PUBLIC POLICY FORUM

OCTOBER 2023

Catching the Wind

How Atlantic Canada Can Become an Energy Superpower

BY PETER NICHOLSON

PPFORUM.CA

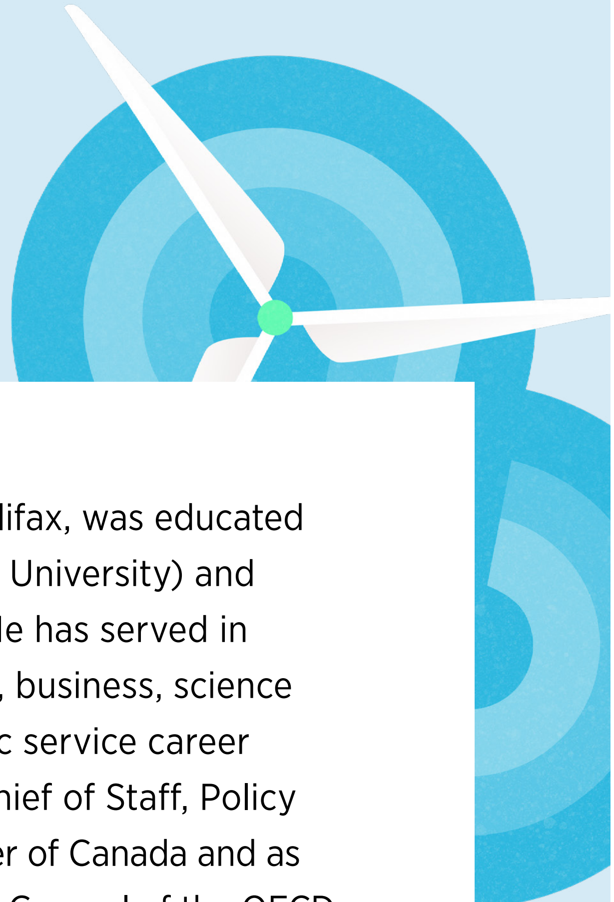
PUBLIC POLICY FORUM
FORUM DES POLITIQUES PUBLIQUES

The Public Policy Forum works with all levels of government and the public service, the private sector, labour, post-secondary institutions, NGOs and Indigenous groups to improve policy outcomes for Canadians. As a non-partisan, member-based organization, we work from "inclusion to conclusion" by convening discussions on fundamental policy issues and identifying new options and paths forward. For more than 30 years, PPF has broken down barriers among sectors, contributing to meaningful change that builds a better Canada.

1400 - 130 rue Albert
Ottawa, ON, Canada, K1P 5G4
Tel : 613.238.7858
www.ppforum.ca **@ppforumca**

ISBN: 978-1-77452-136-6

TABLE OF CONTENTS



Peter Nicholson, a native of Halifax, was educated in physics (BSc, MSc, Dalhousie University) and mathematics (PhD, Stanford). He has served in numerous posts in government, business, science and higher education. His public service career included positions as Deputy Chief of Staff, Policy in the Office of the Prime Minister of Canada and as Special Advisor to the Secretary-General of the OECD in Paris. Dr. Nicholson's business career has included senior executive positions with Scotiabank and BCE. He is the Chair of the Board of the Canadian Climate Institute, although this paper reflects his personal views and not necessarily those of the Institute. Dr. Nicholson is a Member of the Order of Canada and the Order of Nova Scotia.

INTRODUCTION

Less than 200 kilometres off the coast of Nova Scotia lies the fabled Sable Island, known to generations of seafarers as the Graveyard of the Atlantic, a testament to the countless ships that foundered on its shallow, sandy reefs. Famous for its unique herd of feral horses that have survived the island's harsh conditions for more than 250 years, this slender crescent of sand is the only promontory on Sable Island Bank, a vast undersea plateau. Here, the North Atlantic winds blow with a strength and consistency that could in future make these shallow waters famous for something else: renewable energy. Indeed, the Sable Island Bank is among the world's best locations for wind energy generation. It and several other similarly endowed areas off the coast of Atlantic Canada hold the potential to place the region among the leading global hubs of offshore wind-powered energy development.

The world's energy system — the motive power of human civilization — is in the early stages of transformation from a dependence on fossil fuels to forms of energy that do not emit climate-changing greenhouse gases. This revolution creates a once-in-a-lifetime opportunity for Atlantic Canada to recover an economic vitality comparable to the Age of Sail — fittingly built again on the power of wind at sea.

If Canada is to meet its goal to eliminate net greenhouse gas emissions by 2050, the Canada Energy Regulator estimates wind power will have to provide about 30 percent of total electricity supply, compared to less than six percent in 2021.[1] Given that the country's overall capacity needs to more than double, this entails a staggering 10-fold increase in wind generation in fewer than three decades. Much of that will come from onshore wind farms, but such facilities will inevitably come into conflict with other land uses. Enter offshore wind.

Offshore wind could be for Atlantic Canada what oil was to Texas or hydro power to Quebec. We are talking here not of something incremental, but monumental

Despite having among the world's longest and windiest coastlines, Canada does not yet have a single turbine either operating or under construction in its offshore waters. Nearly 30 countries are ahead of us. The North Sea alone, bordered by seven European countries, is home to thousands of turbines with a combined capacity of 30 gigawatts (GW) of offshore wind power, with almost five times that capacity targeted by 2030[2] [see Box 1 for terminology]. The rapid expansion of offshore wind energy in places such as the U.K., Europe and China illustrates the historic opportunity available to Atlantic Canada.

How big might this be? Consider that the Sable Island Bank alone could accommodate at least 1,000 offshore turbines, each with 15-megawatt (MW) capacity. That adds up to approximately 70,000 gigawatt hours (GWh) of clean, renewable electricity every year. It is enough to supply 6.5 million average Canadian homes or almost twice the total electricity currently consumed in Atlantic Canada annually. And Sable Island Bank is only one of several potential sites in the region. Offshore wind could be for Atlantic Canada what oil was to Texas or hydro power to Quebec. We are talking here not of something incremental, but monumental.

The federal-provincial Clean Power Roadmap for Atlantic Canada has already recognized the opportunities for both onshore and offshore wind power.[3] Nova Scotia's provincial government, for example, has set a target to license five GW of offshore generation capacity by 2030 and at least one developer has already come forward with an offshore proposal.[4,5] Others have proposed several onshore wind projects that would produce "green" hydrogen via electrolysis of water, primarily for export to Europe.[6] But while such projects will help create a wind energy ecosystem of infrastructure, skills and other capabilities, green hydrogen is just one piece on a chessboard of clean energy possibilities.

While Atlantic wind may be available in abundance, its development and integration into the North American grid will require vast amounts of capital from sources that have many urgent and competing opportunities worldwide

A much bolder vision is there for the taking. The massive development of wind energy off Atlantic Canada's coast can play a major role in fulfilling the national decarbonization objective while laying the foundation for durable economic development that the region has been seeking for generations. Beyond securing clean electricity supplies for Atlantic Canadians, the benefits to the region would come in three ways:

- **the supply chain activities created to put in place and maintain a multi-billion-dollar, decades-long investment program in offshore wind generation, which will create business opportunities and jobs throughout the region and beyond;**
- **a new stream of earnings from the sale of electricity to other parts of Canada and potentially to the United States; and**
- **investments from a variety of industries looking for stable jurisdictions with world-class sources of clean, renewable energy.**

An historic turning point like this does not come without challenges. While Atlantic wind may be available in abundance, its development and integration into the North American grid will require vast amounts of capital from sources that have many urgent and competing opportunities worldwide. And although a vast ocean area is potentially available for siting wind facilities, there are environmental considerations and existing uses such as fisheries and shipping that will need to be safeguarded. Experience elsewhere suggests they can be.

Canada is starting from behind. Until recently, our rich endowment of fossil fuels and hydro power reduced the incentive to seek alternatives. Now, with few sites for major new hydro generation and a commitment to decarbonize, Canada's energy development priorities have changed dramatically. Fortunately, the global race to develop offshore wind energy has only just begun, and there are benefits in being an early follower — lessons learned, innovations to adopt, economies of scale to capture and negative impacts to avoid. But a greater sense of urgency is needed. The global climate clock is ticking. The energy transformation is gaining momentum and long-term contracts for essential inputs are getting signed. A year's delay today can translate to many years delay for project delivery. Canada's sclerotic regulatory and permitting processes are not compatible with the urgency of both the challenge and the opportunity. As the fight to halt climate change becomes more pressing, Canada needs to turn its inexhaustible wind resource into infinitely renewable electricity. That will require a new level of ambition, even audacity.

Canada needs to turn its inexhaustible wind resource into infinitely renewable electricity. That will require a new level of ambition, even audacity

This paper builds on extensive work already underway and outlines a vision for offshore wind energy as a genuinely transformative undertaking — a true game changer — in enabling a prosperous future for Atlantic Canadians. While it is beyond the scope of a single paper to assess and recommend detailed policy requirements, it does provide an overview of wind power's prominent role in the global energy transformation and lays out the special opportunity for Atlantic Canada.

The final section addresses the potential market for Atlantic Canada's offshore wind energy, its cost competitiveness, what's required to develop a regional supply chain to support offshore wind at large scale, and the need for a supportive policy and regulatory environment.

This is our contribution to the much bolder clean energy vision that beckons.

BOX 1

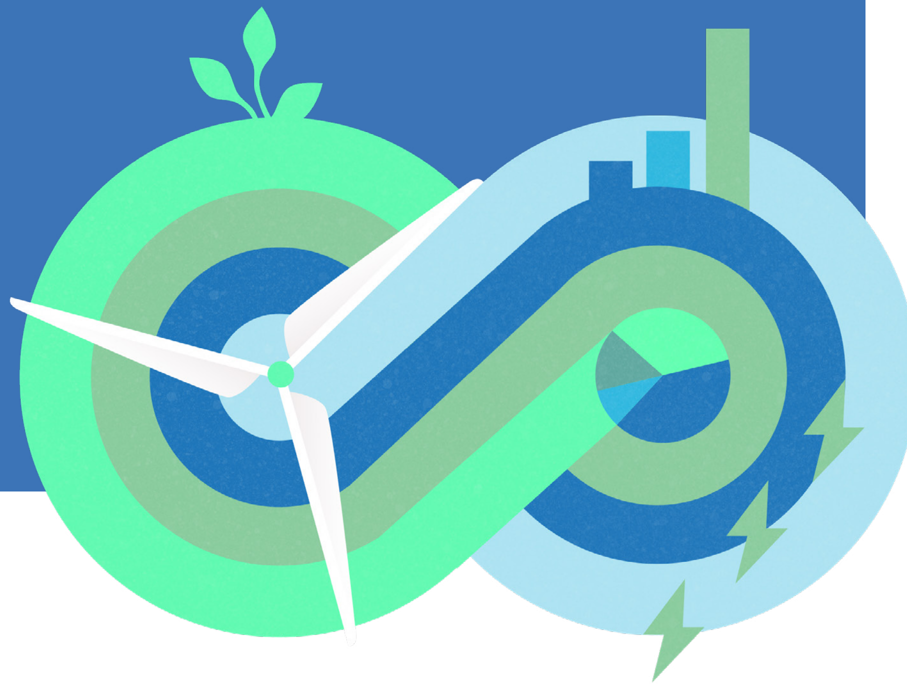
ELECTRICAL ENERGY BY THE NUMBERS

Energy facts and figures can be confusing, in part because they're expressed in a variety of measurement units — megawatts, gigawatt hours, petajoules, Btus (British thermal units), barrels of oil equivalent, etc. When the topic is electricity, power (i.e., energy generated per unit of time) is expressed in various multiples of a watt — kilowatt (kW), megawatt (MW), gigawatt (GW) and terawatt (TW) — signifying successive multiples of 1,000. Energy is expressed in units of power multiplied by a unit of time — e.g., kilowatt hour (kWh), which is the amount of electrical energy produced by a one-kilowatt source operating for one hour.

