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Does Nova Scotia have an electric future?

Response to
The Nova Scotia Department of Energy's Consultation Paper
Nova Scotia's Renewed Energy Strategy and Climate Change Action Plan

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Executive summary

Energy and its impact on society will be one of the major issues of the twenty-first century. Rising energy costs will increase the price of almost all goods and services. Rising world demand for energy, coupled with problems in producer nations, is expected to result in short- and long-term shortages. Nova Scotia, which imports almost 90 percent of its energy, is ill-prepared for energy price rises or energy shortages or both.

Energy security, the uninterrupted supplies of energy at affordable prices is the responsibility of most governments. Since the release of the 2001 energy strategy, the province has done little to improve the energy security of Nova Scotians. Sable natural gas, Deep Panuke, and a limited number of wind turbines is not the basis of a provincial energy security policy.

The report shows that Nova Scotia Power's reliance on insecure, high-carbon coal puts Nova Scotians at risk should supplies ever be curtailed. Projected future growth in renewables such as wind will make limited impact on coal consumption.

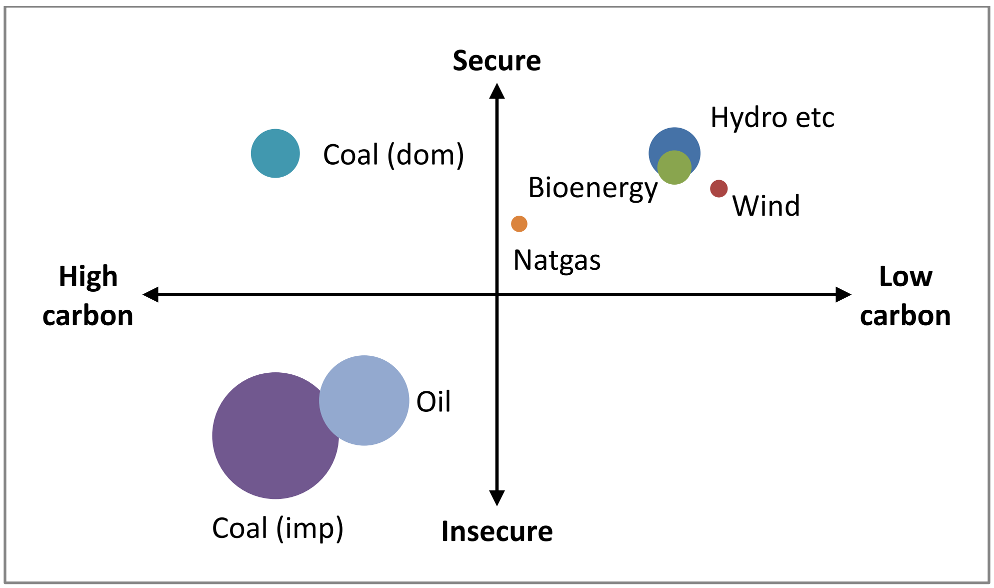

Figure 2: NSPI's supply mix and associated generation for 2006 (NEB, 2007)

Broadly speaking, energy security consists of two components: supply and infrastructure. The failure or absence of either will compromise the energy security of a jurisdiction. If supplies of refined petroleum products such as gasoline or home heating fuel become difficult or too expensive to obtain, Nova Scotians could well turn to electricity to meet their end-use energy applications. Those with sufficient income will move towards electricity to meet their transportation needs with, for example, plug-in hybrid vehicles. On the other hand, many who are unable to afford heating fuel will turn to electricity to stave off the effects of winter cold.

This report considers these and other issues facing Nova Scotians in the twenty-first century. A number of recommendations are given that will encourage Nova Scotians to reduce their consumption of electricity and for Nova Scotia Power to replace coal with energy from other sources.

The report concludes that Nova Scotia is facing considerable challenges when it comes to energy security and that electricity is one of these challenges.

