbines operate most efficiently in currents above 1.5 m/second (3 knots). Lower velocities do not generate enough power to be economical, while much higher currents place increasing stress on the turbine blades. Water velocity near the surface in the Minas Channel can reach almost 5 m/second (9.5 knots), which is approaching the maximum operating specifications for the blades. In addition, high sediment loads, ice and other factors make the Bay an even more challenging environment for turbine technology. The thinking is that any devices designed to meet a hypothetical "Bay of Fundy Standard" should be able to operate anywhere. However, TiSEC technology is still at an early stage of development and still evolving. There has been little experience in operating them for any length of time or in evaluating their interactions with the environment. Furthermore, in Canada there are currently no policies, guidelines or regulations regarding the deployment and operation of such devices in the marine environment.

Forward with FORCE

In order to evaluate the performance and environmental effects of turbines being considered for commercial use in the Bay of Fundy, it was decided to establish a major test facility at a carefully chosen site in the upper reaches of the Bay. This would allow deployment and testing of a small number of promising TiSEC devices that might eventually be considered for large scale commercial use in the area. Minas Basin Pulp and Paper, one of the key proponents of tidal power development in the Maritimes, won the contract for building the test facility, subject to completion of a site specific environmental assessment. Once completed, the $12-14 million facility would be owned and operated by a not-for-profit corporation that would lease test berths to proponents approved by the province. The site eventually selected for the test facility is located offshore from Black Rock on the northern shore of the Minas Channel, about 10 Km west of Parrsboro. This town has a harbour, municipal infrastructure and power grid which should be useful in operating and maintaining the test facility. Three test berths in the channel, all within a kilometre of each other, have been leased for the three TiSEC devices selected for testing. The turbines will be brought to the area and deployed from a boat and barge. There is concern about the ability to position the devices successfully on the seafloor given that there will be only 20 minutes of slack water four times a day before the tidal currents rise substantially. From each turbine unit, electrical cables will converge at a common node, from which a single cable will come ashore at Rams Head. Once installed at the test site, the devices will be monitored for wear on the turbine mechanism, performance in generating electricity and effects on the environment. The Department of Fisheries and Oceans is now in the process of determining the scope and scale of the environmental monitoring program to be carried out at the site.

Originally called the Fundy Tidal Energy Centre, the proposed test facility has since been re-branded with a much more dynamic and pronounceable acronym – FORCE or “Fundy Ocean Resource Centre for Energy”. It was anticipated that the test facility would also include an onshore tidal energy centre of excellence, where advanced research could be carried out on various aspects of tidal energy and its commercial development. As of the summer of 2009, there is still uncertainty as to whether such a centre will become a reality, how it might be managed and operated, and where it might be located. The community would like to have it in Parrsboro, possibly associated with the Fundy Geological Museum, while the proponents prefer it closer to where the cable comes ashore. An interpretation centre to provide public education about tidal energy development is also being considered as part of the complex.

Tidal Trio on Trial

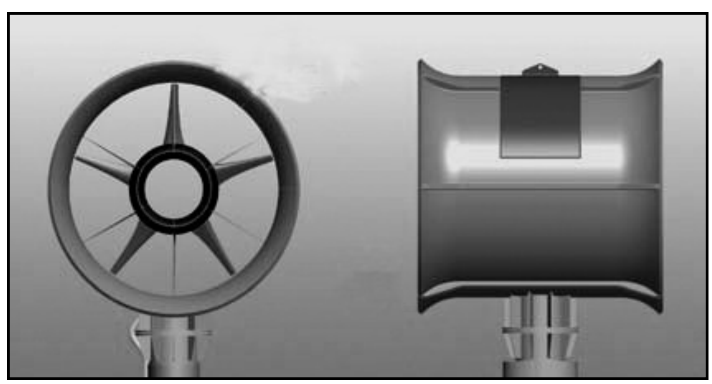
Seven proposals for testing different types of tidal energy devices were submitted to the Nova Scotia Public Tenders Office by the deadline in November, 2007. Following careful technical evaluation of each of the design proposals submitted, three TiSEC devices received approval for deployment at the Bay of Fundy test site:

