Nova Scotia Electricity System Review

Summary Report—Emerging Technology and Market Trends Studies

NOVA SCOTIA

Contents

Background

1.1 A review of our electricity system

In Fall 2013, the Government of Nova Scotia announced a comprehensive review of the province's electricity system. A legislated commitment under the Electricity Reform Act, the review focuses on three areas:

- emerging technologies
- market trends in supply and demand
- trends in the oversight and delivery (governance and structure) of Nova Scotia's electricity marketplace

Technical studies on these topics were developed as part of the first phase of the Electricity System Review. The purpose of the studies is to help the Department of Energy and the public better understand the challenges, opportunities, and possible solutions for the province's electricity marketplace over the next 10 to 30 years.

The studies will be further refined as more information becomes available. For example, the Utility and Review Board (UARB) is currently leading an integrated planning process to examine future needs and options for supply of electricity using a variety of planning scenarios. This process includes extensive input from stakeholders. The results will be integrated into the Electricity System Review studies later this year.

The findings of the studies will form the basis for public consultation on Nova Scotia's electricity future, which will take place in Fall 2014.

This document summarizes the findings of the studies on emerging technology and supply and demand. The governance study will follow later.

1.2 Nova Scotia's electricity system today

Nova Scotia has a vertically integrated utility, meaning that Nova Scotia Power Inc. (NSPI) generates, transmits, and distributes most of our electricity. NSPI owns over 95% of the province's systems for the creation and delivery of electricity.

NSPI is a publicly regulated private corporation, so the amount of capital it can invest is limited and the UARB regulates the amount of profit it is allowed to earn on those investments. Provincial law caps the amount of executive salary that can be recovered through rates, and the UARB regulates the operating costs of the utility.

NSPI traces its roots back to a time when Nova Scotia had multiple electricity utilities—the provincially owned Nova Scotia Power Commission, the privately held Nova Scotia Light and Power Company Limited, and numerous municipally owned utilities. In 1972, the Power Commission consolidated much of the electricity sector when it bought out the private utility.

The result was the Nova Scotia Power Corporation (NSP), a utility with economy of scale to serve all parts of the province. In 1992, NSP was sold in a public offering to private investors, who took responsibility for the utility's debt. The new company eventually evolved into a separate company known as Nova Scotia Power Inc. (NSPI), which is wholly owned by the publicly traded company Emera Inc., with head offices in Halifax.

Six of the municipally owned utilities remained independent. They operate small electric grids in Antigonish, Berwick, Canso, Lunenburg, Mahone Bay, and Riverport. These utilities buy electricity from NSPI and other sources, generate some of their own, and sell directly to their customers. Like NSPI, the municipal utilities are regulated by the UARB.

Independent Power Producers (IPPs) generate electricity and sell it to NSPI. They currently supply a significant amount of the province's renewable energy, such as wind and biomass. More than 70%[1] of the large-scale wind turbines generating electricity in Nova Scotia are independently owned by companies other than NSPI.

1.3 Past energy generation

In order to consider the future of electricity in Nova Scotia, it's important to understand our past.

Many of the first electricity customers in Nova Scotia were served by small hydroelectric facilities throughout the province. As demand for electricity grew, new sources had to be found.

By the 1970s, oil had become the primary source of electricity. That changed in the aftermath of the double OPEC crises when oil supply shortage caused prices to double, then double again. The age of cheap oil—and cheap electricity from oil—was over.

[1] NSPI's website (www.tomorrowspower.ca/story/future) indicates that there are 178 commercial-sized turbines in Nova Scotia, 128 of which are independently owned.

In the face of global price shocks, the province decided to produce electricity from coal. Much of it was mined locally and prices were relatively low, so investing in coal-fired plants made economic sense at the time. Historically, and even as recently as 2006, coal and related products provided more than 80% of the province's electricity needs.

Over the past decade, the situation has changed. Closure of local coal mines and changes to emissions regulations mean that a significant portion of the coal used to produce electricity is now imported from the United States and Colombia.

Reliance on imported coal leaves Nova Scotia vulnerable to the volatility of global coal prices. Prices rose as much as 75% in recent years, before falling back somewhat. Each time prices rise and fall, they fall back to levels that are higher than the initial prices. Current forecasts show that prices will continue to rise due to growing global demand for coal.

Volatile prices paired with environmental standards have led Nova Scotia to begin moving from coal to less-polluting or non-polluting supplies such as natural gas and renewable energy.

1.4 Generation today

Electricity is generated at power plants located throughout the province, using fossil fuels (e.g. coal, pet coke, oil, and natural gas) and renewable sources of energy (e.g. wind, hydro, tidal, and biomass).