Does Nova Scotia have an electric future?

1 Introduction

It is generally agreed that the world is entering a time of rapid and radical changes in energy markets (IEA, 2007a; NPC, 2007). The cost and availability of crude oil is helping drive the cost of other primary energy sources, notably coal, natural gas, and uranium, which are, in turn, increasing the cost of secondary energy products such as gasoline, home heating fuel, and electricity (IEA, 2007b). Jurisdictions that rely on supplies of crude oil, coal, and natural gas will be particularly vulnerable to cost increases and supply shortfalls (IEA, 2007b). One such jurisdiction is Nova Scotia, which imports about 90 percent of its primary energy (Hughes, Energy Security in Nova Scotia, 2007).

At the same time, there is a growing realization that our energy habits are harming both human health and the environment. Emissions of carbon dioxide from the combustion of fossil fuels is contributing to climate change (IPCC, 2007), while criteria air contaminants, mercury, and particulate emissions are known to be detrimental to human health (for example, see (UNEP, 1992)).

A solution touted by many is the increased use of electricity to meet future energy demand and to maintain present lifestyles. Electricity is presented as a clean energy source allowing energy services such as plug-in hybrid vehicles and electric heating. However, to meet the world's increasing demand for electricity means finding new sources of generation—all of which are subject to supply and environmental problems.

This report considers the question, "Does Nova Scotia have an electric future?"

2 Review

2.1 Nova Scotia's electrical supply

Almost all of Nova Scotia's electricity demand is met by Nova Scotia Power (NSPI). Between 1997 and 2006, the average annual demand during this period was about 11,000 GWh, as shown in Figure . A sharp downturn in demand in 2006 occurred because of industrial action at a major industrial consumer.

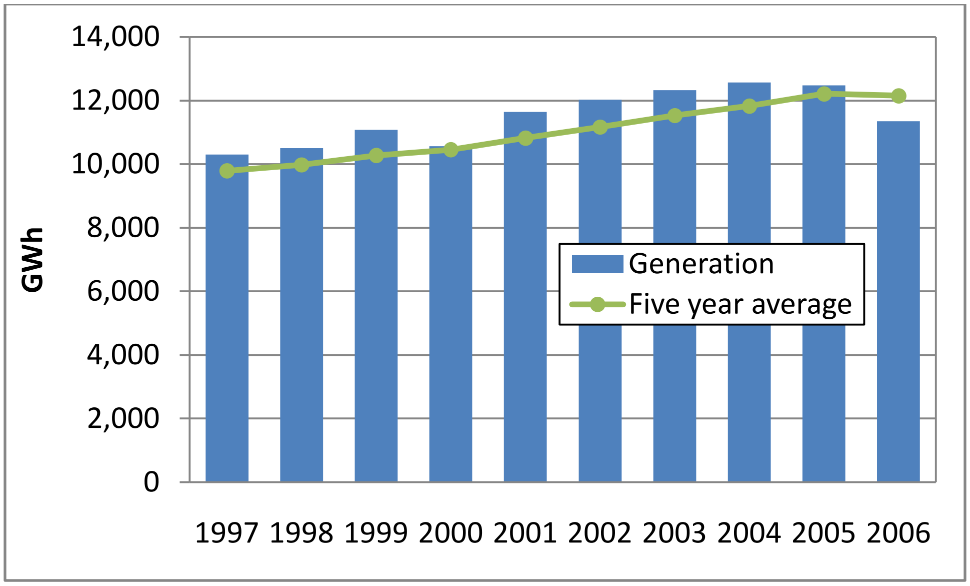

Figure 1: Nova Scotia's electrical demand as met by NSPI

NSPI relies on insecure, high-carbon fuel sources to meet most of its demand: coal from Colombia, Venezuela, and the United States, and petcoke from the United States. Examples of this insecurity include the inability to access supplies of petcoke from the United States in 2005-06 after Hurricane Katrina, and the refusal of a shipper to transport coal from Colombia because of political tensions (Mensah-Bondsu, 2007).