OpenHydro - Nova Scotia Power (NSP) teamed up with an Irish Company, OpenHydro Tidal Technology, to test one of their turbine units. NSP’s parent company, Emera Inc., also acquired a 7% interest in OpenHydro and a seat on its Board of Directors. The OpenHydro turbine device will be placed directly on the seabed, invisible from the surface and deep enough to avoid any hazard to shipping. The device comprises an open-centre turbine design which has the blades of the rotor (the only moving part of the generator) attached within an outer circular housing forming a duct, leaving a large central opening through which marine organisms can pass. In addition, this design eliminates the need for pollution-causing lubricating fluids and has blades that rotate comparatively slowly, producing little mechanical noise. The prototype has been undergoing testing since 2006 at the European Marine Energy Centre in Stromness, Orkney Islands. The version initially tested was mounted between two vertical posts, which extended above the sea surface, allowing it to be raised and lowered for monitoring and servicing. However, the unit to be installed in the Bay of Fundy will be mounted on a tripod–shaped base weighing 200 tonnes placed directly on the seafloor. It is anticipated that the OpenHydro turbine, to be deployed at the test site in the autumn of 2009, will be the first units in the water, now that the environmental impact assessment has been deemed satisfactory.


From OpenHydro Tidal Technology

OpenHydro turbines on seafloor

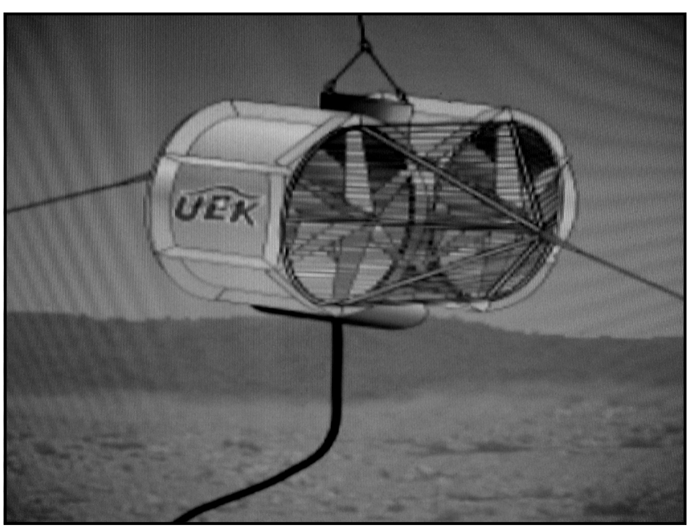
Clean Current – Clean Current Power Systems Inc., incorporated in 2001 in British Columbia, is deploying the only Canadian technology to be used in the initial round of testing. One of its 65 KW turbines that is 3.5 metres in diameter has been successfully operating since 2006 as a demonstration project at Race Rocks Ecological Reserve in Juan de Fuca Strait where it has experienced currents as strong as 7 knots. Similar to the OpenHydro design, the Clean Current rotor is situated within a cylindrical duct, but the four-bladed rotor assembly, the only moving part of the unit, turns upon a central axis so the central hole is much smaller. It too is designed to be installed on a heavy base directly on the seafloor, in deep


From Clean Current Power Systems Inc.

Clean Current Turbine

water and well away from navigation. The turbine is also bi-directional and operates when the tidal currents flow either way. The proponent claims that the unit will last for 25 to 30 years, although seals for the bearings will need to be replaced every five years and the generator will need to be overhauled every ten years. The demonstration unit to be deployed in Fundy, the Clean Current Mark III model, will have blades that are 17 metres (56 feet) in diameter and produce about 400 GW hours of electricity per year, or enough to supply about 400 average homes. This turbine is expected to be deployed at the test site sometime in 2010, pending the outcome of an environmental impact assessment.