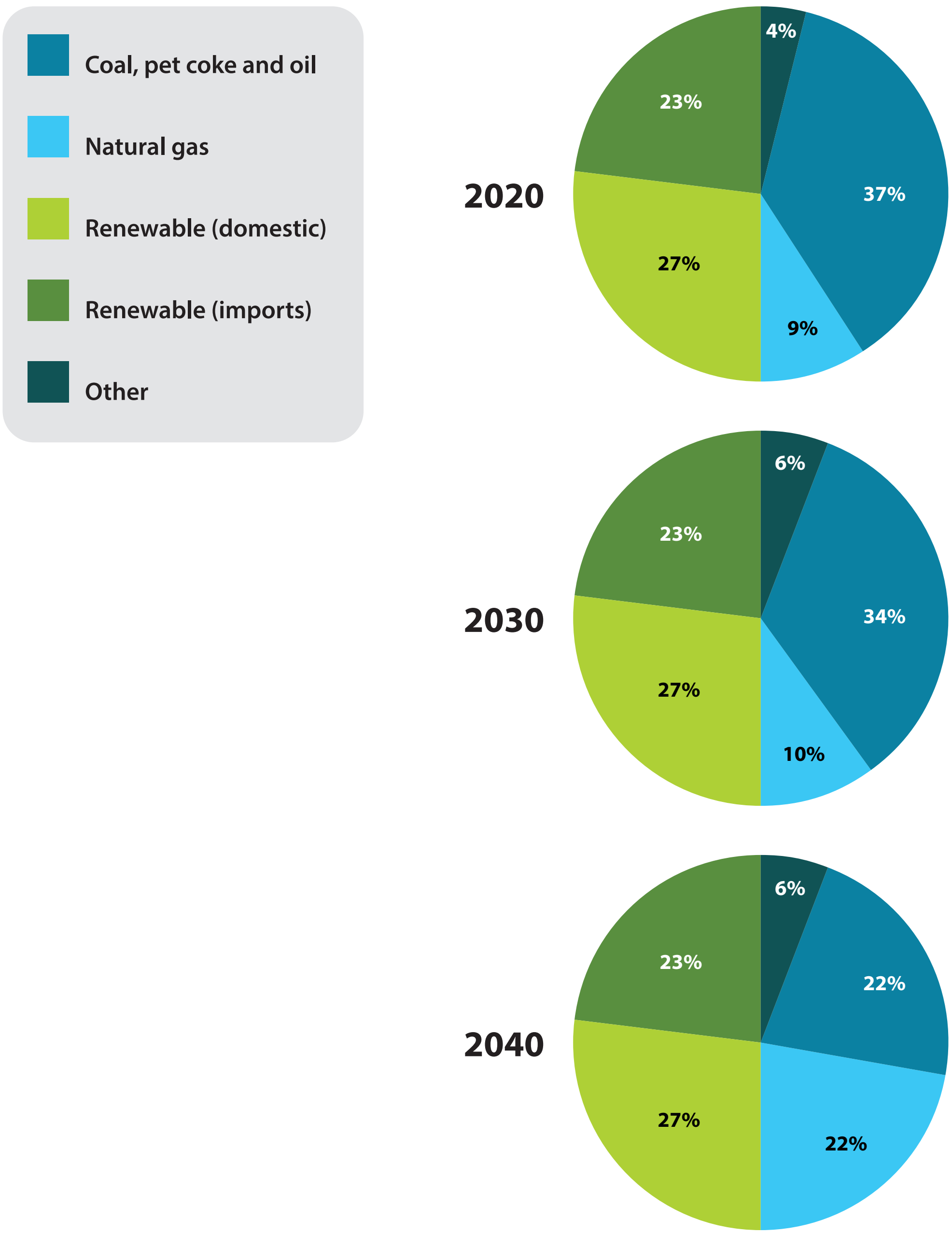
NSPI also imports electricity through a transmission line connecting Nova Scotia with New Brunswick. Together, local generation and imports make up the fuel or generation mix, which can change from year to year based on factors such as fuel prices, additions to renewable energy generation, and environmental regulations.

In 2012, NSPI generated 63% of the province's electricity from coal and pet coke, 12% from natural gas, 20% from renewables, and 5% from other sources such as oil and imported energy.

By 2020, 40% of the province's electricity will come from renewable sources of energy. That legal requirement will be met through existing projects under contract or new construction, including the Maritime Link.

Through the Maritime Link agreement between Emera and the Newfoundland and Labrador utility, Nalcor, an electrical connection will be built between Nova Scotia and Newfoundland. In return for paying the cost of building the link, NSPI will receive a fixed amount of electricity plus guaranteed access to surplus energy at accessible market price.

Estimated energy generation – 2020, 2030, 2040 (Fig. 1)



Source: "Analysis of proposed development of the Maritime Link and associated energy from Muskrat Falls relative to alternatives". Power Advisory, January 16, 2013

Demand

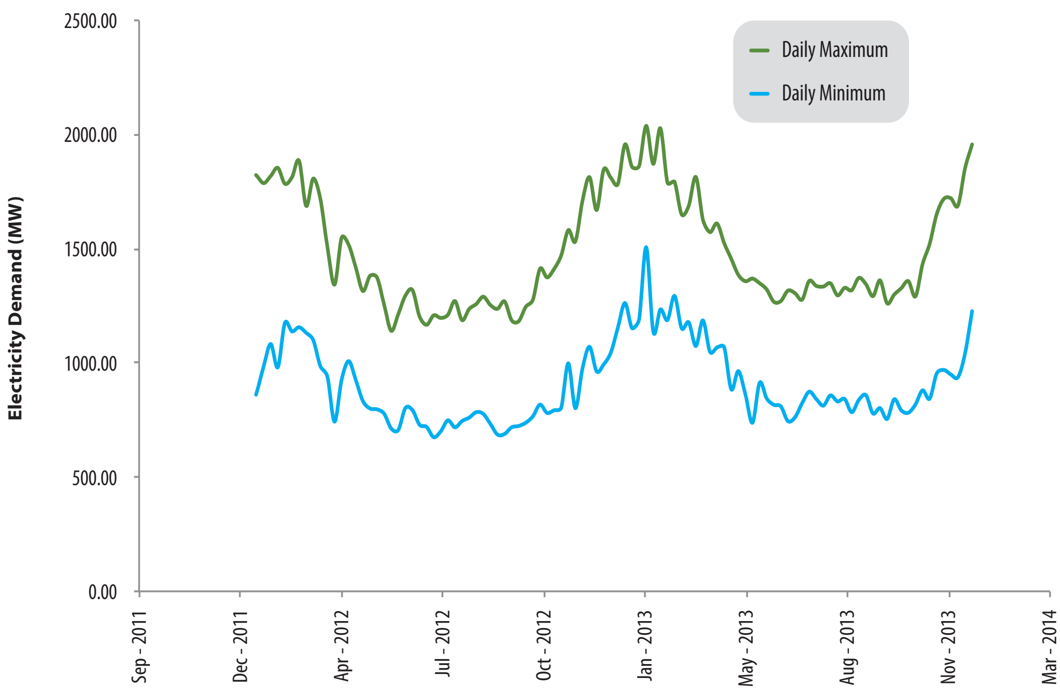
2.1 How much electricity do we need?