The supply mix for 2006 is shown in the security-climate graph in Figure 2.

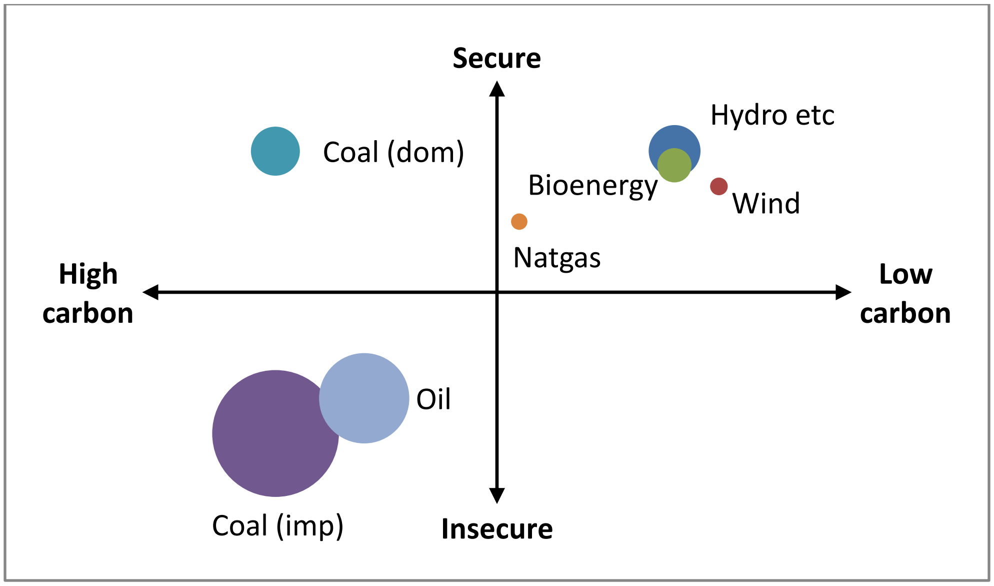

Figure 2: NSPI's supply mix and associated generation for 2006 (NEB, 2007)[1]

The National Energy Board (NEB) scenarios for Nova Scotia's demand for electricity suggest little change between 2006 and 2020, averaging about 11,600 GWh during this period; however, the mix of fuels is expected to change quite dramatically. When comparing Figure 2 and Figure 3 (the scales are the same), it is clear that consumption of coal, natural gas, bioenergy, and wind is projected to increase, while consumption of refined petroleum products will drop.

[1] Terminology used in the security-climate graphs: "dom" – domestic; "imp" – imported; "natgas" – natural gas; "hydro etc" – electricity from sources of moving water, notably hydroelectricity and tidal.