At the level of national electrical systems, power is usually expressed in gigawatts (GW) or terawatts (TW), and total energy generated, or consumed, in gigawatt hours (GWh) or terawatt hours (TWh) per year. For example, global electrical energy generation in 2020 was 26,780

TWh, whereas Canada generated about 630 TWh — only 2.4 percent of the global total. But Canadians are big electricity users, consuming almost five times the world average per capita. The average Canadian household uses about 11 megawatt hours (MWh) of electricity annually, varying widely from 17.7 in Quebec to 6.8 in Alberta.[7]

The various sources of electricity generation — hydro, nuclear, natural gas, coal, wind, solar, geothermal, etc. — do not operate at their full power capacity for every one of the 8,760 hours in a year; all are intermittent to varying degrees. **An important characteristic is therefore the "capacity factor," which is the ratio of the actual amount of energy generated in a typical year to the amount that would have been generated if the source operated at its full rated power capacity for the entire year.** For example, offshore wind turbines typically have annual capacity factors ranging from 0.45 to 0.55 and even higher in winter. A 15 MW turbine with a capacity factor of, say, 0.52 would be expected to generate about 68,330 MWh of energy in a year (15 x 0.52 x 8,760). Nuclear plants have capacity factors of about 0.9; solar panels typically in the range of 0.15 to 0.2 (in Canada); large hydro generation about 0.7; onshore wind turbines about 0.3 to 0.4. The average capacity factor of Canada's entire electrical system of 150 GW is approximately 0.48. So, in addition to knowing the rated power capacity of a given generating facility (typically in MW or GW), one also needs to know its capacity factor to estimate the actual energy that can be generated in a year.



THE ROLE OF WIND IN THE GLOBAL ENERGY TRANSFORMATION

The global clean energy transformation now underway will be the greatest undertaking in human history. It is critical to preserving a livable climate and clean air to breathe. It's also being driven by technological developments that, in many places, have already made clean renewable energy more cost efficient than fossil fuels.[8] The combination of environmental and economic imperatives makes the transformation unstoppable. Only the precise timeframe is still in question.

Electricity will dominate the new energy system, eventually replacing fossil fuels in transportation, industrial processes and the heating and cooling of buildings. Electricity has unparalleled advantages in terms of versatile and efficient use, instantaneous transmission and an ability to be generated cleanly and renewably. The world will therefore be producing vastly more electricity as fossil fuels are replaced and as economies worldwide continue to grow.

The International Energy Agency (IEA), regarded as the preeminent authority on global energy developments, has projected a pathway by which the world energy system would emit no net greenhouse gases by 2050.[9] The

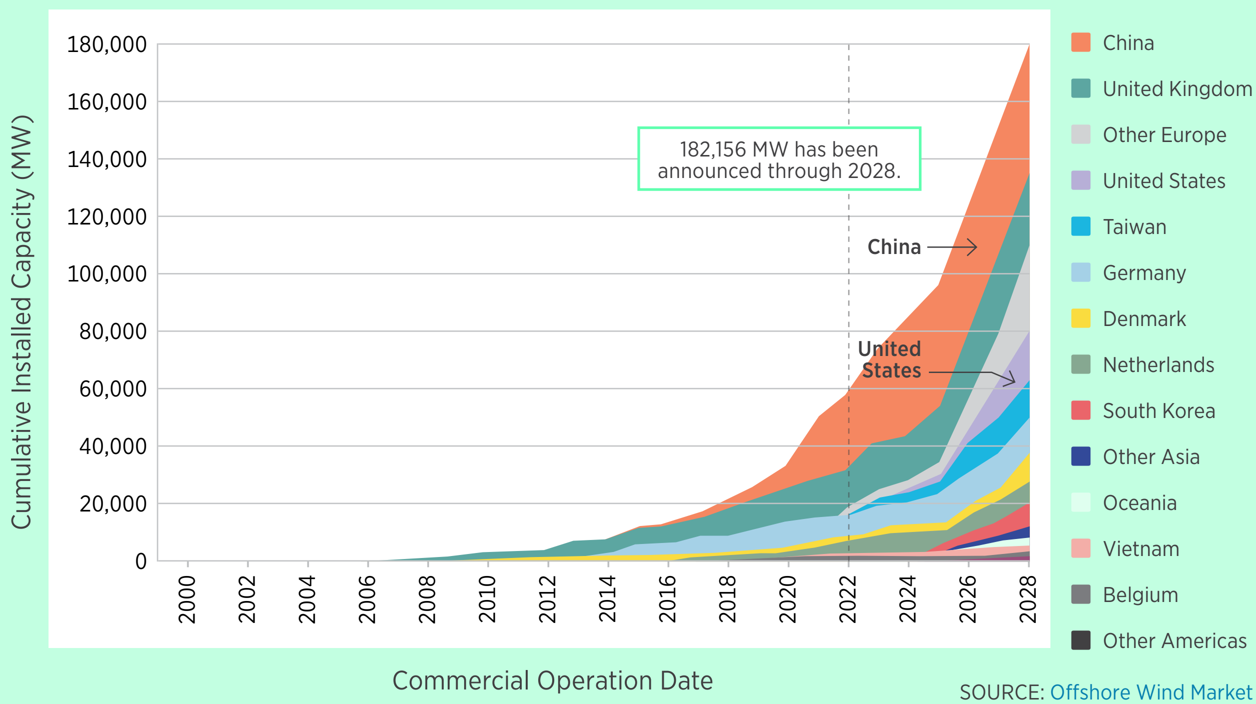
Net Zero scenario projects that global electricity generation in 2050 will be about 2.6 times the 29,000 TWh the world generated in 2022. Wind generation (onshore and offshore combined) in this scenario would grow 11 times from seven percent of world electricity generation in 2022 to 31 percent by 2050 (from six percent in 2020). Whether or not this latest IEA projection is precisely borne out, it's the best available picture of where the world is headed and provides a credible basis for long-term strategic planning.

Denmark pioneered offshore wind energy in the 1990s, beginning with very small projects. For countries bordering the North Sea, the impetus to decarbonize energy production — in the face of limited available land area for solar and wind facilities — led to very rapid expansion offshore after 2010. The shallow waters and windy conditions of the North Sea proved ideal.

As of 2022, global offshore wind generation capacity totaled just under 60 GW, or about seven percent of total

The Global Offshore Wind Development Pipeline

Based on Developer-Announced CODs Through 2028



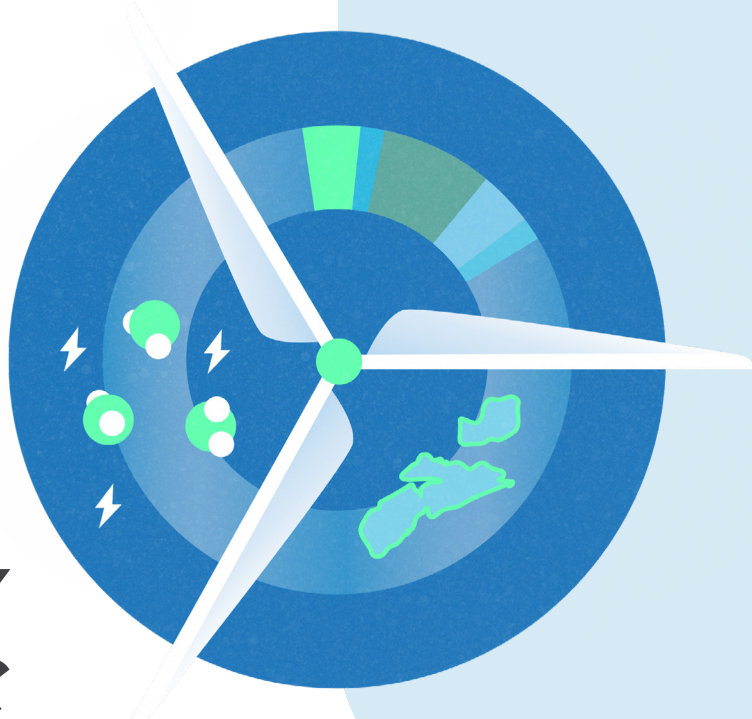
SOURCE: Offshore Wind Market Report: 2023 Edition (page 76) wind power capacity.[10] China, despite its massive greenhouse gas emissions, is by far the world leader, having installed 45 percent of global offshore capacity. The U.K. is next at 23 percent. Based on projected delivery dates, offshore capacity is slated to triple to 182 GW by 2028, with more than twice this amount in the development pipeline. This is a strong indicator of solid momentum, despite recent cost inflation that has led developers to pull back from some projects.[11] Globally, offshore wind construction is projected to climb to about 45 GW *annually* by 2030.[12] The U.S., for example, has an ambitious plan to develop 30 GW of offshore wind power between now and 2030, much of it in the Gulf of Maine and off the coast from Massachusetts to New Jersey — although the recent cost uncertainty means the 2030 target is likely to slip.[13]

The U.S. target pales in comparison with Western Europe's ambition, laid out in the 2023 Ostend Declaration and signed by nine countries bordering on and adjacent to the North Sea.[14] In part it states:

"We will jointly develop The North Seas as a Green Power Plant of Europe, an offshore renewable energy system connecting our countries with a particular focus on joint hybrid/multi-purpose and cross-border offshore projects and hubs, offshore wind and renewable hydrogen at massive scale ... We encourage all relevant institutions to address all bottlenecks and barriers arising from permitting procedures, in order to speed up the green transition ... We aim to more than double our 2030-capacity of offshore wind to at least 300 GW by 2050."

The scale of international development demonstrates that offshore wind technology is reliable and commercially viable. In fact, wind accounted for 27 percent of the U.K.'s electricity usage in 2022, split about evenly between onshore and offshore, though offshore is growing much faster. International experience also suggests the impact of offshore wind development on the environment and on potentially competing marine activities such as fishing and shipping can be managed acceptably. Indeed, offshore wind is arguably the least disruptive way to power the energy transformation. As international installation expands, the combination of scale economies, operating experience, ramped-up supply chains and continued technological improvement will push costs down and investor confidence up. Atlantic Canada can ride this global wave.