Nova Scotia's future electricity needs are based on complex and changing factors. Changes in our population, the economy, and the price of electricity affect how much electricity we need. The main factors driving our electricity use are weather and economic conditions.

Nova Scotia has a significantly greater need for electricity in the winter than the spring, summer, or fall. Like many other parts of North America, we use a lot of electricity to heat our homes, institutions, and offices during our peak season (December to February). That means the demand for electricity drops significantly from the spring to the fall, when there is little need for heating or cooling and the longer days reduce the need for lighting. Unlike other parts of the continent, we have relatively little need for air conditioning. There is a significant difference between our peak demand for electricity in the winter (2,200 MW) and in summer (700 MW).

This difference in seasonal need has a significant impact on what kinds of electricity generation we need (firm or intermittent)[2] and where we get it. It affects how our current power plants are operated and the kind of electrical generation sources we need in the future.

Electricity demand by date (Fig. 2)



[2] Firm sources of energy can be controlled by the utility, while intermittent sources are controlled by natural cycles (daylight, seasons, tides, etc.).

The different needs of electricity consumers will also affect our future need for electricity. The province currently uses about 11 TWh[3] of electricity annually, with approximately 44% used in the residential sector, 34% in the commercial sector, and 24% in the industrial sector.

Our planning for future needs is affected by the fact that close to 25% of our electricity sales are concentrated in five large industrial customers. This amount is lower than it was in the past; nevertheless, the addition or loss of large industrial customers can still significantly change the overall amount of electricity required to meet demands.

This is important for all electricity users because investments in generating plants, transmission, and distribution systems are largely fixed costs that still need to be paid for by all customers, even when less electricity is being used.

Getting the right balance takes careful long-term planning, and planning for some eventualities is easier than others. In today's global economy, our large industrial companies face business risks (world market trends, pollution standards, currency changes, etc.) that create uncertainties that may not be easily anticipated, or may be difficult to overcome.

Significant changes in the industrial sector (increases or decreases) and the resulting change in demand for electricity could come suddenly. With little time to plan, a reduction in industrial load would have a more significant impact on the electricity system than an increase. A properly organized and managed electrical system should accommodate increases in demand more easily.

Other factors affecting demand include a slow growing or falling population, growing numbers of electric appliances per household (more smart phones, multiple big-screen TVs and gaming consoles, etc.), improving efficiency of appliances and equipment, and a general shift toward energy efficiency. As all of these factors play out over time, outcomes could be widely different.

2.2 Forecasting electricity demand

Forecasting how much electricity we need in the future is a key part of the technical studies commissioned for the review, and understanding the implications of different long-range forecasts is a complex matter. To help build consensus, NSPI leads regular reviews with stakeholders and then reports to the UARB. This results in an update to an Integrated Resource Plan (IRP)[4] . A new IRP is currently underway.

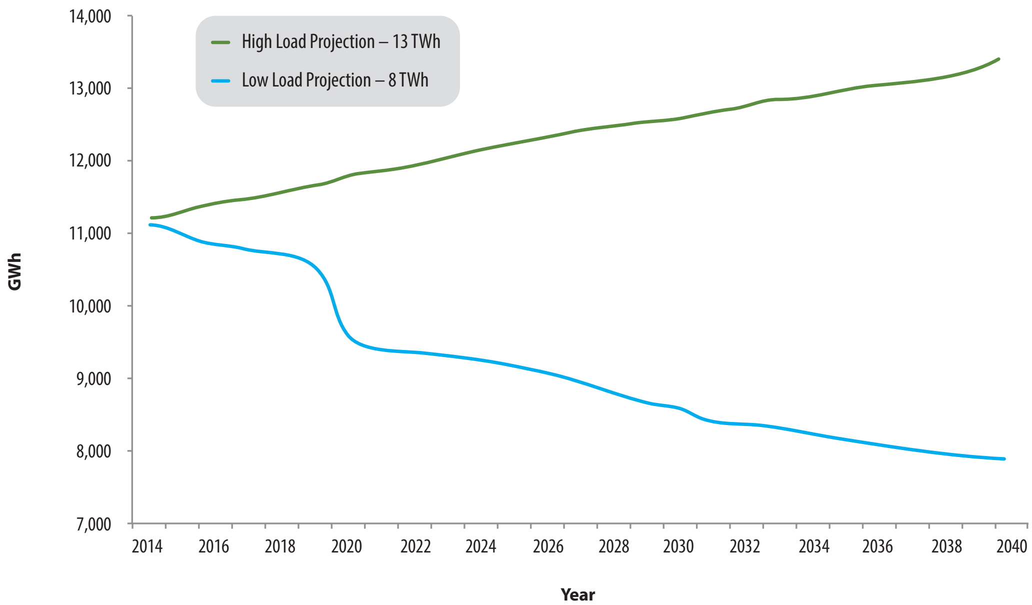
[3] TWh is a measure of the energy consumed by using one trillion watts for a period of one hour (www.nspower.ca).

