2020

INTEGRATED RESOURCE PLAN

NEW BRUNSWICK
POWER CORPORATION

Énergie NB Power

the power of possibility
débordant d'énergie

Contents

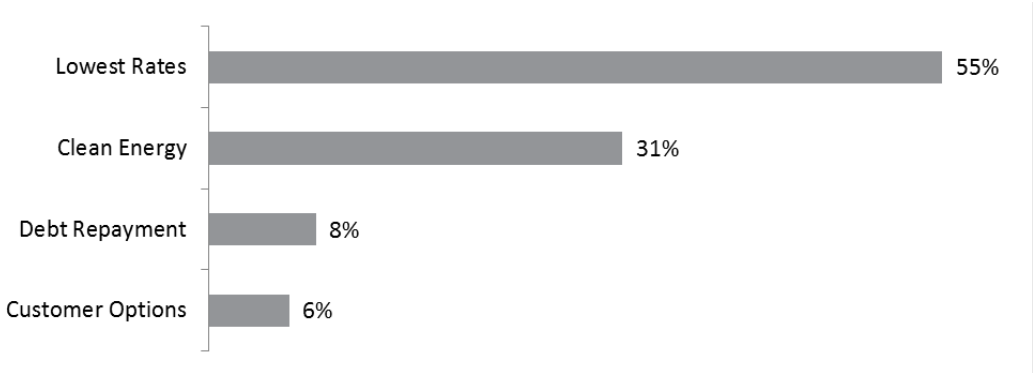
1 Executive Summary

NB Power has a vision of providing sustainable energy for future generations of New Brunswickers. Many important factors contribute to bringing that vision to life, while still providing reliable, safe and competitively priced energy for all New Brunswick homes and businesses.

The Integrated Resource Plan (IRP) paints a robust, long-term picture for New Brunswick's energy supply and demand, with a continued focus on reducing NB Power's greenhouse gas emissions profile. By providing a 20-year outlook, the plan ensures NB Power will make the best short- and long- term energy decisions for customers. It balances supply-side (generating stations) with demand side (customer level) options while seeing NB Power stay ahead of minimums set in federal and provincial regulations, and recognizing the corporation's mandate and the provincial *Electricity Act.* The IRP also continues NB Power's environmental leadership and responsibilities in an evolving energy landscape.

As a Crown corporation, NB Power is owned by New Brunswickers. It is important to involve New Brunswickers in the planning process for the 2020 Integrated Resource Plan. In late 2019, NB Power engaged New Brunswickers, including First Nations, through a broad, multi-platform public engagement campaign to better understand what mattered most to customers when considering the province's energy future. Out of this, New Brunswickers prioritized low rates above clean energy, customer options and debt management.

Figure 1: What is Important to Customers



Every three years, the Integrated Resource Plan is refreshed to reflect the changing energy landscape and customer expectations. Once updated, as per the *Electricity Act*, NB Power submits the Integrated Resource Plan to the Government of New Brunswick for approval and to the New Brunswick Energy and Utilities Board following that approval.

The plan follows three core principles

- least-cost planning
- economic and environmental sustainability
- risk management

It is important to balance these principles with NB Power's mandate to keep rates low and stable for New Brunswickers while reaching a debt-to-equity ratio of 80/20 by 2027. The *Electricity Act* requires the New Brunswick Energy and Utilities Board to consider the most recent Integrated Resource Plan when they make decisions on rate setting and major capital spending. While this plan supports that process, it does not include information on electricity rates or detailed financial statements. This information is included in NB Power's annual 10-Year Plan, which, per the *Electricity Act*, must align with the most recent IRP.

In 2015, Canada along with 194 other countries signed the Paris Agreement, and collectively committed to reduce global emissions[1]. In March 2016, the First Ministers released the Vancouver Declaration on Clean Growth and Climate Change[2], which included a nationwide targeted reduction of emissions to 30 per cent below 2005 levels by 2030.

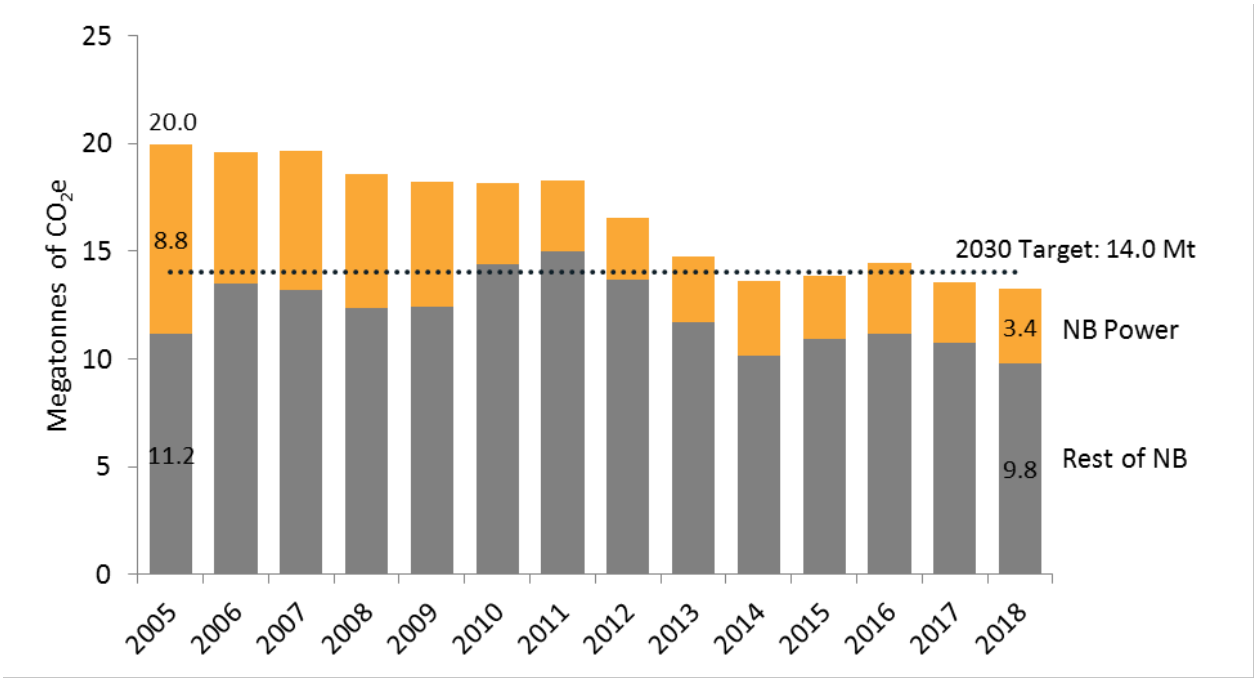
In 2005, the province of New Brunswick's greenhouse gas emissions were 20.0 Mt[3], putting the 30 per cent reduction target at 14.0 Mt for 2030. In 2018 (the most recent year information is available at the time of writing) provincial emissions more than achieved the target and stood at 13.2 Mt[4]. During this same period, NB Power's contribution to provincial emissions decreased from 8.8 Mt in 2005 to 3.4 Mt in 2018, an over 60 per cent reduction since 2005. New Brunswick has achieved its emissions goals of reducing provincial greenhouse gas emissions to 14.8 Mt by 2020[5], and achieved the 30 per cent reduction from 2005 levels in four of the last five years, significantly ahead of the 2030 target.

[1] "Paris Agreement," Government of Canada, last modified January 6, 2016, https://www.canada.ca/en/environment-climate-change/services/climate-change/paris-agreement.html/.
[2] "Vancouver declaration on clean growth and climate change," Canadian Intergovernmental Conference Secretariat, March 3, 2016, https://scics.ca/en/product-produit/vancouver-declaration-on-clean-growth-and-climate-change/.
[3] National Inventory Report data are subject to change from one version to the next. The 1990-2006 National Inventory Report reported 2005 emissions as 20.1 Mt, resulting in a reported 2030 target of 14.1 Mt.
[4] "National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. Part 3," Government of Canada, last modified April 15, 2020, https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html.
[5] "Transitioning to a Low Carbon Economy," Government of New Brunswick, 2016, https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf

NB Power's emissions reductions did not occur by chance but were actively initiated and pursued. Key actions taken by NB Power include

- adding 311 MW of wind generation since 2007
- closing two fossil fueled generating stations in 2010 and 2012
- completing world's first refurbishment of a CANDU-6 nuclear reactor in 2012
- increasing renewable energy to over 40 per cent (42 per cent in 2019 and a projected 44 per cent in 2020)
- adding 78 MW of new community-based wind energy by 2022
- adding 40 MW of embedded generation from renewable sources by 2023
- increasing energy efficiency through demand side management programs (Energy Smart NB) resulting in a 70 MW reduction to peak demand since 2013

Figure 2: New Brunswick's Historical Greenhouse Gas Emissions 2005-2018[6,7,8]



While efforts to reduce emissions to date are encouraging, NB Power recognizes climate change is real and there is still much more work to do to mitigate its effects. The Province of New Brunswick has set aspirational climate goals of reducing provincial greenhouse gas emissions to

[6] "National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. Part 3," Government of Canada, last modified April 15, 2020, https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html.
[7] NB Power emission data based on internal data for NB Power owned facilities.
[8] The rest of New Brunswick's emissions calculated as the difference between the provincial total as reported in the National Inventory Report and NB Power's environmental compliance reports for NB Power emissions.

10.7 Mt by 2030 and 5 Mt by 2050[9], and NB Power recognizes that while it is a leader in emissions reductions since 2005, it must not rest on this success and it will need to continually improve at a pace that keeps electricity affordable for New Brunswickers. This plan assumes that both the Mactaquac Life Achievement Project and the Advanced Metering Infrastructure (Smart Meter) Project to modernize the grid will be approved and contribute to keeping emissions low in New Brunswick for the foreseeable future. The continued investment in Energy Smart NB lowers energy and demand requirements in the province, saving customers money and reducing greenhouse gas emissions in New Brunswick.

Since the 2017 Integrated Resource Plan, the Government of Canada made two changes to federal greenhouse gas emissions regulations which have major impacts on the 2020 Integrated Resource Plan.

The first regulation change[10] sees coal generation effectively phased-out in Canada by 2030, or equivalent emissions reductions from the electricity sector are obtained. The Government of New Brunswick is negotiating an equivalency agreement with the federal government that would allow NB Power to continue to use coal beyond 2030, while reducing its emission trajectory to the same or better than if coal-fired electricity was phased-out in 2030. An equivalency agreement for New Brunswick would see at least the same emissions reductions as if coal was phased-out in 2030 but would be significantly more affordable for New Brunswickers. It would lower the overall cost to deliver electricity by $1.1-$1.4 billion ($2020 net present value) over the next 20 years while limiting emissions to 63 Mt (cumulative), or an average of 3.15 Mt per year.

This represents a more than 11 Mt, or 15 per cent, reduction from the 2017 Integrated Resource Plan. Simply put, an equivalency agreement for New Brunswick does not emit more carbon than if coal is retired in 2030, rather it is a more affordable plan to achieve the same emissions reductions as if coal was phased-out.

The second regulation change[11] focuses on carbon pricing and emissions performance standards. To adapt to climate change, the federal government put a backstop pricing arrangement in place for facilities that emit more than 50 kt of greenhouse gas emissions per year. This applies to electrical generators including NB Power's Belledune, Coleson Cove and Bayside generating stations. New Brunswick is seeking the adoption of a Made-in-New-Brunswick plan on carbon

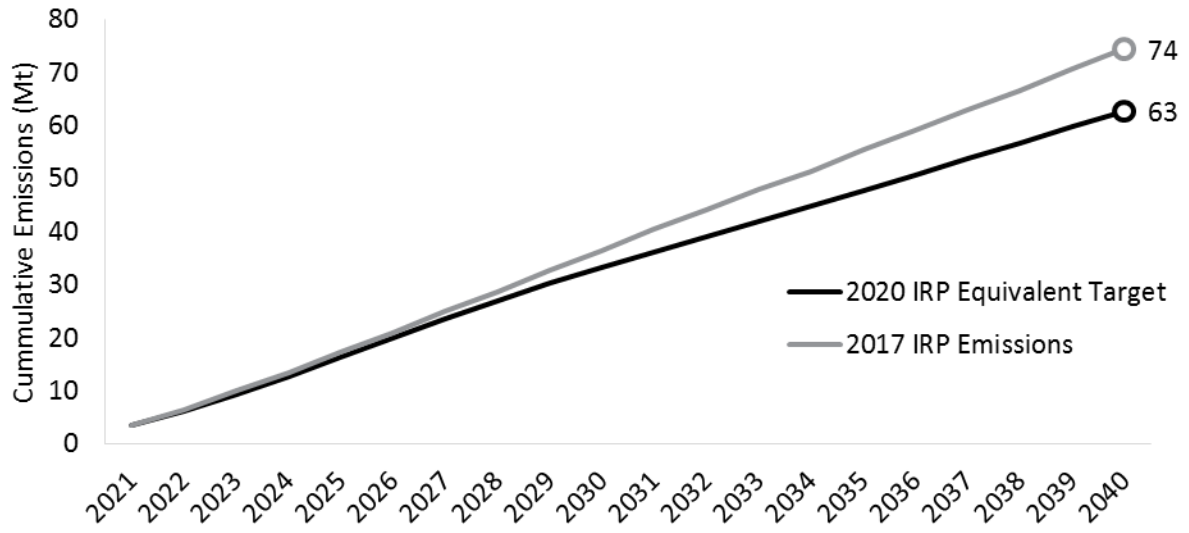
[9] "Transitioning to a Low Carbon Economy," Government of New Brunswick, 2016, https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf

[10] "Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations: SOR/2018-263," Canada Gazette, Part II, Volume 152, Number 25, Government of Canada, November 30, 2018, http://www.gazette.gc.ca/rp-pr/p2/2018/2018-12-12/html/sor-dors263-eng.html.

[11] "Output-Based Pricing System Regulations (SOR/2019-266)," Justice Laws Website, Government of Canada, last modified May 14, 2020, https://laws-lois.justice.gc.ca/eng/regulations/SOR-2019-266/index.html.

pricing for the province's large emitters[12]. This plan would meet federal regulations and be more affordable for New Brunswickers by an estimated $498 million ($2020 net present value).

Figure 3: 2020 versus 2017 IRP Emissions Trajectory



This Integrated Resource Plan assumes the Government of New Brunswick enters into an equivalency agreement and the federal backstop carbon pricing plan is in force.

The 2020 Integrated Resource Plan will help NB Power balance New Brunswick's ongoing energy needs and renewable and emissions requirements while keeping costs low for all New Brunswickers.

The IRP meets the requirements of section 100(1) of the *Electricity Act*, and provides the following information

- identifies near-term supply-side investment requirements
- defines a reasonable range of options for demand side programs
- provides a range of sensitivities to demonstrate how external factors influence results

NB Power recognizes the COVID-19 global pandemic has caused a great hardship on New Brunswickers and an upheaval in many of the short-term planning assumptions used in this Integrated Resource Plan. However, over the long-term it is expected that New Brunswickers will persevere through the pandemic and planning assumptions will return to normal levels and not alter the first 10 years of the recommended expansion plan. The effects of the pandemic on this

[12] "Holding Large Emitters Accountable: New Brunswick's Output-Based Pricing System," Government of New Brunswick, June, 2019, https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/HoldingLargeEmittersAccountable.pdf.

IRP were explored in a sensitivity analysis that studied the outcomes if the short-term impacts on planning assumptions were to persist into the long-term and are included in Section 13.5 (COVID-19 Scenario).

The key takeaways of the plan include

- establishing an equivalency agreement will allow Belledune Generating Station to operate using coal up to 2040, reducing emissions to 63 Mt between 2021 and 2040, and reducing costs to New Brunswickers
- implementing the Made-in-New Brunswick Carbon plan will reduce costs to New Brunswickers over the next 20 years while maintaining the same 63 Mt emission target as the emissions achieved produced under the federal plan
- implementing an equivalency agreement and the Made-in-New Brunswick Carbon Plan can save New Brunswickers over $1.5 billion over the next 20 years, and do so while achieving carbon reductions and meeting all legislative requirements
- extending the life of the Bayside Generating Station is the most economic choice to meet energy and capacity requirements after its original retirement date and offers significant emissions reductions, while still supplying reliable electricity, as compared to coal
- extending the life of the Millbank and Ste. Rose generation stations is the most economic choice for meeting peak load and reserve requirements beyond their original retirement date
- pursuing the Energy Smart NB plan to meet the goal of 420-476 MW of innovative demand-side management initiatives including energy efficiency and demand response programs by 2040 will help customers lower their bills by $413 - $514 million ($2020 net present value) and help reduce greenhouse gas emissions over the next 20 years
- replacing generation on Grand Manan Island will maintain reliability in a vulnerable part of the New Brunswick's electrical system should one of the subsea cables serving the island suffer a prolonged outage
- aside from life extensions and back-up capacity resources, only carbon free generators are recommended in the final expansion plan
- although not included in the IRP as a supply option, small modular nuclear reactors may provide a scalable solution for New Brunswick's electricity system to become near carbon-free in the future
- the recommendations of the final expansion plan in the first 10 years are robust decisions that are not influenced by changes to key assumptions, including a scenario of prolonged impact of recent market changes associated with the COVID-19 global pandemic

The 2020 Integrated Resource Plan balances the principles of least-cost planning, economic and environmental sustainability, and risk management. The recommended actions will continue NB Power's journey to a sustainable energy future for New Brunswickers.

Table 1: Final Expansion Plan

Fiscal Year	Integrated Plan	Scheduled Retirement
Ongoing	Energy Smart NB (420 - 476 MW)	
2021	LORESS Projects (78 MW)	Milltown (3 MW)
2022	Embedded Generation (20 MW)	
…	…	…
2025		Grandview (95 MW)
2026	New LM2500 in Grand Manan (23 MW)	Grand Manan (29 MW)
2027	Bayside Life Extension (277 MW)	
…	…	…
2031	Millbank/Ste Rose Life Extension (496 MW)	
…	…	…
2033	Mactaquac Life Achievement (668 MW) New Wind (200 MW)	
…	…	…
2038	Industrial Demand Response (90 MW)	Bayside (277 MW)
2039	Point Lepreau In-Kind Replacement (670 MW)	Point Lepreau (670 MW)

2 Introduction

For 100 years, NB Power has been a part of the fabric of New Brunswick. The provincial electric utility has one of the most diverse generation fleets in North America and provides safe, reliable and sustainable energy to over 400,000 direct and indirect customers.

The energy industry is evolving from the traditional utility model to a broader focus, including energy solutions. Through that transition, NB Power is staying focused on customers' expectations while developing demand side solutions to enable a greener and cleaner future for New Brunswick.

NB Power is owned by New Brunswickers, by virtue of being a provincial Crown corporation. The New Brunswick Government's *Electricity Act* (2013) guides NB Power in how electricity is produced and delivered to all New Brunswickers. The New Brunswick Energy and Utilities Board (EUB) ensures that customers receive safe and reliable service and that electricity rates are just and reasonable.

Under the *Act* and regulations, NB Power must balance customer needs with the following when planning the province's energy future

- deliver safe, reliable energy at low and stable rates
- ensure sustainable energy supply for the future
- supply 40 per cent of electricity sales from renewable sources
- achieve a capital structure of at least 20 per cent equity

New Brunswickers energy priorities are an important part of this Integrated Resource Plan (IRP). In November 2019, NB Power hosted in person and online engagement sessions to capture input from customers across the province on what mattered most to them when considering New Brunswick's energy future. This input allows NB Power to develop solutions that will meet New Brunswickers changing energy needs.

2.1 NB Power Strategic Objectives, Vision, Mission and Values

Our Mission	Our Vision	Our Core Values
To be our customers' partner of choice for energy solutions	Sustainable energy for future generations	Safety, Quality, Diversity and Innovation

NB Power's mission has been, and continues to be, customer focused. NB Power's relationships with customers and stakeholders constantly evolve to enhance this focus. NB Power's 2,600

employees are New Brunswickers through and through and care deeply about the future of this province and its economic and social well-being. It is recognized that the electricity industry and customer expectations of their energy company are changing, and as a result, NB Power's vision of Sustainable Energy for Future Generations is reflected in this IRP. NB Power's history is rooted in New Brunswick and its people. As the utility evolves, NB Power's mission, vision and values remain focused on the needs of New Brunswick.

2.2 Integrated Resource Planning Process

NB Power delivers New Brunswickers a mix of energy from many sources. It's a balance of cost, reliability and environmental impact. There's a lot of planning that goes into keeping that balance.

This is where the IRP comes in. This plan outlines long-term strategies to ensure NB Power's system stays reliable, financially stable, environmentally sound and efficient. It also identifies ways NB Power can continue to meet energy demand, while increasing renewables and decreasing its environmental footprint.

The IRP's development requires in-depth analysis in three key areas

- energy efficiency and demand considerations (which reduce and shift consumption) as well as supply considerations
- reliability and security of supply
- policy and regulatory considerations

Gathering input from New Brunswickers is an essential part of the IRP process. NB Power sought the input of customers and key stakeholders, including First Nations, to gain a deeper understanding of what's important to them as they think about New Brunswick's electricity future.

Options to supply future electricity needs are selected based on

- system reliability
- environmental footprint
- overall cost effectiveness
- stakeholder input

These options cover a wide range of generation sources (e.g. wind, solar, hydro, nuclear, natural gas) and storage technologies (e.g. batteries, compressed air energy storage). The cost of each supply option is strongly considered when weighing supply options. The plan needs to be realistic and ensure all selected supply-side options (including the environmentally preferred power generation choices) are affordable and reliable for New Brunswickers.

In addition to supply options, consideration is given to energy efficiency and demand management programs. These programs reduce New Brunswick's electrical consumption through customer energy savings and demand reduction. These are part of NB Power's Energy Smart NB plan. This plan focuses on reducing and shifting consumption and grid modernization.

A modern grid will be smarter, cleaner, more resilient and efficient so New Brunswickers will have more choices and opportunities in the future for how they use energy. It will enable new technologies and services, while keeping the grid stable, efficient and reliable for customers.

The IRP is consistent with section 100(1) of the *Electricity Act*, and provides the following information

- identifies near-term supply-side investment requirements
- defines a reasonable range of options for demand side programs
- provides a range of sensitivities to demonstrate how external factors influence results

To create this plan, NB Power follows an industry standard, well-defined process. This process can be broken down into a series of steps

1. provide energy literacy and seek input from stakeholders through public engagement to better understand customers' expectations of New Brunswick's energy future
2. determine the long-term forecast of in-province electricity requirements
3. look at the existing system and make certain reasonable assumptions about the corresponding parameters (e.g. future fuel prices, polices or regulations)
4. look at the life expectancy of the existing supply resources (power plants) including the expiry dates of power purchase agreements
5. compare New Brunswickers' existing supply resources with long-term electrical consumption requirements to identify any gaps that may exist
6. research all reasonable supply and demand options and rank them according to cost and other relevant attributes
7. determine if least-cost options are reliable and ensure renewable portfolio standard is met and if so, the viable supply and/or demand option feeds back to 5 to help close any gaps
8. the Process until all gaps are closed and an IRP can be recommended to New Brunswickers

3 Stakeholder Engagement

3.1 Overview of Public Engagement Process

As NB Power began planning for this IRP, it was important to involve New Brunswickers. This was accomplished through a multi-platform public engagement strategy. The design of the engagement process was a collaborative effort between NB Power and its engagement consultant, National Public Relations. In November 2019, NB Power hosted in-person and online engagement sessions to capture input from New Brunswickers from across the province to learn what matters most to them when considering New Brunswick's energy future.

The objectives of the engagement were to

- gain a deeper understanding of what is most important to customers as they consider New Brunswick's energy future, and the role they, as New Brunswickers, are willing to play in it
- provide ample and appropriate information, in an easy to understand format, about New Brunswick's energy landscape, the scope of the IRP process, and what can be influenced
- host an engagement process in person or online, allowing New Brunswickers to contribute based on their own perspective, experience, ideas and what is most important to them
- be transparent in sharing results from the engagement effort

3.2 Scope of Engagement

The public engagement campaign consisted of an online survey and in-person customer engagement sessions hosted across New Brunswick.

NB Power promoted these engagement opportunities to New Brunswickers in both official languages through the following tactics

- social media platforms such as Facebook and Twitter were leveraged to connect with key audiences
- video was used on the website and social media as a key component of the educational process for the survey
- inQueue messaging was developed for when customers were on hold with NB Power Customer Service (customers were informed of the online survey and encouraged to visit website to complete the survey)
- direct email invitations were sent to over 8,000 customers who previously consented to receiving ongoing communications from NB Power
- paid media and digital ads on The Weather Network, Google Ads, Google Display Network, and Facebook
- First Nations open houses where invitations were extended to participate in the survey and open invitations for face-to-face meetings were extended
- community events such as markets, hockey rinks, or community meetings such as Quest

Six thousand, two hundred and sixty-three (6,263) New Brunswickers participated online, while 442 were engaged at in-person opportunities, for a total of 6,705 engagements. The level of engagement improved five times from stakeholder engagement efforts for the 2017 Integrated Resource Plan.

Table 2: Summary of Public Engagement

Engagement Format	Number of Engagements
Community Event Face-to-Face Conversations	315
First Nations Open House Meetings	75
Quest Community Energy Municipal Workshops	42
One-On-One Stakeholder Meetings	10
Online Survey	6,263
Total	**6,705**

3.3 Online Engagement Approach

The online engagement experience was designed with a general audience in mind. Content was concise and used plain language. The website included an informational video to provide context for the discussion and short survey questions.

It explored the following topics

- affordability
- clean energy
- customer options

Participants could also include their own comments at the end of the short survey.

3.4 In-person Engagement Approach

In-person customer engagement sessions were held in a variety of formats across the province.

3.4.1 Face-to-Face Conversations with New Brunswickers

NB Power wanted to meet with people in places where they naturally gather and socialize to capture the attention of New Brunswickers and gather feedback for the 2020 IRP. NB Power met with customers at four different community events in November to have these discussions. These took place in farmers markets and hockey rinks in Fredericton, Moncton, Restigouche and Grand Falls.

3.4.2 First Nations Engagement

NB Power respects the significance, distinct interests and culture of New Brunswick's First Nations communities and continues to work hard to build and strengthen positive relations. NB

Power attended open houses in seven First Nations communities across New Brunswick. In addition, NB Power maintains open invitations for on-going face-to-face meetings to all First Nations communities.

3.4.3 Quest Community Energy Municipal Workshops

NB Power presented at six municipal community workshops in the province. Workshop attendees were informed of the IRP and were invited to share their input through the online survey.

3.4.4 One-on-One Stakeholder Meetings

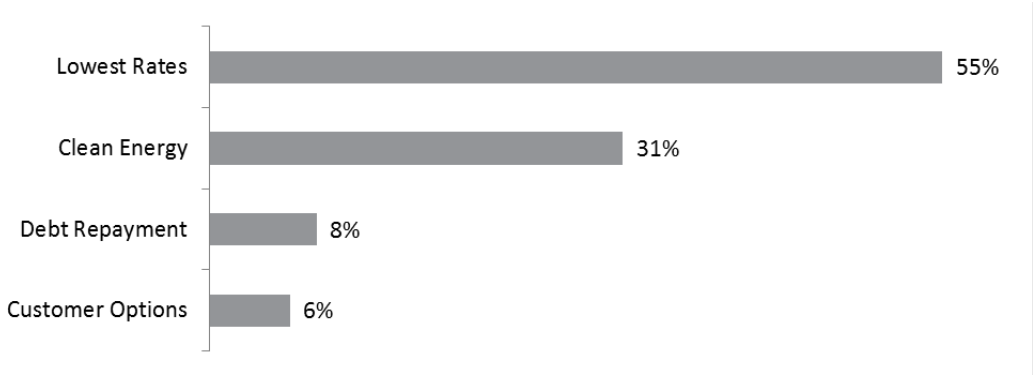
Where the online engagement tool primarily targeted residential and small business customers, face-to-face meetings were held with other customer classes and interested stakeholders from across the province to ensure representative balance and avoid of gaps in the process. NB Power offered face-to-face meetings with these customers to ensure their input was properly reflected in the development of the IRP.

