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MARITIME ELECTRIC
A FORTIS COMPANY

July 21, 2023

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The Island Regulatory and Appeals Commission

Island Regulatory and Appeals Commission
PO Box 577
Charlottetown PE C1A 7L1

Dear Commissioners:

Please find attached the Addendum to the December 2022 Maritime Electric Capacity Resource Study. The Addendum highlights the capacity impact of the February 3 to 5, 2023 extreme weather event. The purpose of the Addendum is to revisit and revise some of the recommendations made in the December 2022 report in light of the polar vortex that occurred in the Maritimes and Quebec.

The event highlighted that i) PEI is more susceptible to mainland electricity import interruptions or curtailments than originally assumed, and ii) Maritime Electric's peak load is higher than previously forecasted during the preparation of the December 2022 report.

Sargent & Lundy is of the opinion that the events that transpired on February 3 to 5, 2023 should serve as an early warning example of the challenges PEI faces with respect to potential electricity disruptions during extreme weather events. Also, regardless of whether global warming is found to increase the rate and/or severity of polar vortex disruptions in the future, extreme cold weather events already occur with sufficient regularity that proper planning of the electrical system is essential, especially when considering the growth of electric heating throughout the Maritimes.

The Addendum also provides previous examples of cold weather events contributing to the failure of electrical systems in Texas and Newfoundland where insufficient generation capacity, combined with both a peak load that surpassed the forecast and untimely system equipment failure, resulted in loss of life, major system disruptions and blackouts.

Fortunately, PEI was able to get through the events of February 3 to 5, 2023 without having to implement load shed due to electricity shortages. However, in many respects, PEI was in the most precarious position of any location within the entire region. This is because PEI does not have enough dispatchable capacity installed on-Island to fully meet peak load and thus required continuous imported electricity from New Brunswick in order to avoid load shed. While the wind generation installed on PEI is an excellent resource from the perspective of lowering carbon emissions, wind generation is not a dispatchable resource in an emergency.

This was evident during the extreme cold event as only 25 per cent of the turbines were operational at the time of peak load and the remainder were in forced or planned outage. PEI was fortunate that ISO New England, Newfoundland and Labrador, and Nova Scotia had small amounts of excess electricity to send to New Brunswick.

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On May 15, 2023, NERC (North American Electric Reliability Corporation) released a Level 3 Essential Actions Alert titled Cold Weather Preparations for Extreme Weather Events III. Level 3 essential actions alert is the highest severity level that NERC issues and this is the first time a Level 3 essential actions alert has ever been issued by NERC. The assessments and recommendations from NERC illustrate that many parts of North America are at risk during extreme cold weather events. Among the locations facing the greatest challenges is Canada's Maritime Provinces region. For PEI, this is an indication that electricity imports from the mainland are not guaranteed during future extreme cold events.

Due to the shortage in dispatchable resources seen during the February 2023 event, Sargent & Lundy revised its previous recommendations to Maritime Electric of installing a minimum of 85 MW of new reciprocating internal combustion engine ("RICE")/combustion turbine ("CT") with biofuel compatibility to a higher range of 125 to 150 MW of the same technology. This recommendation is based on the Maritime Electric record peak load of 359 MW experienced on February 4, 2023. Sargent & Lundy continues to recommend the integration of both onshore wind and solar photo voltaic to help meet Maritime Electric's decarbonization goals but notes that these non-dispatchable resources may not be available to provide reliable generation during an emergency event as was experienced during the February 3-5, 2023. In addition, Sargent and Lundy continues to note that a new battery energy storage system ("BESS") demonstration project could help identify the BESS functions/use cases that offer the maximum benefit for the Island.

Yours truly,

MARITIME ELECTRIC

Angus Orford

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ASO04
Enclosure

Extreme Weather Event Capacity Impact

Addendum to December 2022 Maritime Electric Capacity Resource Study

Prepared for

Maritime Electric Company, Ltd.

Prepared by Sargent & Lundy

Report SL-017775

Final

July 12, 2023

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ISSUE SUMMARY AND APPROVAL PAGE

This is to certify that this document has been prepared, reviewed, and approved in accordance with Sargent & Lundy's Standard Operating Procedure SOP-0405, which is based on ANSI/ISO/ASSQC Q9001 Quality Management Systems.