[4] An Integrated Resource Plan is a long-term, flexible strategic plan for the electricity system. The IRP planning process looks at supply-and-demand scenarios and includes input from stakeholders.

As part of the 2014 IRP, NSPI developed forecasts for electricity demand considering scenarios with variations based on: (1) different levels of energy efficiency investments or demand-side management (DSM)[5], (2) growth in the use of electricity (or load on the system), and (3) changes in the industrial sector.

With this range of scenarios, the forecasts vary widely and illustrate the challenge of planning for the future—they range from 8 TWh to 13 TWh of electricity required in 2040.

IRP load growth projections (Fig. 3)



[5] *Demand-side management focuses on reducing the amount of energy we need through the use of energy efficiency and conservation programs (www.efficiencyns.ca).*

2.2.1 Demand in the industrial sector

As noted earlier, just five large customers dominate our industrial sector. They use two-thirds of the electricity in this sector and approximately one-quarter of the electricity used overall.

These large customers are mainly in the pulp and paper, cement, and rubber and plastics industries (e.g. tires). A significant change in technology, process, or production levels by any of these customers can have a major impact on electricity demand for the province. In general, the addition or loss of a large industrial customer could have considerable impact on future electricity demand.

2.2.2 Demand in the commercial sector

Nova Scotia's commercial sector uses just over one-third of the province's electricity. This share of the electricity demand has been declining over the last five years as use in the residential sector has grown.

Demand in this sector is related to the province's gross domestic product (GDP), and is impacted by factors such as the weather, demand-side management, and efficiency standards.

Projections based on these factors suggest that electricity use in the commercial sector will grow at around 1.2% a year, but energy efficiency programs and technologies will offset that growth by more than that amount. As a result, there is expected to be an overall drop in demand in this sector.

2.2.3 Demand in the residential sector

Residential demand accounts for 44% of Nova Scotia's electricity consumption. Residential sector demand is related closely to population growth, which is expected to continue at a very modest 0.2% per year. Other factors play a role as well: personal disposable income, electricity intensity of appliances (how much electricity is used by household appliances), weather, and the price of electricity.

By 2016, energy efficiency programs and technologies are expected to reduce residential electricity demand by more than the expected growth, resulting in an overall decline in the need for electricity in this sector.

2.3 Energy efficiency

Energy efficiency and DSM activities are resources that Nova Scotia Power and Efficiency Nova Scotia can use to meet Nova Scotia's forecasted growth in demand for electricity services. To this end, Nova Scotia began increasing its investment in energy efficiency program delivery in 2008.

From 2008 to 2013, 604 GWh of electricity (or 5.1%) were saved through energy efficiency activities. At the current electricity price, this amounts to close to $70 million. This saving comes from avoiding the cost of fuel for generating plants, and delaying the need for costly new generation that would be paid for by all customers.

The Government of Nova Scotia's Electricity Efficiency Plan—Using Less Energy outlines how the future of DSM will be steered by the IRP process. There is potential for energy efficiency to make a significant contribution to meeting Nova Scotia's future electricity needs.

2.4 Future electricity use

As discussed above, our future electricity needs depend on complex factors such as population growth and economic growth. Our future demand is also closely tied to the needs of our industrial sector, which is vulnerable to global and economic factors. Other external factors include the availability of natural gas, and environmental requirements such as federal regulations around the use of coal.

The IRP process models all of these impacts and uses modeling to examine scenarios with widely different outcomes for how much electricity we need. Not included in the modeling are events whose magnitude and impact are too uncertain to fully understand. For example, a new round of offshore exploration has just begun. A significant discovery could accelerate economic growth and impact the amount of electricity used in the province; however, the likelihood and timing are unpredictable.

Technology also has an impact on electricity use. Air-source heat pumps have become the heating source of choice for new homes in the province, creating further divides in our winter peak and summer low. Growth in the availability of electric vehicles, including the potential use for public transportation, will likely come over time, offering opportunities for planning. On the other hand, a change in industrial load could happen rapidly, with significant consequences.

2.5 Implications

The uncertain nature of electricity demand in the province speaks to a need for electricity system planning that is flexible and responsive to unpredictable and highly varied demands. A flexible system would include a range of electricity sources that can be accessed as needed.

A robust system with diverse energy sources is needed to manage the impacts of demand shocks. A sudden decrease in industrial load would have greater and more immediate impact than a steady increase in demand (e.g., through economic development).

Supply

3.1 Where does our electricity come from?

As discussed in the Background section, our electricity comes from a number of sources: coal and pet coke (on the decline), natural gas (used in varying amounts depending on whether price is high or low), and wind (increasing). This growing use of wind presents a challenge, as wind blows strongly enough to drive a turbine only about a third of the time in Nova Scotia. Energy production also tends to come up and down fairly quickly; however, as experience grows, the change can be predicted in advance.

As noted earlier, our need for electricity varies significantly by season. In the winter our heating demands are high, while in the summer our cooling needs are low. While this presents a challenge for operations with all forms of generation, fossil fuel plants can be idled and save on fuel when they aren't needed, while wind turbines produce electricity when the wind blows or the opportunity is lost.

It is also a challenge for the system to have a lot of our electricity coming from a source that is not always available when it's needed. How much capacity is too much for intermittent sources of energy? This is where seasonal changes play an important role. In the winter, wind could represent less than a quarter of our supply but on a warm June evening, when we usually need less electricity, wind could make up more than two-thirds of our supply.