3.5 Public Engagement Findings

According to the survey results, affordability and clean energy are the top priorities for New Brunswickers.

While clean energy is very important to respondents, affordability was ranked higher by a ratio of almost two-to-one. All age categories ranked affordability most important followed by clean energy.

Figure 4: Summary of Public Engagement Findings



Based on survey responses, New Brunswickers want NB Power to be a leader in clean energy and energy efficiency, but to do so with affordability in mind. Many believe that all New Brunswickers have a responsibility to make changes to address climate change. Responses also show most New Brunswickers support the transition to cleaner energy but only if it doesn't increase rates. The majority of respondents said they're not willing to pay more for clean energy.

The statements New Brunswickers agreed the most with were

- New Brunswick's transition to a clean energy future needs to minimize impacts on rates and the economy (85 per cent)
- I want NB Power to be a leader in energy efficiency (85 per cent)
- New Brunswickers have a responsibility to make changes to help address climate change (84 per cent)

The statements New Brunswickers agreed with the least were

- I am personally willing to pay more for clean energy (30 per cent)
- I am interested in purchasing an electric vehicle (33 per cent)
- I am interested in producing my own electricity (49 per cent)

Demographic information collected through the survey shows the single largest group of respondents were aged 55 and over, at 53 per cent. Those aged 35-54 provided 33 per cent of the responses and respondents younger than 35 made up 11 per cent of responses.

A full report on findings and input can be found in the *What Was Said Report*[13].

[13] "What Was Said Report", National Public Relations, 2020, https://www.nbpower.com/en/about-us/our-energy/integrated-resource-plan.

4 Policy Considerations

As a Crown corporation, NB Power adheres to various policies and regulations set out by the provincial government. This section provides background on the *Electricity Act*, Regulations, and NB Power's Mandate Letter. Refer to Appendix 2 (Status of Policy and Regulation Considerations) to see how the *Electricity Act* and other Regulations are addressed in the IRP.

4.1 The *Electricity Act*

The New Brunswick *Electricity Act* is the legislation that sets out the framework and rules of law for how the electricity sector is managed in the province. The current *Electricity Act* was enacted in 2013.

NB Power's Integrated Resource Plan is impacted by a number of provisions and requirements in the *Electricity Act*. Section 100 of the *Electricity Act* establishes the requirement for an Integrated Resource Plan. It lists several elements that must be included in the Integrated Resource Plan, as well as setting out required timelines for submission to and approval by the Executive Council of the Government of New Brunswick. Subsection 100(2) requires the Integrated Resource Plan be developed by the Corporation in accordance with the principles of least-cost service, economic and environmental sustainability and risk management.

The *Electricity Act* also includes government policy directives that guide utility planning, notably in Section 68

- NB Power is to achieve a capital structure of at least 20 per cent equity (s. 68(a))
- ensures New Brunswickers have safe, secure and equitable access to electricity at least cost of service (s. 68(b))
- taking into account the above policy requirements, and to the extent practicable, rates shall be maintained as low as possible and stable from year to year (s. 68(c))

The *Electricity Act* also makes NB Power responsible for promoting, developing and delivering energy efficiency, energy conservation, and demand side management programs in New Brunswick.

4.2 Electricity from Renewable Resources Regulation – Electricity Act

In 2014, the Government of New Brunswick committed to develop more renewable energy in New Brunswick. The *Electricity from Renewable Resources Regulation - Electricity Act*[14] guides the development of renewable electricity resources in New Brunswick. The regulation requires

[14] "Electricity from Renewable Resource Regulation – Electricity Act," New Brunswick Regulation 2015-60 under the Electricity Act (O.C. 2015-263), Government of New Brunswick, filed November 12, 2015, https://www2.gnb.ca/content/dam/gnb/Departments/ag-pg/PDF/RegulationsReglements/2015/2015-60.pdf.

NB Power to supply 40 per cent of its in-province electricity sales with renewable energy by 2020. NB Power achieved this milestone in both 2019 and 2020.

While the goal of the regulation is to reduce the use of fossil fuel generation and emissions, that objective can be met by either reducing energy use through energy efficiency or by acquiring renewable generation. In many cases, reducing energy use through energy efficiency programs is more cost-effective than building new renewable generation.

Energy efficiency also helps achieve New Brunswick's environmental goals. By reducing and shifting customer electricity consumption the Energy Smart NB plan will reduce the need for future generation from fossil-fuelled plants and increase the share of New Brunswick's electricity needs provided by renewables. Innovative programs that lead to significant energy reduction will allow NB Power to maintain or exceed the 40 per cent renewable portfolio standard in the most cost-effective and efficient way while also reducing greenhouse gas emissions.

Although not part of the renewable portfolio standard, New Brunswick's largest provider of carbon-free energy is the Point Lepreau Nuclear Generating Station. The Point Lepreau Nuclear Generating Station provides approximately 35 per cent of New Brunswick's electricity requirements and avoids approximately 4 Mt of greenhouse gas from being emitted into the environment annually. NB Power forecasts that at least 75 per cent of New Brunswick's electricity requirements will be met by carbon-free sources over the next 20 years.

The *Electricity from Renewable Resource Regulation – Electricity Act* also enables the Locally Owned Renewable Energy Projects that are Small Scale Program and the Large Industrial Renewable Energy Purchase Program. These programs contribute to the 40 per cent renewable energy target described above.

The key objectives of the *Electricity from Renewable Resource Regulation – Electricity Act* are[15]

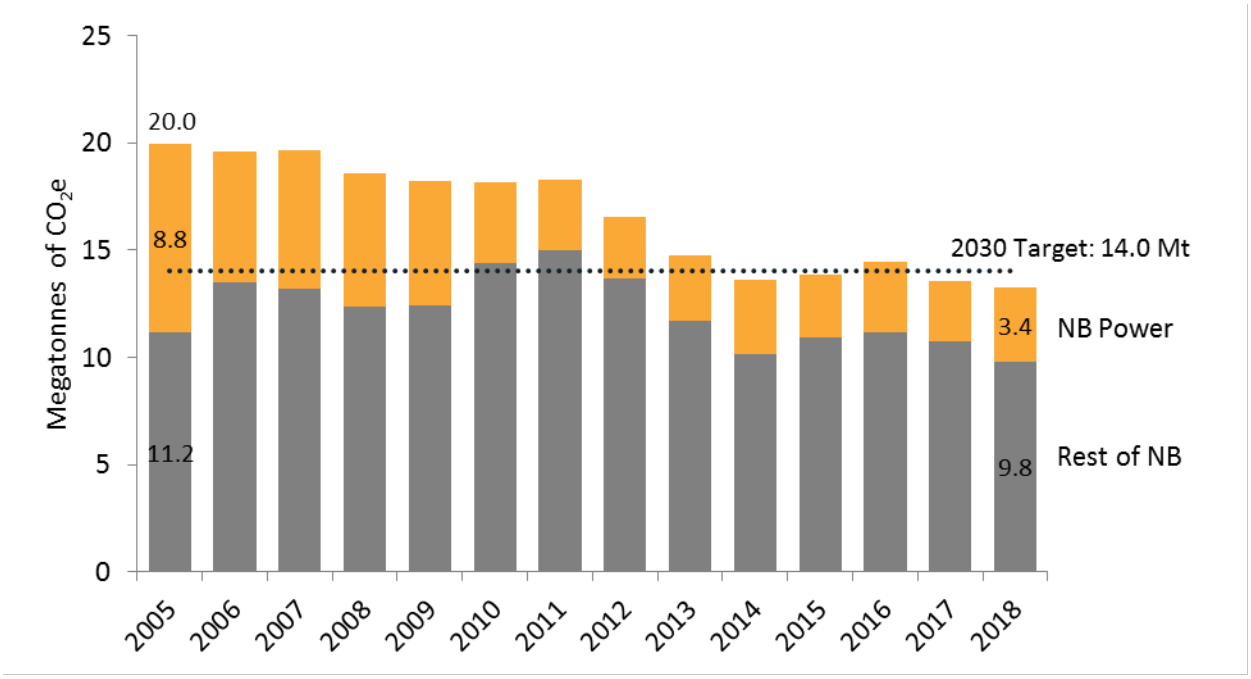
- low and stable energy prices – integrate additional renewable energy to help shield ratepayers from the cost volatility of electricity generated from fossil fuels
- energy security – develop additional indigenous renewable energy to lessen NB Power's dependence on imported fossil fuels
- environmental responsibility – additional renewable energy will reduce NB Power's greenhouse gas and associated emissions by reducing fossil fuel electricity generation

[15] "Renewable Portfolio Standard", Natural Resources and Energy Development, Government of New Brunswick, accessed March 30, 2020, https://www2.gnb.ca/content/gnb/en/departments/erd/energy/content/energy_blueprint/content/renewable_portfolio.html.

4.3 Greenhouse Gas Regulations

In 2015, Canada along with 194 other countries signed the Paris Agreement, and collectively committed to reduce global emissions[16]. In March 2016, the First Ministers released the Vancouver Declaration on Clean Growth and Climate Change[17], which included a nationwide targeted reduction of emissions to 30 per cent below 2005 levels by 2030. New Brunswick has set aspirational climate goals of reducing provincial greenhouse gas emissions to 14.8 Mt by 2020, 10.7 Mt by 2030 and 5 Mt by 2050[18].

Figure 5: New Brunswick's Historical Greenhouse Gas Emissions 2005-2018[19,20]



New Brunswick's 2005 emissions were 20.0 Mt[21], putting the 30 per cent reduction target at 14.0 Mt for 2030.

[16] "Paris Agreement," Government of Canada, last modified January 6, 2016, https://www.canada.ca/en/environment-climate-change/services/climate-change/paris-agreement.html/.
[17] "Vancouver declaration on clean growth and climate change," Canadian Intergovernmental Conference Secretariat, March 3, 2016, https://scics.ca/en/product-produit/vancouver-declaration-on-clean-growth-and-climate-change/.
[18] "Transitioning to a Low Carbon Economy," Government of New Brunswick, 2016, https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf
[19] "National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. Part 3," Government of Canada, last modified April 15, 2020, https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html.
[20] NB Power emission data based on internal data for NB Power owned facilities.
[21] National Inventory Report data are subject to change from one version to the next. The 1990-2006 National Inventory Report reported 2005 emissions as 20.1 Mt, resulting in a reported 2030 target of 14.1 Mt.

New Brunswick has achieved this goal in recent years, and NB Power's actions have contributed to this achievement, including

- adding 311 MW of wind generation since 2007
- closing two fossil fueled generating stations in 2010 and 2012
- refurbishing the world's first CANDU-6 nuclear reactor in 2012
- increasing renewable energy to over 40 per cent (42 per cent in 2019 and a projected 44 per cent in 2020)
- adding 78 MW of new community-based wind energy by 2022
- adding 40 MW of embedded generation from renewable sources by 2023
- increasing energy efficiency through demand side management programs (70 MW reduction to peak demand since 2013)

These actions have resulted in a reduction in NB Power's emissions from 8.8 Mt to 3.4 Mt in 2018 (over 60 per cent reduction) since 2005. The rest of the Province of New Brunswick's emissions have also decreased from 11.2 Mt to 9.8 Mt over the same period[22]. This allowed New Brunswick to achieve the 2030 goal in four of the last five years.

This IRP assumes that both the Mactaquac Life Achievement Project and the Advanced Metering Infrastructure Project to modernize the grid will be approved by the New Brunswick Energy and Utilities Board and contribute to keeping emissions low in New Brunswick for the foreseeable future.

New Brunswick's Climate Change Action Plan[23] includes 118 provincial government actions to address climate change in New Brunswick. The assumptions and analysis in this IRP are supported by a number of these actions, notably

- #33 – mandate energy efficiency delivery agents to provide energy efficiency initiatives
- #37 – continue to encourage innovation such as smart grid technologies to facilitate additional efficiency gains in electricity service in the mid to long-term
- #40 – work with the federal government, our neighbouring provinces, local stakeholders and the electric utility toward eliminating coal-fueled electricity generation as quickly as possible
    - if adequate support can be found to minimize impacts on energy costs and the local economy, eliminate coal by 2030
    - alternatively, phase-out coal by the status quo date of 2040 with interim emission reductions aligned with new federal regulations
- #41 – GHG emissions from electricity generation in the province will be regulated in alignment with provincial emissions targets

[22] The rest of New Brunswick's emissions calculated as the difference between the provincial total as reported in the National Inventory Report and NB Power's environmental compliance reports for NB Power emissions.
[23] "Transitioning to a Low Carbon Economy," Government of New Brunswick, 2016, https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf

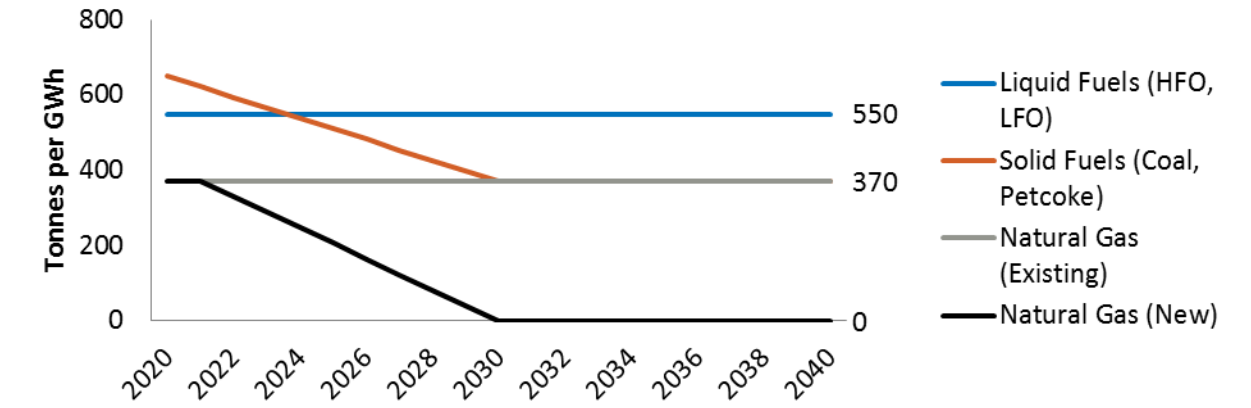
- #43 – review the outcomes of the small-scale community renewable energy program upon completion and expand or modify the program accordingly

4.3.1 Output-Based Pricing System Regulations

The IRP is based on the Federal Output-based pricing system (OBPS) for large emitters[24]. Large emitters are facilities or generating stations that emit more than 50 kt of greenhouse gas emissions per year. For NB Power, the regulated units would be the Belledune, Coleson Cove and Bayside generating stations. The Government of New Brunswick continues to work with the federal government on a more affordable Made-in-New Brunswick plan that will achieve emissions reductions and maintain the competitiveness of industry.

Carbon pricing under the Output Based Pricing System is $30 per tonne in 2020. It's expected to increase to $40 per tonne in 2021 and $50 per tonne in 2022. Performance standards[25] vary by fuel type. These standards tighten over time for all fuel types, except for liquid fuels and existing natural gas facilities. NB Power will be subject to carbon taxes on emissions that exceed the federal standards set out in the regulations.

Figure 6: Federal Emission Intensity Standards



The Made-in-New-Brunswick Output-Based Pricing System[26] is structured similarly to the federal system, but alters the emission intensity standards as outlined in Table 3. In the IRP, NB Power

[24] "Output-Based Pricing System," Government of Canada, last modified May 7, 2020, https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system.html.

[25] The Output-Based Pricing System uses a performance standard in the form of average emissions per unit of electric output. The utility would pay only on the emissions above this emission intensity standard. For example, if the performance standard were 370 tonnes per gigawatt-hour, and a station's actual emission intensity were 470 tonnes per gigawatt-hour, the portion above 370 tonnes per gigawatt-hour, or 100 tonnes per gigawatt-hour, would be subject to the carbon price.

[26] "Holding Large Emitters Accountable: New Brunswick's Output-Based Pricing System," Government of New Brunswick, June, 2019, https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/HoldingLargeEmittersAccountable.pdf.

assumes a declining emission intensity target for new natural gas that reaches zero by 2030: however it remains to be seen exactly how the Government of New Brunswick would regulate emissions beyond 2022.

Table 3: Proposed New Brunswick Emission Intensity Standards

Year	Solid Fuels (tonnes/GWh)	Liquid Fuels (tonnes/GWh)	Natural Gas (tonnes/GWh)
2020	811	795	420
2021	802	790	420
2022	793	785	420

An analysis that compares the cost of these different carbon pricing plans is included in Section 12.5 (Greenhouse Gas Regulation Analysis).

4.3.2 Coal Phase-Out

In 2018, the federal government announced the phase-out of traditional coal fired generation by 2030[27] or the achievement of equivalent emissions reductions as if coal was phased-out. NB Power is scheduled to retire its only remaining coal-fired generating station located in Belledune in December 2040. The regulation would see Belledune cease to burn coal 10 years earlier than its planned retirement date, or the electricity system would need to achieve the same or better emission reductions as if it did retire in 2030. Belledune is a reliable source of low-cost energy and capacity that is only second to Point Lepreau in terms of providing energy for New Brunswickers. The early phase-out of coal requires significant investment in either new infrastructure to allow for alternative fuels to be used at Belledune or new generation with similar operating characteristics (i.e. dependable and predictable (dispatchable) generation with the ability to be base loaded). Analysis clearly indicates early phase-out of coal creates a significant cost burden (in excess of $1 billion ($2020 NPV)) for New Brunswickers. An analysis on the cost of equivalency and other coal phase-out alternatives is included in Section 12.5 (Greenhouse Gas Regulation Analysis).

The federal acts and regulations include a provision for provinces to negotiate equivalency agreements, and in turn be exempted from the phase-out of coal regulations. Equivalency

[27] "Canada's coal power phase-out reaches another milestone," Government of Canada, December 12, 2018, https://www.canada.ca/en/environment-climate-change/news/2018/12/canadas-coal-power-phase-out-reaches-another-milestone.html.

agreements of this nature are already in place in both Nova Scotia[28,29] and Saskatchewan[30,31]. NB Power has been assisting the Government of New Brunswick in its efforts to negotiate an equivalency agreement with the federal government that would allow Belledune to operate using coal as a fuel source until its scheduled end of life in December 2040. This would require a new regulation to be developed by the Province of New Brunswick which would replace the federal regulation. The provincial regulation would hold the total emissions of the electricity sector to specific targets over the period of the agreement.

Under the proposed framework, Belledune would continue to operate using coal, though at reduced output. The total emissions targets for the electricity sector would be determined through projections to 2040, and these projections would be inclusive of the impacts as if coal was indeed phased-out in 2030. NB Power's emissions would then be regulated by the Province of New Brunswick and achieve these regulated targets at a lower costs to New Brunswickers[32] than phasing out coal and retiring the Belledune Generating Station in 2030. The goal of the equivalency agreement is to achieve the intended emission reductions of the federal coal phase-out regulation, at lower cost to New Brunswickers. Over the next 20 years greenhouse gas emissions would be equivalent to, or lower than what they would be if coal were phased-out in 2030. Given the framework to achieve an equivalency agreement is already in place, and the federal government has already negotiated these agreements with two different provinces, it is expected the federal government would enter into an agreement with New Brunswick. The 2020 IRP assumes an equivalency agreement is in place for New Brunswick.

[28] "Canada-Nova Scotia equivalency agreement consultation: carbon dioxide emissions from coal-fired generation of electricity," Government of Canada, March 29, 2019, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/agreements/equivalency/canada-nova-scotia-consultation-carbon-dioxide-electricity.html.

[29] "Greenhouse Gas Emissions Regulations," Nova Scotia Regulation 260/2009 under the Environment Act (S.N.S 1994-95, c. 1), Government of Nova Scotia, filed October 4, 2013, http://canlii.ca/t/52462.

[30] "Canada-Saskatchewan equivalency agreement regarding greenhouse gas emissions from electricity producers," Government of Canada, May 10, 2019, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/agreements/equivalency/canada-saskatchewan-greenhouse-gas-electricity-producers.html.

[31] "The Management and Reduction of Greenhouse Gases (General and Electricity Producer) Regulations," Government of Saskatchewan Regulation RRS c M-2.01 Reg 1, filed January 4, 2018, http://canlii.ca/t/5324v.

[32] Section 12.5 shows that the value of an equivalency agreement to New Brunswick is over $1 billion ($2020 NPV).

4.4 NB Power's Mandate

The Mandate Letter from the Government of New Brunswick sets out the provincial government's intentions and expectations of NB Power. These items from the 2021 Mandate Letter have a direct impact on the development of the IRP

- achieve a capital structure of at least 20 per cent equity by 2027 through cost reductions and other appropriate mechanisms that will maintain low and stable rates for New Brunswickers
- continue to work with communities in the province, with a focus on First Nations, to provide opportunities to collaborate and partner in the electricity sector
- ensure opportunities remain open and available under the net metering and embedded generation programs (these programs will continue to operate under strict technical requirements of the utility and under sound financial practices)
- work with the province to reduce greenhouse gas emissions using least-cost options and provide advice and information in a timely manner as required to advocate for fair treatment by the federal government under national policies and legislation

5 Economic Assumptions

In order to develop an integrated plan that keeps rates low and stable, NB Power performs various economic analyses to determine the financial impact of potential supply-side (such as a large generator) and demand-side (customer driven actions) resources. The financial parameters used to complete the IRP analyses are

- consumer price index
- electric utility construction price index
- foreign exchange rate
- weighted average cost of capital

NB Power recognizes the COVID-19 global pandemic has caused a great upheaval in many of the short-term assumptions used in the Integrated Resource Plan. However, over the long-term it is expected that assumptions will return to normal levels. Furthermore, a sensitivity analysis explored the impact to NB Power if the short-term changes resulting from the COVID-19 global pandemic were to persist in the long-term, included in Section 13.5 (COVID-19 Scenario).

5.1 Consumer Price Index

The consumer price index (CPI) is used to adjust operations, maintenance and administration (OM&A) and regular capital expenditures in future years. CPI is forecast to increase by 2 per cent per year. The April 2019 Bank of Canada Monetary Policy Report[33] advised NB Power's CPI projection for this IRP[34].

5.2 Electric Utility Construction Price Index

Over the last 20 years, annual construction costs have increased an average of 3.2 per cent per year for Hydro generation projects and 3.6 per cent per year for all other generation projects[35]. Capital stock turnover is expected to accelerate due to aging infrastructure in the next 20 years. In response, industrial commodity prices (like structural steel, concrete, copper, etc.) are also expected to increase. The IRP has assumed a growth in construction prices consistent with historical trends.

5.3 Foreign Exchange Rate

The long-term foreign exchange rate assumed in this IRP is $1.21 (USD/CAN)[36]. This is the rate used in NB Power's 2021-2030 10-Year Plan[37] and is based on the Conference Board of Canada

[33] "Monetary Policy Report," Bank of Canada, April 2019, https://www.bankofcanada.ca/wp-content/uploads/2019/04/mpr-2019-04-24.pdf.
[34] Due to timing and schedule requirements, economic forecasts from the most recent long range forecast are used in the development of this IRP (NB Power's 2021-2030 10 Year Plan).
[35] Handy Whitman Bulletin No. 189.
[36] Conference Board of Canada Quarterly Rates Data/Forecast Published April, 2019.
[37] "NB Power's 10-Year Plan Fiscal Years 2021-2030," NB Power, prepared September 2019, https://www.nbpower.com/media/1489656/10-year-plan-2021-to-2030.pdf.

Quarterly Rates forecast (April 2019). In the short-term, the IRP uses the same rates as those in the 2021 NB Power Budget. A sensitivity analysis examines the impact exchange rates have on fuel and electricity market prices. The results of those analyses are available in Section 13 (Sensitivity Analysis).

5.4 Weighted Average Cost of Capital

The weighted average cost of capital (WACC) is the calculation of a company's after-tax cost of capital, where each source of capital (debt and equity) is proportionally weighted. WACC is commonly used by companies to discount cash flows in the evaluation of investment decisions.

Table 4: Weighted Average Cost of Capital

Developer	Credit Rating	Debt Ratio	Equity Ratio	Long Term Bond Rate[38]	Spread (bps)[39]	Guarantee Fee	Interest Rate	Return on Equity	WACC
Private	BBB	60%	40%	3.70%	180	0.00%	5.50%	11.00%	6.74%
Public	A+	80%	20%	3.70%	90	0.65%	5.25%	5.25%	5.25%

A reputable and creditworthy private power developer, such as Emera or Algonquin, has a BBB credit rating[40,41]. The credit rating of government-sponsored enterprises, such as NB Power, is assumed to be rated same as the sponsoring government entity. The credit rating of the Government of New Brunswick is A+[42]. For projects developed by NB Power, it is assumed that such projects are 80 percent debt-financed, and a loan guarantee of 0.65 percent applies. The return on equity for NB Power was assumed to be equivalent to the debt financing rate. It is assumed a private developer would have a debt ratio of 60 percent with a levered ROE of 11 percent.

Table 4 shows two calculations of WACC. One represents a publicly-owned Crown corporation like NB Power. The other represents a private investor-owned company. In the IRP, NB Power

[38] Based on NB Power's 2021-2030 10 Year Plan.
[39] Based on an internal analysis of Canadian Bond rates (November 2019).
[40] "Credit Ratings," Emera, March 24, 2020, http://investors.emera.com/Credit-Ratings.
[41] "DBRS Upgrades Algonquin Power & Utilities Corp.'s Issuer Rating and Preferred Shares Rating to BBB and Pfd-3, Stable Trends," DBRS Morningstar, January 25, 2019, https://www.dbrsmorningstar.com/research/339004/dbrs-upgrades-algonquin-power-utilities-corps-issuer-rating-and-preferred-shares-rating-to-bbb-and-pfd-3-stable-trends.
[42] "Credit Ratings," Government of New Brunswick, April 19, 2020, https://www2.gnb.ca/content/gnb/en/departments/finance/investor_relations/content/credit_ratings.html.

assumes the WACC for is 5.25 percent versus 6.74 percent for private investors. A lower WACC results in a lower overall cost to New Brunswickers for a given project.