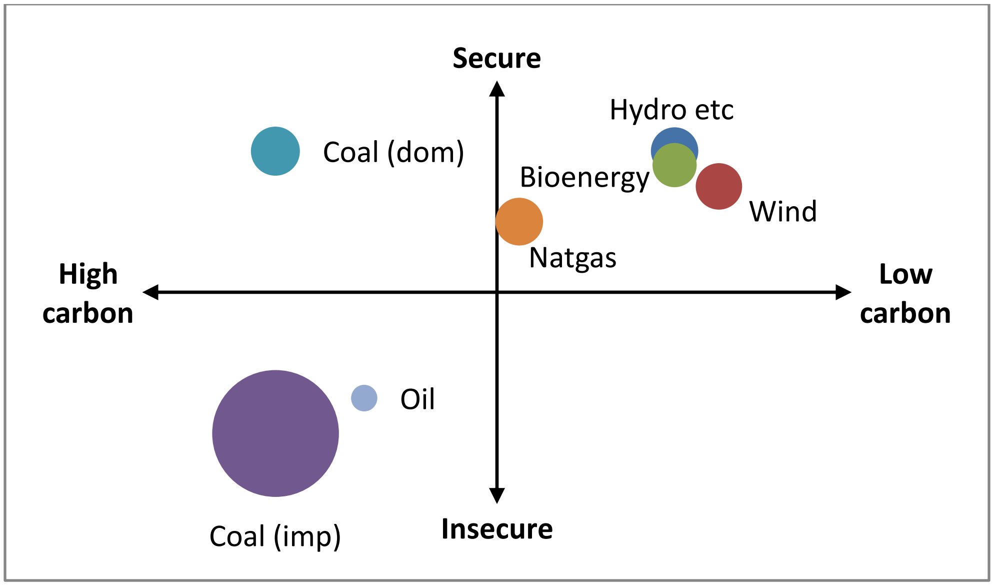

Figure 3: NSPI's supply mix and associated generation for 2020 (NEB, 2007)

It is unclear how the NEB expects NSPI to increase its consumption of natural gas when, by 2020, Sable will have ceased production and Deep Panuke will be in its final year of operation (NEB, 2007). If the natural gas supply is to be met from LNG, the natural gas bubble in Figure 3 will drop into the insecure, low-carbon quadrant.

2.2 Nova Scotia's energy end-use

End-use energy is the energy consumed in doing useful work, for example, in transportation, heating, lighting, and industrial processes, as opposed to, for example, electrical generation, which transforms one type of energy to another. Table 1 shows Nova Scotia's present energy end-use requirements for 2005 and projected to 2020. The end-use is met at present from a variety of sources, including electricity, refined petroleum products, and biomass.

Table 1: Nova Scotia's energy end-use in PJ[2] (from (NRCan, 2005))

Sector	2005	2020
Residential	34.1	37.3
Commercial-Institutional	39.9	52.3
Transport	82.9	96.0
Industry	40.3	40.5
Total energy end-use	197.2	226.1

If the end-use were to be met electrically, the total number of gigawatt-hours (GWh) required

[2] PJ or petajoule. A petajoule is 10^{15} joules or roughly the amount of energy found in 28 million litres of gasoline.

in 2005 and 2020 would be about 55,000 GWh and 63,000 GWh, respectively.[3]

2.3 Discussion

At present, electricity from NSPI meets about 22 percent of Nova Scotia's existing energy end-use requirements. If, as the NEB suggests, total supply does not change but overall energy end-use requirements increase, electricity could meet about 19 percent of projected end-use requirements in 2020. If Nova Scotia is to increase its consumption of electricity, it will require more generating capacity than it does at present. Given the cost of new generation facilities, it would be prudent for Nova Scotians to reduce their end-use consumption before increasing supply.

3 Reduce

The purpose of energy reduction is to lower the amount of energy required by a specific end-use activity. Energy reduction requires an improvement (i.e., reduction) in energy intensity (or an increase in energy efficiency); however, this is not enough, as an improvement in energy intensity does not necessarily translate into the anticipated or promised reduction in energy consumption (Sorrell, 2007). The question becomes one of, how is actual, measurable reduction going to be achieved?

3.1 Voluntary reductions

Reducing energy consumption can be achieved through voluntary programs, in which people "do the right thing" and reduce their consumption of energy. However, without an additional incentive, most voluntary programs fall short of expectation and people revert to their former habits (Mullally, 2007).

Overcoming the tendency of people to revert to their previous habits can be achieved, in part,

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[3] Converting PJ to GWh is a two-step process. First, PJ are converted into TWh (terawatt-hours) by dividing the number of PJ by 3.6, and then multiplying the number of TWh by 1,000 to obtain the number of GWh, as shown in the following table:

Energy	2005	2020
Total final demand	197.2	226.1
PJ to TWh	54.8	62.8
TWh to GWh (x 1000)	54,777.8	62,805.6

through the use of technological innovations that are designed to reduce energy consumption; examples of these include Energy Star appliances, fuel efficient vehicles, and improving a home's building envelop. However, as mentioned above, improving energy efficiency need not result in an actual energy reduction; for example, if the financial savings associated with reduced energy consumption are translated into higher energy consumption activities, any or all of the savings can be lost (Sorrell, 2007).