THE OFFSHORE WIND OPPORTUNITY FOR ATLANTIC CANADA

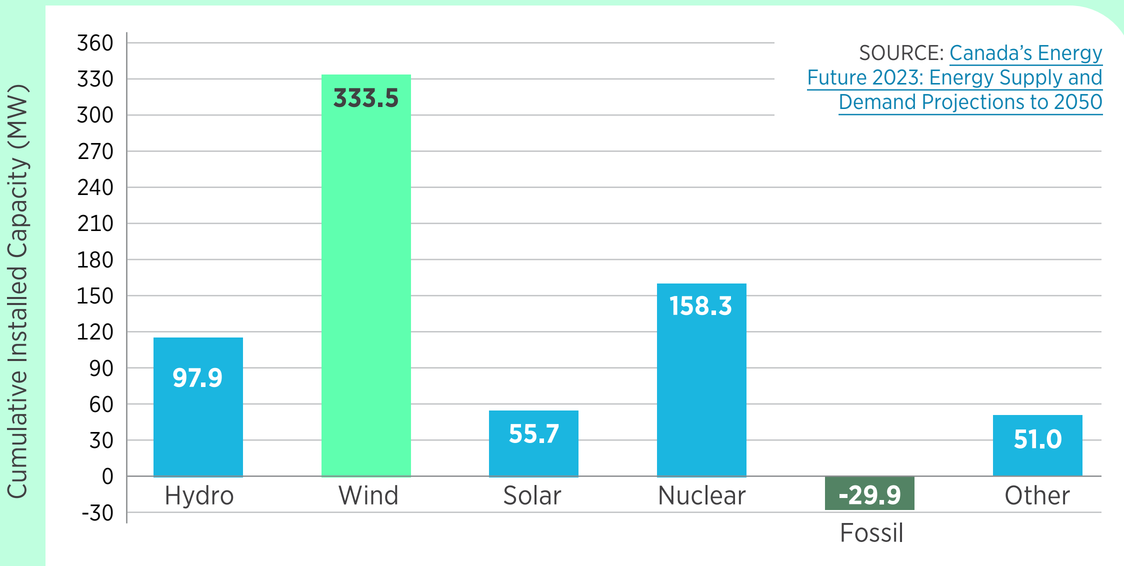


Earlier this year, the Canada Energy Regulator (CER) published two scenarios setting out paths consistent with Net Zero greenhouse gas emissions by 2050.[15] These draw on the IEA's Net Zero scenario for global context but include much greater detail for Canada, including at the provincial level. The CER projects that electricity generation will more than double between 2021 and 2050. Delivering this projection will be, in the words of the Public Policy Forum, the "Project of the Century" for Canada.[16]

In the CER Net Zero scenarios, at least half of the net increase in annual electricity generation between 2021 and 2050 will be supplied by wind [see chart below]. Total Canadian electricity generation is projected to be 667 TWh greater in 2050 than in 2021, while wind-generated energy will be 334 TWh greater — an increase to 370 TWh from 36 TWh in less than 30 years. The sheer scale of wind energy that Canada will require raises the question as to its sources. There is good potential for onshore development in many parts of the country, including Atlantic Canada, but there is often local resistance to large wind farm siting related to land use conflict and to esthetic, environmental and even health concerns.[17] Such opposition will almost certainly increase as the scale of implementation accelerates.

At the very least, NIMBYism that even extends to the reluctance of some

Increase in Electricity Generation: 2021-50 Canada Total (TWh)



provincial governments will delay build-out and discourage investment.[18] While unfortunate for Canada's emissions objectives, this creates a major opportunity to develop offshore wind in Atlantic Canada in an amount far beyond the anticipated power generation needs of the region, which the CER projects will increase by 60 percent to 100 TWh by 2050 (from 62 TWh in 2021).[19]

The transformative opportunity is to supply offshore wind power to North American grids, and not only for green hydrogen production, which to date has been promoted as the primary use in Atlantic Canada.[20,21] The specific factors that justify this kind of game-changing vision are as follows:

THE RESOURCE POTENTIAL

Estimates of the technical potential for offshore wind development in Canada suggest a virtually unlimited amount when all coasts and the Great Lakes are included — for example, one recent study estimated 20,000 TWh per year could be theoretically possible, about 30 times Canada's current generation of electricity.[22] The commercial potential would be far less than theoretical estimates, but there are nevertheless several areas off the Atlantic coast, including the Gulf of St. Lawrence, that provide some of the world's best wind conditions and could support very large energy generation facilities.

Initially, the most promising areas — taking into account speed and consistency of wind, water depth, marine environmental conditions and potential impact on other uses and ecosystems — appear to be on the Scotian Shelf and specifically the Sable Island Bank and Middle Bank [see Box 2].[23] These are two large, ice-free areas with water depths of less than 60 metres that would allow turbines to be fixed on the seabed. They are significantly further from shore than most current installations, which are typically 10 to 50 km out. But while distance increases cost, the far offshore location has the important benefits of providing higher and more consistent wind speeds and less likelihood of interfering with other marine activity or facing NIMBY resistance.[24]

These two areas, among others, were identified in a recent study for Net-Zero Atlantic by the Danish consulting

BOX 2

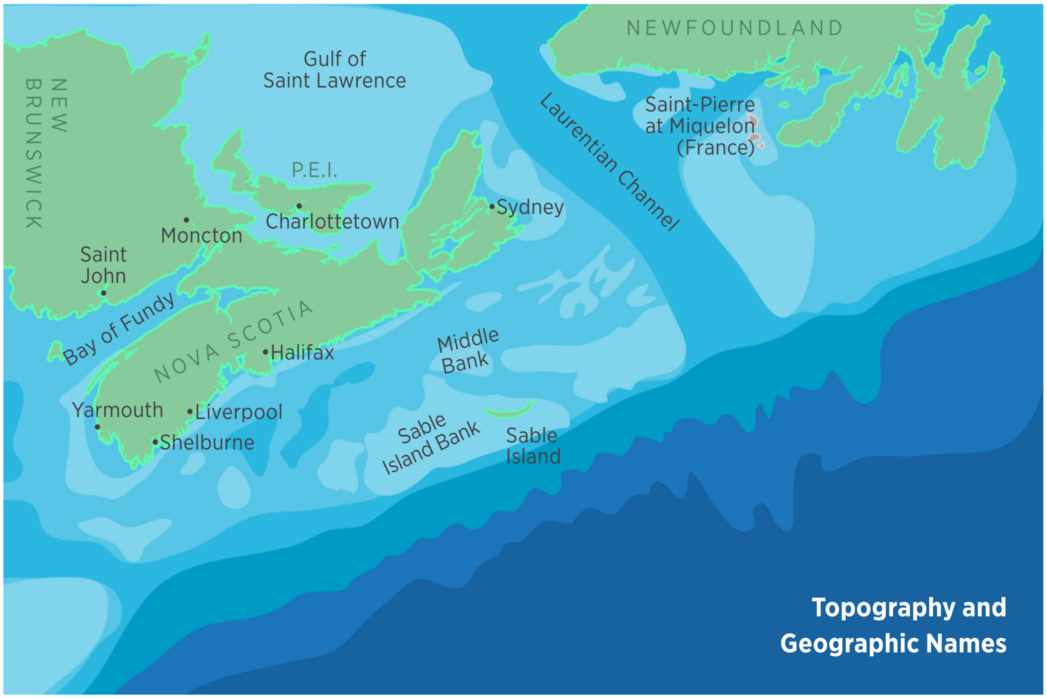
OFFSHORE WIND ENERGY POTENTIAL

A Hypothetical Example

The following example provides a sense of what might be possible with a major development of offshore wind on Canada's east coast.

For purposes of illustration, assume several offshore installations with total "nameplate capacity" of 15,000 MW (15 GW). (It is estimated, for example, that **the Sable Island Bank could support wind installations totalling at least 15 GW in an area of more than 8,000 km^2** where water depth of less than 60 metres would permit installation of turbines anchored on the ocean floor.) The ultimate potential of Atlantic Canada's coast would be much greater than 15 GW, but the extent of eventual development would depend on economic and regulatory factors. Full development would take place over several decades.

Averaged over a year, an offshore wind farm would have a capacity factor



ranging from 0.50 to more than 0.55, so the total energy generated would likely be greater than half the maximum rated capacity. Assuming use of individual turbines with nameplate capacity of 15 MW (the scale now being promised by manufacturers in Europe and China), the installations would contain 1,000 turbines and would cover a total surface area of 3,500-4,000 km^2. Currently, the world's largest offshore wind farm (Hollandse Kust Zuid) has a capacity of 1.5 GW generated by 139 turbines, each with a capacity of just under 11 MW.[25]

The total *annual* electrical energy generated by 15 GW of installed capacity would be approximately 70,000 GWh — almost double the total currently consumed in the Atlantic provinces, and more than 10 percent of all the electricity currently generated in Canada. An installation of this magnitude would thus depend on an export market for the power that was surplus to regional needs.

firm AEGIR.[26, 27] That investigation was limited to areas adjacent to Nova Scotia; other similar studies should be undertaken to identify potential sites throughout the Atlantic coast and in the Gulf of St. Lawrence. Although the gulf and more northerly areas are subject to sea ice and the icing of turbine blades, experience in Finland suggests these challenges can be overcome at a cost that, depending on other factors, can still be commercially viable.[28]

As floating turbine platforms, which are anchored to the seabed by cables, are further developed and their projected cost comes down, shallow water for planting turbines would no longer be a requirement.[29, 30] A vastly larger coastal area would thus open for potential development, limited only by market demand and cost competitiveness.

THE BENEFITS OF OFFSHORE WIND AS AN ENERGY SOURCE

Among the reasons why offshore wind is such an attractive energy source is that it's extremely clean, with a typical life-cycle greenhouse gas footprint of about 10 grams of CO_2 per kWh of electricity generated.[31] That means a one-GW facility — which is sufficient to supply power to almost one-third of the households in Atlantic Canada — would generate, on full life-cycle accounting, approximately 45 tonnes of CO_2 annually or about the same as 10 gasoline-powered cars.[32] No significant energy source is more climate friendly.

A further key benefit of offshore wind is that it is stronger and more reliable than typical terrestrial sources and far less intermittent than solar. And it's strongest in the colder months, when demand in Canada is greatest, and is thus complementary to solar generation. The effect of variable wind speed on electricity production can be offset with battery storage, and curtailment losses could be minimized by enabling an offshore wind farm to use power, when surplus, to produce hydrogen.[33,34] Among intermittent sources of electricity, offshore wind is among the most economically accommodated by the grid. Indeed offshore wind from Atlantic Canada could help balance out variation in the output of intermittent energy sources in Canada by averaging electricity supply over a much broader geographic area than the region alone.

No energy source is entirely free of impact on its surrounding environment, and that's true of offshore wind, too. Marine mammals, fish, birds and underwater flora can be affected. These impacts have been extensively studied in the context of existing and planned installations, particularly in the U.K., Western Europe and the U.S.[35] Although many uncertainties remain, experience in Denmark, which has the world's longest track record for offshore wind energy, suggests the environmental impact is both moderate and manageable.[36]

It's important to recognize that impact cannot be considered in a vacuum. Risks need to be weighed in the context of benefits, and particularly the benefit of offshore wind energy in mitigating climate change, the biggest environmental threat of them all.

THE ECONOMIC BENEFIT

The installation and maintenance of massive offshore wind generation will create jobs and income at a high level of intensity for several decades during buildout and continuing indefinitely with ongoing maintenance and replacement activity. For example, the installation of 15 GW of offshore wind generation would create an average of approximately 30,000 direct jobs annually

The installation of 15 GW of offshore wind generation would create an average of approximately 30,000 direct jobs annually

during several years of construction and installation, and about 1,200 permanent jobs for ongoing operation and maintenance.[37,38] The number of jobs filled by Atlantic Canadians would of course depend on local investment in the supply chain and on availability of skills, which could be further developed through focused training programs to counter the risk that shortages could seriously disrupt the pace of development.