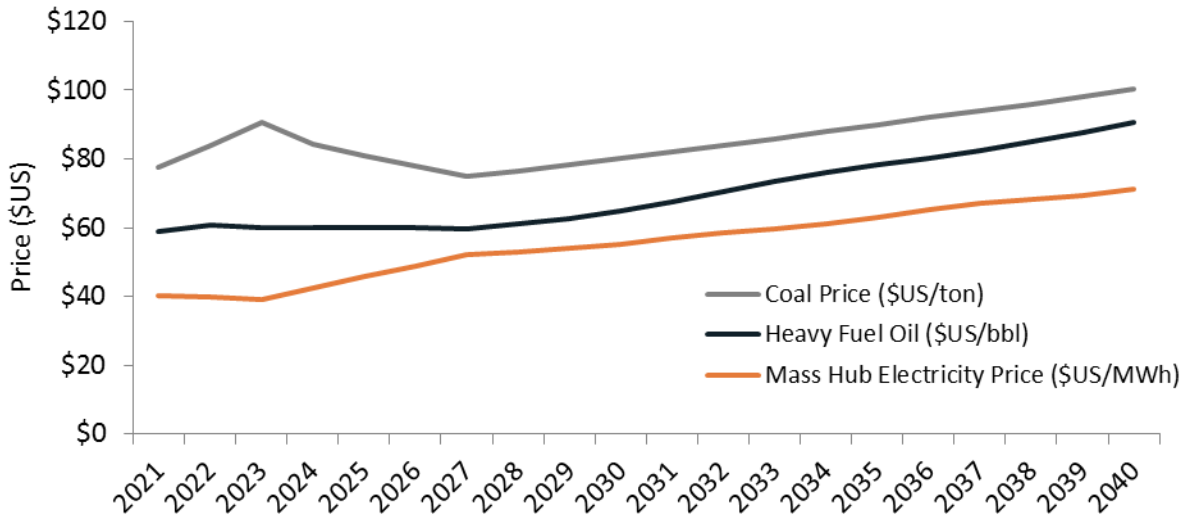
6 Fuel and Electricity Market Price Forecast

NB Power runs a diverse power systems that results in a direct dependence of various sources of fuel (e.g. coal, heavy fuel oil, light fuel oil, natural gas and nuclear). NB Power is also subject to commodity fuel prices through power purchase agreements and wholesale market electricity purchases.

With a diverse fuel mix, NB Power can often mitigate the price risks associated with individual commodities. The fuel mix is complemented by a comprehensive hedging strategy to reduce risks from short-term variations in fuel and electricity market prices and better plan for impacts on electricity prices.

To develop a fuel price forecast for the IRP, NB Power used a combination of forward prices from the 2021 NB Power budget and long-term forecasts developed by its fuel price forecasting consultant, Energy Ventures Associates. This fuel price forecast was also used to develop NB Power's 2021-2030 10-Year Plan. Figure 7 and Figure 8 shows select data from the resulting fuel price forecast. Fuel price forecasts do not include the cost of transportation or other costs and fees that would be applicable to NB Power.

Figure 7: Fuel & Electricity Price Forecasts

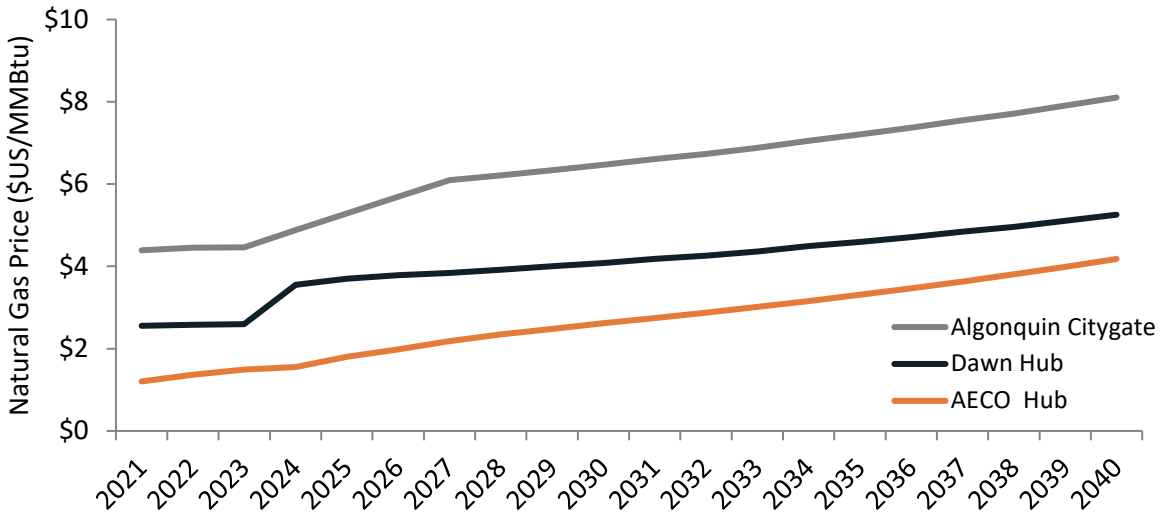


However, over the long term it is expected that commodity prices will return to normal levels. Furthermore, a sensitivity analysis was completed to explore the impact to NB Power if the short-

term changes resulting from the COVID-19 global pandemic were to persist in the long term and is included in Section 13.5 (COVID-19 Scenario).

The electricity market prices shown in Figure 7 are Massachusetts Hub (Mass Hub) prices. These are highly correlated to natural gas prices. The Mass Hub price index is a key indicator for any electricity imports or exports that NB Power purchases or sells in the wholesale market. Heavy fuel oil is the primary fuel used by the Coleson Cove Generating Station. Coal is the primary fuel used by the Belledune Generating Station. Natural gas is used by Grandview as well as the newly acquired Bayside Generating Station.

Figure 8: Natural Gas Price Forecasts for Algonquin Citygate[43], Dawn Hub[44] and AECO[45]



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[43] Algonquin Citygate is a natural gas trading hub located in Massachusetts.
[44] The Dawn Hub is a natural gas trading hub located in southwestern Ontario.
[45] AECO Hub is a natural gas trading hub located in southern Alberta.

In March 2019, NB Power bought the Bayside Generating Station (Bayside). After adding this station to New Brunswick's energy mix NB Power secured a long-term supply source and the required pipeline reservations to bring competitively priced natural gas from AECO Hub in Western Canada to New Brunswick. As a natural gas fueled station, Bayside offers significant carbon savings over the use of coal and allows NB Power to shift electrical production to this lower emissions emitting station, and thus could play a vital role in proving reliable electricity and reducing emissions until its retirement date.

Natural gas pricing assumptions used in the IRP depend on the operating characteristics of the generation supply option. Combined cycle generators are one example. They are relatively efficient and operate at higher capacity factors than other less efficient generators, and often need a longer-term, stable fuel supply. This means they require firm commitments on fuel volumes and transportation, which is assumed to be facilitated through the Dawn Hub. Gas-fired peaking units operate less often and at irregular periods, therefore spot market gas purchases using the Algonquin Citygate Hub is a more appropriate price for the purposes of the IRP. For each source, it is assumed there will be enough supply in the long term and prices will stay competitive compared to other fuel sources such as heavy fuel oil and electricity market prices. NB Power continues to look at alternate natural gas sources and transportation options.

Sensitivity analyses have been conducted to assess the impact of higher or lower fuel and purchased power prices. The results of those analyses are available in Section 13 (Sensitivity Analysis).

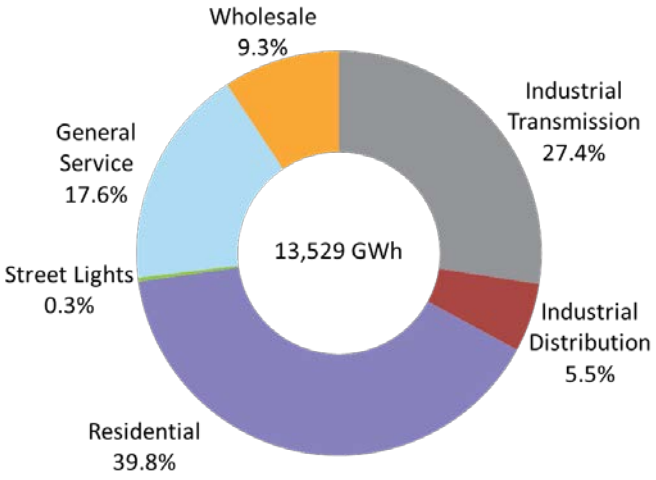
7 Load Forecast

The load forecast is a projection of New Brunswick's electricity requirements into the future. NB Power produces a load forecast annually for purposes of budgeting, and planning for the future. This IRP is based on the NB Power Load Forecast 2020-2030[46] completed during the summer of 2019. Customers are grouped in six customer classifications based on their electricity consumption patterns and types of end-uses, with customers in each group impacted by similar factors (e.g. weather, economic activity)

1. residential
2. general service
3. street lighting
4. industrial distribution
5. industrial transmission
6. wholesale (which includes sales to customer classifications noted above by municipal utilities in Saint John and Edmundston)

Figure 9 shows the relative proportions of NB Power's energy sales in the 2019 fiscal year to each of the six customer classifications.

Figure 9: 2019 Total Sales



7.1 Residential

Typical New Brunswick households make up over 96 per cent of the residential group. Also included in this group are churches and farms (less than 3 per cent total residential energy) and seasonal customers (approximately 1 per cent total energy requirements).

[46] Matter 458 Exhibit NBP01.40 Appendix S.i. - Load Forecast 2020-2030.

In the 2019 fiscal year, residential customers made up 44.3 per cent of the total in-province electrical energy sales (39.8 per cent directly by NB Power and 4.5 per cent by wholesale utilities).

Residential electricity consumption is forecasted using an end-use model that forecasts the consumption of individual appliance types and aggregates them for the customer class. The model can be simply stated as:

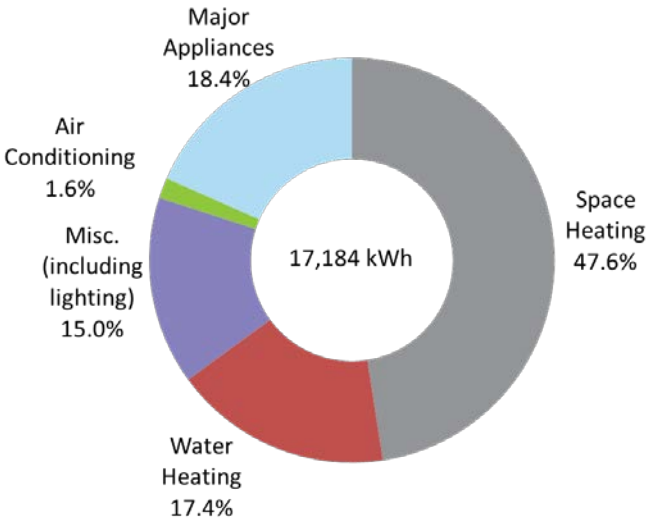
$$\text{Energy} = \text{Year round Customers} \bullet \text{Average Use per Customer}$$

Where:

$$\text{Average Use per Customer} = \sum (\text{Appliance} \bullet \text{Average Use})$$

Average household energy use includes electric space heating, water heating and other uses (appliances, lighting, cooling).

Figure 10: 2019 Average Residential Customer Use



In 2019, there were approximately 349,000 year-round residential customers in New Brunswick. Of those, 309,000 were direct NB Power customers and 40,000 were municipal utility customers in Saint John and Edmundston.

Growth in the residential forecast is driven by the addition of new customers. Growth in the number of customers is driven by the societal trend of smaller household size, resulting in the same population being spread over more homes. Increasing average customer use is offset by demand-side management programs delivered by NB Power and naturally occurring, energy efficient choices made by customers.

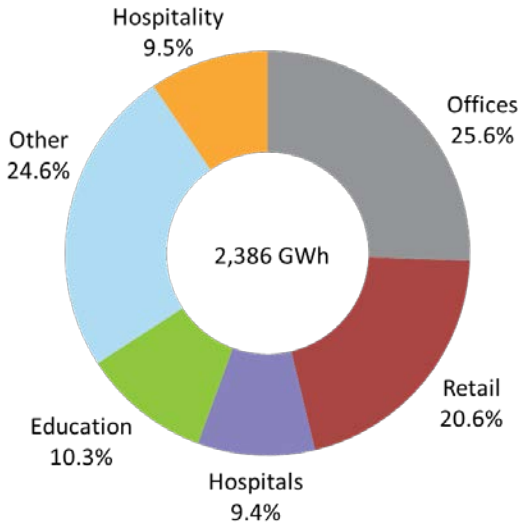
7.2 General Service

The general service classification includes commercial (retail, hospitality, offices, etc.) and institutional customers (hospitals, schools, universities, etc.).

As of March 2019, NB Power served approximately 26,600 general service customers while, New Brunswick wholesale utilities served approximately 5,000 general service customers, for a total of 31,600.

In the 2019 fiscal year, general service energy requirements made up 21.7 per cent of the total in-province energy sales (17.6 per cent directly by NB Power and 4.0 per cent by Wholesale utilities). Figure 11 shows the amount of NB Power's total general service sales by sector.

Figure 11: 2019 General Service Sales



Approximately 30 per cent of general service sales are to the institutional sector. The remaining general service sales in New Brunswick reflect the level of commercial activity and are closely related to the provincial gross domestic product (GDP). Weather affects the amount of electricity required for heating or cooling. The general service forecast uses an econometric model to relate changes in the level of sales to changes in the provincial GDP, the price of electricity and the number of heating degree days.

7.3 Industrial

New Brunswick's industrial customers account for about 33 per cent of the total in-province energy use.

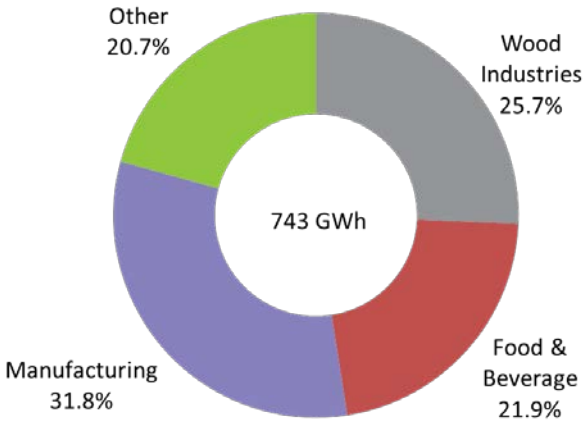
Industrial customers are divided into two groups

- Industrial distribution customers (served at transmission voltages less than 69 kV)
- Industrial transmission customers (served at transmission voltages of 69 kV and above)

7.3.1 Industrial Distribution

NB Power serves approximately 1,700 industrial customers at distribution voltages (less than 69 kV), while wholesale utilities serve approximately 70 others, totaling 1,770. Together, they account for approximately 5.9 per cent of the total provincial electrical energy requirements.

Figure 12: 2019 Industrial Distribution Sales

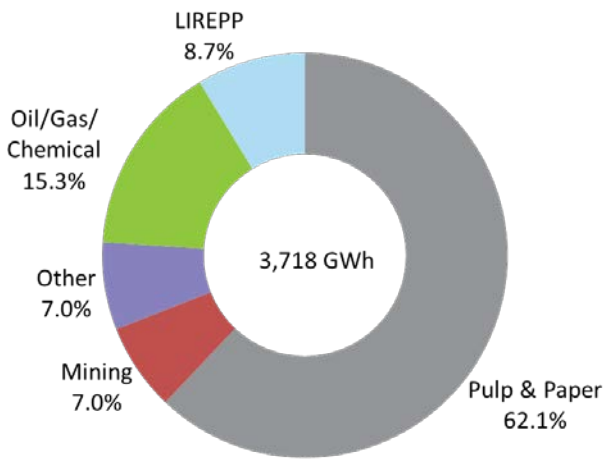


The industrial distribution forecast uses an econometric model to relate changes in the level of sales to changes in the provincial GDP.

7.3.2 Industrial Transmission

There are 43 industrial customers served at transmission voltages (69 kV and above). These customers make up the majority of the industrial group's sales. Figure 13 shows the 2019 portions of total industrial transmission sales to each of the main industry groups.

Figure 13: 2019 Industrial Transmission Sales



The forecast for these customers is done individually and includes the opening of a major mining operation within the forecast period.

Under the Large Industrial Renewable Energy Purchase Program (LIREPP), NB Power purchases electricity from qualifying large industrial customers who have renewable electricity generating facilities in New Brunswick. LIREPP renewable energy purchases help NB Power meet the renewable portfolio standard set out in the *Electricity from Renewable Resources Regulation – Electricity Act* for the benefit of all New Brunswickers. The revenue from qualifying renewable energy resources help these qualifying customers reduce their net electricity costs and increase their competitiveness in the global market. LIREPP sales differ from typical sales. They are generated exclusively at customer owned facilities. The energy for LIREPP is produced and consumed simultaneously on site. Therefore, it doesn't impact NB Power's capacity planning requirements, system losses or transmission system requirements. Because of this, LIREPP sales are sometimes reported separately from other system energy requirements.

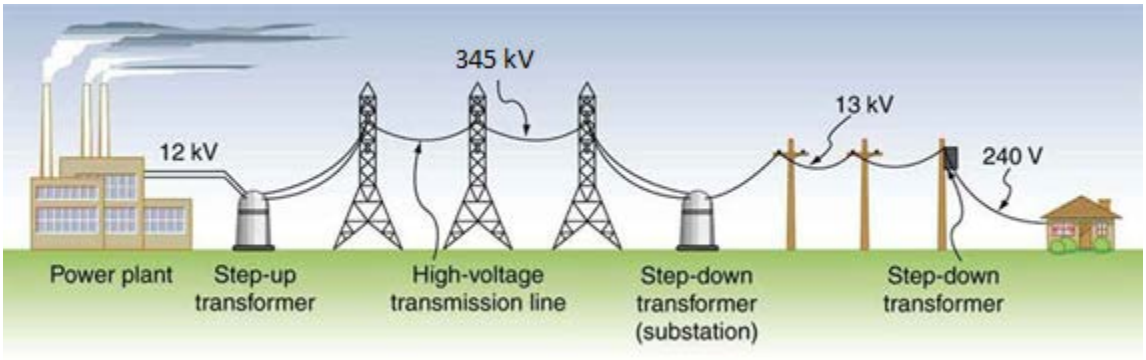
7.4 System Losses

Delivering electricity from generation sources to customers happens in three stages

1. high voltage transmission
2. transformation to lower voltages
3. distribution to the customers at standard service voltages

There are losses at each of these stages. Many factors play into losses such as the physical distance from the generation source to the customers, technical characteristics of the transmission and distribution systems and load level.

Figure 14: How Power is Delivered to Homes



The basis of the forecast energy losses on the transmission system is the Open Access Transmission Tariff[47] loss factor, currently 3.3 per cent. Loss factors or percentages are multiplied by the amount of energy delivered over the system to meet NB Power's total energy requirements.

Distribution losses are forecast based on an analysis of the energy supplied over the distribution system compared to billed distribution sales. Energy losses on the distribution system are estimated to be 4.0 per cent of the total distribution sales over the forecast period. In addition, a substation transformer loss factor of 0.6 per cent is applied to all distribution energy requirements, for a total of 4.6 per cent.

7.5 Peak Demand

Peak demand is a critical factor to consider when planning for system operations and new supply sources. Peak demand is the maximum energy requirement on the system during a one-hour period. As a winter peaking utility, NB Power commonly experiences the highest peaks in January and February, which are the coldest months the province faces. It is during these coldest months that New Brunswickers rely heavily on their heating systems to help keep their homes and businesses comfortable. Due to electric space heating being the most common heat source in homes and businesses in the province, all this heating load raises demand and creates a peak in the winter months.

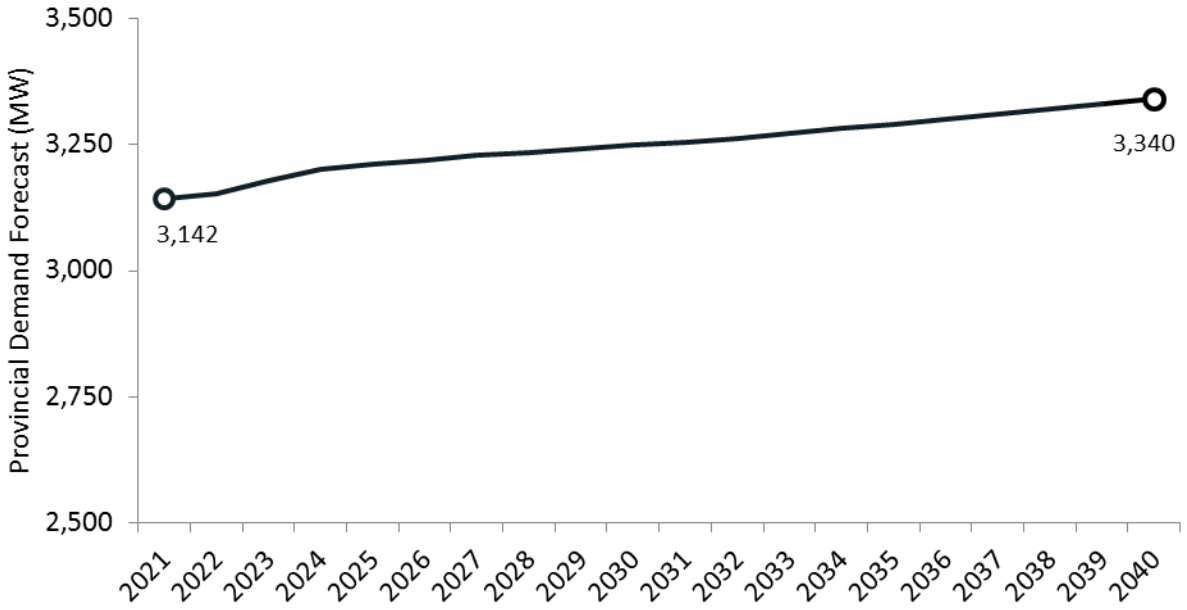
Peak demand is driven by weather. The system peak typically happens on one of the coldest days of the year. Residential and General Service loads are subject to the same weather patterns, and peak at roughly the same time. Industrial loads tend to be less affected by weather and remain relatively flat throughout the year.

[47] The NB Power OATT provides a real power loss factor that is applied to all transmission service within NB, and is subject to approval by the New Brunswick Energy and Utilities Board.

7.6 Load Forecast Results

The total customer load is determined by combining the total electricity consumption of the six customer classifications, and the transmission and distribution losses related to delivering that electricity. Beyond 2030, the forecast is escalated by class, with a technique that uses time-series regression models to project load growth. Using forecasts for each customer sector, the data is combined to create the total in-province load forecast. The forecast includes estimates of energy-efficiency measures that consumers are anticipated to implement without a demand side management program offering from NB Power. Estimates of energy efficiency and demand reduction programs as part of the Energy Smart NB plan to reduce and shift consumption are excluded from the forecast presented in Figure 15. This creates the foundation upon which the supply and demand side analyses will be conducted.

Figure 15: Provincial Demand Forecast



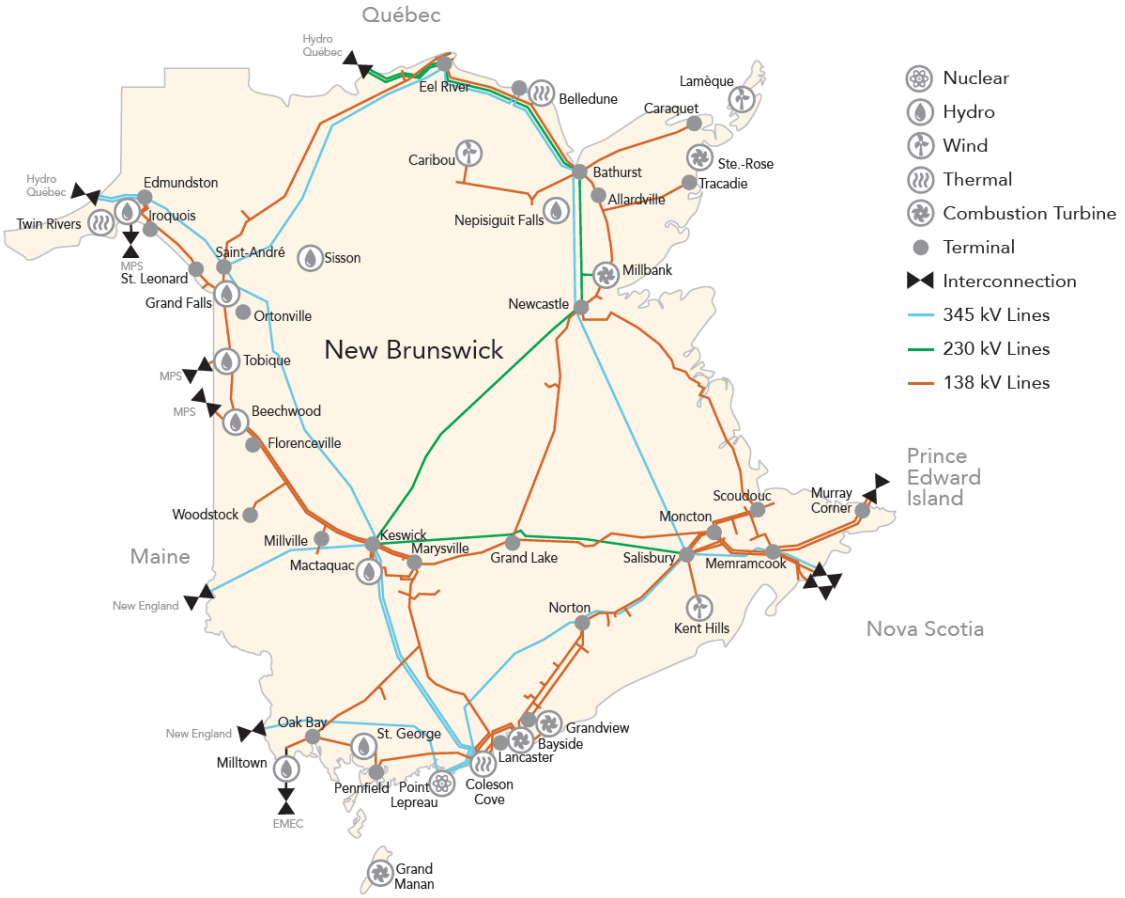
The average growth rate for peak demand is 0.5 per cent per year. Detailed load forecast data is included in Appendix 4 (Load Forecast Details).

8 Existing Resources

8.1 Generation Resources

NB Power has a diverse mix of generation resources and power purchase agreements. The utility serves the electric needs of the province with hydro, nuclear, oil, coal, wind, natural gas, biomass and solar resources. Over 40 per cent of New Brunswick's energy requirements currently come from renewable energy sources. Combining those with the Point Lepreau Nuclear Generating Station sees over 75 per cent of New Brunswickers needs being served from carbon-free sources.

Figure 16: System Map



At this time, no new generation has been committed for construction. However, NB Power has entered into power purchase agreements for additional renewable energy from Embedded Generation and Community Energy Projects that are under various stages of construction. These projects are expected to add a combined total of 83 MW to the current 409 MW of installed renewable generation under contract to NB Power, resulting in a total of 492 MW of renewable

generation Power Purchase Agreements by 2022 in addition to the 889 MW of NB Power-owned hydro resources.

The Mactaquac Generating Station is a 668 MW a run-of-the-river[48] hydro facility built in 1968. Since the 1980s, concrete portions of the station have been affected by a chemical reaction called an alkali-aggregate reaction. This reaction causes concrete to swell and crack. This results in significant annual maintenance and repairs. Without additional capital improvements, the station is expected to reach the end of its service life in 2030.

NB Power has proposed a life achievement capital project to ensure the station can operate until at least its intended 100-year lifespan of 2068. Pending the necessary environmental and economic approvals are obtained, the Mactaquac Life Achievement Project will start construction in 2027. During the construction phase of the project, Mactaquac will be available but with a reduced capacity and energy availability (from 668 MW to 556 MW). Hydro-Quebec, who has considerable engineering experience with hydro-electric stations with similar reactions, will provide expertise to New Brunswick during this project through a contractual arrangement.

The Belledune Generating Station is the only coal-fired facility in NB Power's diverse system. The facility reliably operates at a high capacity factor due to its low fuel cost. In December 2018, the federal government announced plans to phase-out coal-fired generation by 2030[49]. There are provisions included in the legislation for provinces to negotiate an equivalency agreement that would allow the continued use of coal, while achieving equivalent emissions reductions. This IRP assumes the provincial and federal governments will enter into an equivalency agreement that will see the plant continue to operate until its end of life in December 2040. For additional details, refer to Section 4.3 (Greenhouse Gas Regulations).