Regulated fuel for generation and purchased power reported by Emera for Nova Scotia in 2013 (Fig. 4)

2013 Annual Production Volumes:

	GWh:	%:
Biomass (Renewables)	130	1%
Purchased Power (Renewables)	845	8%
Wind & Hydro (Renewables)	1,234	11%
Purchased Power (Other)	491	4%
Oil	89	1%
Natural Gas	1,317	12%
Coal & Petcoke	7,098	63%
Total:	**11,204**	**100%**

Source: "We Are Energy – Annual Report 2013", Emera, 2013

To date, there are commitments for wind totaling approximately 550 MW. Many of the province's wind farms operate under Purchase Power Agreements (PPAs)—long-term contracts between private owners and Nova Scotia Power to purchase renewable energy. Most of these contracts are for 15 to 20 years. The rest of the wind farms are owned by Nova Scotia Power and the cost is amortized over a similar period of time.

The province's first wind farm was commissioned in 2006, so PPAs can be expected to expire starting in 2026. With the bulk of Nova Scotia's wind projects built between 2010 and 2016, most agreements will have come to an end by 2036. This includes the majority of wind projects developed under the Community Feed-in Tariff (COMFIT) program[6]. It is important to note that with reinvestment and renewal, some wind projects could continue to operate into the 2040s, at a price that would be expected to be at market rates.

With these wind contracts, combined with the new contract for imported hydro and the potential for new tidal resources, the province has enough existing and committed energy supply (either owned by NSPI or under contract) to meet predicted demand until the end of the next decade.

While an increase in demand is predicted for residential and commercial sectors, an increase in energy efficiency and demand-side management, new large-scale wind projects, and the projected completion of the Maritime Link in late 2017 will allow the province to meet both forecasted demand and environmental commitments.

3.2 Becoming more connected

Today, Nova Scotia has very limited access to energy produced outside the province. That will soon change.

The Maritime Link project's 500 MW connection between Newfoundland and Nova Scotia will allow the province to access a firm 154 MW of electricity, and an additional 198 MW if we need it and when it is cost-effective. This additional energy is guaranteed to be at the accessible market price which has, generally, been lower than current energy costs in Nova Scotia. Depending on the season, imported hydro at market rates could provide a very significant share of our needs.

[6] COMFIT encourages community-based, local renewable energy projects by guaranteeing a rate per kilowatt hour for the energy the project feeds into the province's distribution electrical grid.

The Link also creates a new Atlantic electricity loop that strengthens Nova Scotia's connection to the North American grid, provides access to other energy import options, and may allow for greater use of our connection to New Brunswick.

Being part of a new energy loop will allow the province to import new supplies of clean energy, use imports to balance intermittent renewable generation in Nova Scotia, and potentially export surplus renewable energy in the future.

The connection with Newfoundland provides a strategic advantage for Nova Scotia by putting us first in line for energy from Muskrat Falls and also from Upper Churchill after it reverts back to Newfoundland in 2041. It allows Nova Scotia to negotiate better prices, since the loop means imports will be more readily available from either New Brunswick/Quebec or Newfoundland.

3.3 Environmental performance

Nova Scotia has committed to reducing greenhouse gas (GHG) emissions by approximately 25% in the electricity sector by 2020 to meet a provincially regulated cap of 7.5 million tonnes (MT), and 55% by 2030 to meet a cap of 4.5 MT.

In 2012, the federal government finalized a GHG regulation that would require Nova Scotia to close most of its coal-fired plants by 2030, at significant incremental cost to ratepayers. Recognizing the province's strong GHG regulations, the federal and provincial governments are finalizing an equivalency agreement that would stand down the federal coal regulation in Nova Scotia in favour of the provincial regulations.

Under the equivalency agreement, Nova Scotia will have more flexibility in how we use our dwindling coal-fired generation. For example, Nova Scotia's regulatory approach to GHG reduction would allow NSPI to concentrate the use of coal in the high-peak winter season.

Nova Scotia's renewable energy targets for the electricity sector are also working to green Nova Scotia's grid and support the goal of GHG reduction. Under the Electricity Act, the Renewable Electricity Standards Regulations require electrical utilities (NSPI and the municipally owned electrical utilities) to increase the portion of electricity generated from renewable sources to 25% by 2015 and 40% by 2020. This has encouraged the development of Nova Scotia's renewable energy sector.

NSPI is steadily decreasing the amount of electricity generated by coal in order to meet emissions and renewables requirements. In 2006, more than 80% of the province's electricity was supplied by coal. Today, approximately 60% of our electricity comes from solid fuels (coal and pet coke). By 2030 that portion is expected to drop well below 50% and perhaps become as low as less than 25% of our electricity production.

With our transformation to renewable energy and our GHG reduction targets, Nova Scotia is making strides to reduce air pollution to protect the environment and the health of all Nova Scotians. Measures to reduce air pollution have been coordinated with GHG reduction measures and the renewable energy transformation so that all three objectives can be met in an integrated and mutually beneficial way.

Nova Scotia approaches air pollution management through a flexible fleet approach, which allows for a variety of choices in fuel selection, unit operation, timing of operation, and seasonal use of units. Our regulated fleet caps will reduce sulfur dioxide emissions by 75% and nitrogen oxides by 44% by 2020. Additionally, by that time NSPI will emit less than 35 kg of mercury per year.

3.4 Planning for 2030 and beyond

Nova Scotia needs to focus planning on 2030 and beyond. Energy development requires long lead times. Large-scale projects and even some smaller-scale projects can take years to implement.

For example, discussions on the Maritime Link project began in 2008; energy will begin flowing almost a decade later in 2017. The province's Community Feed-in Tariff (COMFIT) program was first established in regulation in 2010 and the call for bids that resulted in the approval of the South Canoe Wind Farm took place the same year; however, South Canoe and many of the COMFIT projects won't be producing energy until 2015.