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition/Clarification
BESS	Battery energy storage system
CAD	Canadian dollars
CT	Combustion turbine
EEA	Energy Emergency Alert
ISO	International Organization for Standardization
kW	Kilowatt
kWh	Kilowatt hour
LIL	Labrador Island Link
Maritime Electric	Maritime Electric Company, Limited
MECL	Maritime Electric Company, Limited
MW	Megawatt
MWh	Megawatt hour
NERC	North American Electric Reliability Corporation
PEI	Prince Edward Island
RICE	Reciprocating internal combustion engines
S&L	Sargent & Lundy
WEICAN	Wind Energy Institute of Canada

EXECUTIVE SUMMARY

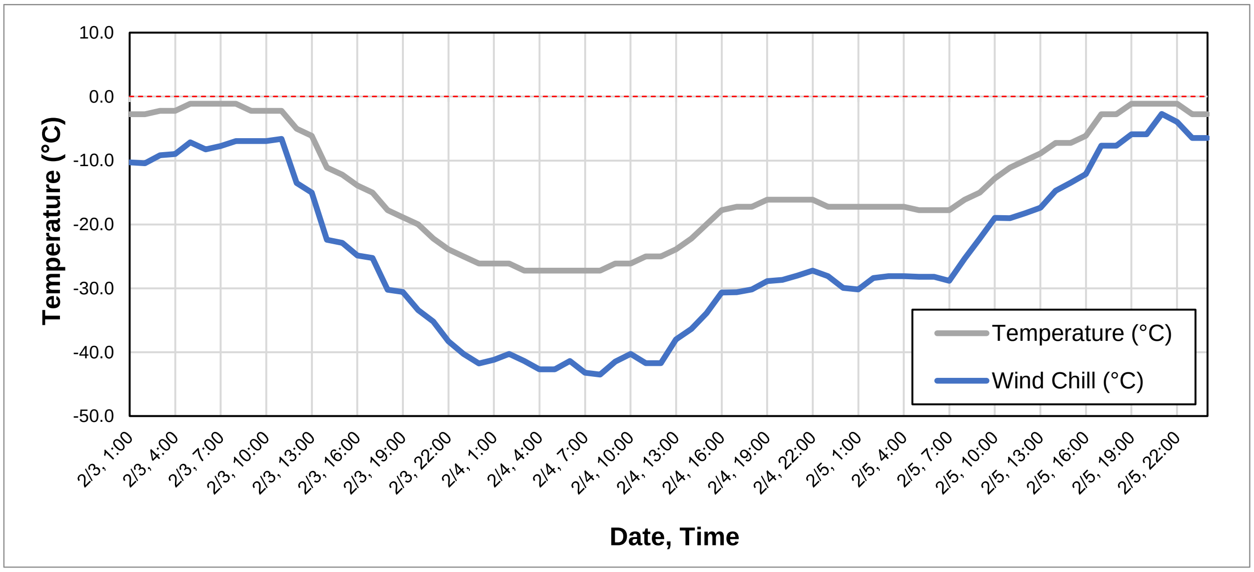
On December 9, 2022, Sargent & Lundy (S&L) issued a report titled *Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company*, which included an evaluation of different electricity capacity resource technologies, cost estimates, and recommend technologies well suited to helping Maritime Electric Company, Limited (MECL) meet its goals and needs. MECL's most important goals include meeting capacity and energy obligations, improving its ability to serve load during interruptions in electricity, and achieving environmental sustainability targets. The report ultimately concluded that a portfolio of reciprocating internal combustion engines (RICE) / combustion turbines (CTs), onshore wind, and solar photovoltaic was best suited to help MECL meet these goals. Based on a review of MECL's forecasted peak load at the time the previous report was written, S&L originally recommended that a minimum of 85 MW of new RICE/CTs with biofuel compatibility should be installed on Prince Edward Island (PEI) as soon as possible to reduce the probability of load shedding and rolling blackouts in the event of electricity import limits and/or interruptions from the mainland. In addition, while S&L's report did not recommend a new battery energy storage system (BESS) as part of the recommended portfolio, S&L noted that a new BESS could provide some benefits for MECL and PEI. As a result, S&L's report suggested that a new BESS demonstration project could be pursued, potentially in coordination with interested PEI stakeholders, to better assess the BESS functions/use cases that offer the maximum benefit for the island.