The current net generation capacity and power purchase agreement portfolio, as well as other statistics of the NB Power system, is provided in Table 5.

[48] All of NB Power's hydro generation facilities are run-of-the-river. Run-of-the-river facilities rely on natural hydro flows to produce electricity and are unable to store large volumes of water. Some run-of-the river facilities have a small amount of storage capability for intraday use, such as the Mactaquac head pond.

[49] "Canada's coal power phase-out reaches another milestone," Government of Canada, December 12, 2018, https://www.canada.ca/en/environment-climate-change/news/2018/12/canadas-coal-power-phase-out-reaches-another-milestone.html.

Table 5: NB Power Generating Capacity and Other Statistics (March 31, 2020)

Generating Capacity Thermal	
Coleson Cove	972 MW
Belledune	467 MW
Bayside	277 MW
Total Thermal	1,716 MW

Generating Capacity Hydro	
Mactaquac	668 MW
Beechwood	112 MW
Grand Falls	66 MW
Tobique	20 MW
Nepisiguit Falls	11 MW
Sisson	9 MW
Milltown	3 MW
Total Hydro	889 MW

Generating Capacity Nuclear	
Point Lepreau	660 MW

Generating Capacity Combustion Turbines	
Millbank	397 MW
Ste. Rose	99 MW
Grand Manan	29 MW
Total Combustion Turbines	525 MW

Total Generating Capacity	
Thermal	1,716 MW
Hydro	889 MW
Nuclear	660 MW
Combustion Turbines	525 MW
Total Generating Capacity	3,790 MW

Power Purchase Agreements (PPAs)	
Kent Hills (Wind)	167 MW
Caribou Mountain (Wind)	99 MW
Lameque (Wind)	45 MW
Wisokolamson Energy (Wind)	18 MW
Grandview (Natural Gas)	95 MW
Twin Rivers (Biomass)	39 MW
Irving Pulp & Paper (Biomass)	33 MW
AV Nackawic (Biomass)	26 MW
AV Cell (Biomass)	21 MW
St. George (Hydro)	15 MW
Edmunston Hydro	9 MW
Other Renewable	21 MW
Total Power Purchase Agreements	588 MW

Number of Lines	
Distribution Lines	21,358 km
Transmission Lines	6,905 km

Exporting and Importing	
Export Capacity	2,538 MW
Import Capacity	2,448 MW

Number of Customers	
Direct Customers	362,513
Indirect Customers	47,381
Total Customers	409,894

This diverse mix of generation capability is expected to meet New Brunswick's electricity requirements well into the future. In addition to the generation resources above, NB Power also has interconnections with neighboring utilities in Quebec, Prince Edward Island, Nova Scotia, and New England. The interconnections provide NB Power with flexibility to import electricity to offset higher cost generation, export surplus energy and increase system reliability.

For accounting purposes, each generating station is depreciated consistent with its assumed technical useful life based on typical experiences for that type of facility. Power purchase agreements have set contract terms and are generally tied to the useful lives of the contracted facilities. In actual practice, retirements are dependent on a technical and economic evaluation for each unit as it approaches the end of its useful life. In this IRP, retirement schedules are based on a useful life, with consideration of a reasonable extension period that allows the facility to continue operations. Consideration of life extension potential is made through studies conducted by NB Power engineering experts and associated economic analyses. The generating station end

of life assumptions are shown below. Life extension analyses for Bayside, Millbank, and Ste. Rose can be found in Section 12 (Analysis & Results).

Table 6: Retirement Schedule

Resource	Fuel Type	Capacity (MW)	End of Life (Fiscal Year)
Milltown	Hydro	3	2021
Grandview	Natural Gas	95	2025
Grand Manan	Diesel	26	2026
Bayside	Natural Gas	277	2027
Millbank	Diesel	397	2031
Ste. Rose	Diesel	99	2031
Point Lepreau	Uranium	660	2040
Belledune	Coal	467	2041
Coleson Cove	Oil	972	2041

Except for Milltown, it is assumed that all hydro facilities will continue to operate through the planning horizon. Renewable PPAs are assumed to be extended, at reduced prices if the underlying resources are technically capable of reliably generating electricity.

8.1.1 Net Metering

NB Power's net metering program allows customers to produce up to 100 kW of their own qualifying renewable energy from sources like biogas, biomass, solar, small hydro or wind. A bidirectional meter records both the electricity delivered to the customer and the electricity NB Power receives back from the customer's generation unit. This allows New Brunswickers to offset their energy consumption. In order to qualify for the program, the requirements detailed in the Government of New Brunswick's *Electricity from Renewable Resources Regulation* must be met.

8.1.2 Embedded Generation

The embedded generation program allows developers and independent power producers to connect environmentally sustainable generation to NB Power's distribution system. The utility purchases energy from these producers at an established rate. NB Power anticipates an additional 20 MW under this program to be online by 2022.

8.1.3 Community Energy Projects

The Locally Owned Renewable Energy Projects that are Small Scale (LORESS) program was established in 2015 through the *Electricity from Renewable Resources Regulation*[50]. The program allows First Nations communities and local entities to generate up to 40 MW of renewable energy

[50] "Electricity from Renewable Resource Regulation – Electricity Act," New Brunswick Regulation 2015-60 under the Electricity Act (O.C. 2015-263), Government of New Brunswick, filed November 12, 2015, https://www2.gnb.ca/content/dam/gnb/Departments/ag-pg/PDF/RegulationsReglements/2015/2015-60.pdf.

to go onto NB Power's system. The program resulted in 78 MW of renewable generation that has been added or is planned to be added to the system.

8.2 Transmission & Interconnections

NB Power's transmission system is made up of 6,900 kilometers of 345 kV, 230 kV, 138 kV and 69kV transmission lines, terminals and control equipment. It's designed to provide reliable energy to New Brunswick customers and allows the utility to export and import energy to and from neighboring utilities.

The existing transmission system has evolved over the past century. It began mainly as 69 kV lines connecting small generating stations in municipal distribution systems in the first half of the 20th century. Following the Second World War, and to keep up with the load growth through the 1960s, the 138 kV system was expanded to form a figure-eight network around the province and to interconnect with Nova Scotia for the first time. Expansion continued in the early 1970s with the completion of a 230 kV system connecting from the northeast (Dalhousie–Bathurst–Newcastle) area to Keswick in the west, and across the province to Salisbury in the southeast. The maximum system voltage increased to 345 kV with the completion of the New England interconnection and the Coleson Cove Generating Station in the late 1970s. Through the 1980s and 1990s, the 345 kV system expanded to encircle the province and extend into Nova Scotia.

New Brunswick's transmission system is a small section of a much larger bulk transmission system (the Eastern Interconnection) which spans from Central Canada to the Atlantic coast (excluding Quebec), south to Florida and to west to the Rockies (excluding Texas). Having strong interconnections with neighbouring systems is very important to NB Power. New Brunswick is well positioned with direct interconnections to Quebec, Prince Edward Island, Nova Scotia and New England. Interconnected transmission lines and an Open Access framework are used to transfer electricity from one jurisdiction to another under strict rules that maintain open, fair, and reliable service. These lines also support the system with direct and indirect contributions to capacity reserves. This lowers costs for New Brunswickers as it lowers the need for additional generation capacity to be committed and online at any given instant to serve customers.

New transmission requirements are driven by several potential factors, including

- the need to connect new generation
- in-province load growth
- import and export requirements
- system reliability
- industry reliability standards
- customer-driven requests

NB Power regularly assesses the transmission system to ensure it meets reliability standards and provides benefits to New Brunswickers and other customers.

Currently, there is enough transmission capacity to meet in-province and customer load requirements. However, NB Power is aware of the potential emergence of transmission constraints within some parts of New Brunswick and NB Power is looking at solutions to address these issues. They include

- adding transmission infrastructure
- targeted demand reductions (smart grid technology/ DSM programs)
- strategically locating any new generation

Opportunities also exist to increase transmission capacity with neighbouring jurisdictions. This would enable increased energy imports into New Brunswick from Quebec and potentially into Nova Scotia from New Brunswick. NB Power is a participant in the federal government's *Atlantic Clean Power initiative*[51] which looks to define what transmission upgrades are required to deliver clean power from Quebec or Newfoundland and Labrador to the Maritimes. In addition, NB Power recently entered into an agreement with Hydro Quebec that will see the two utilities consider building new interconnections between Quebec and New Brunswick.

A summary of major transmission infrastructure upgrades expected over the next 10 years is available on the NB Power Transmission & System Operator website[52].

The next 20 years (and beyond) could see changes to generation supply types and locations. These changes may require new transmission infrastructure. Specific transmission projects are outside of the scope of the IRP, but the results of the plan will help inform future transmission projects.

[51] "Atlantic Growth Strategy – Clean Energy," Atlantic Canada Opportunities Agency, Government of Canada, March 1, 2019, https://www.canada.ca/en/atlantic-canada-opportunities/news/2019/03/atlantic-growth-strategy--clean-energy.html.
[52] "10-year Transmission Plan", NB Power, November 2018, https://tso.nbpower.com/Public/en/op/market/data.aspx.

9 Capacity Planning Reserve Criteria

NB Power must deliver safe and reliable power to New Brunswickers. This includes the reliable operation of transmission, distribution and generation resources. Generation reliability criteria are governed by a metric known as loss of load expectation. This is the expected number of days each year when the available generation capacity is not enough to meet the daily load demand. NB Power is a member of the Northeast Power Coordinating Council and this council sets reliability practices that interconnected electricity systems follow. The Northeast Power Coordinating Council sets a benchmark of a loss of load expectation of no more than 0.1 days per year[53].

NB Power is the reliability coordinator for the Maritimes Area. The reliability coordinator is responsible for reporting to the Northeast Power Coordinating Council that reliability standards for the region are being met. A recent assessment of the reliability of the Maritimes Area[54] showed a loss of load expectation of 0.01 days/year. This exceeds the Northeast Power Coordinating Council reliability benchmark. The same study shows the minimum reserve criterion for the Maritimes Area is 20 per cent. This means the capacity of generation resources must exceed the maximum firm peak demand by a minimum of 20 per cent in order to have sufficient generation available to meet reserve requirements. The IRP uses this 20 per cent reserve margin to plan for generation capacity.

9.1 Intermittent Resources

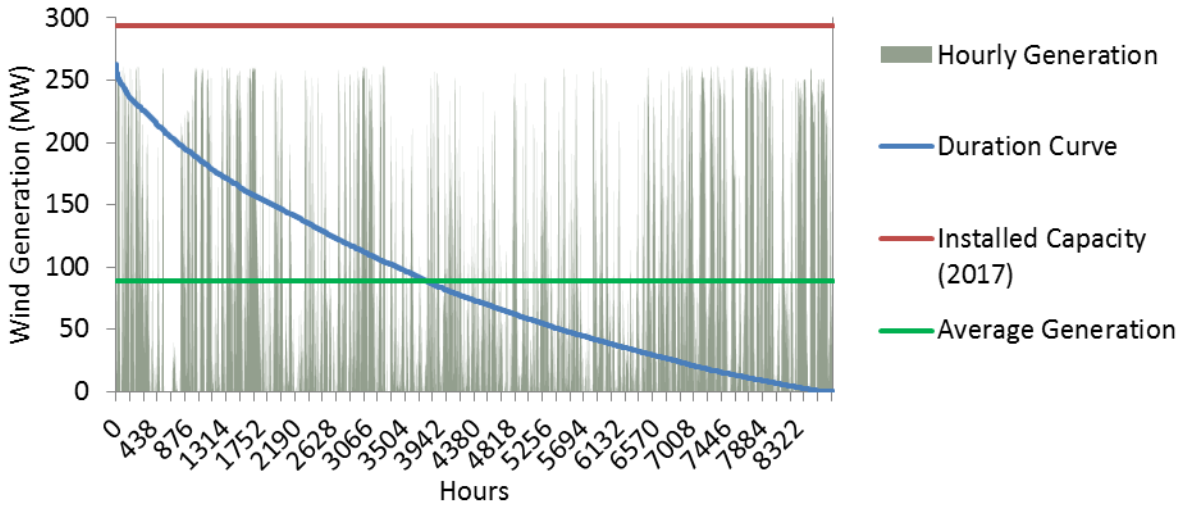
NB Power has acquired 329 MW of wind generation with another 80 MW scheduled to come online in 2022. Wind generation is a valuable resource as it helps NB Power meet the 40 per cent renewable portfolio standard. Wind is also an intermittent resource, with varied and largely unpredictable generation.

Figure 17 shows that in 2017, New Brunswick's three largest wind farms, which had a total capacity of 294 MW, operated at less than one-third capacity for more than half of the hours in the year. During those same hours they also produced less than a quarter of their total annual wind generation. The 294 MW of installed wind creates an average daily ramping requirement of 251 MW. This highlights the challenges of balancing intermittent resources such as wind or solar. Additionally, any thermal units needed to meet the next day's peak demand, balance load or balance renewables must remain online, as these units cannot be cycled on and off daily.

[53] "Regional Reliability Reference Directory # 1 Design and Operation of the Bulk Power System," Northeast Power Coordinating Council, Inc., revised March 5, 2020, https://www.npcc.org/Standards/Directories/Directory1_Design%20and%20Oper_20200305.pdf.

[54] The Northeast Power Coordinating Council defines the Maritimes Area as New Brunswick, Nova Scotia, Prince Edward Island, and Northern Maine.

Figure 17: 2017 Wind Output Duration Curve



Beyond balancing generation, there are complications with wind that arise in low load conditions. NB Power's system requirements can sometimes be as low as 850 to 900 MW on mild summer nights. There are many generating stations and contracts that can't be ramped down for these low load periods (e.g. Point Lepreau (660 MW), run-of-river portion of the hydro system (100-150[55] MW), other must-take contracts (587MW), for a total of 1,347-1,397 MW). NB Power must consider these low load conditions when looking at the costs and benefits of adding any incremental intermittent resources, like wind.

9.2 Intermittent Resource Planning Capacity Contribution

Intermittent resources present an interesting challenge for capacity planning. Electricity generation from intermittent resources, such as wind and solar, is varied and largely unpredictable. Intermittent resources are non-dispatchable which means utilities have no control over when these sources will produce energy as it is dependent on the weather. They generate when the wind blows or the sun shines, regardless of the needs of the system. For fossil fuel stations, a forced-outage rate of five per cent would be considered typical. This means that five per cent of the hours in a year, the station would be unable to provide its full generation output to serve load. Loss of load expectation studies simulate the fleet of generating stations to determine overall system reliability and the ability to serve all customer load. The likelihood of whether wind, solar and other non-dispatchable technologies could contribute toward serving load when needed is considerably less than traditional generating stations. The correlation of

[55] 100-150 MW represents the portion of the Hydro system that is run-of-river during periods of relatively low hydro flows. Rain, snow-melt or other weather conditions can increase the run-of-river portion considerably. During the spring freshet, the hydro system loses all flexibility and is entirely run of river.

generation between sites (wind, for example) also limits the contribution of that technology toward resource adequacy and results in diminishing benefits for larger penetrations.

The IRP includes an analysis comparing the contribution of non-dispatchable technologies with dispatchable options. This was done by simulating the New Brunswick system first with 391 MW of installed wind capacity (the sum of the current installed capacity and the LORESS program) and determining the loss of load expectation value. Wind was then removed and the simulation was run again with traditional dispatchable generating resources and a forced outage rate of five per cent. The analysis shows a 93 MW dispatchable resource would result in an equivalent loss of load expectation. This means the 391 MW of installed wind capacity has the equivalent impact to loss of load expectation as a 93 MW dispatchable resource. The second stage of the analysis considers additional penetrations of wind generation. First, the system was simulated with an additional 400 MW (791 MW total) of installed wind, then re-simulated without it. It was determined the additional 400 MW of wind had an equivalent impact to 49 MW of dispatchable generation.

Table 7: Diminishing Capacity Planning Credit of Wind Energy

NB Installed Wind Capacity (MW)	Planning Capacity (MW)	Average Planning Capacity Credit
391	93.0	24%
+ 400	+ 49.0	12%

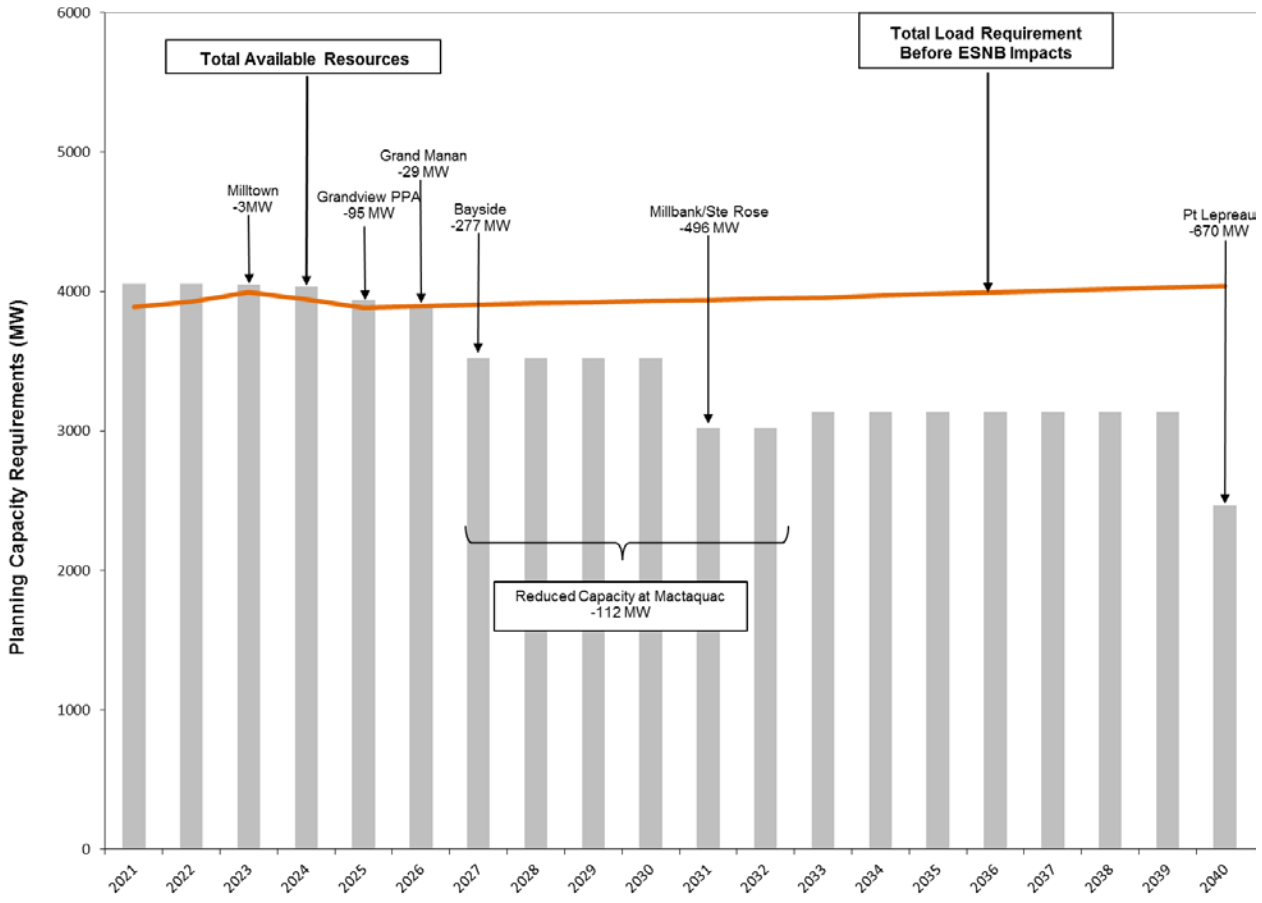
Although wind is an excellent source of low-cost energy the analysis demonstrates wind generation is not a good source of capacity. As more wind power is added to the system, its value for capacity planning declines.

9.3 Load and Resource Balance

The chart in Figure 18 provides a snapshot of NB Power's electricity requirements. Generation resources, as described in Section 8.1 (Generation Resources) are compared to the current load and reserve requirements[56] as well as assumed growth.

The Load and Resource review is the base for the IRP when considering cost effective demand side management programs and supply side generation options. Energy and demand side management reductions from future Energy Smart NB initiatives are not included in this assessment.

Figure 18: Load & Resource Review



From this review, the need for capacity begins around 2027. This is when NB Power will see the retirement of two generation stations (Grand Manan and Bayside) preceded by the end of a

[56] NB Power must provide reserve capacity equivalent to 20 per cent of its firm load.

power purchase agreement with Grandview and assumed retirement. Over the IRP's 20-year outlook, over one third (approx. 1,560 MW) of NB Power's overall generation capacity is scheduled for retirement

This IRP assumes the Mactaquac Life Achievement Project will be complete in 2033. If the project is sanctioned and obtains the necessary approvals (see Section 8.1, Generation Resources), one unit (about 112 MW) will be unavailable at any one time. At the end of the project, in 2033, all units will be fully available. Other hydro facilities are assumed to be replaced in kind.

The Point Lepreau Nuclear Generating Station supplies about 35 per cent of New Brunswick's energy needs. Fueled by nuclear energy, Point Lepreau helps NB Power provide 75 per cent of energy demand from carbon-free or renewable sources. To ensure NB Power can continue to meet future carbon-free targets and baseload requirements, Point Lepreau's capacity and energy will be replaced in-kind after its scheduled retirement date. Over the next 20 years, new options could become available that will help maintain this carbon-free energy. Small modular reactor technology is one of those options (refer to Section 10.4, Small Modular Reactors for more details). As the IRP is refreshed every three years, NB Power will continue to evaluate all available options.

Even though the load and resource assessment shows a shortfall starting in 2027, it also highlights a slight period of surplus capacity during a transition period from 2021 to 2026. Having a surplus capacity positions NB Power well to potentially market this small surplus capacity to its neighbouring systems which brings additional value to New Brunswickers, and helps offset the need for higher electricity rates.

As part of the IRP process, NB Power will review the potential life extension of Bayside Generating Station, as well as the potential life-extension of the Millbank and Ste. Rose Generating Stations.

10 Supply Side Resources

10.1 Supply Options

The IRP looks at supply options of varying sizes, fuel sources, operating characteristics and costs. While the economics of each option are important in order to be consistent with least-cost supply planning, there are other factors that need to be considered like environmental sustainability and risk management considerations such as reliability and dispatch characteristics. Table 8 summarizes the available supply options and whether the option is renewable or carbon-free. It also includes each option's respective dispatch characteristics (i.e. Intermittent, Peaking, Load Following, and Baseload).

Table 8: Supply Options

	Supply Option	Renewable or Carbon Free	Dispatch Characteristics			
			Intermittent	Peaking	Load Following	Baseload
Conventional Supply Options	Grand Falls Additional Power	Yes			Yes	
	Interconnection Energy/Capacity Purchase	Yes/No			Yes	Yes
	Simple Cycle Gas Turbine - High Efficiency			Yes		
	Simple Cycle Gas Turbine - Mid Efficiency			Yes		
	Small Simple Cycle Gas Turbine - Diesel			Yes		
	Large Combined Cycle				Yes	Yes
	Small Combined Cycle				Yes	Yes
	Microturbine			Yes		
	Nuclear - Large	Yes				Yes
Alternative Supply Options	Natural Gas Fuel Cells					Yes
	Biomass Combined Heat & Power	Yes			Yes	Yes
	Biomass Bubbling Fluidized Bed	Yes			Yes	Yes
	Municipal Solid Waste	Yes			Yes	Yes
	Geothermal Energy	Yes				Yes
	Small Modular Reactor	Yes			Yes	Yes
	Small Wind	Yes	Yes			
	Large Wind	Yes	Yes			
	Very Small Solar Photovoltaic - Fixed Tilt Racking	Yes	Yes			
	Small Solar Photovoltaic - Fixed Tilt Racking	Yes	Yes			
	Large Solar Photovoltaic - Fixed Tilt Racking	Yes	Yes			
	Large Solar Photovoltaic - Single Axis Tracking	Yes	Yes			
	Small Hydro	Yes			Yes	
	Wave Power	Yes	Yes			
	Tidal Stream Power	Yes	Yes			
Storage Options	Lithium Ion Battery Energy Storage System			Yes		
	Flow Battery Energy Storage System			Yes		
	Compressed Air Energy Storage			Yes		
	Pumped Hydro Storage			Yes		

Dispatch characteristics are an important consideration, because not all generation supply options are equally capable of meeting New Brunswick's electrical system's demands. Electricity consumption is constantly changing, and energy supply must always be in balance with energy demand. NB power also needs to maintain a minimum level of reserve generation to meet reliability standards. Some generation options are better at these tasks than others.

Generally, a supply option is either considered dispatchable (reliable and predictable) or non-dispatchable (unreliable and unpredictable). Dispatchable options can be ramped up or down and can adjust output to meet the requirements of the electrical system. Non-dispatchable generation can't be controlled in this way.

Intermittent supply sources like wind and solar are examples of non-dispatchable options. These options are dependent on factors like weather conditions and time of day. Because of that, they're not able to efficiently respond to the consumption needs of New Brunswickers. These resources generate when they can, and don't generate when they can't, regardless of the needs of the system. To make these options viable, they need to be paired with dispatchable sources, demand side management programs or energy storage to meet demand.

Currently, demand side management programs and energy storage are not at a point where they can reliably and economically balance large volumes of intermittent resources. Over the next several years, new developments may emerge that can provide more opportunities to balance intermittent resources. For example, as New Brunswick's smart grid develops more demand response programs and storage solutions are expected to become viable alternatives. Until then, as intermittent sources are added to the system there will be requirements for supply options capable of providing peaking and load following services to balance the variable generation output against electricity demand.

On the coldest days of winter New Brunswick experiences periods of high (peak) energy consumption as New Brunswickers turn to electric heating systems to keep their homes and businesses comfortable. Peaking supply options are dependable, reliable, and dispatchable generators that operate during those times. They can be turned on and off quickly and are fast to respond to changes in system requirements. They also provide reliable backup generation, or reserve, to the electrical grid. For example, if a baseload generator is needed to go offline without warning, peaking supply options can turn on quickly to replace the lost generation without impacting customers. Because they can react quickly to changes in demand, they are capable of balancing load and/or intermittent resources. But generating costs for peaking plants are high, as they are inherently less efficient sources of energy.

Load following supply options are dispatchable generation resources. Their output is flexible. It can be adjusted anytime during the day to meet demand. These options can balance load changes

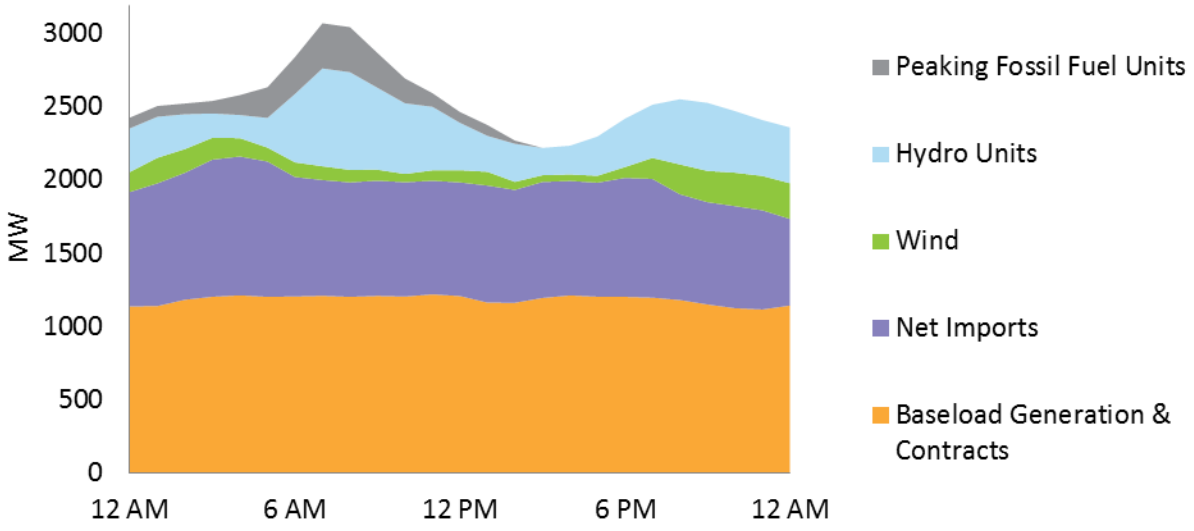
or intermittent resources like wind. They are not able to respond to changes in demand as quickly as peaking generation options, but they are more cost efficient than peaking supply options, so they can supply energy at a lower average cost.