3.2 Technological transparency

One way of overcoming the limitations associated with voluntary measures is through the adoption of technological solutions that offer the same services while reducing energy intensity. A good example of this is the compact fluorescent light which can replace incandescent light bulbs, producing the same number of lumens while consuming less electricity. Similarly, most modern refrigerators consume less electricity than models built a decade ago. These technological solutions which are effectively invisible or transparent to the consumer as they impose no hardship on the consumer, offer the same functionality while reducing energy intensity.

As energy intensity decreases, the cost of operating the item can decrease as well. However, as with voluntary reductions, if consumers take the financial savings gained through using less energy and apply these savings to other energy consuming products, the end result can be an increase in energy consumption.

3.3 The cost of electricity

Voluntary measures and technological transparency offer limited success in reducing energy consumption. An alternative approach to encouraging consumers to change their energy consumption patterns is energy pricing. By adjusting the price of energy down, consumers typically respond by increasing consumption, while adjusting the price up often results in decreased consumption.

Electricity pricing is somewhat easier than pricing other energy products, such as gasoline or home heating fuel, in that the consumer typically has a single meter registering consumption. With these other products, registering consumption is more of a challenge as the consumer has the choice of multiple vendors.

The vast majority of NSPI's consumers use induction meters which simply record the total consumption of electricity, naturally leading to a flat-rate billing system in which the consumption charge is obtained by multiplying the total consumption by a unit-energy charge. Flat rate billing offers little scope for price signaling. Increasing the unit-energy charge is a very coarse instrument as it must incorporate all fuel costs into a single price.

Inverted block billing takes the consumer's total consumption and divides it into blocks; each block is associated with a unit-energy charge that increases with each subsequent block. The inverted block offers much more scope for price signaling—increased consumption means increased cost. However, as with flat rate billing, the cost of the electricity need not reflect the actual cost of its generation.

The cost of the electron varies with the means by which it was produced—utilities assign a "merit order" to each of their generation units, specifying the order in which generation units are brought on line. Merit order is usually determined by the fuel cost associated with each generation unit; for example, the merit order of a utility such as NSPI would be coal, hydroelectric, oil, and natural gas. Electricity generated overnight is typically less expensive than that generated during the daytime—the most expensive electricity is generated during the evening peak hours. Clearly, to be fair to all consumers, the cost of the electricity they consume should reflect the cost of the energy used for its creation.

In order that the consumer pay the actual cost of generation, it is necessary to match the consumption with the fuels used at the moment of generation—induction meters do not capture the time element as they have a single register. Multiple register meters that record the amount of electricity consumed at a given time interval are commercially available and are used by utilities such as NSPI in their domestic service time-of-day tariff that has variable electricity costs, depending upon the time of day and season. The time-of-day tariff charges the consumer less for electricity consumption during the overnight hours when the generation comes from coal, and more during the daytime and peak, when the generation comes from a variety of more expensive sources.

Time-of-use meters with multiple registers allow price signaling, not only to encourage consumption reduction during times of expensive generation, but also to discourage consumption of electricity generated from "undesirable" fuels such as coal.

3.4 Discussion

Reduction in the consumption of electricity is possible given the right conditions. A number of studies have shown that reduction in energy consumption in one area often leads to increases in consumption in another. As a result, the energy consumption of individuals and society increases inexorably.