The province expects a gradual reduction in operating times of the existing coal-fired generation units, leading to their eventual retirement (approximately 153 MW toward the end of the decade), coupled with the need to refurbish some of the existing renewable generation facilities. This will require significant long-term planning to replace these sources with environmentally responsible and affordable alternatives.

Recent regional studies and the Electricity System Review's technical studies have all concluded that, with current and approved energy projects, Nova Scotia is expected to have all of the energy it needs until 2030. This general conclusion is subject to some qualification. For example, NSPI may need to modernize or replace the Tufts Cove generation plant in Dartmouth with a new base-load combined-cycle natural gas plant before 2030, or we may see significant tidal development in the next decade[7] . However, the general conclusion remains—much of the province's existing investments and commitments will meet our needs well into the next decade, which gives us time to design for the future.

The studies suggest that we use the next 5 to 15 years to plan for 2030 and beyond, investigate potential energy solutions, and manage demand growth through investments in grid modernization, energy efficiency, storage strategies, and possibly other generation technologies (once they are further developed).

3.5 Implications

2030 is becoming a critical planning point for electricity generation. The retirement of wind-power purchase agreements will allow for either renegotiation or a switch to whatever the most cost-effective renewable technology is at the time.

While post-2030 coal requirements are uncertain, it is likely that use will decrease as plants reach the end of their useful life. Having long lead times means we need to start planning now for a diverse future supply.

[7] The Marine Renewable Energy Strategy envisages upwards of 300 MW in capacity from in-stream tidal current devices in the next decade. However, that capacity comes only when the currents are running strong and the average output would be 120 MW (after accounting for the time of no output between tidal phases).

Price

4.1 What role does the price of electricity play?

One of the largest factors impacting our electricity system is the cost of electricity. It affects demand, supply, and the cost-effectiveness of technologies for the province.

Electricity prices have risen significantly over the past decade. One of the key factors for this increase was a rise in the price of coal at a time when coal was the primary fuel source for the province. This experience has highlighted two key lessons: (1) depending on one fuel source leaves the province highly susceptible to market fluctuations, either good or bad, and (2) these fluctuations should be mitigated by long-term, stable sources of electricity with predictable costs.

4.1.1 Renewable energy

Long term renewable electricity contracts tend to be higher than market-priced electricity; however, they offer long-term price guarantees that insulate against price shocks. Renewables offer more stable and predictable prices for the future. There are no associated spikes in fuel costs; they tend to have lower operating costs; and they are under long-term contract or fixed-investment regimes.

Transitioning to more renewable energy, and away from sources such as coal, makes it easier for the province to meet its requirements to reduce greenhouse gases and other air pollutants. The inclusion of renewable energy sources, including wind, tidal, and biomass, in Nova Scotia's energy mix helps to decrease the electricity system's overall carbon footprint.

Developing renewable energy sources in the province also makes it possible to secure longer-term contracts at lower prices than if NSPI were competing in the global marketplace. This is expected to stabilize energy prices in the long term.

Some municipalities (including in rural areas) also receive increased revenue and other economic benefits from renewable energy projects.

4.1.2 Natural gas

Natural gas is a cleaner fossil fuel and a stable energy source. This makes it very appealing in situations where energy stability is critical, such as in hospitals or other institutions. The use of natural gas in power generation has grown recently.

However, over the last two winters (2012/13 and 2013/14), high natural gas prices resulted in increased use of fuel oil. New England has recently experienced spikes in electricity costs due to reliance on natural gas as a primary electricity fuel.

As it is difficult to predict how long today's lower natural gas prices will last in an uncertain energy future, natural gas will continue to be just one piece of the province's cleaner energy mix.

4.1.3 Fuel diversity

With such uncertainty and volatility in future energy markets, diversity is the option that best balances price stability, environmental considerations, and energy security now and in the decades to come.

Future fossil fuel prices and limited access to supply represent the most significant risk for future price increases. This can be managed with access to less expensive supplies of electricity or expanded infrastructure for natural gas. Future policies (provincial or federal) that reflect a price penalty for carbon could also impact the cost of fossil fuel–generated electricity. This could potentially include natural gas.

Nova Scotia's fuel mix will be at least 40% renewable by 2020, and thus much better insulated against fossil fuel fluctuations.

4.2 Implications

It is anticipated that future electricity prices in Nova Scotia will be less volatile and will likely be in line with general inflation.

Technology

5.1 What role does technology play?

In addition to economic factors, there are technological developments that could significantly change the energy picture for Nova Scotia in the coming decades. Breakthroughs in technology are certain but no one can predict which new technologies will be successful, how or if they'll work in the Nova Scotia system, and when they will be available and cost-effective.

In general, technologies that could impact our future electricity system break down into two categories:

- those that change the way we generate electricity
- those that change the way we manage our system

These two concepts need to be considered separately and together. For example, a way to generate electricity that is promising but doesn't necessarily deliver it when we need it (such as solar or tidal) may become more attractive if we can store the electricity for use at a later time. In the case of these intermittent technologies, the costs today may be high, but if they come down enough over time, these technologies could play a significant role in creating a new electricity future over the medium and longer term.

The studies compare a number of innovative emerging technologies that are either still under development or commercially available but currently not deployed on a large scale within the province. The emerging technology study looks at solar (photovoltaic and thermal), hydrokinetic, carbon capture and storage, and onshore and offshore wind energy systems, and compares their cost of production in cents/kWh for the province. These cost estimates allow us to make comparisons between technologies and assess what impact their large-scale deployment could have on rates.

5.2 Comparing investment options

Both generation and management technologies require up-front investment over long periods of time. When comparing the relative merits and costs of different solutions, it's important to consider the length of these investments.