Baseload supply options are reliable and constant generation sources that meet the minimum level of electricity demand. Baseload stations are typically highly cost efficient and have the lowest energy supply costs.

How a generator is used is highly dependent on cost-effectiveness and the generator's dependability, reliability, and predictability to serve load. There are several scenarios where peaking units like Coleson Cove are needed to operate for longer periods of time. Similarly, baseload units like Belledune may be used for load following when there's less demand.

This graph shows a typical peak winter day and how daily energy demand is met with different generation sources.

Figure 19: Winter Dispatch Example



In this example, as electricity demand increases in the morning, when New Brunswickers wake up, and get ready for work or school, energy output from intermittent wind resources decreases. Peaking thermal generation and hydro are increased to balance the decrease in intermittent resource output and provide the additional generation required to meet the morning peak. Throughout the day, hydro generation is used to meet most of the load following requirements. Baseload generation is met primarily by Point Lepreau, Belledune and energy imports. A second peak occurs in the evening as New Brunswickers return to their homes, have dinner and prepare for the next day. As the evening peak progresses, energy output from intermittent wind resources increases and energy imports are reduced. During the overnight hours as New

Brunswickers sleep, load naturally falls and NB Power lowers output from hydro generation to build up water levels in anticipation of the following days' peak energy requirements.

10.2 Capital and Operating Cost Assumptions

Cost is a critical piece of the supply-side analysis. It has a significant impact on recommendations made through the IRP process. NB Power engaged a consultant, Hatch Ltd, to provide project and operating cost parameters for each of the supply options shown in Table 8 (Supply Options) and NB Power data. A summary of project cost and operating parameters for each option is provided in Appendix 3 (Project and Operating Cost Parameters).

In order to support the IRP's principle of risk management, many of the supply options considered in the IRP are in wide-spread commercial operation. High level cost estimates and operating characteristics are given for pre-commercial options. These estimates are based on current information and experience. No provision has been made to predict what new options may be available in the future, including potential cost improvements. However, as the IRP is updated every three years, any new information available at the time of an update will be included in each subsequent update.

Capital costs are based on NB Power's consultant's in-house data from recent similar projects, and on publicly available industry data from conferences, reports, professional papers and other publications. Historical project costs were adjusted for inflation and to 2020 Canadian dollars as needed.

The cost estimates reasonably reflect the cost of building the generator in New Brunswick. Specific sites were not selected for the alternatives except in cases involving modifications to NB Power's existing generation assets.

Carbon costs were not included in the estimates from NB Power's consultant. The impact of carbon pricing was analyzed separately while developing the levelized cost of energy estimates and detailed production cost modelling.

Capital costs provided by NB Power's consultant were expressed as overnight costs[57]. NB Power included an interest rate during construction of 5.25 per cent, consistent with public-financed projects. Escalation was also applied to capital projects that reflected the electric utility construction price index, projected at 3.2 per cent per year for new hydro projects and 3.6 per cent per year for all other supply options. All other costs, including Operating Maintenance & Administration costs, were projected to increase by 2 per cent per year based on the Consumer Price Index forecast. Capital cost estimates did not include transmission interconnections or upgrade costs since these would be site specific. NB Power has included an additional 8 per cent

[57] Overnight costs exclude interest during construction and escalation.

to account for overhead costs, owners' costs and transmission costs not included in the original project estimates, consistent with planning assumptions used for other major projects. For more details, refer to Section 5 (Economic Assumptions).

Typical plant operations and operating modes are described in support of the operating maintenance & administration cost estimates. Costs include operators of the facility, maintenance, labour and materials as well as administrative costs to provide the facility service. Operating costs do not include fuel costs. However, information is provided on typical heat rates for each thermal power technology. NB Power estimates the appropriate fuel costs for each alternative using the thermal characteristics of the source and long-term fuel price forecasts provided by NB Power's fuel price forecast consultants.

10.3 Distributed Energy Resources

In addition to traditional supply options, NB Power must also consider the expanding roles that customers will play in the future. Distributed energy resources are small electrical generators (typically renewable) or energy storage devices. They are connected to the distribution system and are close to the loads they serve. NB Power currently has programs in place that fall into this category. As smart grid progresses there will be more opportunity to integrate distributed energy resource technologies into the distribution system. Refer to Section 11 (Energy Smart NB) for more details on distributed energy resources.

NB Power understands some New Brunswickers have a growing interest in producing and storing their own energy but also want reliable backup energy from the grid. To facilitate these interests, NB Power must continue to modernize the New Brunswick electrical system and make it smarter. The utility continues to study viable business models for customer owned generation to support these goals. For the purposes of the IRP, two sensitivity analyses were completed for high penetrations of two representative technologies: electric vehicles and customer-owned solar photovoltaics.

10.4 Small Modular Reactors

As NB Power maps out a sustainable, carbon-free energy future for New Brunswick, the utility is studying the role advanced and inherently safe small nuclear reactors may play. In addition to supply planning, carbon-free nuclear can help meet evolving emissions requirements. The potential benefits of the emerging small modular reactor market are noteworthy to New Brunswick and Canada as a whole.

NB Power has extensive experience in safely operating and maintaining a nuclear generation station. Using this experience, its in-house team of nuclear experts provides details about small modular reactor technology and the industry in Appendix 5 (Small Modular Reactors). Cost estimates remain uncertain at this time and are not included in this IRP. Small modular reactors

were considered as a potential solution to phasing out of coal (refer to Section 12.5, Greenhouse Gas Regulation Analysis). Furthermore, the technology represents a scalable solution for New Brunswick's electricity system to become near carbon-free by the year 2041 or before.

10.5 Results of Supply Analysis

The following sections provide detailed analysis for each of the supply options included in the IRP. Each supply option is evaluated using levelized cost analysis. Levelized cost analysis is a methodology used to evaluate the relative economics of generation projects with different sizes, fuel types, capacity factors and useful lives. This analysis acts as a screening tool to decide which technologies should be included as potential options for detailed capacity planning and production cost modelling.

The analysis includes all costs for each project over its lifetime. Specifically,

- initial investment costs
- operating, maintenance and administrative costs
- fuel costs (if applicable)
- financing costs
- environmental costs (if applicable)
- risk premiums for unproven technologies
- balancing/load following adders for intermittent options (used for levelized cost comparisons only)

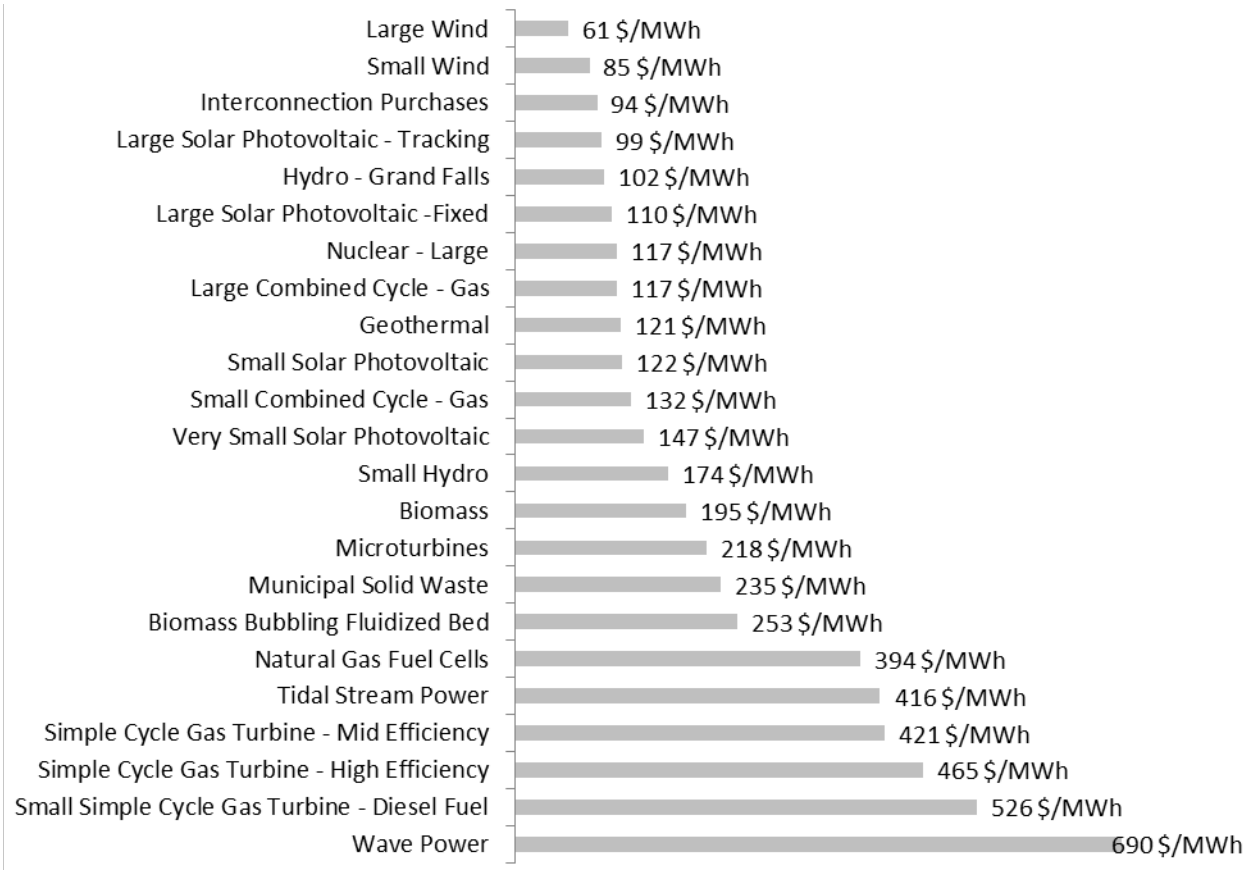
Three types of levelized cost analyses are needed to evaluate potential energy sources and capacity against system requirements.

10.5.1 Levelized Cost of Energy

Levelized cost of energy is the average revenue per unit of energy production (expressed as dollars per megawatt-hour (MWh)) required by a project owner to recover all investment and operating costs[58]. Levelized costs range from a low of $61 per MWh for Large Wind options to a high of $690 per MWh for Wave Power. The levelized cost of energy analysis identifies the cost at which technologies provide energy to the grid. It does not consider dispatch characteristics, load following potential or contribution to capacity requirements.

[58] "Levelized Cost of Electricity and Levelized Avoided Cost of Electricity Methodology Supplement," U.S. Energy Information Administration, July 2013, https://www.eia.gov/renewable/workshop/gencosts/pdf/methodology_supplement.pdf.

Figure 20: Levelized Cost of Energy



**Levelized cost of energy for small modular reactors is under development.*

10.5.2 Levelized Cost of Storage

Levelized cost of storage is the average revenue per unit of energy discharged (expressed as dollars per MWh) required by a project owner to recover all investment and operating costs[59]. Levelized costs for mature storage options range from a low of $167 per MWh for Pumped Storage Hydro to $229 per MWh for compressed air energy storage. Battery storage is developing rapidly and variations of two technologies are included in this analysis. Levelized costs range from a low of $332 per MWh for smaller, long duration Flow Battery technologies to a high of $1,210 for short duration Lithium Ion Battery Storage Systems. All of these storage options are currently not cost competitive with other options, but these costs are coming down and NB Power will continue to monitor those developments.

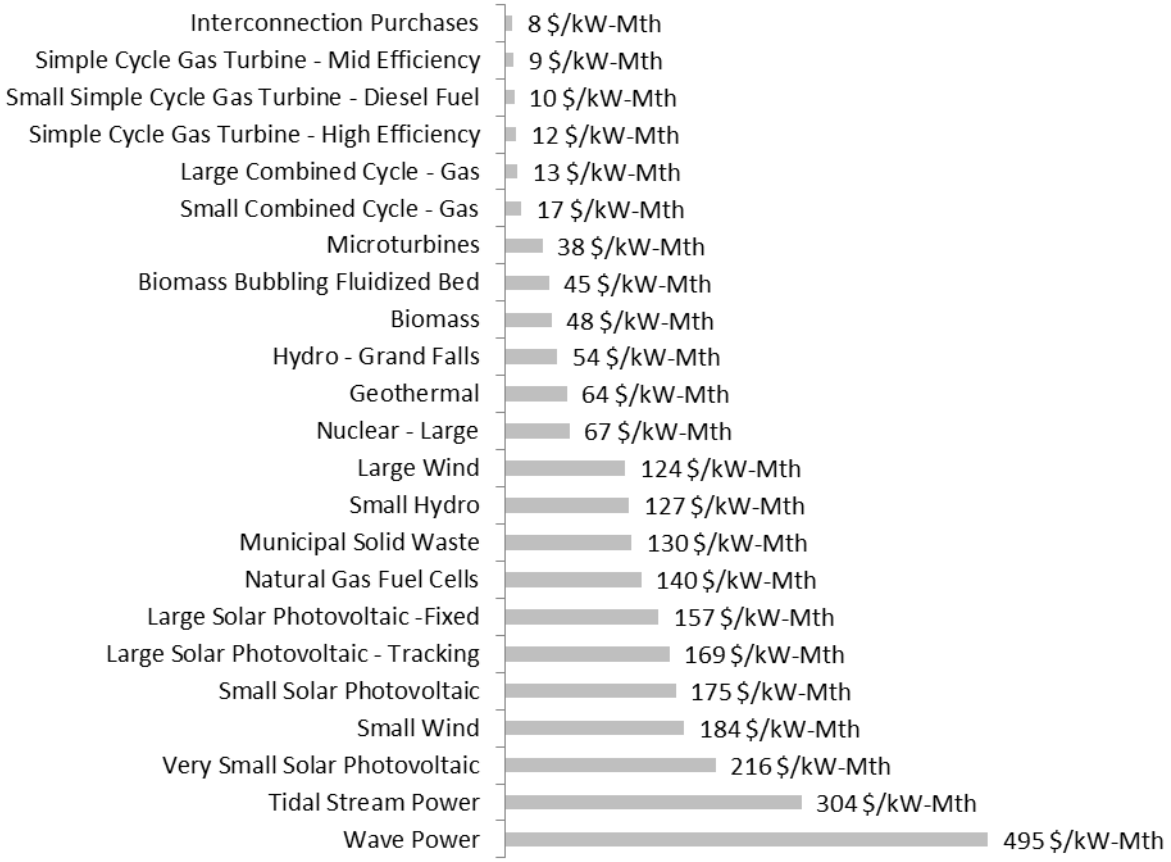
10.5.3 Levelized Cost of Capacity

The levelized cost of capacity is the revenue per unit of capacity (expressed as dollars per kilowatt-month (kW-Month)) adjusted for the respective capacity credit for each option that is

[59] "Lazard's Levelized Cost of Storage Analysis – Version 4.0," Lazard, November 2018, https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf.

required to recover all investment and fixed operating costs. NB Power must maintain a level of reserve generation equal to 20 per cent of its firm load. For traditional dispatchable generating technologies, the installed capacity and capacity credit are equal. For intermittent or non-dispatchable technologies, the capacity credit is less than the installed capacity. For example, the total capacity costs for a 100 MW Wind Farm is allocated to just the 12 MW (100 MW x 12 per cent)[60] of capacity benefit that generation type would bring to the New Brunswick electrical system. This results in a relatively high levelized cost of capacity when compared to dispatchable generation resources. Levelized costs range from a low of $8 per kW-Month for the Interconnection Purchases to $495 per kW-Month for Wave Power.

Figure 21: Levelized Cost of Capacity



**Levelized cost of capacity for small modular reactors is under development*

10.5.4 Cost of Private Financing

The cost of capital for private power projects is estimated by reviewing recent actual experience of major independent power producers in Canada. With this information, the IRP assumes private

[60] The capacity credit for new wind is assumed to be 12 per cent. Refer to Section 9.2 (Intermittent Resource Planning Capacity Contribution) for additional details.

projects after-tax weighted cost of capital is 6.74 per cent compared to 5.25 per cent for public projects (Section 5 - Economic Assumptions). On average, the higher cost of private financing increases the levelized costs of energy and capacity for generation supply options by approximately 20 per cent. Increasing generation supply costs through private financing will result in higher costs for NB Power and New Brunswickers.

10.5.5 Levelized Cost Summary

Based on the levelized cost analysis and the load and resource assessment, it is possible to develop alternative system plans that can be evaluated in detail through production cost and financial modelling. System plans need to address renewable portfolio standards, greenhouse gas emission limits and long-term capital stock turnover. Supply options show a significant variation in both energy and capacity cost. Screening was based on emission profiles, dispatch characteristics and economics. Emission profiles of each option were reviewed to ensure a sufficient level of renewable or carbon-free generation options were made available in the analysis to meet current and future renewable portfolio standard and emission targets. Dispatch characteristics of each option were reviewed to ensure the various system and reserve requirements would be met. Finally, levelized costs were reviewed and generating technologies with costs lower than $150 per MWh or $15 per kW-Month were included in in the initial screening. For similar options, only one technology was screened in. For example, the Simple Cycle Gas Turbine (High Efficiency) was not selected for further analysis as it is very similar to the Simple Cycle Gas Turbine (Mid-Efficiency) option, but with a slightly higher cost. Based on the results of the levelized cost analysis, system requirements, environmental and dispatch characteristics of each supply option, the following mix of conventional and alternative options were selected for further evaluation using the Strategist detailed capacity expansion model.

Table 9: Results of Supply Option Screening

	Supply Option	Renewable or Carbon Free	Dispatch Characteristics			
			Intermittent	Peaking	Load Following	Baseload
Conventional Supply Options	Grand Falls Additional Power	Yes			Yes	
	Interconnection Energy/Capacity Purchase	Yes/No			Yes	Yes
	Simple Cycle Gas Turbine - Mid Efficiency			Yes		
	Small Simple Cycle Gas Turbine - Diesel			Yes		
	Large Combined Cycle				Yes	Yes
	Nuclear - Large	Yes				Yes
Alternative Supply Options	Geothermal Energy	Yes				Yes
	Large Wind	Yes	Yes			
	Large Solar Photovoltaic - Single Axis Tracking	Yes	Yes			

11 Energy Smart NB

Customer expectations, climate change and advances in technology are causing significant changes to the future of the energy industry. It is impossible to precisely predict what the landscape of the electricity industry will be. The Energy Smart NB plan provides NB Power with the flexibility to respond to change by building out technology, capabilities and programs that will benefit customers and result in lower emissions regardless of how the future unfolds.

The plan provides value through lowering fuel and purchased power costs, reducing the need of building new generation and transmission assets, creating operational efficiencies, improving the customer experience and minimizing New Brunswick's carbon footprint.

There are three interdependent components of this plan:

Smart Grid: Build and operate a smarter, cleaner, more reliable and efficient power grid.

Smart Habits (Demand-side management): NB Power's energy efficiency and demand response programs to help New Brunswickers reduce and/or shift their energy usage resulting in lower emissions.

Smart Solutions: Offer products and services that save customers time, energy and money while also lowering emissions.

Smart Grid lays the foundation for a wide range of benefits through its two-way communication. These benefits include grid visibility and reliability, outage response as well as operational improvements and efficiencies. Grid modernization will enable fuel and purchased power savings, lower emissions, capacity deferral and new revenue streams.

In addition, NB Power can better understand how and when energy is being consumed and use that information to operate more efficiently. Customers can also benefit from this with better service, new energy-saving products and services and more flexible rate plans. These capabilities will allow NB Power to stay competitive as new technologies and companies emerge on the market, to be our customers' partner of choice.

A modern grid is also essential to the expansion of renewable and distributed energy sources contributing toward a greener, cleaner future with lower emissions. This includes alternatives to new centralized generation resources. As more variable energy sources are connected to the grid, NB Power will face greater challenges in cost-effectively managing that variability to balance supply and demand while maintaining grid stability (Section 9.1, Intermittent Resources and Section 9.2, Intermittent Resource Planning Capacity Contribution). By building smart technologies into the electricity system (e.g. Advanced metering infrastructure (Smart Meters), digital communication, and distributed energy management system), NB Power can better

manage a changing electricity system and support customer participation in renewables, while also improving reliability and efficiency—and give New Brunswickers more choice, control, and convenience.

Smart Habits is a continuation of NB Power's Demand Side Management (DSM) programs that help reduce fuel and purchased power costs and lower emissions. These programs can defer the need to expand infrastructure, help customers reduce and/or shift their energy consumption and lower their bills without compromising the overall value of electricity service.

Smart Solutions will leverage a smarter grid to deliver future services that New Brunswickers are coming to expect from NB Power, like opportunities to manage their energy consumption, reduce their environmental footprint and lower their bill. Smart Solutions also provides an opportunity to develop new lines of business if customers adopt alternatives like distributed generation, energy storage and energy efficiency solutions.

Energy Smart NB is focused on building an economically and environmentally sustainable energy future for New Brunswick, while recognizing that technological advancements are driving dramatic change in the world. Utilities are not immune to the challenges and benefits evolving from advancing technology and climate change. They must adapt to ensure energy sustainability and security, while keeping pace with customer expectations, including maintaining the affordability of electricity. NB Power is transforming itself to prepare for this new technological environment.

Both NB Power and its customers will benefit from the investments in the Energy Smart NB Plan. NB Power will become a modernized, flexible, financially and environmentally viable utility that can generate, deliver and manage electricity and associated products and services throughout New Brunswick well into the future.

11.1 ESNB Historical Impacts

NB Power's Energy Smart NB journey began in 2011 through investments in technology, customer education and incenting customers to reduce and shift demand. NB Power has undertaken many related projects under the Energy Smart NB banner, building in-house knowledge and creating value and lowering emissions for both customers and the utility.

PowerShift Atlantic – PowerShift Atlantic was a multi-year initiative focused on finding more effective ways to integrate renewable energy sources like wind energy into the electrical systems of the Maritime Provinces. The initiative included demonstration programs for residential and commercial customers across the Maritimes. PowerShift Atlantic demonstrated one of the world's first fully grid-integrated virtual power plants to allow for more effective integration of wind power. By remotely shifting cycles a few minutes here and there and combining loads from

many customers – PowerShift Atlantic tested ways to optimize wind-generated energy, without requiring changes in customer behaviour or consumption. It was different from typical demand response services. The virtual power plant uses load and wind forecasting with aggregation capabilities to perform near real-time load shifting of commercial and residential loads. It could also provide new ancillary services to the grid. The targeted end-uses have storage capacity like electric water heaters and electric thermal storage heating. Many of these resources remain operational today.

LED Lighting Products – In 2013, NB Power began to actively replace all utility-owned streetlights in the province from traditional high-pressure sodium bulbs to light emitting diode (LED) lights. The project was successfully completed in 2017. It provides operational savings through reduced maintenance and replacement costs and lowers their electricity consumption which leads to lower energy costs and lower emissions. Building on this project's success, NB Power is now doing the same for dusk-to-dawn lights. That project is expected to be complete in 2022.

EcoPeak and EcoLink Water Heating Products – NB Power has researched and piloted several types of controllable (shiftable) water heaters. Currently, all of NB Power's water heaters are energy efficient and include pipe insulation. Two technologies - EcoPeak and EcoLink- are specifically designed to shift load. EcoPeak water heaters passively shift load without impacting customers. EcoLink is a communication device installed on a standard water heater. When a system peak happens, EcoLink pauses water heating for short periods of time using cellular communications. This helps NB Power manage overall system demand requirements and improve reliability with minimal impact to customer comfort. Both products are in market and projected to grow in the future.

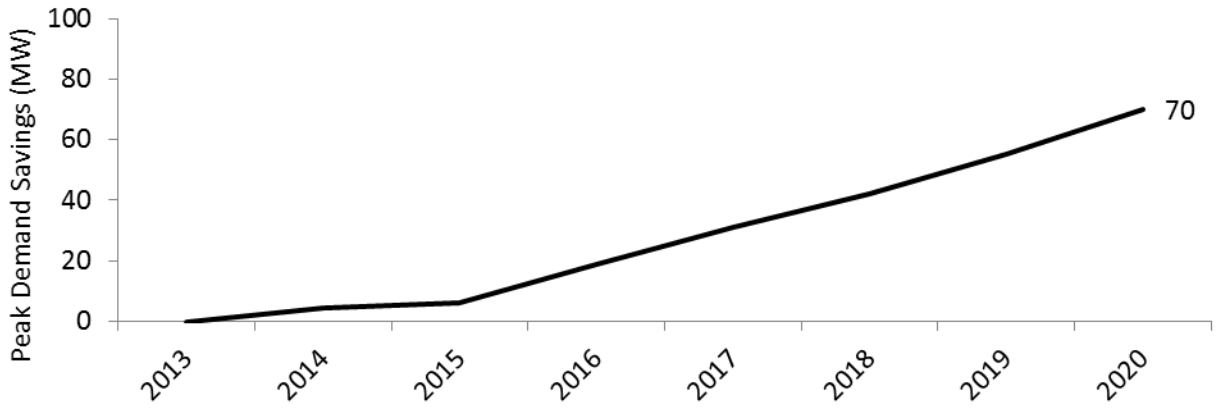
NB Power Internal Demand Side Management – Leading by example, NB Power has undertaken many demand management and energy efficiency projects at its stations and offices. In the stations, projects include lighting retrofits, heating system repairs and optimization and installing an auxiliary boiler at Coleson Cove to reduce plant heating costs and lower emissions. Coordination of certain batch processes are scheduled to reduce station service loads when called upon. In office facilities, NB Power has upgraded lighting, heating, ventilation and air-conditioning systems as well as an automation network that operates the buildings. This allows for the use of smart grid technology to automatically shed loads during system peaks.

Demand Side Management – Demand side management (DSM) is a cornerstone of NB Power's vision and mission. Although the primary goal of these programs is to promote energy efficiency in New Brunswick homes and businesses, these programs also improve comfort, create jobs, reduce greenhouse gas emissions, stimulate the economy and lower customer costs. On April 1, 2015, NB Power became the service provider for energy efficiency programs in the province. With this expanded role, NB Power has funded and administered several programs to help customers

lower their energy consumption and environmental footprint, while reducing costs. Some examples of these programs include Small Business Lighting, Total Home Energy Savings and Industrial Efficiency.

Through investments in Energy Smart NB, NB Power has seen over 250 GWh of savings achieved and 70 MW of peak demand reduction since 2013. The utility has also reached its goal of deferring significant capital investment in new generation and continues to maintain that goal through this IRP.