One way of encouraging reduction in energy consumption is through pricing. Since the cost of generating electricity varies throughout the day, it makes sense to vary prices with time. NSPI's recently approved Fuel Adjustment Mechanism allows the company to calculate the cost of electricity for the fuel used in generation rather than estimating it during a rate case. Although the company's hourly fuel consumption is know, consumers are still charged an aggregated price because induction meters only indicate the volume of electricity consumed. Time-of-use meters with multiple registers can record the volume of electricity consumed for specific periods throughout the day, this information, when joined with the utility's production data, means the consumer can be charged for the energy used to create the electricity consumed. This eliminates cross-subsidies and can be used to implement policies that encourage changes in consumption habits.

For as unpalatable as price increases may seem, by increasing prices through taxation and using the revenues for energy reduction programs, it may be possible to prepare Nova Scotians for world energy price increases and potential shortages. Reduction can only go so far—it is also necessary to find new sources of electricity to meet existing and future growth in electrical demand.

4 Meeting demand: replacement and growth

In the late twentieth century, the major concerns surrounding energy focused on the environmental impacts of various energy sources. Today, in addition to the environment, there is a growing awareness of the importance of energy security. Our reliance on electricity illustrates this.

Although electricity is considered a "clean" energy source, it is often generated from "dirty" primary sources, most notably coal. From an environmental perspective, the push is to eliminate coal—in terms of energy security, if the coal is from domestic, secure sources, it is more secure than imported coal. On the other hand, wind is considered to be a benign energy source, making it attractive environmentally, but its intermittency can require backup, which can reduce its attractiveness as a secure form of energy.

The relationship between energy security and carbon emissions can be illustrated in a security-climate graph, as shown in Figure 4.

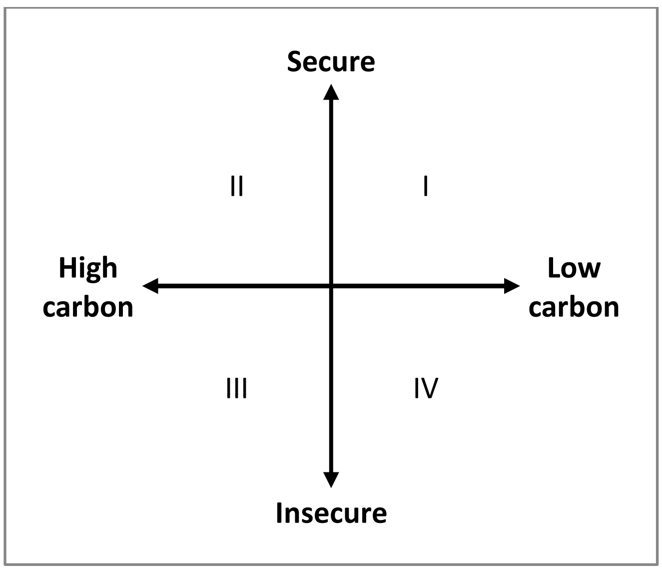

Figure 4: A security-climate graph

Each quadrant in the graph represents a security-climate combination—the characteristics of each quadrant are:

I. Secure, low-carbon. Energy sources in this quadrant offer a jurisdiction security of supply and lower emissions; as the source moves to the upper-right of the quadrant, its security increases and emissions decrease. Energy sources in this quadrant include domestic supplies of natural gas, nuclear (fueled with domestic supplies of uranium), hydroelectric, and solar thermal (thermal and photovoltaic).

II. Secure, high-carbon. This quadrant includes domestic energy sources with "high" carbon emissions, ranging from brown coal through petcoke and heavy-to-medium crudes.

III. Insecure, high-carbon. Energy sources in this quadrant are the least desirable in that they are both insecure and high-carbon emitters. Sources become more insecure and higher-carbon as they move further to the bottom-left; for example, from imported oil to imported coal.

IV. Insecure, low-carbon. Examples of these energy sources include imports of natural gas or liquefied natural gas, which are low-carbon but can be easily curtailed by the supplier.