The purpose of this addendum is to revisit and revise some of the recommendations made in the prior report based on the observations made during a recent extreme cold event that transpired in the Maritimes region between February 3 through 5, 2023. The recent event highlighted both that (1) PEI is more susceptible to mainland electricity import interruptions or curtailments than originally assumed and (2) MECL's peak load is higher than previously forecasted during the preparation of the prior report.

EXTREME COLD WEATHER EVENT ON FEBRUARY 3 TO 5, 2023

During the period between February 3 and 5, 2023, large areas of Eastern Canada and the Maritimes provinces experienced extreme cold, driven by the disrupted southward movement of the northern polar vortex. This caused wind temperatures and wind chills to drop to below -40°C, as shown in Figure ES-1.

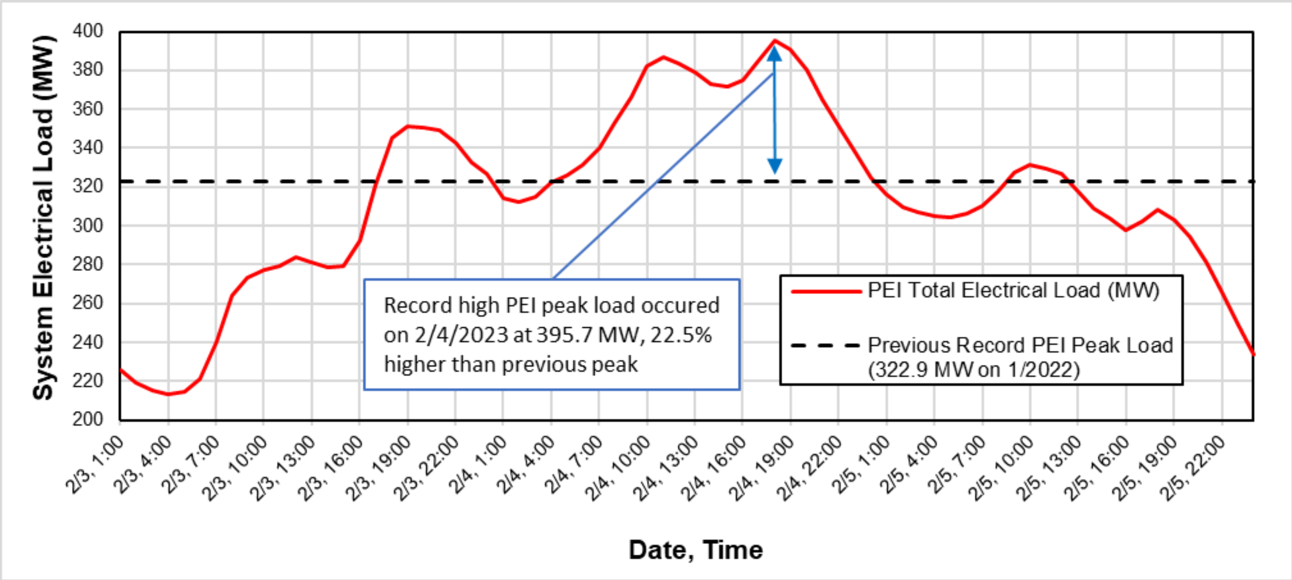
Figure ES-1 — Temperature and Wind Chill, Charlottetown (Feb. 3 to 5, 2023)



IMPACT TO PEI AND REGIONAL ELECTRICAL SYSTEMS

The extreme cold weather during February 3 to 5, 2023, caused record high demand for electricity on PEI and throughout Eastern Canada due to increased home heating load, commercial / industrial loads, and electrification. The high load resulted in significant stress on the electrical system, both locally and regionally. PEI experienced record electrical demand, with peak load for PEI soaring to 395.7 MW. This exceeded the previous load peak for PEI (set in 2022) by 22.5%.