Like a house, these investments have a long life and, like a mortgage, the cost of paying for the investments will take place over many years. Different investments can have different costs. Some are mainly up-front, while others have continuing costs or require periodic upgrades or renewals. Inflation can be a factor in long-term investments, and so can the cost of capital to make the investments, including interest on debt or dividends on equity.

Using the house analogy, a mortgage can be seen as four costs: (1) an up-front cost (present value), plus (2) a series of payments that include a principal or capital repayment (payment), plus (3) the cost of capital (interest) and (4) a final amount of zero when the mortgage is paid off (future value).

It is possible to calculate the present value for each scenario and determine which has the lowest cost. A levelized cost takes into account the various streams of costs during the life of the investment. It allows us to compare projects that might have a low capital investment but continual costs (such as fuel) against projects that might have higher capital costs but then save energy every year.

Levelized cost of electricity (Fig. 5)

Technology	Unit	2020	2030	2040
Distributed On-Shore Wind	$/kWh	$0.133	$0.126	$0.118
Central Station On-Shore Wind	$/kWh	$0.091	$0.087	$0.081
Off-Shore Wind	$/kWh	$0.230	$0.212	$0.188*
Distributed Residential Solar PV	$/kWh	$0.354*	$0.314	$0.290*
Distributed Commercial Solar PV	$/kWh	$0.320*	$0.286*	$0.263*
Central Station PV	$/kWh	$0.213	$0.196	$0.178
Central Station Concentrating Solar Power	$/kWh	$0.275	$0.254	$0.227
Tidal Current	$/kWh	$0.212	$0.158	$0.158
Wave	$/kWh	$0.506	$0.345	$0.249
In-Stream (run-of-the-river)	$/kWh	$0.265	$0.217	$0. 217
Biomass	$/kWh	$0.146	$0.142	$0.136
Central Station Geothermal	$/kWh	$0.121	$0.121	$0.121
Combined Cycle Natural Gas Generation	$/kWh	$0.087	$0.096	$0.103
New Pulverized Coal Plant with Carbon Capture and Storage	$/kWh	$0.200	$0.180	$0.180

Note: Nova Scotia has recently set rates for tidal development within the province. **(*) updated June 16, 2014.**

This is the framework that enables us to determine the economic feasibility of an investment in technology. Many technologies are technically possible today, but if they aren't economically feasible, their deployment may result in an increase in electricity rates.

Cost impacts are often a question of scale. Small-scale investment in emerging technologies or pilots has relatively little impact. However, large-scale adoption of technologies with a higher levelized cost of electricity (LCE) than our current investments means electricity rates will likely increase.

Calculating the LCE also factors in the suitability of a technology for our system given the availability of the resource within the province. For example, the capital cost of a technology may decrease significantly, but if the province doesn't have enough of the fuel source when we need it or a system that can store it, the levelized cost will stay fairly high.

Renewable sources of energy have the added benefit of drawing on local resources like wind or water. This keeps more money in the province, creates local jobs, and provides energy security and price stability by allowing for longer-term contracts under more favourable conditions.

Finally, some technologies already have global deployment and many strong international technology players, with no particular advantage for Nova Scotia. Others, such as tidal current technology, may have more economic promise because there is no dominant player or jurisdiction with significant experience.

Nova Scotia has the advantage of a world-class resource base and significant ocean industry capability. The province is taking advantage of this opportunity to concentrate efforts on developing tidal knowledge and experience here for exporting around the world.

There will be more opportunity to incorporate emerging generation technologies in the 2030s as the province replaces older central station coal and natural gas plants. Potential exists to further develop wind and tidal power to fill this gap.

Determining which technologies are cost-effective for our system is important because of the cost for customers. Nova Scotians must compare the cost of producing a KWh of electricity (the levelized cost of energy) with the cost of electricity in the province. Jurisdictions that have much higher cost of electricity (UK, New York) are able to access more expensive technologies without impacting the rate base.

5.3 Summary of generation technologies

The following section highlights generation technologies that are relevant to Nova Scotia.

Solar to generate electricity (photovoltaic, or PV): Nova Scotia has a good solar regime (many hours of sunshine) so hot water heating by solar can be quite economic. However, when it comes to generating electricity, the best days for sun are the days when we need it the least.

Given that we are currently committed to significant intermittent wind resources, adding more large-scale intermittent sources of electricity (such as solar PV) will require more control systems and storage systems.

Integration costs for the first 500 MW of capacity were fairly reasonable, but technology studies by General Electric and Hatch have pointed out that those costs will be much higher if we move beyond that level. This assumption is based upon the current cost of technology and systems.

Biomass: Biomass fuel stocks and research may provide opportunity for innovation within the province. Agricultural biomass may provide research and development opportunities for a wide range of energy products and, in some cases, fuel for firm electricity supply.

Geothermal for electricity generation: Aside from Springhill, there is little geothermal potential within the province for electricity generation. Geothermal heating is possible, but it is used to lessen demand, not to generate electricity on a large scale.

Carbon capture and storage: There are no significant opportunities for carbon capture and storage within the province. The Carbon Capture and Storage Research Consortium of Nova Scotia is currently working in Cape Breton to determine whether there is sufficient technical storage capacity for one coal plant.

District energy systems: At the community scale, District Energy (DE) systems represent potential opportunity for the province. They generate and distribute energy to buildings within a specific geographic area. The implementation of these systems is site-specific (depending on geographic location, fuel type, and availability). Net environmental benefits of proposed DE systems should be considered in relation to existing alternatives. Natural gas is currently the most commonly used fuel source in Canadian DE systems.