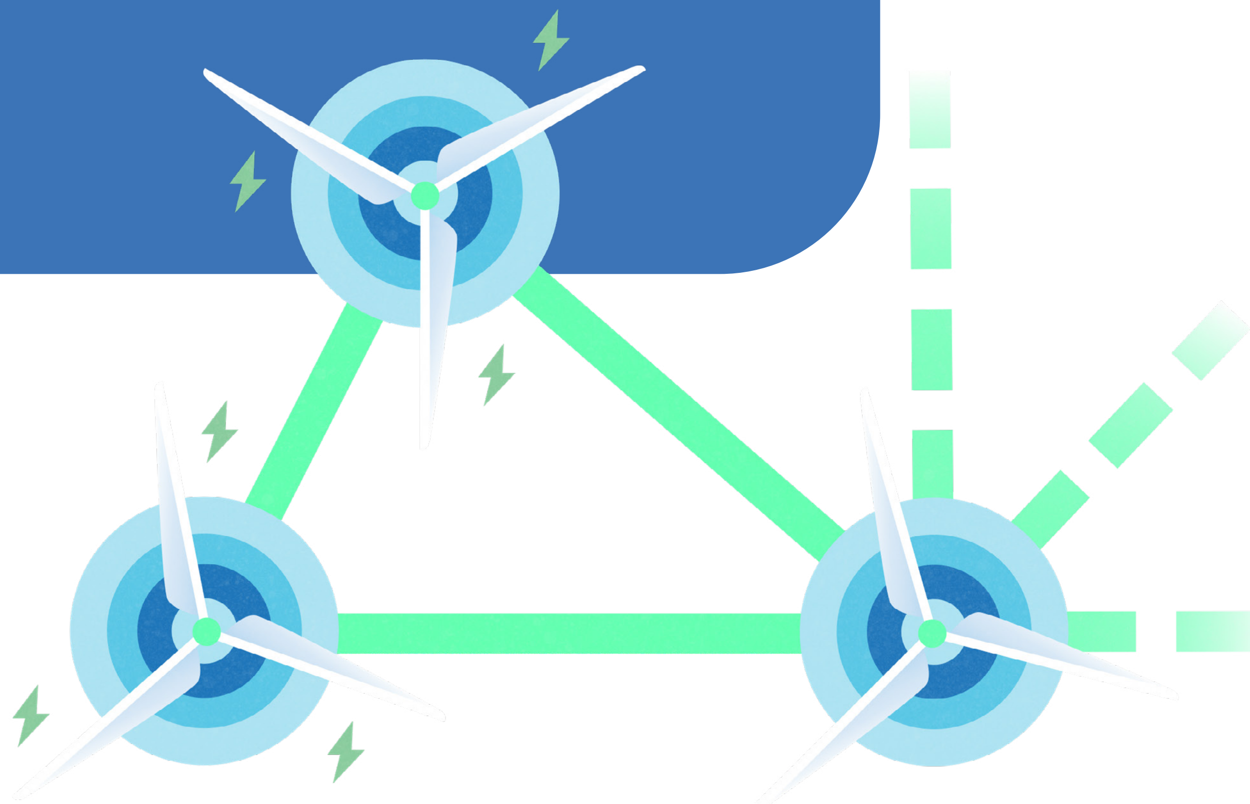
Were Atlantic Canada to become a major centre for offshore wind development, a supporting supply chain ecosystem would naturally develop, including component manufacturing, logistics, offshore servicing and monitoring systems.[39] These activities would be complemented by project planning and management, various consulting engineering disciplines, dedicated human resources development and training, specialized financial services, and research and development. Many of the skills would support a new Atlantic Canadian export industry to serve the global expansion of offshore wind installation.

Like the tide that lifts all ships, the prosperity generated by large-scale offshore wind energy would spread throughout the four Atlantic provinces

As the world shifts to carbon-free energy, those areas that have large and reliable supplies of clean electricity will become progressively more attractive locations for energy-intensive activity of all kinds, much as abundant hydro power made Quebec a global centre for the aluminum industry and its spinoffs.[40] Surplus offshore wind energy can combine with other regional advantages like access to deep-water ports to greatly improve the investment attractiveness and export vitality of Atlantic Canada.

Offshore wind farms will be installed in those specific areas where conditions combine to optimize commercial criteria and regulatory approval. But, like the tide that lifts all ships, the prosperity generated by large-scale offshore wind energy would spread throughout the four Atlantic provinces, and indeed beyond the borders of the region. Furthermore, the compact geography of Atlantic Canada facilitates the spread of benefits. The communications and transportation infrastructure, including regional air service, would thicken to form a dense web of interconnection, further intensifying the region's economic capability.

The development of offshore wind at very large scale could do for Atlantic Canada what the oil and gas supply sector has done for Western Canada, creating an economic game changer for the region and making it, to echo the words of the Ostend Declaration, Canada's own green power plant. It would be unfortunate if short-sighted parochialism — always a risk — were to stand in the way of the interprovincial collaboration needed to fully realize the transformative opportunity created by offshore wind energy developed at world-class scale.



HOW TO MAKE IT HAPPEN

Europe, Asia and the United States are already committed to significant offshore wind development. Commercial contracts in various markets and ambitious plans for major development demonstrate that offshore wind can be cost competitive. The technology is thoroughly proven, and still improving. The impacts on the environment and marine activities appear to be manageable.

The challenge for Atlantic Canada is to transform opportunity into reality. That will depend on attracting very large amounts of investment under conditions of intense competition for capital to fund the global energy transformation. And that depends in turn on several factors:

- **market scale and access;**
- **cost competitiveness;**
- **presence of complementary assets; and**
- **a fully supportive policy and regulatory environment.**

Each is necessary and none by itself is sufficient.

MARKET SCALE AND ACCESS

As noted earlier, projections by both the International Energy Agency and the Canada Energy Regulator leave no doubt that there will be a very large demand for wind energy if we are to achieve Net Zero greenhouse gas emissions by 2050.

There is also a potentially large market for green hydrogen, both for domestic use and (in the form of "green" ammonia) for export overseas. Several onshore wind projects are already proposed to feed this demand, but when a hydrogen economy materializes there would be a large market as well for offshore wind to produce it [see Box 3].[41]

By far the largest potential market for Atlantic offshore wind energy is to feed:

1. **growing regional demand as the economy expands and fossil fuels are eventually eliminated;**
2. **the enormous future wind energy requirements of the rest of Canada and particularly Ontario;[42]**
3. **potentially the huge increased demand for electricity in the northeastern U.S.**

Both (2) and (3) require major transmission capacity connecting Atlantic Canada with Quebec and the northeastern U.S., the latter either directly or via Quebec. The possibility of high-capacity undersea transmission directly linking wind energy from the Scotian Shelf with New England has been analyzed in a recent white paper on behalf of the New England-Maritimes Offshore Energy Corridor (NEMOEC) Coalition.[43]

Although the U.S. has its own ambitious plans for offshore wind development, the northeast coast projects proposed so far have met with considerable local opposition, much of it ill-informed but nevertheless politically salient.[44] If such opposition results in significant delay or project cancellation, there would be an opportunity for substantial electricity export from Atlantic Canada. The legal and policy considerations that surround potential green energy export to the northeastern states are complex. At the U.S. federal level, there don't appear to be any significant roadblocks. But most state governments have adopted strategies to promote green energy, including offshore wind, and have put restrictions in place that could make it difficult or impossible to import green energy from Canada.[45] At present, the most accessible markets in the northeast appear to be Massachusetts and Connecticut.

In any event, Atlantic Canada's ability to supply large amounts of offshore wind-generated electricity to the rest of Canada will require, as an essential first step, completion of the Atlantic Loop [described in Box 5]. That critically important project needs to be seen as providing complementary two-way transmission — hydro power into the region and wind power out to Quebec and beyond. Since Quebec has limited options to develop large new hydro power but is facing a rapidly growing need for clean electricity, there appears to be strategic complementarity between Quebec's future demand and Atlantic Canada's potential offshore energy supply.[46] Depending on the scale of offshore wind development, the Atlantic Loop as presently contemplated would need to be augmented eventually with much larger outbound transmission capacity.

Atlantic Canada's ability to supply large amounts of offshore wind-generated electricity to the rest of Canada will require, as an essential first step, completion of the Atlantic Loop

COST COMPETITIVENESS

Building offshore wind facilities is capital-intensive and premised on an operating turbine life of 20-30 years.[47] Investments of this kind usually require negotiated long-term contracts with reliable customers — typically electric utilities though, as more of the economy is electrified, large users such as infotech giants may contract directly with wind facilities. In any event, customers will almost always have alternative sources of electrical generation. So, competitive terms, usually set by auction, must be offered by the offshore wind energy provider.

BOX 3

TURNING WIND INTO GREEN HYDROGEN

In the wake of an August 2022 co-operation agreement between Canada and Germany, several proposals have ramped up to use wind energy in Atlantic Canada to produce green hydrogen, primarily for export to Europe.[48] Initially, the projects would develop onshore wind farms to provide power to generate hydrogen via electrolysis of water, thus avoiding the CO_2 emissions generated in the conventional production of "grey" hydrogen from natural gas. In September 2022, the Nova Scotia government announced a target to license five GW of offshore wind energy by 2030 stating that: "The most promising use for offshore wind energy is generating renewable electricity to produce green hydrogen for use in the province and for export."[49] The Canada Energy Regulator has projected that **Canadian production of hydrogen will grow from three megatons (Mt) currently to about 14 Mt by 2050** (all low- or zero-emitting), of which about five Mt would be for export.

The issue is cost. Green hydrogen currently costs about US$5 per kilogram, almost five times the cost of hydrogen produced from natural gas.[50] This reflects the prevailing cost of electrolysis equipment (which is expected to decline significantly) and the fact that about 50 kWh of electricity is consumed to produce one kg of green hydrogen. The energy needed to produce green hydrogen at scale is staggering — for example, to produce five Mt of electrolytic hydrogen per year would require approximately 60 GW of offshore wind capacity, or about 40 percent of Canada's current *total* electrical generation capacity. **Economic viability of green hydrogen therefore depends critically on abundant, clean, cheap electricity.** Governments worldwide are providing very large financial incentives to kickstart green hydrogen production in the expectation that costs will fall rapidly with economies of scale and technological innovation. The Canadian government, for example, has earmarked more than $17 billion of support through 2035.