Figure 22: Historical Demand Savings



11.2 Looking Ahead

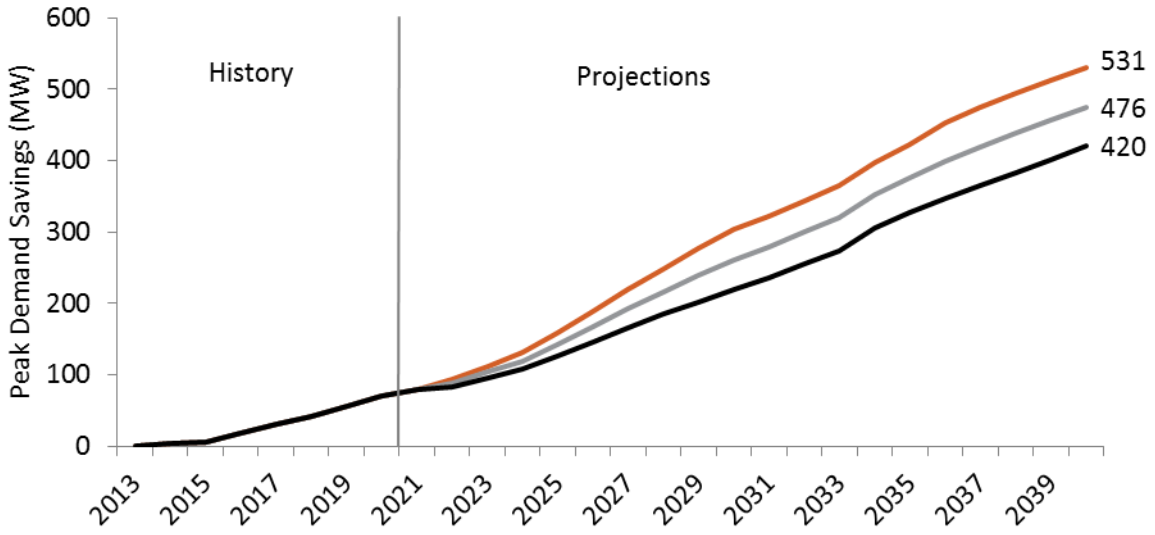
NB Power has many projects and initiatives underway that are assumed to continue. These include DSM program offerings, Advanced Metering Infrastructure (Smart Meters), Conservation Voltage Reduction and internal DSM initiatives. These initiatives are foundational to the IRP and NB Power's future.

Ahead of developing this IRP, NB Power and the Government of New Brunswick engaged Dunsky Energy Consulting (Dunsky) to conduct a long-term, multi-fuel (electricity and combustible fuels) demand-side management potential study for New Brunswick. The study quantified energy and demand savings potential from multiple DSM sources. It was founded on up-to-date market data for both the residential and non-residential sectors. This primary research provided New-Brunswick specific saturation and baseline efficiencies of equipment in homes and businesses across the province. In addition, a survey was used to assess customer barriers to adopting energy efficient technologies.

Based on the results of the potential study, Dunsky provided three energy efficiency projections and details for optional demand response programs that could be undertaken, if required. The chart below shows the peak demand savings of the three scenarios inclusive of other Energy

Smart NB impacts ranging from 420 – 531 MW. Annual energy savings from these programs equate to 931 – 1,554 GWh annually by 2040. The average program cost for energy efficiency programs for the low projection is 2.8 cents per kWh, 3.3 cents per kWh for the medium projection and 3.8 cents per kWh for the high projection.

Figure 23: Energy Smart NB Peak Demand Savings for Energy Efficiency Scenarios



**All scenarios developed include provisions for reparticipation of historical savings as required.*

12 Analysis & Results

12.1 Methodology

Developing the least-cost IRP, NB Power must look at the following together: supply side resources (new generating stations) and demand side resources (energy efficiency, demand response and smart grid). Demand side resources are essential to develop a least-cost plan. They provide an alternative to power plants and can delay or even displace the need for investments in new generation. Supply side resources must balance the need to provide low cost generation while meeting regulations for greenhouse gas emissions and renewable generation.

Consistent with the *Electricity Act* and the 2017 IRP, this IRP uses the least cost-of-service and greenhouse gas emission impacts as key metrics. Least cost-of-service is measured by taking the present value of the estimated annual revenue requirements (PVRR) over 20 years for each expansion plan. Emission impact is determined by calculating the total emission output for each plan over the 20-year planning horizon. All plans are developed in a way that renewable generation requirements and equivalent emission targets are met. For the 2020 IRP, an additional metric (short term average unit energy cost) is used to measure the financial pressure to the utility and rate payers over the first ten years of the plan.

NB Power uses a software application called Strategist to determine the least-cost plan. Strategist is a long-term production simulation model used by utility companies to optimize future resource additions and other strategic planning purposes. To develop the least cost plan, all reasonable and feasible supply-side and demand-side alternatives are provided as inputs and run through an optimization module within Strategist, called PROVIEW. This allows the utility to find the least-cost plan that reliably meets future load forecast requirements including reserves within New Brunswick while meeting RPS and emission requirements. The PROVIEW module has been used by NB Power to develop previous IRPs and is widely used in the electricity industry. It has been reviewed and accepted by the New Brunswick Energy and Utilities Board.

12.2 Emission Reference Case Calculation

The first step in the IRP analysis is determining the reference case emission level to be used for comparing the various expansion plans. Section 4.3 (Greenhouse Gas Regulation) of this IRP assumes an equivalency agreement will be reached with the federal government, allowing for the continued operation use of coal at Belledune to its scheduled end of life in December 2040, but achieve the same emissions reductions as if coal was phased-out in 2030. Expansion plans that have the same or fewer emissions as the emission reference case are deemed equivalent.

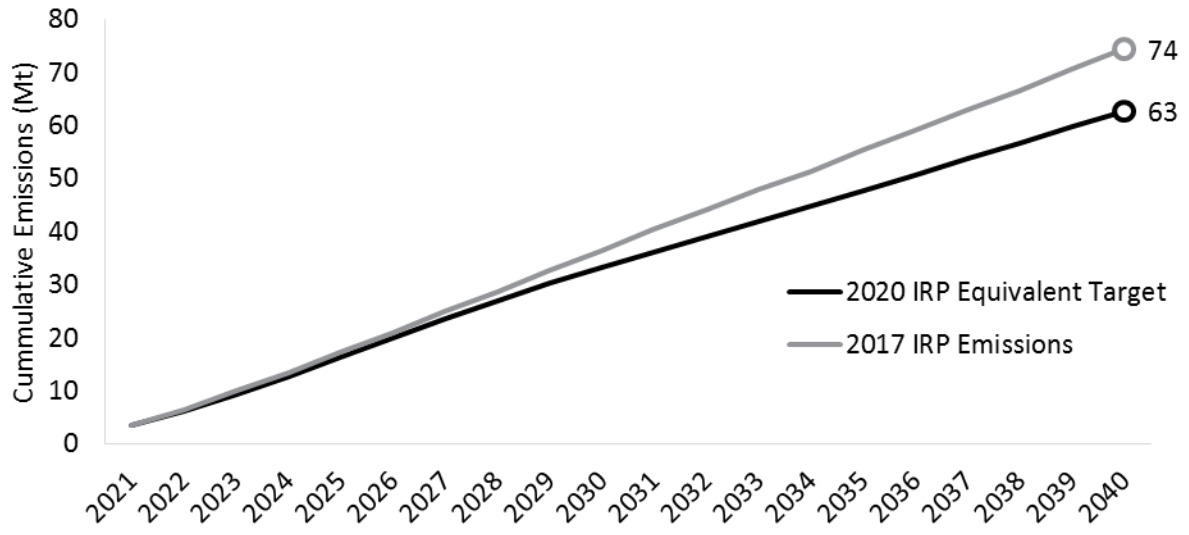
The emission reference case is calculated by developing a scenario consistent with the regulations where coal is phased-out in 2030 and the impacts of several early actions taken by NB Power to reduce emissions are removed, including

- additional renewable resources added since 2015 including LORESS and embedded generation
- historical Energy Smart NB reductions since 2015
- the 40 per cent renewable portfolio standard target

In addition, a key action that NB Power can take in the future to lower its emission trajectory is to pursue the Mactaquac Life Achievement Project. The Mactaquac Station avoids up to 1.3 Mt per year of carbon emissions in New Brunswick. As this project still has not achieved the necessary approvals, the impacts of pursuing this project are also removed from the emissions reference case.

The phase-out of coal results in retiring Belledune early in 2030 and requires the construction of replacement fossil fueled generation of comparable size and operating characteristics. The resulting emission output profile serves as the emission baseline for other scenarios in the IRP. All scenarios developed for the IRP have emissions that fall at or below this level. For the 2020 IRP the emission baseline is a total of 63 Mt over 20 years (from 2021 to 2040). This represents a decrease of 11 Mt or 15 per cent from the 2017 Integrated Resource Plan for the same period (74 Mt).

Figure 24: 2020 versus 2017 IRP Emissions Trajectory



12.3 Base Case Analysis

The development of the base case provides direction on three key strategic options that NB Power has considered in this IRP

- Bayside life extension
- Millbank and Ste. Rose life extensions
- demand side management portfolio optimization

Each strategic option is analyzed using the metrics described in Section 12.1 (Methodology)

- 20-Yr Revenue Requirement Impact ($NPV) - provides the impact each scenario has on cost-of-service by comparing the present value of annual revenues requirements over 20 years
  - A positive value indicates the scenario increases cost-of-service whereas negative value indicates a decrease to cost-of-service
- Change in Short Term Average Unit Energy Cost - measures the financial pressure that the scenario places on the utility and rate payers over the first 10 years of the plan
  - it is calculated by comparing the total cost to rate payers divided by in province energy sales while respecting the need to achieve at least a 20 per cent equity target by 2027
  - a positive value indicates an increase in short term cost pressure whereas a negative value indicates a decrease in short term cost pressure
- Meets Equivalent Emission Target – is used to confirm that the scenario meets renewable generation requirements and equivalent emission targets
  - a check mark indicates the conditions are met.

The demand side management portfolio optimization scenario includes a forth measure

- Benefit Cost Ratio – is used to measure the overall value provided by each demand side management portfolio
  - it is calculated by dividing the total benefits provided by the program by the total program cost (the more a result exceeds 1.0 the more value the initiatives provide customers)

12.3.1 Life Extension of the Bayside Generating Station

In March 2019, NB Power purchased the Bayside Generating Station (Bayside). Bayside is a 277 MW natural gas-fired combined cycle power plant located in Saint John. The purchase of the station allows NB Power to integrate the facility into its existing fleet for more economic dispatch and better alignment of the station's interests with NB Power's interests to deliver safe, reliable, and low cost electricity to New Brunswickers. Prior to the purchase, NB Power purchased output from Bayside through a long-term power purchase agreement.

Bayside is set to retire in 2026. However, as a natural gas fueled station, Bayside offers significant carbon savings over the use of coal and allows NB Power to shift electrical production to this lower emissions emitting station, and thus could play a vital role in proving reliable electricity and reducing emissions into the future. An internal engineering analysis was conducted in 2020

to determine the estimated capital investment required to keep it operating until 2038. Based on this analysis, an end of life of 2038 can be achieved through regular maintenance and inspections, allowing these capital costs to be spread over the remaining life of the facility. The incremental capital cost for achieving an end of life of 2038 was estimated at $144 million over the life of the plant.

Table 10: Bayside Life Extension Results

Measure	High Energy Efficiency Scenario	Low Energy Efficiency Scenario
20-Yr Revenue Requirement Impact ($NPV)	-$506 M	-$716 M
Change in Short Term Average Unit Energy Cost	-$4.59/MWh	-$4.80/ MWh
Meets Equivalent Emission Target	✓	✓

The optimal level of energy efficiency has not yet been determined at this stage of the analysis. Therefore, the economic analysis of Bayside was completed at the two bookend levels of energy efficiency to determine the range of impacts for Bayside's life extension. Under both scenarios there is significant positive economic benefit associated with life extension, lowering overall system costs by $506 to $716 million (NPV). Short-term average unit energy costs decrease in both cases. This means the extension of Bayside will reduce financial pressure over the next 10 years. The equivalent emission target is met in both cases.

Life extension replaces the need for the construction of a natural gas combined cycle generating station in 2027. This is the most significant benefit and a key consideration as other major capital investments, like the Mactaquac Life Achievement Project, are expected to ramp up around that time.

Adding to the value of the life extension is the relatively low fuel costs. NB Power has secured a low-cost fuel source and transportation reservation from Western Canada that will be in place until 2038. As a result of this low-cost fuel source, operating hours of the plant increase significantly and reduces the need to purchase higher priced electricity and run higher cost generation.

12.3.2 Life Extension of the Millbank and Ste. Rose Generating Stations

The Millbank and Ste. Rose generating stations were constructed in 1991 and were originally expected to run for 25 years. As the generating stations are mainly used to provide backup capacity and reserve for the grid, they have low operating hours and are in relatively good

condition. In order to ensure that New Brunswickers have a reliable electrical system that can withstand many major disruptions that last many days, the stations have approximately seven days-worth of fuel stored on site. This would make their replacement with a battery storage solution not only technically unfeasible, but also economically unfeasible. However, NB Power continues to note both improvements in the technical capability and capital costs for storage solutions and will revisit this finding if technically and economically feasible solutions can be deployed at a lower cost for New Brunswickers. The book lives for the stations have already been extended to 2030. The 2020 IRP considers a further extension. Based on an engineering analysis the retirement date can be extended beyond the study period through regular maintenance and inspections, spreading capital costs over many years. To achieve this, incremental capital investments of $192 million would begin now and be spread out over the remaining life of the facilities.

Table 11: Millbank/Ste. Rose Life Extension Results

Measure	High Energy Efficiency Scenario	Low Energy Efficiency Scenario
20-Yr Revenue Requirement Impact ($NPV)	-$198 M	-$225 M
Change in Short Term Average Unit Energy Cost	-$0.77/MWh	-$1.03/MWh
Meets Equivalent Emission Target	✓	✓

NB Power performed the analysis based on high and low levels of energy efficiency to determine the impact of the life extensions. The economic benefit of life extension ranges from $198 to $225 million over the 20-year study period. In each energy efficiency scenario, the life extensions avoid construction of four new combustion turbines in 2031 and one in 2039. In the low energy efficiency scenario, the life extension also eliminates the need to implement an industrial demand response program in 2031 as Millbank and Ste. Rose are able to meet the increased capacity requirement. Capital costs of the extensions are spread out over the remaining life of the facilities, resulting in reduced levels of capital investment that would otherwise be needed during the Mactaquac Life Achievement Project. Short-term average unit energy cost decreases in both cases. This means there is reduced financial pressure over the next 10 years. The equivalent emission target is met in all cases.

12.3.3 Optimize Demand Side Management Portfolio

NB Power engaged with Dunsky Energy Consulting to provide three scenarios around energy efficiency based on the most recent DSM potential study. NB Power worked with the consultant to provide three energy efficiency projections and details for optional demand response

programs that could be undertaken if required. The programs, inclusive of other Energy Smart NB impacts, provide demand savings of 420 – 531 MW and energy savings of 931 – 1,554 GWh annually by 2040. Section 11.2 (Looking Ahead) provides more details.

Table 12: Demand Side Management Scenario Results

Measure	High Energy Efficiency Scenario	Medium Energy Efficiency Scenario	Low Energy Efficiency Scenario
20-Yr Revenue Requirement Impact ($NPV)	-$551 M	-$514 M	-$413 M
Change in Short Term Avg. Unit Energy Cost	$5.25/MWh	$3.78/MWh	$2.47/MWh
Benefit Cost Ratio	2.09	2.49	2.90
Meets Equivalent Emission Target	✓	✓	✓

Each energy efficiency scenario helps lower emissions, meets the equivalent emissions target and adds significant economic benefit from $413 million (low energy efficiency scenario) to $551 million (high energy efficiency scenario) over 20 years. Benefit cost ratios are also strong in each scenario from 2.90 (low energy efficiency scenario) to 2.09 (high energy efficiency scenario). In the low energy efficiency scenario, there is a need for generation capacity in 2038. Both the medium and high energy efficiency scenarios defer this need for capacity beyond 2040.

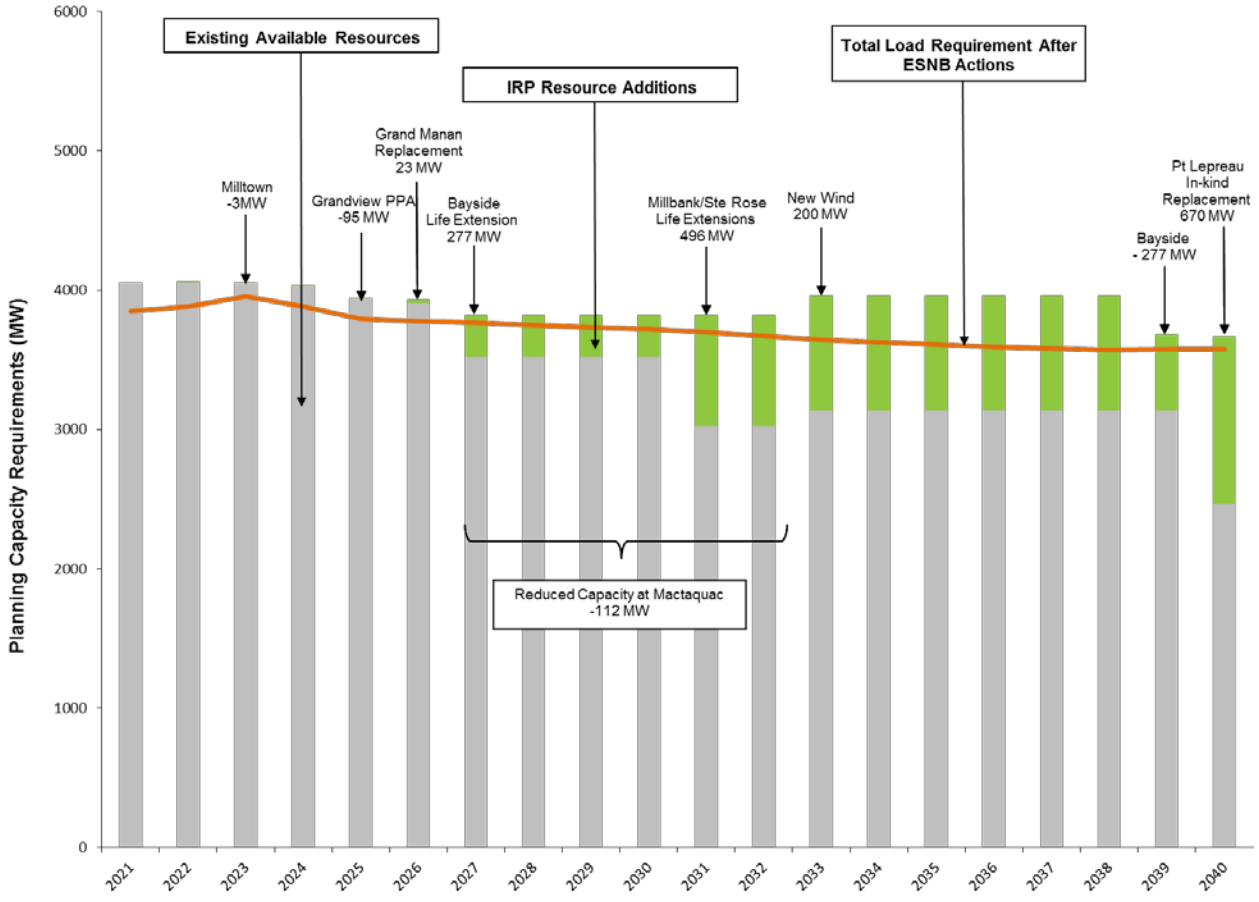
A large portion of the value of energy efficiency for NB Power comes from its ability to defer future investments in generation capacity. Since capacity deferrals are happening late in the study period, the value of this capacity deferral is economically challenged. While higher levels of energy efficiency provide greater levels of long-term economic benefit and emissions reductions, they also create short term financial pressure for the utility and rate payers. This places the IRP principles of least cost planning in tension with economic and environmental sustainability and risk management. The average program costs increase from 2.8 cents per kWh for the low scenario to 3.8 cents per kWh for the high scenario. Table 12 shows the increasing short-term average unit cost for higher scenarios. While each has its own strengths, both the medium and low projections offer reasonable trajectories for the DSM portfolio.

12.4 Final Integration Results

One of the greatest attributes of the Energy Smart NB plan is its flexibility and ability to adapt over time. Based on the analysis, it is recommended that a range of demand side management between the Low and Medium is reasonable. In the High scenario additional economic

sustainability and risk management pressures are created and outweigh the incremental long term benefit to revenue requirement. This will maintain program flexibility while balancing benefit-cost ratio, short term financial pressure, customer cost reductions and defer the need for investment in new generation capacity during the study period. With a range of demand side management programming possible, NB Power maintains the ability to increase or decrease the level of energy efficiency programming and optimize the value provided as new opportunities or challenges arise. This range of programs represents a reduction of 13 per cent to 15 per cent of peak demand over the period. For the purpose of modelling further scenarios, a mid-point estimate of these two scenarios was used.

Figure 25: Load and Resource Requirements after Final Integration[61]



The orange line on the load and resource chart in Figure 25 shows New Brunswick load requirements after ESNB actions over the next 20 years. Existing capacity resources are

[61] Total load requirement after ESNB actions is based on the mid-point of the low and medium energy efficiency scenarios. This provides 448 MW of demand savings by 2040.

depicted in the grey shaded area of the columns. The green shading represents the new capacity additions recommended in the least-cost integrated plan is outlined in Table 13. The addition of Energy Smart NB measures defers the need for new capacity beyond the study period.

Table 13: Final Expansion Plan

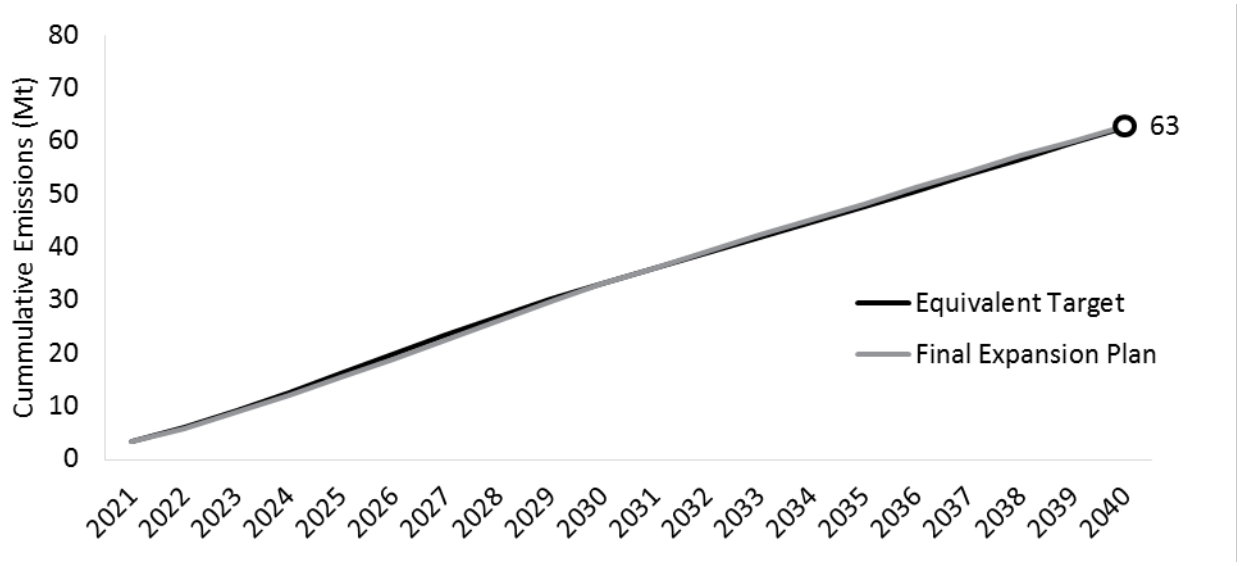
Fiscal Year	Integrated Plan	Scheduled Retirement
Ongoing	ESNB Plan (420 - 476 MW)	
2021	LORESS Projects (78 MW)	Milltown (3 MW)
2022	Embedded Generation (20 MW)	
…	…	…
2025		Grandview (95 MW)
2026	New LM2500 in Grand Manan (23 MW)	Grand Manan (29 MW)
2027	Bayside Life Extension (277 MW)	
…	…	…
2031	Millbank/Ste Rose Life Extension (496 MW)	
…	…	…
2033	Mactaquac Life Achievement (668 MW) New Wind (200 MW)	
…	…	…
2038	Industrial Demand Response (90 MW)	Bayside (277 MW)
2039	Point Lepreau In-Kind Replacement (670 MW)	Point Lepreau (670 MW)

The expansion plan includes investments in Energy Smart NB and existing resources, as well as investments in new generation sources. The first investment in new generation is required in 2026 when the existing generator on Grand Manan Island retires. On-island generation is required in order to provide back-up generation in the event of a prolonged subsea cable failure. The LM2500 small diesel-powered combustion turbine is recommended if an economically feasible carbon-free solution cannot be implemented. Renewable and storage options, such as rooftop solar and battery storage, are not economically feasible solutions at current prices. However, NB Power recognizes that as technology improves and costs come down these may become viable options. NB Power will continue to monitor developments in this area. All remaining investments are either in cost effective life extensions of NB Power's existing assets or in new renewable or carbon-free resources. In 2033 an additional 200 MW of new wind becomes economic to add to the system, provided that NB Power has cost effective means to balance the new intermittent generation. This is predicated on the successful completion of the Mactaquac Life Achievement Project providing electrical system balancing services and reserve.

The greenhouse gas emissions associated with the Integrated Plan are available in Figure 26. The emissions shown are associated with serving in-province load and firm export contracts. The IRP

assumes an equivalency agreement will be reached with the federal government allowing Belledune to run on coal until the original end of life in December 2040 (Section 4.3, -Greenhouse Gas Regulations). The emissions for the integrated plan average 3.15 Mt per year and meet the equivalent emissions cap of 63 Mt over 20 years. Compared to the 2005 level of 8.8 Mt, the average annual emissions of 3.15 Mt in this IRP represents a reduction of over 60 per cent. This is more than double the 2030 targeted reduction of 30 per cent below 2005 levels. The total emissions of 63 Mt represent a decrease of 11 Mt or 15 per cent from the 2017 Integrated Resource Plan for the same period (74 Mt).

Figure 26: Final Expansion Plan Greenhouse Gas Emissions Compared to the Phase-Out of Coal in 2030 Reference Case



Renewable and non-emitting resource additions combined with the existing fleet allow NB Power to continue to meet the 40 per cent renewable portfolio standard throughout the planning period.

12.5 Greenhouse Gas Regulation Analysis

The IRP includes pricing under the Federal Output Based Pricing System as a foundational assumption. This pricing plan would subject NB Power to carbon prices on emissions that exceed the federal standards set out in the regulations as described in Section 4.3.1, Output-Based Pricing System Regulations.

NB Power is supporting the Government of New Brunswick's efforts to implement a Made-in-New Brunswick Carbon Plan. The proposed plan would use a similar structure to the Federal Output-Based Pricing System but with modified performance standards, as described in Section 4.3.1. This would allow New Brunswick to reduce emissions while ensuring that New

Brunswickers are not put in a competitive disadvantage compared to other provinces in Canada, or jurisdictions abroad.

Carbon pricing under both plans is $30 per tonne in 2020. It's expected to increase to $40 per tonne in 2021 and $50 per tonne in 2022.