Given the importance of energy security and climate change, jurisdictions should be encouraging movement in electrical generation towards quadrants I and II:

- Existing thermal generation (i.e., coal, oil, and natural gas) should replace existing insecure supplies with ones that are from secure sources, preferably domestic (quadrant II).
- New generation should occur in quadrant I.

The above illustrates the dichotomy between security and climate: increasing security can occur at the expense of the climate if the jurisdiction opts to increase its use of carbon-intensive fuels. In Nova Scotia, growth is occurring in quadrants I and III, with increased coal consumption and a growth in renewables (notably wind), as shown above in Figure 3.

Nova Scotia does have quadrant II options, notably increased consumption of coal from its existing mines. It has two quadrant I electrical options:

- The proposal for 300 MW of tidal power capacity in the Minas Basin could produce about 1,300 GWh of electricity at 50 percent capacity factor. This figure is subject to a number of caveats, notably the state of the technology, the impact of the technology on the environment, and whether the anticipated energy actually exists.
- The province’s goal of some 500 MW of wind could produce about 1,000 GWh of electricity at 25 percent capacity factor. Despite its proponents’ claims to the contrary, wind is intermittent and will need backup sources of energy—Nova Scotia has limited options here: natural gas turbines (would result in additional greenhouse gas emissions), pumped storage (a viable option that has environment implications), and compressed air (storing the electricity as air in salt caverns, such as the one proposed for natural gas near Alton).

Other quadrant I options open to Nova Scotia include nuclear power (a single 1,000 MW nuclear reactor, operating at 80 percent capacity factor would generate about 7,000 GWh of electricity with limited greenhouse gas emissions) and the purchase of electricity from outside the province (for example, from New Brunswick or Newfoundland and Labrador).

4.1 Energy end-use

The problem with the province's focus on electricity supply is that it fails to take into account the type of end-use application that will need the electricity. One of the results of this are energy policies that require utilities to take ever increasing volumes of intermittent electricity without regard to the impact on overall supply. These problems can be overcome by considering how the energy will be used by the end-use application and then matching the application with the supply.

Space and water heating are examples of an end-use application that could be coupled with an intermittent source of electricity such as wind (Hughes, Dhaliwal, Sheth, & Long, 2006). Wind-heating is an example of a quadrant I application that is both secure and low-carbon.

4.2 Discussion

Replacing supplies of energy to meet Nova Scotia's existing and future electrical needs will be a challenge, given the twin problems of energy security and climate change. The province's overwhelming reliance on coal from Venezuela and Columbia and the proposals for more intermittent wind will do little to improve energy security and reduce carbon emissions.

To improve energy security it will be necessary to find secure sources of domestic electricity. Although New Brunswick is pushing for 1,000 MW of new nuclear and Newfoundland and Labrador expect to have 2,800 MW from Gull Island and Muskrat Falls (Lower Churchill) on-line sometime in the next decade, there are other players with designs on these supplies of electricity—in other words, there is no guarantee that Nova Scotia will have access to them. Furthermore, even if Nova Scotia could enter into contracts for this energy, the competition will be such that the total may only be a few hundred megawatts.

Which leaves Nova Scotia looking at its supply of coal, which is secure, being domestic, but is a significant source of carbon dioxide when used in the generation of electricity. The province's geology means there is little prospect for carbon capture and storage or carbon sequestration, meaning that the Nova Scotia's coal is secure but high-carbon.

Nova Scotia's tidal and wind electricity prospects offer the opportunity to replace existing insecure, high-carbon coal with secure, low-carbon sources—however, this may be offset by:

- The need for backup to overcome the intermittency associated with wind and to a lesser extent, tidal electricity.
- The need for more electricity should Nova Scotians push for more electricity to meet their end-use applications.

One way of addressing the above is to match applications that can be charged intermittently with intermittent supplies of intermittent electricity, including plug-in hybrids and electric thermal storage. In order to match applications with supply, advanced metering and the development of an intelligent grid is necessary.