Because hydrogen is difficult to transport over very long distances, the export-oriented projects in Atlantic Canada will convert green hydrogen into denser ammonia (NH_3) prior to overseas shipping. But about half of the energy input is lost in converting electricity into ammonia, and if ammonia were converted back into hydrogen at the destination, only about one-quarter of the original electrical energy would be retained.[51] That's why the importer will usually use the "green" ammonia directly — for example, in fertilizer production.[52] Although very wasteful in energy terms, green hydrogen may still be profitable if the customer is willing to pay enough for the environmental benefit, or if the input electricity is cheap and plentiful enough, or if government subsidies are big enough. Based on the number of projects underway globally, price and subsidy competition will be fierce.[53] Consequently, there is skepticism in some quarters that producing green hydrogen for export would be the first best use of Atlantic Canada's offshore wind energy resource.[54]

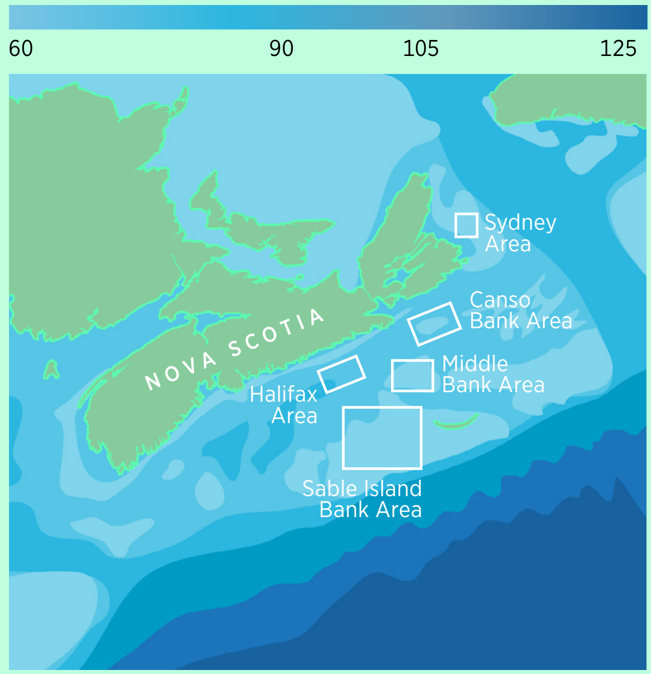
After years of steady reduction,[55] the cost of implementing offshore wind has recently increased sharply due primarily to inflation in the cost of materials (especially steel), competition for scarce inputs and higher interest rates. This has caused the developers of some pending projects in the U.S. to request renegotiated contracts at higher prices per kWh.[56] On the other hand, cost pressures are already moderating, while also leading to innovative technical solutions and development of new supplies of materials and skills.[57]

The direct cost of delivering offshore wind energy depends on the costs of:

- **turbines, substations and transmission lines to shore;**
- **initial installation;**
- **annual maintenance/operations;**
- **eventual decommissioning; and**
- **financing, including return on investment.**

Areas on Scotian Shelf with High Potential for Wind Energy

LCOE – OFFSHORE WIND (CAD/MWh)



Areas that combine relatively low levels of constraints with relatively attractive project economics

SOURCE: AEGIR Value Mapping Nova Scotia's Offshore Wind Resources (Page 24)

The cost of generation, typically averaged over a year and expressed as cents per kWh (or $/MWh), is called the levelized cost of electricity (LCOE), a parameter that can be used to compare the economics of different generation technologies. The LCOE depends on a great many local factors, including government subsidies of various kinds, so there is wide variation in the LCOE for each generating technology.

In a 2023 report, the consulting firm Lazard, a leading authority on energy cost analysis, cited LCOE ranging from seven to 14 cents US per kWh for offshore wind generation; 2.4 to 7.5 cents for onshore wind; and 4.6 to 10.2 cents for solar (with storage).[58] Clearly, offshore wind generation is substantially more costly than onshore today. But the cost will decrease as economies of scale and "learning by doing" efficiencies develop, and as cost-reducing innovations, including much larger turbines, are implemented. The latest analysis of cost trends by the U.S. National Renewable Energy Laboratory (NREL) projects a decrease in LCOE for offshore wind of more than 25 percent (relative to 2021) by 2030, and almost 45 percent by 2050.[59]

Although the LCOE of offshore wind will usually be greater than for onshore facilities, the relative consistency of offshore wind, and the fact that it is strongest in winter when Canada's electricity demand is greatest, means that it is more valuable to the grid than either onshore wind or solar — an advantage that will become increasingly important as wind and solar contribute a much larger share of electrical generation. In short, the competitiveness of different generation sources depends on a total system perspective, and not just on the LCOE of a particular facility.

Without detailed engineering and supply chain analysis, it's impossible to pinpoint the future cost of offshore wind electricity in Atlantic Canada. In the AEGIR study of potential sites for wind generation on the Scotian Shelf, the consulting firm estimated — based on European experience — an LCOE of about 6.5 cents (Cdn) per kWh for wind facilities on the Sable Island Bank and Middle Bank [see map above]. Such a cost would be a little lower than recent estimates of the LCOE for projects in the North Sea.[60] The AEGIR analysis assumed two GW on each site delivered by 100 20 MW turbines with commercial operation beginning in 2035. Cost estimates would likely be higher now due to the recent spike in inflation, but so too would the cost of other new sources of electricity. Commercial feasibility will also be heavily influenced by government policies, and particularly by tax and other incentives of the sort announced in the 2023 federal budget[61] and summarized in Box 4.

It's important to remember that the energy transformation is a decades-long global undertaking of unprecedented scale and scope. There will inevitably be bumps along the way that will cause short-term feasibility assessments to ebb and flow in response to transient factors. That's why a long-term vision, rooted in economic and environmental fundamentals, is

Specialized Offshore Wind Installation Vessel.
Image Courtesy Dominion Energy Via Offshore Magazine

essential. Viewed from this perspective, the growth prospects of offshore wind remain extremely bright.[62]

COMPLEMENTARY ASSETS

The offshore wind opportunity will require a support infrastructure in Atlantic Canada, including:

- **port facilities that can accommodate the enormous size of the turbines;**
- **various components of the supply chain;**
- **skilled workers in all phases of installation and maintenance (local capability for most tasks would eventually be developed);**
- **engineering and environmental services; and**
- **R&D.**

By virtue of a centuries-long maritime legacy, Atlantic Canada is exceptionally well-positioned to host the modern offshore wind industry. The region has several deep-water port facilities — such as St. John's, Sydney, Point Tupper/

Port Hawkesbury, Saint John and Halifax — that can accommodate the giant specialized vessels needed to convey offshore turbines to installation sites. Halifax has recently hosted installation ships serving the new Vineyard 1 wind facility off the coast of Massachusetts.[63] This opportunity is thanks to a lack of U.S.-built turbine installation vessels and an arcane American law that prevents foreign-built vessels shipping from point to point in the U.S. Eventually, the U.S. will construct these installation vessels[64] but, in the meantime, Atlantic Canadian ports have a unique opportunity to gain experience that can be put to use in our own offshore installations.

By virtue of a centuries-long maritime legacy, Atlantic Canada is exceptionally well-positioned to host the modern offshore wind industry

The offshore oil and gas industry has created a labour force with transferable skills in the region, particularly in Newfoundland and Labrador. Both the Halifax and St. John's areas, among others, have vibrant ocean technology sectors that could readily adapt to the needs of the offshore wind industry. Moreover, there has been extensive experience over many years with onshore wind facilities in Atlantic Canada and some of this would be transferable to offshore development.

The universities and community colleges in the four provinces provide training and marine-oriented research capacity across many of the requirements, and major offshore wind development would give rise to further capabilities. There is also an important opportunity to collaborate formally with U.S. academic and government research communities. Universities in the northeast and organizations like the National Renewable Energy Laboratory (NREL) are deeply engaged in research specific to offshore wind development in the Gulf of Maine and along the U.S. east coast — areas that obviously have a great deal in common with Canada's Atlantic coast.

Finally, there are several companies elsewhere in Canada that specialize in various elements of the wind energy supply chain, including some offshore aspects. Northland Power, for example, is an international energy company with offshore wind projects in operation and planned in Europe and Asia, and

LM Wind Power (a GE facility in Gaspé, Que.) manufactures turbine blades for offshore wind installations in the U.S. and Europe.[65, 66] The lack of a well-developed offshore wind supply chain in Canada is obviously due to the absence to date of offshore wind facilities in this country, a situation that would quickly change once major *sustained* installation was underway.[67]

POLICY AND REGULATORY SUPPORT

The federal and Atlantic provincial governments should be ready to co-operate to attract the massive private investment required to develop Atlantic Canada's vast offshore wind opportunity. Governments will need to commit to supporting long-term, world-scale offshore wind development in order to mobilize the capital and international expertise that the job requires.

The following areas of policy and regulatory initiative will be critically important:

- **fiscal incentives;**
- **licensing, regulation and federal Impact Assessment Act processes; and**
- **provincial electric utility regulation (including interties within Atlantic Canada and with the rest of Canada and the eastern U.S.).**

Fiscal incentives: To achieve Canada's Net Zero commitment, offshore wind energy capacity on the Atlantic coast should be seen as a national asset, rather than simply a regional one. Current federal fiscal incentives to support green energy appear sufficient to get the ball rolling, and they go some distance in levelling the playing field with the incentives provided in the year-old U.S. Inflation Reduction Act [see Box 4]. Further tailored support from the federal government would be justified in light of the national significance of potentially massive development of offshore wind.

Because wind energy projects are capital-intensive, their cost is heavily front-loaded. This creates substantial risk for the facility developer, particularly in Atlantic Canada where there has been no previous offshore wind energy experience. When the industry was first developing in Europe, project risk was usually mitigated by government-backed guarantees of a fixed price for energy generated over some number of years — a so-called feed-in tariff. This certainty attracted developers and made projects bankable. As the European industry matured, pricing methods became more market responsive and efficient. The U.K., for example, now employs a contract for differences (CFD) model using an auction to determine a fixed reference price for power — the strike price.[68] Subsequently, if the prevailing market price for power is below the strike price, the offshore wind provider is given a top-up payment equal to the difference; if the market price exceeds the strike price, the provider repays the surplus.

BOX 4

FEDERAL INCENTIVES DIRECTLY RELEVANT TO OFFSHORE WIND ENERGY

The 2023 federal budget featured a major commitment to the clean energy future, noting in particular that "Canada has the potential to become a clean electricity superpower with a cross-Canada electricity grid that is more sustainable, more secure, and more affordable."[69] The claim was supported with tax credits, program spending and major investment targeting. Although obviously not directed exclusively at offshore wind development, the following measures are tailor-made to support the vision articulated in this paper:

- **A Clean Electricity Focus for the Canada Infrastructure Bank:** The CIB will invest at least $10 billion through each of its Clean Power and Green Infrastructure priority areas — i.e., at least $20 billion to support the building of major clean electricity and clean growth infrastructure projects (like offshore wind farms).
- **Canada Growth Fund:** A $15-billion, arm's-length public investment vehicle that will help attract private capital to build Canada's clean economy by using

investment instruments (like contracts for differences) that absorb certain risks to encourage private investment in low carbon projects and supply chains.

- **Clean Electricity Investment Tax Credit:** A 15 percent refundable tax credit for investments including non-emitting electricity generation systems, stationary electricity storage systems and equipment for the transmission of electricity between provinces (estimated 10-year cost: $25.7 billion).

- **Clean Hydrogen Investment Tax Credit:** Support varying between 15 percent and 40 percent of project costs, depending on the carbon content of the production method (estimated 10-year cost: $17.7 billion).

- **Clean Electricity Projects:** $3 billion over 13 years, including continued grid innovation support, and new investments in science-based activities to help capitalize on Canada's offshore wind potential, particularly off the coasts of Nova Scotia and Newfoundland and Labrador.

- **Clean Technology Manufacturing Investment Tax Credit:** A refundable tax credit equal to 30 percent of the cost of investments in machinery and equipment used to manufacture or process key clean technologies, presumably including elements of the offshore wind supply chain (estimated 10-year cost: $11.1 billion).

- **Clean Technology Projects:** $500 million over 10 years to the Strategic Innovation Fund to attract and spur high-quality business investments to support the development and application of clean technologies in Canada, presumably including inputs to offshore wind technology.