Table 14: Summary of Output-Based Pricing Systems Sensitivity

Measure	Federal OBPS (included in Base Case)	Made-in-NB Carbon Plan
20-Yr Revenue Requirement Impact ($NPV)	$612 M	$114 M
Change in Short Term Average Unit Energy Cost	$1.95/MWh	$0.56/MWh
Meets Equivalent Emission Target	✓	✓

The Federal OBPS adds costs to New Brunswickers of $612 million. The Made-in New Brunswick system would result in a cost increase of only $114 million, a $498 million reduction from the federal plan. The Made-in-New Brunswick Carbon Plan does not result in any changes to the expansion plan. It supports the life extensions of Bayside, Millbank and Ste. Rose and continuing with demand-side management plans. Emissions are limited in both carbon pricing scenarios by the equivalent emissions target, so there is no difference between the total emissions for the two plans. Cost savings are generated from lower carbon costs.

As described in Section 4.3 (Greenhouse Gas Regulation), the federal government announced in 2018 a planned phase-out of coal fired generation by 2030. The end of life for Belledune, NB Power's only remaining coal fired generating station is December 2040. The most likely scenario from an emission and least-cost perspective is the successful negotiation of an equivalency agreement between the Government of New Brunswick and the Government of Canada. Alternative scenarios have been explored to capture the value of pursuing an equivalency agreement for the benefit of New Brunswickers.

Table 15: Belledune Generating Station Scenarios

Scenario	Description
Equivalency Agreement (Base Case)	Continued operation of Belledune using coal until the scheduled retirement date in December 2040, at reduced output levels.
Early retirement of Belledune	Closure of Belledune Dec. 2029, resulting in accelerated amortization of station assets and a need for new capacity in 2030.
Belledune Conversion to LNG (Liquefied Natural Gas)	Belledune is reconfigured to burn natural gas with LNG as the fuel source beginning Jan 2030. This requires significant investment in fuel unloading, fuel storage and plant upgrades.
Belledune Conversion to Natural Gas	Belledune is reconfigured to burn natural gas with new pipeline infrastructure built to tie Belledune into the Maritimes & Northeast Pipeline beginning Jan 2030. Requires significant investment in natural gas pipeline and plant upgrades.

An analysis was conducted to determine both the cost of an equivalency agreement and the cost impact of not reaching an equivalency agreement. The cost of not reaching an equivalency agreement was explored through alternative scenarios for the Belledune Generating Station. Each scenario requires fossil fuel generation. Alternative sources of carbon-free generation were also considered but deemed not economically feasible at this time

- electricity imports
    - existing interconnections with neighbouring jurisdictions are not sufficient to replace the energy and capacity that Belledune provides without significant capital investment and lead time to construct transmission infrastructure
    - uncertainty and risk around the availability of energy and the commercial agreements that would be required to replace the energy and capacity provided by Belledune on this infrastructure makes this option unfeasible
- renewable generation and storage options
    - there are currently no economically feasible renewable and storage options capable of replicating the energy and capacity that Belledune provides
    - NB Power will continue to monitor advances in this space for improvements in technology and cost

The impact of each equivalency scenario is sensitive to which carbon pricing system is assumed. Therefore, the results of these scenarios are presented under both carbon pricing structures.

Table 16: 20-Year Revenue Requirement Impact ($NPV) for Coal Phase-Out and Carbon Pricing Under Federal OBPS

	Equivalency Agreement	Early Retirement of Belledune	Belledune conversion to LNG	Belledune conversion to Nat Gas
Federal OBPS Cost	$0.6 B	$0.6 B	$0.6 B	$0.6 B
Coal Phase-Out Cost	$0.1 B[62]	$1.2 B	$1.2 B	$1.2 B
Total Carbon Regulation Cost	$0.7 B	$1.8 B	$1.8 B	$1.8 B

Table 17: 20-Year Revenue Requirement Impact ($NPV) for Coal Phase-out and Carbon Pricing Under Made-in-New Brunswick Carbon Plan

	Equivalency Agreement	Early Retirement of Belledune	Belledune conversion to LNG	Belledune conversion to Nat Gas
Made-in-NB Carbon Plan Cost	$0.1 B	$0.1 B	$0.1 B	$0.1 B
Coal Phase-Out Cost	$0.1 B[63]	$1.4 B	$1.5 B	$1.4 B
Total Carbon Regulation Cost	$0.2 B	$1.5 B	$1.6 B	$1.5 B

The early retirement of Belledune would require the construction of a new 432 MW natural gas combined cycle plant as the least-cost option for New Brunswickers. The conversion to LNG and natural gas scenarios do not result in any changes to the recommended expansion plan. The cost of meeting the coal phase-out obligations through an equivalency agreement is $0.1 billion compared to $1.2-$1.5 billion for the other alternatives considered. In the absence of an equivalency agreement, the alternatives are comparable in cost. These alternatives would need to be considered in detail in the future if an equivalency agreement were not reached.

The total impact of the two greenhouse gas regulations is cumulative, with the overall cost impacts ranging from $0.2 - $1.8 billion ($2020 NPV) over the 20-year planning horizon. An equivalency agreement and the Made-in-New Brunswick Carbon Plan can save New Brunswickers

[62] Cost for coal phase-out for equivalency includes only redispatch costs associated with prioritizing lower emission generation resources. It does not include the investments being made in renewable energy, such as Mactaquac, or demand side management initiatives that reduce load.
[63] See previous note.

over $1.5 billion over the next 20 years and do so while achieving carbon reductions and meeting all legislative requirements.

NB Power explored two other alternatives, but cost uncertainty limited the scope of these analyses. The first involves the use of biomass fuel at Belledune. Torrefied biomass would use a lot of the same fuel handling equipment available at Belledune, but the volume of required biomass is significant. To run Belledune, at similar generation levels to today, more than 2 million cubic metres of green biomass per year would be needed. This is equivalent to about one third of the biomass currently harvested in New Brunswick each year. The province does not currently have a surplus allocation of biomass that could be granted to NB Power.

The second opportunity is small modular reactors (SMR). SMRs present a unique opportunity to significantly reduce emissions beyond the equivalency target. 400 MW of SMRs could reduce the cumulative greenhouse gas emissions by 15-20 Mt over the 10-year period from 2031 to 2040. SMRs also represent New Brunswick and Canada's best opportunity for providing carbon free electricity and replacing fossil fuel fired generation. SMR's can enable New Brunswick to further reduce emissions outside of this IRP's planning horizon and meet the 2050 provincial target of 5 Mt.

13 Sensitivity Analysis

NB Power use sensitivity analyses to test the robustness of the IRP under changing conditions. Sensitivity analyses helps assess the risk levels of a plan. If a plan is robust (low risk,) there would be minimal variation under changing conditions.

In the case of this IRP, energy efficiency programs (Section 11, Energy Smart NB) would make the plan more robust, as they help the utility stay flexible and adapt to changing operations. The level of energy efficiency programming can be ramped up or down in response to these changes.

To analyze the decisions, made in Section 12 (Analysis and Results) around Bayside, Millbank and Ste. Rose and energy efficiency programs, NB Power used Strategist (software application) to re-optimize as each major assumption in the plan was changed.

The critical parameters used in the IRP are

- capital costs
- fuel and market prices
- load forecasts
- distributed Energy Resources
- COVID-19 Scenario

Each sensitivity is analyzed using the metrics described in Section 12.1 (Methodology)

- 20-Yr Revenue Requirement Impact ($NPV) - provides the impact each scenario has on cost-of-service by comparing the present value of annual revenues requirements over 20 years
  - a positive value indicates the scenario increases cost-of-service whereas negative value indicates a decrease to cost-of-service
- Change in Short Term Average Unit Energy Cost - measures the financial pressure that the scenario places on the utility and rate-payers over the first 10 years of the plan while respecting the need to achieve at least a 20 per cent equity target by 2027
  - it is calculated by comparing the total cost to rate payers divided by in province energy sales
  - a positive value indicates an increase in short term cost pressure whereas a negative value indicates a decrease in short term cost pressure
- Meets Equivalent Emission Target – is used to confirm that the scenario meets renewable generation requirements and equivalent emission targets
  - a check mark indicates the conditions are met

13.1 Capital Cost Sensitivities

Many factors influence capital-related project costs. NB Power focuses on two factors that cover a wide range of potential scenarios

- direct capital costs
- financing rates

The scope of these changes is limited to supply options being considered. It does not impact regular capital at existing facilities or existing financing costs.

13.1.1 Direct Capital Costs

Generating station costs are relatively well defined with competitive bidding processes and fixed price contracts. There is potential for cost overruns due to various circumstances. Construction cost escalation rates may also vary from those used in base assumptions. A range of +/- 25 per cent was considered to capture the potential variation in direct capital costs in this sensitivity analysis.

Table 18: Direct Capital Cost Sensitivity Summary

Measure	High Capital (+ 25%)	Low Capital (– 25%)
20-Yr Revenue Requirement Impact ($NPV)	$65 M	-$33 M
Change in Short Term Average Unit Energy Cost	$0.24/MWh	-$0.24/MWh
Meets Equivalent Emission Target	✓	✓

In the High Capital sensitivity there is no change to the expansion plan. However, in the Low Capital sensitivity, projects with high capital costs and low fuel costs become more attractive. The Grand Falls Generating Station expansion becomes a cost-effective choice in 2031, replacing the need for a demand response program in 2038. Both sensitivities support the extensions of Bayside, Millbank and Ste Rose and continuing with demand side management programs.

13.1.2 Financing Rates

In the IRP, it is assumed all generation projects are financed using the public sector borrowing cost of 5.25 per cent. This cost has a direct impact on all supply options. The rate is largely based on Canadian long-term bond rates. Bond rates are sensitive to factors like interest and inflation rates that can vary over the economic cycle. The sensitivity analysis captures this variation by applying a +/- 1 per cent adjustment to the public financing rate. The high financing rate is also a better estimate for private financing costs.

Table 19: Financing Rate Sensitivity Summary

Measure	High Financing Rate (6.25%)	Low Financing Rate (4.25%)
20-Yr Revenue Requirement Impact ($NPV)	$30 M	-$28 M
Change in Short Term Average Unit Energy Cost	$0.33/MWh	-$0.33/MWh
Meets Equivalent Emission Target	✓	✓

The integrated plan is the most cost-effective option in both the high and low financing rate sensitivities. Both sensitivities support the extensions of Bayside, Millbank and Ste Rose and continuing with demand side management programs.

13.2 Fuel and Market Prices Sensitivities

One of NB Power's largest expenditures is the combined cost of fuel and electricity market purchases. The industry can be volatile and any long-term plan must represent how this risk may impact plans.

13.2.1 Nuclear

Nuclear fuel prices have historically remained stable compared to other fuel types. Fuel costs make up only a small portion of the total nuclear plant costs. A sensitivity analysis focused solely on nuclear fuel prices was not considered necessary.

13.2.2 Heavy & Light Fuel Oils

Heavy Fuel Oil (HFO) is used at the Coleson Cove Generating Station. HFO use is relatively low due to high prices and lower thermal efficiency of oil-fired stations compared to other generation sources. Light Fuel Oil (LFO) is used at the Millbank, Ste. Rose and Grand Manan combustion turbine stations. These stations primarily provide back-up power in the case of an unexpected outage at another station or on the transmission system. This combined with higher fuel costs and low thermal efficiency of combustion turbines limits the use of LFO. A sensitivity focused solely on heavy and light fuel oils was not considered necessary.

13.2.3 Coal

Coal is a low-cost fuel used at the Belledune Generating Station. Due to the relatively low price of coal, there is little room for downward price movement. Significant price increases are unlikely due to greenhouse gas regulation. Coal prices are expected to remain stable and no new coal stations were considered in the development of the IRP. Because of this, a sensitivity focused solely on coal prices was not considered necessary.

13.2.4 Natural Gas

Natural gas is used at the Bayside Generating Station and at the Grandview Co-Generation Station. Natural gas is a fuel expected to be in abundance in the future. Compared to other fossil fuels like oil or coal, natural gas has a much lower emission intensity, giving it a significant advantage over coal and oil fired generation stations. Because of this, this IRP considers natural gas one of the primary fuels for conventional generation supply options.

Electricity market prices are highly associated with the price of natural gas. Sensitivity analysis on natural gas prices should not be done in isolation of electricity market prices. Sensitivities of +/- 25 per cent were applied to natural gas prices and electricity market prices concurrently for this study.

Table 20: Natural Gas and Electricity Market Price Sensitivity Summary

Measure	High Fuel Natural Gas and Electricity Market Prices (+ 25%)	Low Fuel Natural Gas and Electricity Market Prices (– 25%)
20-Yr Revenue Requirement Impact ($NPV)	$503 M	-$473 M
Change in Short-Term Average Unit Energy Cost	$4.19/MWh	-$2.73/MWh
Meets Equivalent Emission Target	✓	✓

The natural gas and electricity market price sensitivities do not result in any changes to the expansion plan. Since the integrated plan relies heavily on natural gas generation and electricity market purchases, there is a significant financial impact. Both sensitivities support the extensions of Bayside, Millbank and Ste. Rose and continuing with demand side management programs.

13.2.5 Foreign Exchange Rates

Most fuels and electricity market purchases made by NB Power are priced in US dollars. Fuel and electricity market purchases represent a significant portion of NB Power's annual operating costs, so foreign exchange rates present a major risk for NB Power. To capture the potential impact of foreign exchange, a range of +/- 15 per cent was considered for sensitivity analysis.

Table 21: Foreign Exchange Rate Sensitivity Summary

Measure	High Foreign Exchange (+ 15%)	Low Foreign Exchange (– 15%)
20-Yr Revenue Requirement Impact ($NPV)	$667 M	-$603 M
Change in Short-Term Average Unit Energy Cost	$4.31/MWh	-$3.50/MWh
Meets Equivalent Emission Target	✓	✓

The high foreign exchange sensitivity results present the addition of the Grand Falls Generating Station expansion in 2031. Although this project is capital intensive, it provides economic benefit when compared to higher priced fuels. Under the low foreign exchange sensitivity there is no change in expansion plans. But there are significant cost reductions related to fuel and purchased power. Both sensitivities support the extensions of Bayside, Millbank and Ste. Rose and continuing with demand side management programs.

13.3 Load Forecast Sensitivities

NB Power used the load forecast from 2019 to develop the IRP. A 95 per cent confidence interval was used for the high and low forecasts. These were based on statistical analyses of historical and future trends. Figure 27 shows the impact on electricity requirements.

Figure 27: New Brunswick Energy Forecast (before Energy Smart NB impacts)

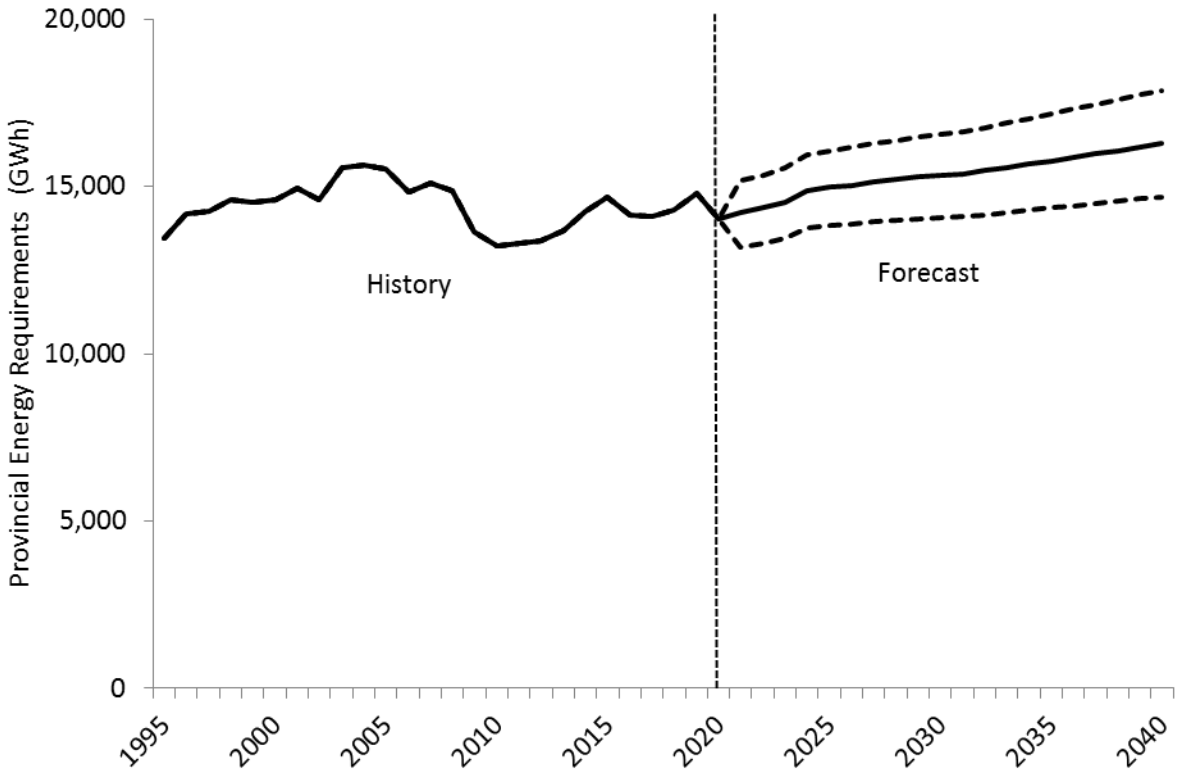


Table 22: Load Forecast Sensitivity Summary

Measure	High Load Forecast	Low Load Forecast
20-Yr Revenue Requirement Impact ($NPV)	$1.5 B	-$1.4 B
Change in Short-Term Average Unit Energy Cost	-$3.89/MWh	$4.73/MWh
Meets Equivalent Emission Target	✓	✓

Each of the load forecast sensitivities recommend similar expansion plans. In the high load forecast sensitivity, the requirement for a demand response program is advanced to 2027. It also includes two additional combustion turbines in 2039. In the low forecast sensitivity, the requirement for an industrial demand response program in 2038 is eliminated. Both sensitivities

support the life extensions of Bayside, Millbank and Ste. Rose and continuing with demand side management programs.

While the cost of the high load forecast sensitivity is significant, the increased sales would result in higher revenue. If these increases are driven by factors like increased economic activity or population growth, higher load levels are positive for NB Power and New Brunswick as they would alleviate short term financial pressures on the utility and ultimately its customers.

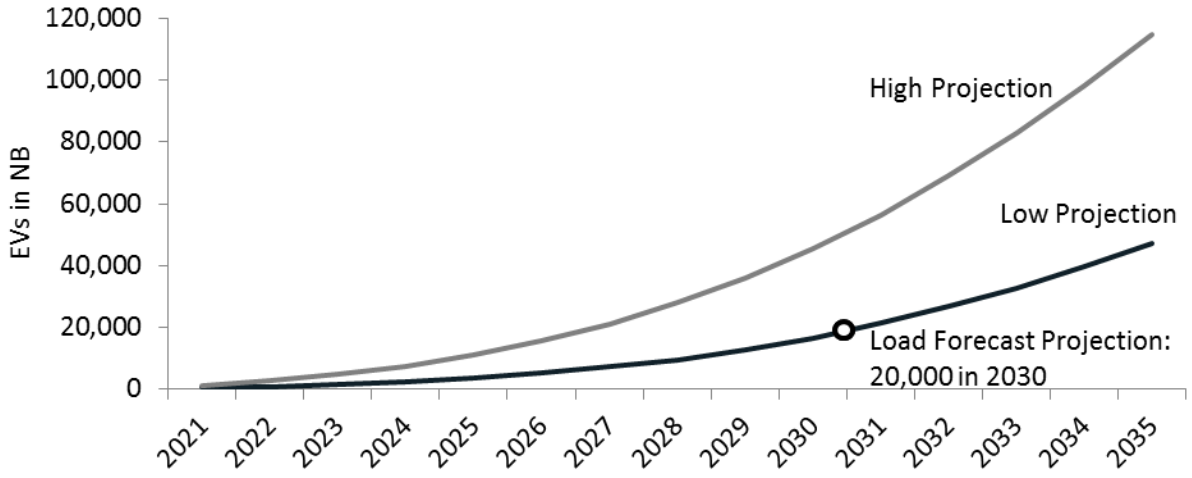
13.4 Distributed Energy Resource Sensitivities

13.4.1 Electric Vehicles

The electric vehicle industry is growing and is expected to have an impact on energy and demand forecasts in New Brunswick's future. In 2016, the provincial government released the *New Brunswick Climate Change Action Pan – Transitioning to a Low-Carbon Economy*, which includes targets for electric vehicle market penetration. NB Power's load forecast was based on meeting the target of 20,000 vehicles in New Brunswick by 2030. This represents a market share of approximately 2.7 per cent of the approximately 500,000 registered vehicles in the province.

In 2019, NB Power engaged a consultant, Dunsky, to assist NB Power in developing a range of forecasts for electric vehicle penetrations in the future[64]. The lower end of the range provided by Dunsky aligns with the provincial 2030 target.

Figure 28: Projections of Electric Vehicle Penetration



[64] Dunsky Energy Consulting, "Electric Vehicles in New Brunswick: Forecasted Adoption and Impacts, 2020-2034," November 2019, New Brunswick Energy and Utilities Board Matter 452, Exhibit NBP11.01.

One hundred fifteen thousand (115,000) electric vehicles in the province would result in approximately 500 GWh in electricity requirements by 2035.

Table 23: Summary of High EV Sensitivity

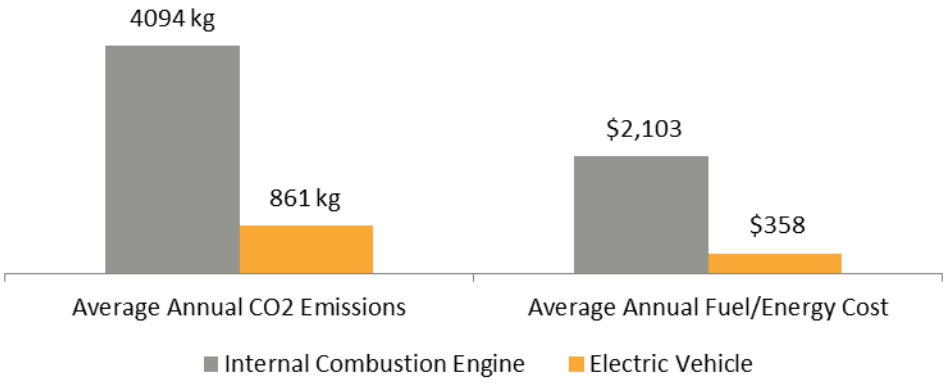
Measure	High EV Forecast
20-Yr Revenue Requirement Impact ($NPV)*	-$83 M
Change in Short-Term Average Unit Energy Cost	-$0.15/MWh
Meets Equivalent Emission Target	✓

**Includes the impact of revenue increases associated with higher EV penetration.*

In the high electric vehicle sensitivity, there is only a minor change in 2039. The sensitivity supports the extensions of Bayside, Millbank and Ste. Rose and continuing with demand side management programs.

Electric vehicles present an opportunity to lower New Brunswick's greenhouse gas emissions. In 2018, approximately 29 per cent of New Brunswick's emissions came from the transportation sector[65]. The average New Brunswick light vehicle produces approximately 4,000 kg of CO_2 annually. Replacing these with electric vehicles could reduce emissions by approximately 65 kt for every 20,000 vehicles in the province (inclusive of impact to electricity sector emissions).

Figure 29: Comparison of Vehicle Fuel Cost and CO2 Emission



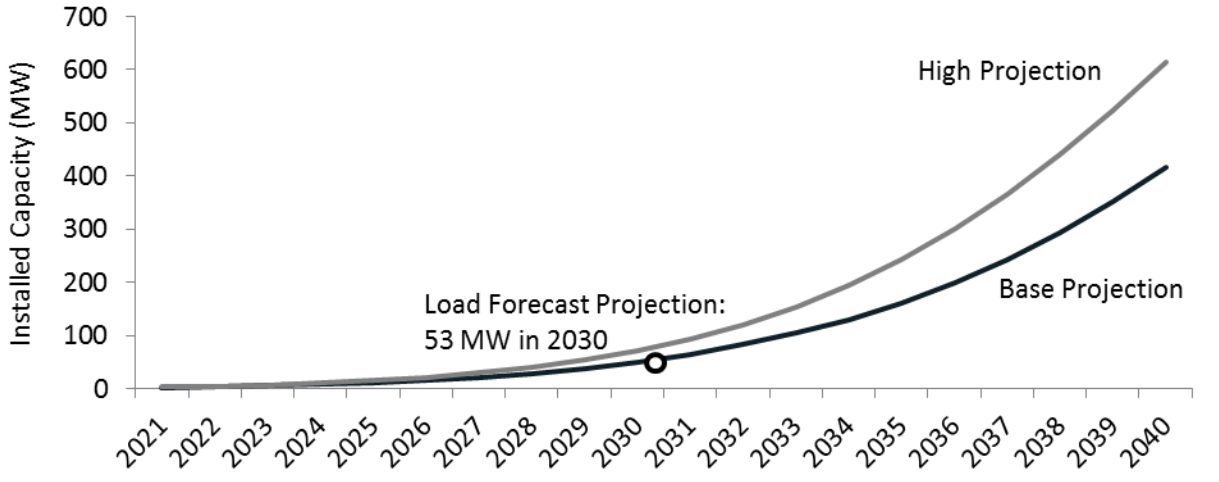
[65] "National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. Part 3," Government of Canada, last modified April 15, 2020, https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html.

13.4.2 Solar Penetration

New Brunswickers are showing an increased interest in solar energy. Solar installations are expected to have an impact on energy and demand forecasts in the future. NB Power's load forecast is based on a 2016 solar penetration forecast provided by Dunsky Energy Consulting.

In 2019, Dunsky updated the analysis, providing forecast for solar penetrations in the future[66]. The base estimate Dunsky provided aligns with prior estimates and NB Power's load forecast, while the upper range assumes additional solar penetration (approximately 600 MW by 2040).

Figure 30: Projections of Solar Penetration



600 MW of solar in New Brunswick would see reductions of approximately 750 GWh in electricity requirements in 2040 (approximately 5 per cent of in-province sales).

Table 24: Summary of Solar PV Sensitivity

Measure	High Solar Forecast
20-Yr Revenue Requirement Impact ($NPV)*	$28 M
Change in Short-Term Average Unit Energy Cost	$0.04/MWh
Meets Equivalent Emission Target	✓

**Includes the impact of revenue decreases associated with increased Solar PV penetration.*

[66] Dunsky Energy Consulting, "Projected Solar Adoption in New Brunswick," May 2017, New Brunswick Energy and Utilities Board Matter 452 Exhibit NBP6.06.

The IRP remains the most cost-effective in the high solar sensitivity. The sensitivity supports the extensions of Bayside, Millbank and Ste. Rose and continuing with demand side management programs.

13.5 COVID-19 Scenario

The future can be very difficult to predict. This IRP makes every effort to test different future scenarios to ensure the recommended expansion plan is reasonable across a range of outcomes. The COVID-19 global pandemic is a very serious and unprecedented event in our history, impacting billions of people across the world. While the new normal has yet to emerge, it is currently believed the impact of this pandemic will be relatively short in the context of a 20-year outlook. It presents a unique set of challenges that continue to evolve. A scenario was created to represent a combination of sensitivities to estimate the potential impact of COVID-19 if recent changes were to persist into the long term. These factors are not currently believed to represent a new long-term normal, but present an interesting stress test environment for this IRP.