Tidal (hydrokinetic) energy: The development of hydrokinetic energy, specifically tidal power from the Bay of Fundy, offers great opportunity to Nova Scotia as a clean renewable source of power. The International Energy Agency believes that these technologies could start to play a sizable role in the electricity mix around 2030.

5.4 Advancements in technology

Today's electrical system is a series of one-way relationships. NSPI and the other utilities plan for general patterns of electricity use and have enough extra power ready in reserve if more is unexpectedly needed. The one-way relationship is from customers to the utility— customers request more electricity, and the utility responds.

Increasingly, though, there is a new one-way relationship. Intermittent generation sources such as wind tell the utility that they have power to deliver. Without an ability to manage these new relationships better, the system will become inefficient and costly for everyone.

Fortunately, technology is emerging that can do a better job of optimizing the system. Communication and forecasting tools combined with storage and load controls can give us a system with many relationships, constantly tuning the supply and demand for electricity.

This new technology holds the promise of more cost-effective micro grids and new rate systems to ensure that we get the best value out of the investments we are making today. It will also provide new options for 2030 when we have largely paid off the investments of the past.

For this reason, gaining greater value from investments already in place (renewables) and soon to be in place (new renewables and the options made possible by the Maritime Link) is a key goal for the next 5 to 10 years. The key to getting that increased value is creating an electrical system that is more responsive.

The future electrical system will be able to respond to an increase in demand from one sector by reducing demand in another. It will respond to a drop in supply from one intermittent source by drawing power out of storage. And it will do this through increasingly complex control systems.

5.5 Managing the need for electricity

Changing our electricity system's one-way relationship into a dynamic two-way relationship is already being tested in the region. PowerShift Atlantic is a research program aimed at enabling the system operator to control customer loads so that it acts as a virtual power plant.

In New Brunswick, the pilot allows the system operator to turn down commercial freezer systems by a degree or two for a while when the demand for electricity is high, then build up the temperature later on when other users need less. It also works well if the wind goes into a lull, with freezers dropping a bit then chilling more when the wind is back up.

In Nova Scotia, the pilot uses electric hot water heaters to shift heating to off-peak times. Customers opt into the program, and adjustments made to their appliances are not noticeable.

5.6 Managing electricity through storage

Not all storage options require the development of new technology. The province's agreement for hydro power through the Maritime Link will provide access to the lowest-cost form of storage possible. Water stored behind dams can be held, or released to generate power. The release can be carefully timed to match changes in need, including changes in the availability of wind.

Two of our larger renewable energy sources today—wind and tidal power—will require new storage technology in order to be used to their full potential.

On very windy days, the output from wind turbines may exceed the overall demand for electricity. Since the technology isn't yet available to capture and store that energy for later use, we "spill" or curtail power we can't use.

The 550 MW of wind energy that the province has committed under contract is essentially all that is cost-effective to integrate into our grid system without new storage technology. Given our low summer demand for electricity, additional sources of wind energy would require storage options or other balancing options for when the wind is not producing enough power.

Solar is another intermittent source of energy that requires storage for large-scale viability. Since Nova Scotia's electricity demand peaks occur in the winter months, and solar systems primarily produce energy when the sun is shining strongly (i.e. during the day in summertime), without storage capabilities large-scale solar isn't currently practical for Nova Scotia.

A number of energy storage technologies are available today and new technologies are being developed. The selection of the most appropriate storage technology depends on whether the objective is power quality (small amounts for relatively short periods of time) or management of the bulk power system (large amounts of power for longer periods of time).

Batteries, flywheels, and supercapacitors are more adapted to address power quality issues, while technologies like pumped hydro and compressed air energy storage are more adapted to managing the bulk power system (handling the integration of renewable energy).

5.7 Communicating and controlling to build our future system

Using advances in telecommunications, computers, and other parts of information technology systems, utilities are beginning to develop a "smart grid" that can pull together all the technologies that generate, shift, and store electricity. Through the development of accurate, low-cost monitoring systems to communicate with suppliers and consumers, the system can be managed more efficiently.

Another key part of our future electricity system is a series of price signals to provide rewards for agreeing to delegate some degree of control. Incentives to allow some hot water heating or commercial chilling to be shifted to the middle of the night (or another period of low demand) help to build support for the change.

Advanced metering infrastructure (AMI) is part of a smart grid. It consists of digital hardware and software that collect and analyze energy-use data and provide continuous two-way communication between on-site electricity meters and the utility.

Essentially, AMI can help a power utility and its customers make informed decisions about energy use based on the price at the time of use (for example, a controller that would turn on a hot water heater at off-peak times). Availability of this real-time load information would result in cost savings, and improved forecasting and planning.

The first step in grid modernization would be to develop a master energy management system (EMS) architecture. An EMS system would allow the utility to integrate a range of renewable generation supplies and storage systems, control consumer loads, and implement advanced signaling to make full use of the transmission and distribution system.

A baseline of information would then allow the system to evolve over time. EMS would likely be developed in phases, with manual controls evolving in the future to automated operation. The EMS would eventually recognize specific energy patterns and would be able to schedule interaction of generation, storage, and loads.

5.8 Implications

In the short term, the province can gain significant value by managing our existing electricity resources better through technologies that focus on automation, communication, and load shifting, with an appropriate rate system that supports such change.

The province should also focus in the short and medium term on opportunities to explore and pilot new technologies such as storage, better utility efficiency, and regulatory support for micro-grid development in preparation for 2030 planning.

Decisions to support technologies with a high levelized cost of electricity should support provincial objectives around innovation and economic development.

Meeting environmental requirements must be done in a way that considers cost-effectiveness. Decisions to adopt new technologies on a large scale need to take into account our current and expected future cost of electricity in terms of both affordability and competitiveness.

NOVA SCOTIA