Figure ES-2 — Electrical Load on PEI (Feb. 3 to 5, 2023)



This higher peak load experienced by PEI and in other parts of the Maritimes provinces, along with the stress the extreme weather had on other aspects of the electrical system (i.e., on generation and electrical equipment performance), resulted in a significant impact to grid operations and overall system reliability. The system's total hourly dispatch through the extreme cold event, in addition the wind generation through the event, are shown in Figure ES-3 and Figure ES-4. Given there is only enough dispatchable generation installed on PEI to meet a fraction (approximately 20%) of the peak electrical load experienced on PEI during the event, significant electricity imports from New Brunswick were required to meet PEI's electricity demand during the event. New Brunswick was able to provide imports with minimal curtailment; however, margins in New Brunswick were also very thin—to the point where New Brunswick had to declare an Energy Emergency Alert Level 2, which indicates that it was at serious risk of being unable to meet its firm load requirements (discussed further below). In addition, during the event the wind generation on PEI dropped significantly due to both the cold temperatures and high wind speeds resulting in equipment failures/shutdowns. PEI's relatively small amount of on-island dispatchable generation was dispatched without issue during the event.

Figure ES-3 — PEI Generation by Source (Feb. 3 to 5, 2023)

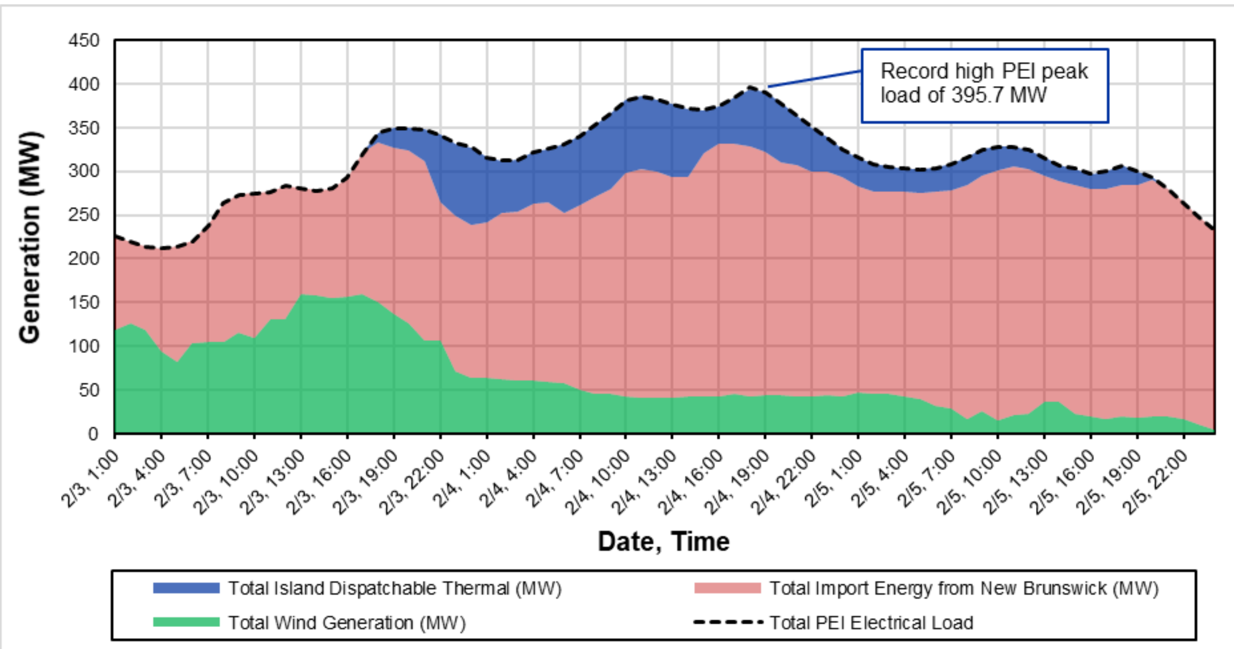
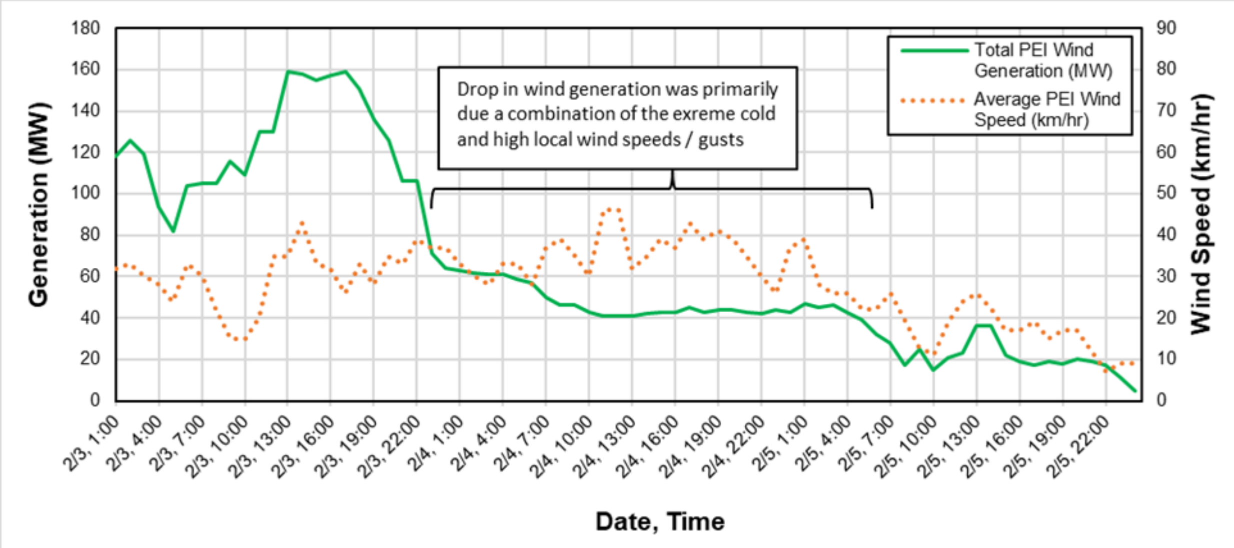
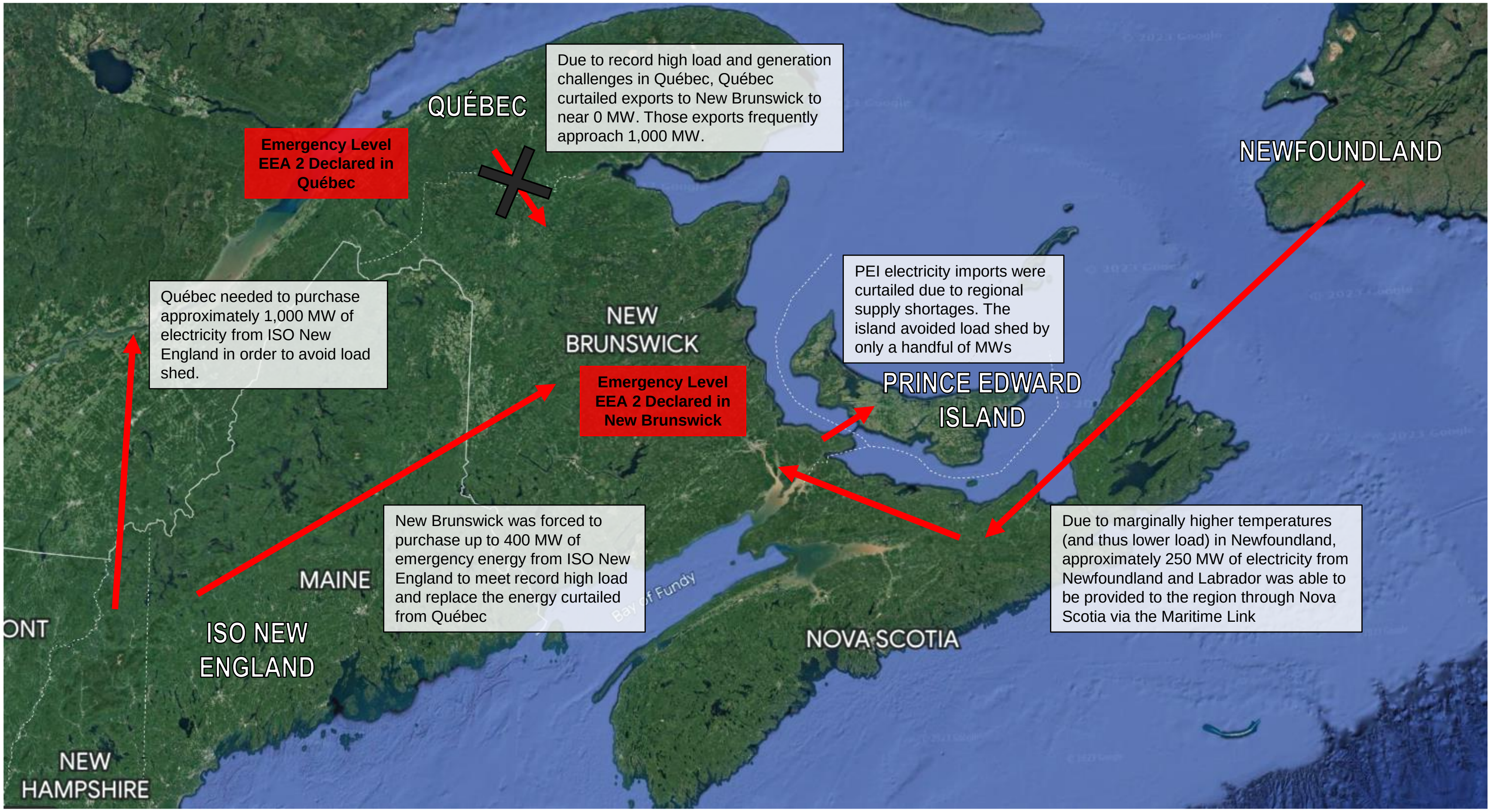