European experience suggests that, initially, offshore wind developers are most likely to be attracted to Atlantic Canada by a feed-in tariff incentive, evolving eventually to a CFD, and ultimately to a completely unsubsidized model.[70,71] Other models such as negotiated power purchase agreements are also possible. Advice in this general regard will be provided to the Minister of Natural Resources by the recently appointed Canada Electricity Advisory Council.[72]

Licensing, Regulation and Impact Assessments: Jurisdictional authority for offshore renewable energy development rests with the federal government through the Canada Energy Regulator (CER).[73] In Nova Scotia and Newfoundland and Labrador, where joint federal-provincial management has long been established under offshore petroleum boards, the federal government has agreed to assign regulatory authority for offshore wind energy to re-mandated boards jointly managed by the federal government and the respective province — the Canada-Nova Scotia Offshore Energy Board and Canada-Newfoundland and Labrador Offshore Energy Board.[74,75]

Federal and provincial ministers will jointly issue calls for bids and approve licences for offshore wind facilities in the waters adjacent to the two provinces.[76] This melding of federal and provincial authority creates, in effect, a one-stop shop and will be seen by project proponents as a significant benefit of investing in offshore wind in Atlantic Canada.

Melding of federal and provincial authority will be seen by project proponents as a significant benefit of investing in offshore wind

The federal Impact Assessment Act requires that studies be conducted to assess the environmental, health, social and economic effects of potential major projects, such as offshore wind facilities, to inform licensing and regulatory decisions.[77] The governments of Canada, Nova Scotia and Newfoundland and Labrador have appointed committees to conduct regional assessments of offshore wind development in waters off each province. The 18-month assessments are scheduled to be completed by September 2024.

The assessments' terms of reference call for detailed investigation of a very broad range of potential impacts for which the scientific evidence is often sketchy or unknown. Inevitably, the siting of offshore wind facilities will have impacts on the adjacent marine environment and species, as well as potential conflicts with uses such as commercial fishing, shipping, tourism and military activity. Fortunately, some areas with high potential for wind facilities have already been investigated in the course of oil and gas development.

So far, international experience suggests that negative impacts can be mitigated and/or compensated for. Nevertheless, local factors and other potentially affected marine uses, particularly fisheries, will have characteristics that are specific to Atlantic Canada's coastal areas. Consultation with directly affected parties, together with transparent public information, will be needed to ensure due process and to secure broad public support. Again, experience elsewhere (including recently in the northeastern U.S.) can inform best practices.[78]

Investment of the magnitude needed to develop offshore wind energy at scale cannot be firmly secured until there is certainty that regulatory approval will be given. The established impact assessment process, in light of experience to date, is protracted and subject to many unpredictable sources of delay.[79] The federal government has recognized the problem and promised to fix it.[80]

Clearly, the impact assessment processes for offshore wind need to be carried out as efficiently as possible, with timetables rigorously enforced and with a recognition that some trade-offs will be required. Subsequent licensing decisions then need to be made without delay. Urgency is critical. Emissions will continue to accumulate *every day* that mitigating technology is not in place. And the enormous investment that must be mobilized is being attracted every day by other opportunities. This is not a time for a business-as-usual approach.

Provincial and electric utility regulation: Once energy that is generated offshore touches the onshore grid, it becomes subject to utility regulatory boards in every province, and thus indirectly to provincial governments. Regulatory boards are mandated to serve the public interest, which at present for electric utilities means delivering power reliably and cost-efficiently, subject to a reasonable return on investment by the utility. The boards are conservative by mandate, and therefore conservative by nature.

This poses a dilemma for a country like Canada trying to fundamentally transform its energy system. This "Project of the Century" calls for bold vision and a bias for action. *Traditional electric utility regulation is not fit for this purpose.* The times demand a broader conception of the public interest. Provinces therefore need to re-mandate their utility boards to support the transformation of the electric energy system, subject always to continued security of supply. Recommendations to this end have been developed by the Canadian Climate Institute in a report entitled "Electric Federalism."[81]

The principal clean renewables — wind and solar — are inherently variable but the peaks and valleys can be evened out, and costs reduced, if:

- **grids are interconnected;**
- **temporary storage of electricity surplus is available;**
- **technology is provided to make the grid and its customers "smarter," so as to optimally balance load with generation in real time; and**
- **sufficient firm capacity is available to maintain reliability requirements.**

This requires both new investment and co-operation among provincial governments to upgrade and integrate grids, and to make the surplus energy that offshore wind could provide available beyond the Atlantic provinces. Completion of the Atlantic Loop [see Box 5] is one example of what is required.

Every provincial government should recognize that collaboration is in the interest of its residents in view of both the urgent mission to halt climate change and the unprecedented economic opportunity created by the global electric energy transformation. Additionally, the need to achieve *national* climate change objectives justifies proactive engagement by the federal government to encourage interprovincial co-operation. There is always the risk that federal-provincial jurisdictional division will lead to an impasse due to conflicting perceptions of the public interest, or different interpretations of the facts. The Atlantic Loop stalemate, illustrated by Nova Scotia's decision not to participate in the proposed project, is a case in point.[82]

There is no easy answer to this age-old conundrum of Canadian federalism. On the one hand, the Constitution provides the federal Parliament with a "declaratory power" to override provincial jurisdiction in any matter declared to be for the "general advantage of Canada or of two or more Provinces."[83] But on the other hand, in a political context, the declaratory power is effectively a "nuclear" option. Its use would risk poisoning the well in the present circumstances — the necessary green transformation of Canada's energy system — where there is no alternative to intergovernmental co-operation. Governments must be willing to act as partners. With enlightened leadership that recognizes the enormity of what's at stake, co-operation would be seen to be in everyone's interest.

BOX 5

THE PROPOSED ATLANTIC LOOP

An Essential Component of an Offshore Wind Strategy

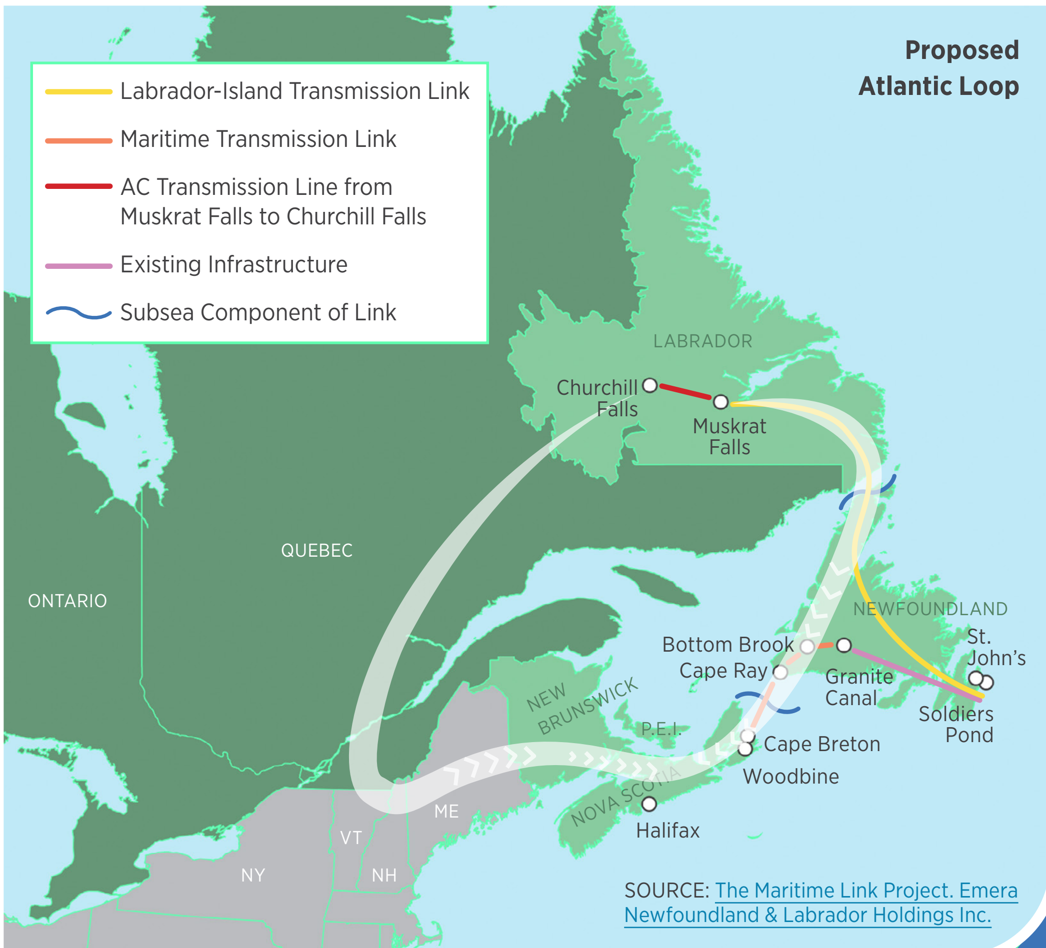
The Atlantic Loop would consist of a series of high-capacity transmission lines connecting Hydro-Québec facilities with New Brunswick, together with upgraded capacity linking New Brunswick and Nova Scotia.[84] The new transmission would complement existing lines that connect the Churchill River system in Labrador to the island of Newfoundland and via an undersea Maritime Link with Nova Scotia, thus closing the loop.

A completed Atlantic Loop would provide access to clean, renewable energy from Hydro-Québec to facilitate replacement of fossil fuel generation in New Brunswick and Nova Scotia in the 2030-35 time period, in accordance with provincial objectives and the new federal Clean Electricity Regulations.[85] Bidirectional design of the transmission facilities could also permit export of clean electricity from Atlantic Canada to Quebec, and via existing connections to Ontario and the northeastern U.S. For that reason, a sufficiently capacious Atlantic Loop would be an essential element in a broader plan to enable major development of offshore wind energy, well beyond the domestic needs of Atlantic Canada. That's why the Atlantic Loop should be seen as a linchpin component of a national clean energy strategy.

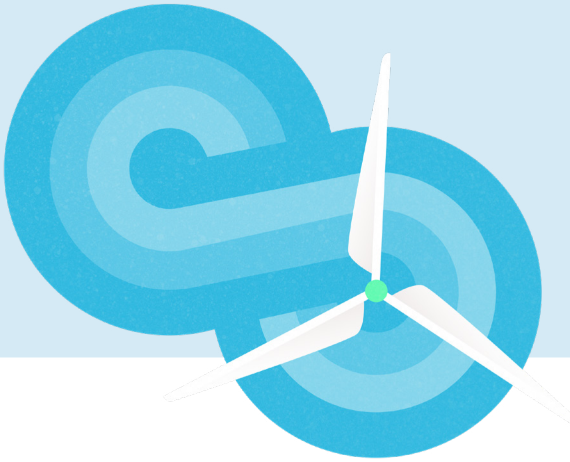
As usual, the sticking point has been cost and who will bear it.

It has been reported that the federal government estimates the project would cost $6.8 billion, $4.5 billion of which could be financed by a 50-year loan from the Canada Infrastructure Bank.[86] Nevertheless, the governments of Nova Scotia and New Brunswick have not signed on, citing uncertainty regarding eventual cost and the nature of the power purchase deal that would need to be negotiated with Hydro Quebec. Meanwhile the clock is ticking to meet decarbonization requirements on time.

A robust Atlantic Loop, combined with development of offshore wind at real scale, would be the ideal complement to Quebec and Labrador's hydro power — a win-win combination for everyone.



SOURCE: The Maritime Link Project. Emera Newfoundland & Labrador Holdings Inc.