Energy consumption has dropped due to businesses and institution closures. The cost of borrowing has declined by approximately one per cent. Commodity prices and foreign exchange rates have also changed. The foreign exchange is up over 10 per cent between April 2019 and April 2020. Commodity prices have shifted dramatically and in unexpected ways. Oil prices are down, hitting historic lows in April 2020. Natural Gas and Market prices are also reduced. A summary of the proposed changes in the scenario are

- low load forecast
- low financing rate (4.25 per cent)
- high foreign exchange (+ 15 per cent)
- low natural gas and market prices (-25 per cent)
- low oil prices (-50 per cent)

Table 25: Summary of COVID-19 Sensitivity

Measure	COVID-19 Scenario
20-Yr Revenue Requirement Impact ($NPV)	-$1.9 B
Change in Short-Term Average Unit Energy Cost	$1.74/MWh
Meets Equivalent Emission Target	✓

The cost of this scenario is lower over the course of 20 years, but it does add near-term financial pressure for the utility. It does not result in any changes to the recommended expansion plan until the late 2030s when the requirement for industrial demand response is eliminated due to the lower overall load requirements. This confirms the prior decisions to extend Bayside, Millbank and Ste. Rose and continue with demand side management programs.

14 Conclusion

The IRP provides strategic insight and analysis to guide NB Power when planning its future resource needs.

The following conclusions are taken from the analysis

- the public engagement process showed both affordability and clean energy are priorities for New Brunswickers
  - while clean energy is a high priority, affordability outranks clean energy by a ratio of almost two-to-one
- NB Power is mandated to achieve a capital structure of at least 20 per cent equity by 2027 in a way that keeps rates low and stable for New Brunswickers and each decision NB Power makes must take this into consideration
- existing greenhouse gas regulations have significant financial impacts on New Brunswickers
  - the financial impact of phasing out coal in 2030 highlights the need for an equivalency agreement with the federal government which would achieve the same or better outcomes as the federal Government policy, to reduce emissions from coal fired generation, without the significant financial burden and cost for New Brunswickers
  - an equivalency agreement and the Made-in-New Brunswick Carbon Plan can save New Brunswickers over $1.5 billion over the next 20 years, and do so while achieving carbon reductions and meeting all legislative requirements
- investment is required for back up generation on Grand Manan Island
- life extension of the Bayside generating station is the most economic choice to meet energy and capacity requirements after its original retirement date and offers a reliable supply of electricity at a significantly lower emission intensity than other thermal generating stations using coal or oil
- life extensions of the Millbank and Ste. Rose generation stations are the most economic choice for meeting peak load and reserve requirements beyond their original retirement date and these decisions are supported in all sensitivity analyses
- the cost of wind generation has declined in recent years and an additional 200 MW of low-cost wind is an economic option for providing energy, providing NB Power has cost-effective means to balance the new intermittent generation
- a mix of energy efficiency and demand reduction programs meet the remaining energy and demand requirements and provide additional long-term value to New Brunswickers over the next 20 years
- SMR technology provides a potential solution for a carbon-free electricity system in the future

Table 26: Final Expansion Plan

Fiscal Year	Integrated Plan	Scheduled Retirement
Ongoing	Energy Smart NB (420 - 476 MW)	
2021	LORESS Projects (78 MW)	Milltown (3 MW)
2022	Embedded Generation (20 MW)	
…	…	…
2025		Grandview (95 MW)
2026	New LM2500 in Grand Manan (23 MW)	Grand Manan (29 MW)
2027	Bayside Life Extension (277 MW)	
…	…	…
2031	Millbank/Ste Rose Life Extension (496 MW)	
…	…	…
2033	Mactaquac Life Achievement (668 MW) New Wind (200 MW)	
…	…	…
2038	Industrial Demand Response (90 MW)	Bayside (277 MW)
2039	Point Lepreau In-Kind Replacement (670 MW)	Point Lepreau (670 MW)

14.1 Action Plan for Next Three Years

The recommended action plan for the next three years is

1. continue to support the Government of New Brunswick in developing a Made-in-New Brunswick carbon plan and an Equivalency Agreement to enable the continued, although reduced, use of coal at the Belledune Generating Station until its scheduled retirement in December 2040
   - this will ensure that an equivalent (or better) carbon emissions outcome is achieved and save New Brunswickers over $1.5 billion during the next 20 years, and do so while meeting all legislative requirements
2. continue to develop Locally Owned Renewable Energy Projects that are Small Scale and Embedded generation projects
   - by focusing on these projects, NB Power will continue to meet renewable energy targets and provide additional opportunities to collaborate and partner with New Brunswickers including First Nations
3. continue to focus on Energy Smart NB programs including Smart Grid, Smart Solution and Smart Habits
   - the IRP recommends NB Power implement a flexible energy efficiency program that provides demand savings ranging from 420 MW to 476 MW by 2040
4. begin planning for replacement of generating capacity on Grand Manan Island for 2026
5. update maintenance plans for Bayside, Millbank and Ste. Rose in future budgets and forecasts to extend the life of the facilities

15 Appendices

15.1 Appendix 1: Assumptions

Category	2020 Integrated Resource Plan Assumption
COVID-19 Global Pandemic	• the COVID-19 global pandemic is a very serious and unprecedented event in our history, impacting billions of people across the world • while the new normal has yet to emerge, it is currently believed that the impact of this pandemic will be relatively short in the context of a 20-year outlook
Greenhouse Gas Regulations	• based on the Federal Output-Based Pricing System for large emitters • Made-in-New Brunswick carbon plan also included in analysis
Coal Phase-Out	• equivalency agreement is in place for New Brunswick which allows for the continued use of coal, at reduced output levels, until 2040
Mandated Capital Structure	• a capital structure of at least 20 per cent equity is achieved by 2027
Economic Assumptions	• consumer price index of 2 per cent based on the April 2019 Bank of Canada Monetary Policy Report • construction price index of 3.2 per cent for hydro generation projects and 3.6 per cent for all other generation projects based on analysis of historical trends contained in the Handy Whitman Bulletin No. 189 • long term foreign exchange rate of $1.21 (USD/CAN) based on Conference Board of Canada Quarterly Rates Data/Forecast published April, 2019 • long term debt financing rate of 5.25 per cent based on an analysis of public financing rates (3.70 per cent long term bond rate, 90 basis point spread, and provincial guarantee fee of 0.65 per cent) • return on equity assumed to be equivalent to the debt financing rate of 5.25 per cent • weighted average cost of capital of 5.25 per cent based on the long term capital structure target, long term debt financing rate and return on equity assumptions
Fuel and Electricity Market Price Forecast	• short term fuel and electricity market prices based on the 2021 NB Power Budget • long term fuel and electricity market price forecasts provided by Energy Ventures Analysis Inc.

Category	2020 Integrated Resource Plan Assumption
In Province Load Forecast	• based on the NB Power Load Forecast 2020-2030 completed in 2019
Export Load	• firm export contracts are assumed to be maintained • other opportunity exports are modelled or estimated based upon margins currently generated from existing export load and changes in plant availability in the future
Capacity Planning Reserve Criteria	• minimum reserve of 20 per cent as per the 2019 Maritimes Area Comprehensive Review of Resource Adequacy published by the Northeast Power Coordinating Council
Generation Resources	• existing generating stations operate until their planned retirement dates • the Mactaquac Life Achievement Project occurs from 2027 and 2032 during which time only 5 of 6 units will be available • hydro generating stations are assumed to be replaced in-kind upon retirement with the exception of Milltown which will be retired in 2021 • Point Lepreau's capacity and energy will be replaced in-kind after its scheduled retirement date in 2040 • renewable PPAs are assumed to be extended, at reduced prices if the underlying resources are technically capable of reliably generating electricity • 78 MW of MW of renewable energy from the Locally Owned Renewable Energy Projects that are Small program is assumed to be online in 2021 • additional 20 MW of embedded generation anticipated by 2022
Supply Side Resources	• supply side options and costs provided by Hatch Ltd. and NB Power data • screening analysis based on emission profiles, dispatch characteristics and cost effectiveness
Energy Smart NB	• three alternative energy efficiency projections and optional demand response programs provided by Dunsky Energy Consulting • the Advanced Metering Infrastructure (Smart Meter) Project is approved • Smart Grid and Smart Solutions impacts included base case

15.2 Appendix 2: Status of Policy and Regulation Considerations

Policy or Regulation Consideration	Status
Electricity Act	
Integrated Resource Plan **100**(1) The Corporation shall, in accordance with subsection (4), submit to the Executive Council for approval an integrated resource plan that covers a planning period of not less than 20 years and that includes the following:	
(a) the Corporation's load forecast for the planning period;	Provided in Section 7: Load Forecast, Appendix 4: Load Forecast Details
(b) demand-side management and energy efficiency plans considered by the Corporation and those it has chosen for implementation;	Provided in Section 12: Analysis & Results
(c) supply-side options considered by the Corporation and those it has chosen for implementation;	Provided in Section 10: Supply Side Resources
(d) the anticipated impact on load of the demand-side management and energy efficiency plans chosen for implementation by the Corporation;	Provided in Section 12.3.3: Optimize Demand Side Management Portfolio
(e) the cost implications of the demand-side management and energy efficiency plans and supply-side options chosen for implementation by the Corporation as projected for the initial 10-year period covered by the integrated resource plan;	Provided in Section 12.3.3: Optimize Demand Side Management Portfolio
(f) any key assumptions relied on by the Corporation in developing the integrated resource plan;	Provided in Appendix 1: Assumptions
(g) a description of the stakeholder consultations carried out by the Corporation in developing the integrated resource plan; and	Provided in Section 3: Stakeholder Engagement
(h) any other information the Corporation considers relevant or that is ordered by the Board under subsection (3) to be included.	Provided in the following sections • Section 12.3.1 Life Extension of the Bayside Generating Station • Section 4.3 Greenhouse Gas Regulations • Section 12.5: Greenhouse Gas Regulation Analysis

Policy or Regulation Consideration	Status
100(2) Subject to any changes requested under subsection (7), an integrated resource plan shall be developed by the Corporation in accordance with the principles of least-cost service, economic and environmental sustainability and risk management.	Provided in Section 12: Analysis & Results
100(3) The Board may, on its own motion, order the Corporation to include additional information in any subsequent integrated resource plans submitted under subsection (1) for the approval of the Executive Council.	Provided in the following sections • Section 12.3.1: Life Extension of the Bayside Generating Station • Section 4.3 Greenhouse Gas Regulations • Section 12.5: Greenhouse Gas Regulation Analysis
Renewable Portfolio Standard	
NB Power supply 40 per cent of its in-province electricity sales with renewable energy	Provisions to verify this were included in the detailed system optimization models. All scenarios meet the requirements set out in Section 4.2, *Electricity from Renewable Resources Regulation - Electricity Act*.

							Levelized Cost of Electricity - LCOE ($/MWh)						
								Operating Costs					
Project	Net Capacity (MW)	Capacity Factor (%)	In-Service Capital Cost ($/KW)	Expected Life (Years)	Representative Heat Rate (Btu/KWh)	CO2 Emission Intensity (t/MWh)	Capital	Fuel	Variable O&M	Fixed O&M	CO2 Cost	Total Operating Cost	Total LCOE
Simple Cycle Gas Turbine - High Efficiency	100	5.0%	1,735	25	9,639	0.511	288.15	103.77	5.27	40.05	27.46	176.55	464.70
Simple Cycle Gas Turbine - Mid Efficiency	95	5.0%	1,275	25	11,329	0.601	211.83	121.96	19.46	35.94	32.27	209.64	421.47
Small Simple Cycle Gas Turbine - Diesel Fuel	23	5.0%	1,448	25	10,485	0.880	240.47	237.09	5.01	38.05	5.08	285.23	525.70
Large Combined Cycle - Gas	432	80.0%	1,906	25	6,635	0.352	19.79	71.43	4.37	2.49	18.90	97.19	116.97
Small Combined Cycle - Gas	122	80.0%	2,424	25	7,241	0.384	25.17	77.95	4.80	3.69	20.63	107.07	132.24
Microturbines	1	80.0%	5,315	25	6,100	0.324	55.17	105.17	30.03	10.71	17.38	163.30	218.47
Natural Gas Fuel Cells	1	80.0%	13,116	20	7,980	0.423	153.38	132.61	0.00	85.93	21.71	240.25	393.63
Biomass	14	80.0%	6,814	25	8,163	0.000	70.72	107.83	5.25	10.71	0.00	123.80	194.52
Biomass Bubbling Fluidized Bed	50	80.0%	5,993	35	12,315	0.000	53.89	167.26	8.29	23.66	0.00	199.21	253.10
Municipal Solid Waste	5	80.0%	14,742	35	16,608	0.000	132.55	0.00	13.19	89.27	0.00	102.46	235.02
Geothermal	30	85.0%	7,201	30	0	0.000	64.71	0.00	18.83	37.73	0.00	56.56	121.27
Compressed Air Energy Storage	100	16.8%	2,583	25	0	0.000	128.07	0.00	87.18	14.09	0.00	101.27	229.34
Nuclear	745	87.0%	8,682	30	11,000	0.000	76.23	5.96	5.65	28.83	0.00	40.44	116.67
Small Wind	5	45.0%	2,684	30	0	0.000	45.57	0.00	12.55	27.07	0.00	39.63	85.19
Large Wind	100	45.0%	1,755	30	0	0.000	29.79	0.00	12.55	19.11	0.00	31.66	61.46
Very Small Solar Photovoltaic	1	17.6%	2,780	30	0	0.000	120.65	0.00	12.55	13.84	0.00	26.40	147.05
Small Solar Photovoltaic	5	17.6%	2,193	30	0	0.000	95.18	0.00	12.55	13.84	0.00	26.40	121.58
Large Solar Photovoltaic -Fixed	25	17.6%	1,935	30	0	0.000	84.01	0.00	12.55	13.84	0.00	26.40	110.40
Large Solar Photovoltaic - Tracking	25	21.3%	2,100	30	0	0.000	75.32	0.00	12.55	11.44	0.00	23.99	99.31
Pumped Storage Hydro	100	41.4%	8,629	60	0	0.000	131.13	0.00	10.67	24.77	0.00	35.44	166.57
Small Hydro	20	35.0%	6,334	50	0	0.000	117.56	0.00	0.00	56.51	0.00	56.51	174.06
Wave Power	10	25.0%	13,566	20	0	0.000	507.67	0.00	11.75	171.02	0.00	182.77	690.44
Tidal Stream Power	50	35.0%	10,545	20	0	0.000	281.85	0.00	0.00	134.13	0.00	134.13	415.99
Hydro - Grand Falls	100	36.4%	5,317	50	0	0.000	95.00	0.00	0.00	6.53	0.00	6.53	101.53
Interconnection Purchases	350	50.0%	0	25	10,000	0.000	0.00	72.76	0.00	21.18	0.00	93.94	93.94
Millbank/Ste Rose Life Extension	496	5.0%	387	25	12,000	1.007	64.29	271.35	0.00	9.55	24.53	305.43	369.72
Lithium Ion BESS (5 MW/20 MWh/4 hrs)	5	14.2%	3,975	10	0	0.000	419.86	0.00	58.89	4.48	0.00	63.38	483.24
Lithium Ion BESS (1 MW/4 MWh/4 hrs)	1	14.2%	5,625	10	0	0.000	594.14	0.00	58.89	19.80	0.00	78.69	672.83
Lithium Ion BESS (5 MW/2.5 MWh/30 mins)	5	1.8%	1,325	10	0	0.000	1,119.63	0.00	58.89	31.28	0.00	90.17	1,209.81
Lithium Ion BESS (20 MW/10 MWh/30 mins)	20	1.8%	988	10	0	0.000	834.44	0.00	58.89	8.31	0.00	67.21	901.65
Flow Battery (5 MW/20 MWh/4 hrs)	5	11.7%	4,450	20	0	0.000	356.84	0.00	77.38	6.18	0.00	83.56	440.40
Flow Battery (1 MW/4 MWh/4 hrs)	1	11.7%	5,875	20	0	0.000	471.11	0.00	77.38	26.30	0.00	103.68	574.79
Flow Battery (5 MW/40 MWh/8 hrs)	5	23.3%	7,350	20	0	0.000	294.69	0.00	77.38	3.66	0.00	81.05	375.74
Flow Battery (1 MW/8 MWh/8 hrs)	1	23.3%	6,000	20	0	0.000	240.56	0.00	77.38	13.72	0.00	91.11	331.67

15.4 Appendix 4: Provincial Load Forecast Details

	Before Energy Smart NB Impacts	
	Energy (GWh)	Demand (MW)
2021	14,446	3,142
2022	14,584	3,152
2023	14,770	3,178
2024	15,099	3,202
2025	15,195	3,210
2026	15,266	3,219
2027	15,360	3,228
2028	15,426	3,235
2029	15,506	3,242
2030	15,565	3,250
2031	15,603	3,254
2032	15,700	3,263
2033	15,798	3,272
2034	15,897	3,282
2035	15,996	3,291
2036	16,096	3,301
2037	16,196	3,311
2038	16,297	3,320
2039	16,399	3,330
2040	16,501	3,340

15.5 Appendix 5: Small Modular Reactors

Small modular reactors are the next generation of nuclear technology. The various designs range from an output of between one and 300 megawatts, with a variety of end applications. The units can be constructed and shipped to locations where they are assembled on site.

Advanced fast spectrum small modular reactors use a coolant other than water, such as molten salt or sodium. They have inherent safety characteristics, simpler design, lower cost, the ability to recycle their used fuel and follow the intermittent variable load from renewable power sources. Although conventional nuclear reactors do not produce much high-level radioactive waste because they are a high-density power source, advanced fast reactors can recycle their used fuel and produce significantly less high-level waste than conventional reactors.

In 2018, Natural Resources Canada brought together representatives from interested provinces, territories and utilities to discuss how Canada can take advantage of the opportunity to lead the emerging domestic and global markets for SMRs. NB Power, along with the NB Department of Energy and Mines, was a participant in this SMR Pan-Canadian Roadmap exercise[67]. Discussions continue with our industry counterparts and federal agencies to progress the SMR roadmap action plan.

To take advantage of the potential emerging opportunities, the Government of New Brunswick, through the New Brunswick Energy Solutions Corporation (NBESC), collaborated in the formation of an advanced SMR research cluster. Through this, a relationship with two very promising advanced SMR vendors followed.

As part of activities related to the Advanced Small Modular Reactor Research and Development cluster, the SMR vendors are

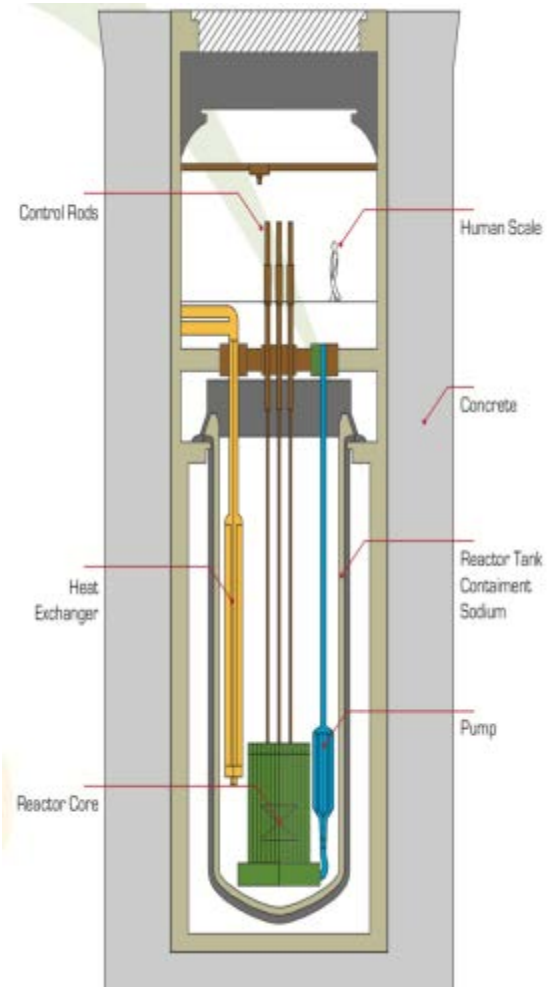
- hiring staff for their offices in Saint John
- working with the University of New Brunswick to establish chair positions and curriculum, and working on plans for upcoming R&D to be performed at CNER/UNB.
- Progressing their conceptual SMR design
- progressing through Phase 1 and Phase 2 of the Canadian Nuclear Safety Commission (CNSC) Vendor Design Review
- engaging in discussions to establish an SMR supply chain in New Brunswick
- engaging in discussions within the province to increase understanding of advanced Small Modular Reactor technologies

[67] "A Call to Action: A Canadian Roadmap for Small Modular Reactors," Canadian Nuclear Association, November 2018, https://smrroadmap.ca/wp-content/uploads/2018/11/SMRroadmap_EN_nov6_Web-1.pdf.

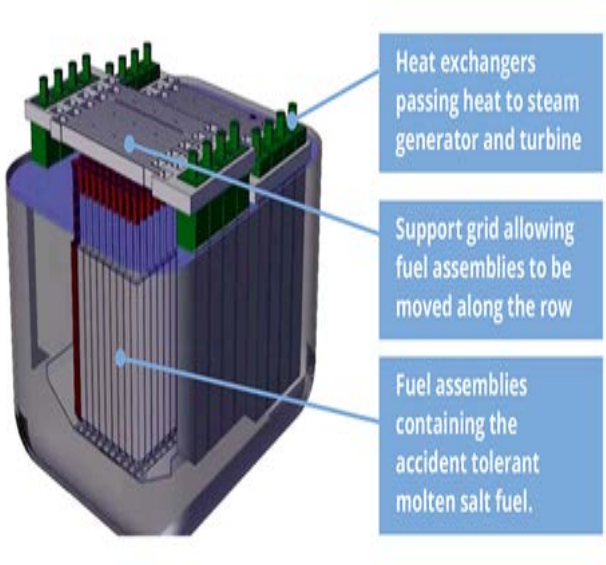
The Advanced SMR initiative has the potential to provide New Brunswickers with safe, reliable, cost effective, clean energy to meet greenhouse gas reduction targets and support intermittent renewable energy sources. SMRs offer New Brunswick a potential new manufacturing sector and supply chain to manufacture and distribute these modules, provide fleet services and to export power to neighbouring jurisdictions and a sizeable export market.

More details of the SMR initiative can be found in the *"Powering Growth – Building New Brunswick Energy Future"*, e-booklet on NB Power's website[68]. It is part of NB Power's ongoing dialogue with the public and First Nations.

Figure 31: Example of Small Modular Reactor Technologies



ARC 100 Sodium Cooled Fast Reactor



Moltex Energy SSR-W Molten Salt Fast Reactor

[68] "Point Lepreau Nuclear Generating Station," NB Power, accessed March 20, 2020, https://www.nbpower.com/en/about-us/in-the-community/point-lepreau-nuclear-generating-station.

15.6 Appendix 6: Comparison to 2017 Integrated Resource Plan

While many of the processes and input requirements used to develop the 2020 IRP are the same as those used in the 2017 IRP, there are several noteworthy changes. Those changes are summarized below.

15.6.1 Stakeholder Engagement

In the spirit of continuous improvement, NB Power made two changes to the public engagement process for the 2020 IRP. First, New Brunswickers were invited to share their input at the start of the process. This allowed the NB Power team to incorporate those views into the initial planning stages. Second, NB Power implemented several new and creative ways to engage with New Brunswickers. This led to over five times the engagement from the 2017 IRP.

Through the 2020 IRP public engagement process, New Brunswickers shared the factors that were most important to them when considering the province's energy future: affordability, followed by clean energy. Affordability ranked higher as priority by a factor of almost 2 to 1. In the 2017 IRP, Clean Energy and Affordability ranked much closer.

15.6.2 NB Power Mandate

Under its mandate, NB Power continues to provide safe, reliable and sustainable energy to New Brunswickers at the lowest possible cost. The 2020 IRP took this into consideration, in addition to a goal to achieve a capital structure of at least 20 per cent equity by 2027.

15.6.3 Greenhouse Gas Regulation

Greenhouse gas regulation has seen significant change since the 2017 IRP. The 2020 plan was created using current federal backstop performance standards. When NB Power put together the 2017 IRP, the federal regulations were not yet finalized, and the proposed regulations at the time were used for sensitivity analysis.

The federal coal regulation includes a provision for individual provinces to negotiate equivalency agreements to continue to allow the use of coal as a fuel source for electricity generation beyond 2030. The 2020 IRP assumes an equivalency agreement will be reached with the federal government, allowing for Belledune to use coal until its planned retirement date in December 2040. In the 2017 IRP, the then-current federal coal regulation limited the use of coal to 50 years from the in-service date, allowing Belledune to use coal until 2043. These greenhouse gas regulations lower emissions to 63 Mt in the 2020 IRP or 15 per cent compared to 74 Mt for the same period in the 2017 IRP.

15.6.4 Existing Generation Assets

Since the 2017 IRP, NB Power acquired the Bayside Generating Station (March 2019). In 2017, NB Power held a power purchase agreement for a portion of the facility's generation. That agreement was scheduled to expire and the station's retirement date was 2026.

A decision was recently made to retire the Milltown Generating Station in November 2020. This retirement was not anticipated in the 2017 IRP.

15.6.5 Energy Smart NB

In the 2020 IRP, the Smart Grid and Smart Solutions portions of Energy Smart NB are included in the base assumptions as they have been integrated into NB Power's core business in recent years. The 2017 IRP framed Energy Smart NB as an alternative to a traditional supply options and analyzed it from that perspective, presenting views both with, and without it.

15.6.6 Supply Side Resources

Generation alternatives considered in the 2020 IRP are like those in the 2017 IRP, with two notable differences. First, the levelized cost of wind has dropped significantly compared to other alternatives. This is due to improvements in technology that result in longer operating lives and higher capacity factors.

New battery storage alternatives are introduced in the 2020 IRP as well. However, they are still uncompetitive compared to other resources at this time. The value of these options is expected to increase as the technology improves and New Brunswick's smart grid develops.

15.6.7 Analysis

NB Power has made several analysis improvements with the 2020 IRP. This plan introduces Levelized Cost of Capacity and Levelized Cost of Storage concepts to help the generation supply side resource analyses. The 2017 IRP only used Levelized Cost of Energy in its analysis of potential generation supply options.

The study period for the IRP has been reduced from 25 years to the legislated required timeframe of 20 years. Using a shorter study period helps to focus attention on the more immediate issues and challenges facing NB Power, like equivalency.

Key near-term decisions around generation life extensions have been analyzed more explicitly in the 2020 IRP. This includes detailed analyses for the Bayside and Millbank/Ste. Rose life extensions, including alternate scenarios where the stations lives are not extended.

Demand side management programs are optimized by analyzing three scenarios that provide demand savings ranging from 420-531 MW by 2040. The demand side management scenarios used in the 2020 plan were founded in a 2019 potential study. This allowed for better program optimization. In 2017, one level of demand side management (providing 620 MW of demand

savings by 2042) was considered in the base case, with additional levels explored through sensitivity analysis.

15.6.8 Conclusions

The key results of the 2020 IRP are below

- life extension of Bayside
- life extension of Millbank and Ste Rose
- continue with DSM programs within a range of (420 to 476 MW), to allow flexibility in Energy Smart NB for the future
- the successful negotiation of an equivalency agreement for the continued use of coal beyond 2030 is critical as it would achieve the same emission reductions as if coal is phased-out in 2030, but come at considerably lower costs to New Bruinswickers

The 2017 IRP did not consider the extension of Bayside because its retirement date was 2026 and NB Power did not own the asset or have access to the owner's data to assess the viability of a life extension at the time. The Millbank and Ste Rose life extensions were recommended, as was continuing with the Energy Smart NB plan. In 2017, an equivalency agreement for Belledune was not considered, as the regulations at the time limited the use of coal to 50 years from the in-service date of the station, rather than to 2030. Cumulative greenhouse gas emissions in the 2020 IRP are 63 Mt compared to 74 Mt or 15 per cent lower for the same period in the 2017 IRP.