5 Recommendations

Although it appears unlikely that Nova Scotia will achieve an "electric future" anytime soon, that does not mean that Nova Scotians will not increase their reliance on electricity for more of energy end-use applications. In fact, as other energy sources become more expensive or scarce, it is likely that people will rely on electricity in increasing numbers given its pervasive nature. For example, individuals unable to purchase heating fuel, either because of its cost or availability, are likely to turn to electricity as their heating source—by turning on their oven or using an electric baseboard heater. In such a scenario, if sufficiently large numbers of people began consuming electricity "unexpectedly", the result could be brownouts or even blackouts.

Given the inevitable increase in demand for electricity, a structure must be in place to handle these changes. The following recommendations lay the groundwork for such a structure:

R1. All electrical consumers must connect to the provincial grid with multiple-register time-of-use meters.

Comment: Multiple-register meters include a time-component, matching consumption with time-of-consumption. This allows consumers to be charged both for the electricity consumed and the type of fuel used in the generation of the electricity. It will also enable intermittent applications to be charged for being supplied with intermittent sources.

R2. The provincial grid capacity must be increased and strengthened to allow Nova Scotians greater reliance on electricity for their end-use applications.

Comment: Increasing demand for electricity will test the limits of the existing grid, increasing the likelihood of grid failures. An ongoing program to upgrade the grid is needed to meet the anticipated demand.

R3. End-use applications that can operate intermittently should be coupled with intermittent generation.

Comment: The two largest end-use applications in the province are transportation and heating—both of which will increase their reliance on electricity. Hybrid plug-in vehicles and electric thermal storage units can operate with intermittent supplies of electricity such as wind.

R4. The province should support the development of technology that integrates intermittent applications with intermittent supplies.

Comment: This technology does not exist at present, but is needed if intermittent supplies are to make a significant contribution to the province's future energy needs.

R5. All energy sources must be subject to energy taxation.

Comment: All energy sources must be taxed to encourage a reduction in consumption and to create a revenue stream to pay for projects to offset rising energy costs. However, taxes must be collected and administered by the government, not private organizations. NSPI's proposed demand side management proposals to raise rates to cover the DSM costs are an example of how this should not be done.

6 Concluding remarks

The volatility now being witnessed in energy markets is expected to continue well into the future. This volatility will be felt in a number of ways, not least in decreasing energy security in jurisdictions, like Nova Scotia, that rely heavily on imported energy. Energy security is more than simply security of supply—it is also security of infrastructure: the failure or loss of either or both of these components will have serious repercussions for the jurisdiction.

As oil prices continue to rise, many Nova Scotians will look for replacement sources of energy. Electricity becomes an ideal choice because its infrastructure reaches most households and businesses in the province. Those with sufficient income will move towards electricity to meet their transportation needs with, for example, plug-in hybrid vehicles. On the other hand, many who are unable to afford heating fuel will turn to electricity to stave off the effects of a cold winter. Still others will turn to electricity for heating as it is considered a clean energy source. Regardless of the application, if Nova Scotia's demand for electricity increases unchecked, energy security will be put at risk with the possibility of brownouts or blackouts and there will be little chance that coal will be replaced by wind or tidal.

One of the first steps in improving Nova Scotia's energy security and moving it to a low-carbon emitter is to change the way electricity is metered. By abandoning induction meters in favour of multiple-register meters, consumers can be charged for the type of generation used to generate the electricity they consume. Multiple-register meters will also allow tracking of applications intended for intermittent sources, such as wind.

In the twenty-first century, the world will change the way it views and uses energy. At present, Nova Scotia is ill-prepared for the changes that are already underway—rising prices and unexpected shortages will probably hurt Nova Scotia more than other provinces because of its reliance on imported energy.

"Does Nova Scotia have an electric future?" The short answer is, yes; however, it will be radically different from what Nova Scotians see today.

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