CONCLUSION

The global clean energy transformation — the greatest undertaking in human history — brings with it the opportunity for Atlantic Canada to be among its leaders. Development at massive scale of the region's world-class offshore wind energy potential would impart new momentum to the Atlantic economy and would be a significant contributor to Canada's clean electricity requirement to reach Net Zero emissions by 2050. What has been missing from the discussion to date — and what this paper has sought to provide — is a full recognition of the sheer scale and scope of this unprecedented opportunity. We need only look to the collective ambition of the European countries bordering the North Sea to appreciate what might eventually be possible here.[87]

The development of Atlantic offshore wind energy therefore needs to be seen as far more than a regional project. It needs to be embraced as a *national* project in the service of Canada's long-term climate objectives. A comprehensive development strategy is needed, including specific capacity targets that are realistic in the near term and visionary in the long term to 2050 and beyond. We should be targeting 10-15 GW installed by 2035-40, with the expectation of much more beyond that. This illustrates

We should be targeting 10-15 GW installed by 2035-40, with the expectation of much more beyond that

the scale and long-term commitment required to attract the global players in the offshore wind industry without whom the opportunity could not proceed.[88]

Such an ambition would far exceed the domestic energy requirements of Atlantic Canada, including prospects for green hydrogen production and export. Indeed, the primary objective should be to supply substantial clean electricity to the national grid and potentially to the northeastern United States. The opportunity therefore exists for a reciprocal win-win partnership with Quebec as both customer and supplier and linchpin connector to North American electricity markets.

Since the Age of Sail in the 19th century, Atlantic Canada's economy has been in search of a new source of momentum. Once again, wind can be the game changer.

ACKNOWLEDGEMENTS

MCKENNA FAMILY FUND

Arthur, Sandra and Sarah Irving

Joyce Family Foundation

Hon. Margaret McCain

Hon. Frank McKenna

Oceans Capital Investment Ltd.

Gerry Pond

Joseph Shannon

McInnes Cooper

TD Bank Group

PPF TEAM

Edward Greenspon
President & CEO

Alison Uncles
Vice-President, PPF Media & Communications

Gareth Chappell
Director of Planning and Operations

Carole Lee Reinhardt
Director, Atlantic

Colin Campbell
Editorial Director

Alishya Weiland
Policy Lead

Lacy Atalick
Digital Editor

Naushin Ahmed
Manager, Production & Brand

CONTRIBUTORS

Mark Stevenson
Handling Editor

Anita Murray
Copyediting

Emmanuelle Demange
Translation

Una Janićijević
Illustration + Design

ENDNOTES

1 Canada Energy Regulator. (Aug. 16, 2023). Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050. Government of Canada. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2023

2 Musial, W., et al. (2023). Offshore Wind Market Report: 2023 Edition. U.S. Department of Energy. https://www.energy.gov/sites/default/files/2023-08/offshore-wind-market-report-2023-edition-summary.pdf

3 Natural Resources Canada. (2022). Clean Power Roadmap for Atlantic Canada. Government of Canada. https://natural-resources.canada.ca/energy/electricity-infrastructure/electricity-infrastructure-publications/clean-powerroadmap-for-atlantic-canada/24190

4 Government of Nova Scotia. (May 2023). Nova Scotia Offshore Wind Roadmap. https://novascotia.ca/offshore-wind/docs/offshore-wind-roadmap.pdf

5 Withers, P. (Aug. 23, 2023). 'Pioneer' Canadian offshore wind farm announced in Halifax. CBC. https://www.cbc.ca/news/canada/nova-scotia/offshore-wind-farm-unveiled-halifax-1.6945106

6 Mclaughlin, B. (Feb. 2, 2023). Atlantic Canada: wind, hydrogen and the folks working to realize the potential. Atlantic Business. https://atlanticbusinessmagazine.ca/article/atlantic-canada-wind-hydrogen-and-the-folks-working-to-realize-the-potential/

7 Statistics Canada. (2022). Household energy consumption, Canada and provinces. Government of Canada. https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=2510006001

8 Roser, M. (Dec. 1, 2020). Why did renewables become so cheap so fast? Our World in Data. https://ourworldindata.org/cheap-renewables-growth

9 International Energy Agency. (2023 Update). Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach. https://iea.blob.core.windows.net/assets/d0ba63c5-9d93-4457-be03-da0f1405a5dd/NetZeroRoadmap_AGlobalPathwaytoKeepthe1.5CGoalinReach-2023Update.pdf

10 Musial, W. (July 20, 2023). Offshore Wind Energy Outlook. National Renewable Energy Laboratory. https://cnee.colostate.edu/wp-content/uploads/2023/07/CELA-July-2023_-Offshore-Wind.pdf

11 Denning, L. (Aug. 1, 2023). Offshore Wind Industry Is Caught In a Financial Hurricane. Bloomberg. https://www.bloomberg.com/opinion/articles/2023-08-01/offshore-wind-industry-is-caught-in-a-financial-hurricane?leadSource=uverify%20wall

12 The Maritime Executive. (Feb. 26, 2023). China Now Has Nearly Half of the World's Offshore Wind Capacity. https://maritime-executive.com/article/china-now-has-nearly-half-of-the-world-s-offshore-wind-capacity

13 Office of Energy Efficiency & Renewable Energy. (Jan. 23, 2023). National Offshore Wind Research and Development Consortium Announces U.S. Offshore Wind Supply Chain Road Map. U.S. Department of Energy. https://www.energy.gov/eere/articles/national-offshore-wind-research-and-development-consortium-announces-us-offshore-wind

14 Ostend Declaration on The North Seas as Europe's Green Power Plant. (April 24, 2023). https:// assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1154445/ostend-leadersdeclaration.pdf

15 Canada Energy Regulator. (Aug. 16, 2023). Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050. Government of Canada. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2023/

16 Annesley, J., Campbell, D., Golshan, A., and Greenspon, E. (July 19, 2023). Project of the Century: A Blueprint for Growing Canada's Clean Electricity Supply – and Fast. Public Policy Forum. https://ppforum.ca/publications/net-zero-electricity-canada-capacity/

17 Boyle, D. (Jan. 14, 2021). Ontario town reignites opposition to wind farm after court overturns cancellation. True North / National Wind Watch. https://www.wind-watch.org/news/2021/01/15/ontario-town-reignites-opposition-towind-farm-after-court-overturns-cancellation/

18 Beer, M. (Aug. 2, 2023). Alberta Slaps 7-Month Moratorium on Solar and Wind, Puts Booming Industry at Risk. The Energy Mix. https://www.theenergymix.com/2023/08/03/alberta-slaps-6-month-moratorium-on-solar-and-windputs-booming-industry-at-risk/

19 Atlantic Canada is conventionally understood to comprise the three Maritime provinces and Newfoundland and Labrador, and the Atlantic Canada statistics in this paper are specific to those jurisdictions. But in the context of offshore wind energy, the region should be thought of as also encompassing the parts of Quebec in and bordering on the Gulf of St. Lawrence.

20 Ouziel, S., and Avelar, L. (June 29, 2021). 4 technologies that are accelerating the green hydrogen revolution. World Economic Forum. https://www.weforum.org/agenda/2021/06/4-technologies-accelerating-green-hydrogenrevolution/

21 Government of Nova Scotia. (Sept. 20, 2022). Province Sets Offshore Wind Target. https://novascotia.ca/news/release/?id=20220920003

22 Dong, C., Huang, G., and Cheng, G. (Dec. 1, 2021). Offshore wind can power Canada. ScienceDirect, 236. https://www.sciencedirect.com/science/article/abs/pii/S0360544221016704

23 Fisheries and Oceans Canada. (2018). The Scotian shelf: an atlas of human activities. Government of Canada. https://www.dfo-mpo.gc.ca/oceans/publications/scotian-atlas-ecossais/index-eng.html

24 The economics of a wind turbine are very sensitive to average wind speed. The energy generated by a turbine of given capacity is approximately proportional to the cube (third power) of wind speed. An area like Sable Island Bank, where the average wind speed is about 11 m/sec, will yield approximately 80 percent more energy than the same turbine in an area where the speed averages, say, nine m/sec [(11/9)^3 = 1.83].

25 Lewis, M. (June 14, 2023). The world's largest wind farm is on the homestretch. Electrek. https://electrek.co/2023/06/14/worlds-largest-wind-farm/

26 AEGIR. (Apr. 20, 2023). Value Mapping Nova Scotia's Offshore Wind Resources. https://netzeroatlantic.ca/sites/default/files/2023-04/Value%20Mapping%20Nova%20Scotia%20Offshore%20Wind%20Resources.pdf

27 AEGIR. (n.d.). Offshore wind intelligence. https://www.aegirinsights.com/

28 The Maritime Executive. (Feb. 17, 2023). Finland Provides Grant to Develop Wind Farm in Freezing Sea Conditions. https://maritime-executive.com/article/finland-provides-grant-to-develop-wind-farm-in-freezing-seaconditions

29 Baraniuk, C. (July 1, 2022). The Race to Build Wind Farms That Float on the Open Sea. Wired. https://www.wired.com/story/floating-wind-turbines/

30 U.S. Department of Energy. (September 2022). Floating Offshore Wind Shot: Unlocking the Power of Floating Offshore Wind Energy. https://www.energy.gov/sites/default/files/2022-09/floating-offshore-wind-shot-factsheet.pdf

31 NREL. (n.d.). Life Cycle Assessment Harmonization. https://www.nrel.gov/analysis/life-cycle-assessment.html

32 Environmental Protection Agency. (Aug. 28, 2023). Greenhouse Gas Emissions from a Typical Passenger Vehicle. https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

33 Drax. (June 8, 2022). Cost of turning off UK wind farms reached record high in 2021. https://www.drax.com/press_release/cost-of-turning-off-uk-wind-farms-reached-record-high-in-2021/

34 Giampieri, A., Ling-Chin, J., and Roskilly, A.P. (Feb. 16, 2023). Techno-economic assessment of offshore windto-hydrogen scenarios: A UK case study. ScienceDirect. https://www.sciencedirect.com/science/article/pii/S0360319923006316

35 Galparsoro, I., et al. (Aug. 10, 2022). Reviewing the ecological impacts of offshore wind farms. https://www.nature.com/articles/s44183-022-00003-5

36 Danish Energy Agency. (2019). Environmental Impacts of Offshore Wind Farms: Assessment and Long-term Monitoring in Denmark. https://ens.dk/sites/ens.dk/files/Globalcooperation/Short_materials/environmental_impacts_of_offshore_wind_farms.pdf

37 Stefek, J., et al. (October 2022). U.S. Offshore Wind Workforce Assessment. NREL. https://www.nrel.gov/docs/fy23osti/81798.pdf

38 The job figures are based on NREL's detailed U.S. analysis (Ibid.) in the context of the target to install 30 GW of offshore wind energy by 2030. The figures cited above for Atlantic Canada, based on 15 GW installed, are prorated to be half those estimated in the NREL study. https://www.nrel.gov/docs/fy23osti/81798.pdf

39 Laurie, C. (Jan. 31, 2023). Road Map Defines Path to a U.S. Offshore Wind Energy Supply Chain. NREL. https://www.nrel.gov/news/program/2023/road-map-defines-path-to-a-us-offshore-wind-energy-supply-chain.html

40 Investissement Québec. (n.d.). Québec Aluminum: A World-class Sector. https://www.investquebec.com/international/en/industries/aluminum.html

41 IEA. (2019). The Future of Hydrogen. https://www.iea.org/reports/the-future-of-hydrogen

42 According to the CER's Net Zero scenarios, Ontario's wind energy supply would increase to 220 TWh by 2050 from 12.5 TWh in 2021, accounting for 62 percent of the 334 TWh increase in wind-generated electricity in Canada.