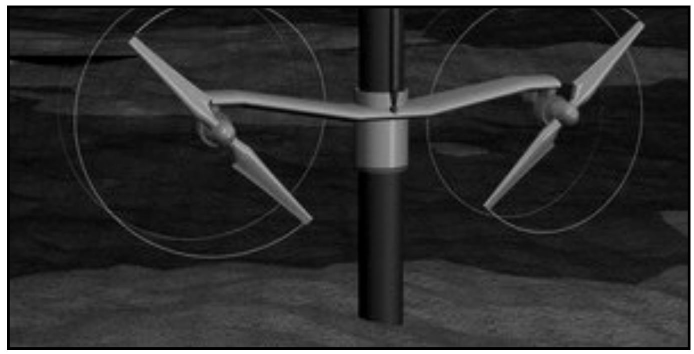
UEK/SeaGen Turbines - Minas Basin Pulp and Power initially planned to deploy an Underwater Electric Kite (UEK) turbine device designed by Canadian Phillippe Vauthier, whose company Underwater Electric Kite Systems is based in Annapolis, Maryland. The UEK was the only one of the accepted test turbines designed to fly in the water column rather than sit on the seafloor. The unit, which has two turbine generators mounted side by side, is positively buoyant and anchored to a single base on the seafloor by a long cable. A computer controls the depth at which the kite "flies", ensuring it is always maintained in a position to maximize power production. The design can reportedly operate in currents from 4 to 8 knots, with the size being tailored to specific site requirements. The dual turbine unit of the production model designed for 5 knot (2.5 m/sec) is about 3 metres high and 5.5 metres in width. The turbine intakes are equipped with screens and bubblers to keep out fish and other marine animals.



From Underwater Electric Kite Systems.

Underwater Electric Kite Turbine Array

However, in August 2008, Minas Basin Pulp and Power decided against using the UEK technology at its Fundy test berth and to use instead a SeaGen turbine unit manufactured by Marine Current Turbines (MCT) Ltd, a UK company based in Bristol. MCT had formerly partnered with a Halifax, NS based company, Maritime Tidal Energy (MTE), in an unsuccessful proposal to test its turbine technology in Fundy. The MCT technology is the most similar in general concept and appearance to standard wind turbine technology in that it has unducted propeller-like blades attached to a support column. It also uses a gear box to drive the generator. MCT deployed an early single propeller version of this technology called SeaFlow off the coast of Devon, England in 2003. This unit had an 11 metre rotor that produces 300 KW of electricity. The later SeaGen model, with two 16 metre rotors attached to wings extending horizontally from the 3 metre diameter tubular steel support column produces 1.2 MW of power in a 2.5m/sec (5 knot) current, enough to supply about 1000 homes. The wings and turbine units can be raised up the support column and out of the water to allow for maintenance. The pitch or angle on the rotor blades can be changed by 180 degrees, allowing them to operate on both ebb and flow tides. One of these units was deployed in 2008 for testing in Ireland's Strangford Lough. The turbine, to be deployed at the Fundy test site sometime in 2010 now that environmental approvals have been received, will be capable of generating 1.5 MW of electricity.



From Marine Current Turbines Ltd.

SeaGen Dual Turbine Array

Contemplating Consequences

Because TiSEC devices are relatively new, especially in terms of commercial scale uses, there are a lot of unanswered questions about their effects on the marine environment and on marine organisms such as fish, diving seabirds and whales. The testing of some of these devices at the FORCE facility will hopefully provide information to address some the questions raised by fishermen, environmental groups, scientists, engineers and the general public. Fishermen in the Minas Channel area probably have the most at stake, both in the short term because of the test facility, as well as in the long term if there is commercial deployment of TiSEC devices. Clearly, they will not be able to fish in a yet to be defined area around where the devices are deployed on the seafloor, for fear of damaging the turbines, their fishing gear, or both. Fisheries exclusion zones will have to be established and the more devices deployed, the greater the area that will be off limits to fishing. Careful selection of sites, in consultation with fishermen, to minimize conflicts and financial compensation to them for lost revenue are the approaches likely to be adopted. Lobster and flounder support lucrative fisheries in the Minas Channel area and fishermen are also worried about the effects that turbines operating on the seafloor might have on the poorly understood migrations of these and other species in the area. Many fishermen in the area supplement their income by trawling or handlining for pollock, haddock and dogfish as well as by drift-netting or gillnetting herring and shad. There are no aquaculture sites in the Minas Basin and Channel area that might be affected by tidal power development, but there could be conflicts if commercial scale turbine arrays are eventually deployed in channels flanking the mouth of the Bay of Fundy, near to where aquaculture sites are concentrated. As the SEA Background Report points out, the best way to avoid such conflicts is to develop *"a comprehensive policy of allocation of coastal resources"*.