43 NEMOEC Coalition. (May 4, 2023). A New England - Maritimes Offshore Energy Corridor Builds Regional Resilience for a Clean Energy Future. https://nemoec.com/wp-content/uploads/2023/05/Power-Advisory-NEMOECShared-Tx-White-Paper_final.pdf

44 Selig, K. (Aug. 8, 2023). The future of East Coast wind power could ride on this Jersey beach town. The Washington Post. https://www.washingtonpost.com/climate-environment/2023/08/08/offshore-wind-energy-eastcoast/

45 Reid, D., et al. (2021). Access to US Markets (Offshore Wind). Net-Zero Atlantic. https://netzeroatlantic.ca/research/access-us-markets-offshore-wind

46 Lowrie, M. (Jan. 3, 2022). Quebec's Hydropower Era Ends as Last Big Megaproject Nears Completion. The Canadian Press. https://www.theenergymix.com/2022/01/03/quebecs-hydropower-era-ends-as-last-big-megaprojectnears-completion/

47 The capital cost of offshore wind projects has averaged between US$3,000-$4,000 per kW (or $3 billion to $4 billion per GW) for projects installed in 2022. https://www.energy.gov/eere/wind/articles/offshore-wind-marketreport-2023-edition

48 Mclaughlin, B. (Feb. 2, 2023). Atlantic Canada: wind,hydrogen and the folks working to realize the potential.Atlantic Business. https://atlanticbusinessmagazine.ca/article/atlantic-canada-wind-hydrogen-and-the-folksworking-to-realize-the-potential/

49 Government of Nova Scotia. (Sept. 20, 2022). Province Sets Offshore Wind Target. https://novascotia.ca/news/release/?id=20220920003

50 Heid, B., et al. (Oct. 25, 2022). Five charts on hydrogen's role in a net-zero future. McKinsey & Company. https://www.mckinsey.com/capabilities/sustainability/our-insights/five-charts-on-hydrogens-role-in-a-net-zerofuture

51 International Renewable Energy Agency. (2021). Green hydrogen supply: A guide to policy making. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/May/IRENA_Green_Hydrogen_Supply_2021.pdf

52 The Royal Society. (2021). The role of hydrogen and ammonia in meeting the net zero challenge. https://royalsociety.org/-/media/policy/projects/climate-change-science-solutions/climate-science-solutionshydrogen-ammonia.pdf

53 Bearak, M. (Mar. 11, 2023). Inside the Global Race to Turn Water Into Fuel. The New York Times. https://www.nytimes.com/2023/03/11/climate/green-hydrogen-energy.html

54 Baxter, J. (Aug. 8, 2023). 'Not smart for Nova Scotia': looking under the hood of the hydrogen hype. Halifax Examiner. https://www.halifaxexaminer.ca/environment/climate/not-smart-for-nova-scotia-looking-under-the-hoodof-the-hydrogen-hype/

55 Our World in Data. (n.d.). Levelized cost of energy by technology, World. https://ourworldindata.org/grapher/levelized-cost-of-energy

56 S&P Global. (June 16, 2023). Offshore wind contract disputes proliferate as high costs jeopardize US buildout. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/offshore-wind-contractdisputes-proliferate-as-high-costs-jeopardize-us-buildout-76164337

57 Fickling, D. (July 26, 2023). How Offshore Wind Can Survive Its Spell in the Doldrums. Bloomberg / The Washington Post. https://www.washingtonpost.com/business/energy/2023/07/26/alternative-energy-offshore-windfarms-can-come-out-of-the-doldrums/4dfee5ee-2bfa-11ee-a948-a5b8a9b62d84_story.html

58 Bilicic, G., and Scroggins, S. (April 2023). 2023 Levelized Cost Of Energy+. Lazard. https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/

59 NREL. (n.d.). Financial Cases and Methods. https://atb.nrel.gov/electricity/2023/financial_cases_&_methods

60 Jensen, M.K. (Aug. 30, 2022). LCOE Update of recent trends (Offshore). AEGIR. https://www.nrel.gov/wind/assets/pdfs/engineering-wkshp2022-1-1-jensen.pdf

61 Department of Finance. (Mar. 28, 2023). A Made-In-Canada Plan: Affordable Energy, Good Jobs, and a Growing Clean Economy. Government of Canada. https://www.budget.canada.ca/2023/report-rapport/chap3-en.html#a6

62 Musial, W. (July 20, 2023). Offshore Wind Energy Outlook. National Renewable Energy Laboratory. https://cnee.colostate.edu/wp-content/uploads/2023/07/CELA-July-2023_-Offshore-Wind.pdf

63 Vineyard Wind. (n.d.). Vineyard Wind 1 Overview. https://www.vineyardwind.com/vineyardwind-1

64 McGowan, E. (Mar. 8, 2022). Giant, turbine-installing ship is Dominion Energy's $500M bet on U.S. offshore wind. Energy News Network. https://energynews.us/2022/03/08/giant-turbine-installing-ship-is-dominionenergys-500m-bet-on-u-s-offshore-wind/

65 Northland Power. (n.d.). About Northland. https://www.northlandpower.com/en/about-northland/aboutnorthland.aspx

66 Prime Minister of Canada. (July 14, 2021). Supporting renewable energy manufacturing in Quebec to create jobs and build a cleaner future. Government of Canada. https://www.pm.gc.ca/en/news/news-releases/2021/07/14/supporting-renewable-energy-manufacturing-quebec-create-jobs-and

67 For example, the Canadian shipping company CSL already has ships that carry wind turbine components and aggregate used in anchoring turbines to the seafloor. https://cslships.com/fleet/multi-purpose-product-vessels/

68 Department for Energy Security and Net Zero. (Sept. 8, 2023). Contracts for Difference. GOV.UK. https://www.gov.uk/government/collections/contracts-for-difference

69 Department of Finance. (Mar. 28, 2023). A Made-In-Canada Plan: Affordable Energy, Good Jobs, and a Growing Clean Economy. Government of Canada. https://www.budget.canada.ca/2023/report-rapport/chap3-en.html

70 AEGIR. (March 2021). Stimulating Offshore Wind in Nova Scotia. https://netzeroatlantic.ca/sites/default/files/2022-12/Stimulating%20Offshore%20Wind%20Development%20in%20Nova%20Scotia%20-%20Final%20Report.pdf

71 The feed-in tariff and CFD models are not the only options that have been implemented (Ibid.). In the U.S., for example, Renewable Energy Certificates are the mechanism of choice. https://www.epa.gov/green-power-markets/renewable-energy-certificates-recs

72 Natural Resources Canada. (May 5, 2023). Minister Wilkinson Launches Canada Electricity Advisory Council to Help Build Canada's Clean Electricity Future. Government of Canada. https://www.canada.ca/en/natural-resourcescanada/news/2023/05/minister-wilkinson-launches-canada-electricity-advisory-council-to-help-buildcanadas-cleanelectricity-future.html

73 Some offshore maritime areas (e.g., certain bays) fall under the jurisdiction of the adjacent province with respect to licensing energy generation facilities. For example, the draft Nova Scotia Offshore Wind Roadmap (May 2023) raises the possibility of approving relatively small offshore wind facilities subject to the authority of the provincial Marine Renewable-energy Act in nearshore waters claimed to be under the jurisdiction of the province. https://nslegislature.ca/sites/default/files/legc/statutes/marine%20renewable-energy.pdf

74 Canada-Nova Scotia Offshore Petroleum Board. (n.d.). Canada-Nova Scotia Offshore Energy Regulator (CNSOER) Updates. https://www.cnsopb.ns.ca/canada-nova-scotia-offshore-energy-regulator-cnsoer-updates

75 Natural Resources Canada. (Apr. 5, 2022). Canada and Newfoundland and Labrador Announce Intent to Expand the Mandate of Offshore Energy Regime to Support the Transition to a Clean Economy and Create Sustainable Jobs. Government of Canada. https://www.canada.ca/en/natural-resources-canada/news/2022/04/canada-andnewfoundland-and-labrador-announce-intent-to-expand-the-mandate-of-offshore-energy-regime-to-support-thetransition-to-a-clean-economy-a.html

76 For waters adjacent to New Brunswick and P.E.I., regulatory authority for renewable energy remains with the CER.

77 Government of Canada. (2019). Impact Assessment Act. https://laws-lois.justice.gc.ca/eng/acts/I-2.75/

78 Marine Renewables Canada. (Nov. 25, 2020). Offshore Wind Stakeholder Engagement Plan for Nova Scotia. Net- Zero Atlantic. https://netzeroatlantic.ca/sites/default/files/2023-03/OSW%20Stakeholder%20Engagement%20Plan%20-%20Final%20Report.pdf

79 Orenstein, M. (Apr. 30, 2023). Federal Impact Assessment Act Under Review: Measuring Progress on Projects and Timelines. Canada West Foundation. https://cwf.ca/research/publications/report-federal-impact-assessment-actunder-review/

80 Budget 2023 committed that, by the end of 2023, the government will outline a concrete plan to improve the efficiency of the impact assessment and permitting processes for major projects, which will include clarifying and reducing timelines, mitigating inefficiencies, and improving engagement and partnerships.

81 Canadian Climate Institute. (May 2022). Electric Federalism: Policy for Aligning Canadian Electricity Systems with Net Zero. https://climateinstitute.ca/wp-content/uploads/2022/05/Electric-Federalism-May-4-2022.pdf

82 CTV News Atlantic. (Oct. 11, 2023). Atlantic Loop no longer part of Nova Scotia plan to hit 2030 renewable energy targets. https://atlantic.ctvnews.ca/mobile/atlantic-loop-no-longer-part-of-nova-scotia-plan-to-hit-2030-renewable-energy-targets-1.6597337#:~:text=Nova%20Scotia%20says%20the%20Atlantic,Quebec%20and%20Newfoundland%20and%20Labrador.

83 Section 92 enumerates matters under exclusive provincial jurisdiction but subsection 92 (10) provides some explicit exceptions, which include: "Such Works as, although wholly situate within the Province, are before or after their Execution declared by the Parliament of Canada to be for the general Advantage of Canada or for the Advantage of Two or more of the Provinces." Section 91 gives the federal Parliament a residuary power defined as follows: "to make Laws for the Peace, Order and good Government of Canada, in relation to all Matters not coming within the Classes of Subjects by this Act assigned exclusively to the Legislatures of the Provinces."

84 Few details about the Atlantic Loop have been made public, including the potential route(s), and specifically whether it would be wholly in Canada or include passage through Maine.

85 Government of Canada. (Aug. 25, 2023). Clean Electricity Regulations. https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/clean-electricity-regulation.html

86 Withers, P. (June 16, 2023). Ottawa, Nova Scotia at odds over $4.5B for Atlantic Loop. CBC. https://www.cbc.ca/news/canada/nova-scotia/ottawa-nova-scotia-atlantic-loop-4-5-billion-dollars-1.6878555

87 Department for Energy Security and Net Zero. (May 3, 2023). Developing the North Seas as a green power plant of Europe: North Sea Summit declarations. Gov.UK. https://www.gov.uk/government/publications/developing-thenorth-seas-as-a-green-power-plant-of-europe-north-sea-summit-declarations

88 Major global developers of offshore wind energy include, for example, Orsted (Denmark), RWE (Germany), Iberdrola (Spain) and Northland Power (Canada). Canada's Brookfield Renewable Partners has many renewable energy assets worldwide; although it has not emphasized offshore wind to date, it has a great deal of relevant expertise.

PUBLIC
POLICY
FORUM