"Whether the economic, engineering, political and environmental stars will eventually align favourably for the large-scale deployment of Tidal energy devices around the Fundy coast is still very much an open question."

Many other possible environmental and ecological effects have been suggested, but in most cases there is scant information on which to judge their significance. This is increasingly true as the development proceeds from small-scale pilot projects involving a few turbines to full-scale commercial deployments of dozens or hundreds of devices. As tidal currents pass by or through the turbines, the water will be slowed to varying degrees. In the vicinity of a large array of turbines this may alter the transport and deposition of sediments, which may in turn affect the food supply for benthic organisms or the rate at which their young stages are able to settle and grow. It is not known how fish, marine mammals and other sea life will respond to the noise and vibration produced by the turbines. Many species migrate or pass through the narrow channels that will be the preferred locations for installing commercial TiSEC arrays to maximize energy production. Would this disturbance deter them from moving through the area? Many marine species are able to detect and respond to electromagnetic fields. Sharks and sturgeon, both of which are present in the Minas Basin, use weak magnetic fields for navigation and prey detection in murky waters. How they will respond to the electromagnetic fields emanating from underwater turbines or submarine cables laid on the seafloor is not at all understood. This is a particular concern, given that large numbers of several species of sharks and other fish such as sturgeon migrate around the coastal waters of the Bay of Fundy each year. It is anticipated that some of these concerns might be addressed during turbine testing in the Minas Channel. However, it is likely that there will still be unanswered questions about the cumulative environmental impacts of commercial scale arrays at various sites around the Bay. Five mammal, eight bird, nine fish and one turtle (the leatherback) species in the Bay of Fundy have been designated under the Species at Risk Act and any threats to their wellbeing by tidal power development must be carefully assessed by law.

A number of questions also relate to the effects of the environment on the turbine structures themselves. How the units will stand up to being sandblasted by high velocity sediments is not known, although it is possible that the constant scouring will retard the growth of fouling organisms on turbine structures. However, recent monitoring in Minas Passage indicates that the turbidity is much lower than originally expected, so the turbine designers do not anticipate significant problems. Larger objects moving in the water column could pose more of a problem. Whales, waterlogged trees and large pans of submerged ice weighed down by embedded sediments could strike and damage turbines. Sediment laden ice, which forms abundantly in the winter on the extensive mudflats around Minas Basin, will need to be carefully monitored at the test site in the Minas Channel. The question of the stability of the seafloor in the test area has also arisen, particularly with regard to possible hazards from waves of mud, silt, sand cobbles or boulders resulting from the strong currents in the area.

The latest chapter in the ongoing saga of tidal energy development in the Bay of Fundy is still being written, reviewed and revised. Whether the economic, engineering, political and environmental stars will eventually align favourably for the large-scale deployment of tidal energy devices around the Fundy coast is still very much an open question. The results of the testing to be carried out at the new FORCE facility in the Minas Channel will clearly play a key role in determining if, how, where and when any new tidal technologies will be commercially deployed in the Bay of Fundy in the foreseeable future. In concluding, we can only echo the concerned ambivalence expressed by life-long Fundy watcher, naturalist and author Harry Thurston when he opined *"It's possible, perhaps, that there are technologies that wouldn't have a major impact from an economic and ecological point of view, but I think it's too early to say that".*

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