Figure ES-4 — PEI Wind Generation and Wind Speed (Feb. 3 to 5, 2023)



The extreme cold weather event severely strained the broader Maritimes regional electric system to the point where load shedding was a significant risk. Figure ES-5 summarizes the regional shortfalls, key electricity import/exports, and declared emergencies during the event. The provinces of Québec, Newfoundland and Labrador, Nova Scotia, and New Brunswick were all significantly impacted. Québec had to declare an Energy Emergency Alert Level 2 emergency and both (1) completely curtailed electricity exports to New Brunswick and (2) purchased emergency energy from New England, New York, and Ontario. As a result of the drop in electricity imports from Québec, in addition to record high peak electrical load, the New Brunswick electrical system was also pushed to emergency levels. Several factors, including electricity imports from ISO New England and Newfoundland and Labrador (through Nova Scotia), helped New Brunswick to avoid load shed. Had these imports not been available, it is likely that New Brunswick would have had to more significantly curtail electricity exports to PEI, which would likely have resulted in load shed on PEI during some of the coldest parts of the extreme cold event.

Figure ES-5 — Regional Recap, Evening February 3, Morning February 4, 2023



SIMILAR RECENT EVENTS AND INDUSTRY GUIDANCE

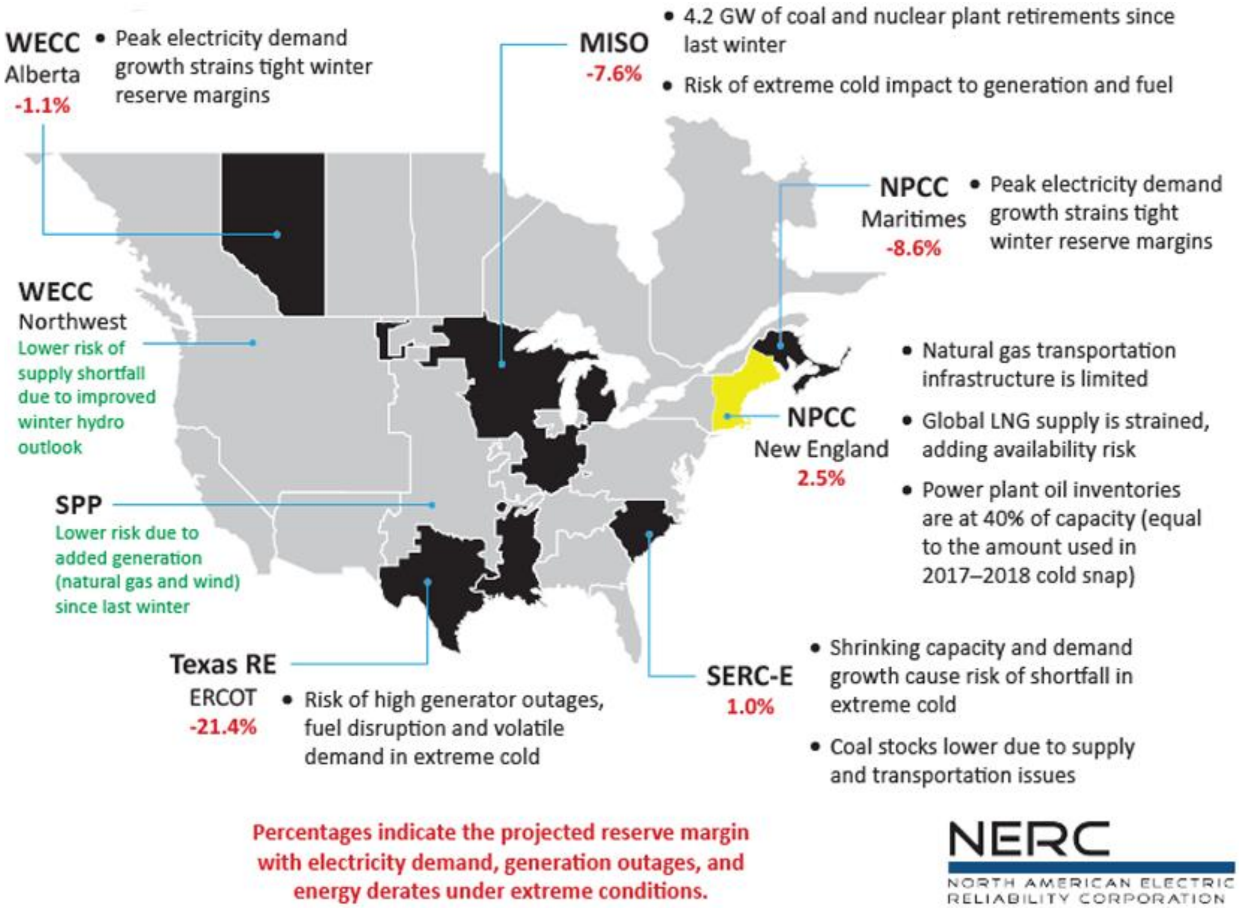
The extreme cold weather event that hit Eastern Canada on February 3 to 5, 2023, had many similarities to other recent events that also resulted in excessive strain on electric systems. The most notable recent event took place in 2021, when extreme cold from the North Pole pushed southward into the United States, all the way into Texas. In Texas, the cold also resulted in very high demand for electricity, disruptions to generators and the supply of natural gas, widespread power outages, and water shortages. The crisis led to billions in dollars of damage and the deaths of 246 people, two-thirds of which died from hypothermia.[2]

Given the stress recent extreme cold weather events have put on electrical systems, the North American Electric Reliability Corporation (NERC) has released a set of planning guidelines and recommendations regarding extreme cold weather events to come. For example, in November 2022, NERC released its *2022-2023 Winter Reliability Assessment,*[3] which highlighted that "some areas [of the bulk power system] are highly vulnerable to extreme and prolonged cold weather and may require load-shedding procedures to maintain reliability." The guideline notes that during extreme cold events, the Maritimes region is likely to have the second lowest electrical system reserve margins of all the electrical systems NERC oversees (see Figure ES-6 taken from the NERC guideline). Only Texas is estimated to have lower reserve margins. For PEI, this is an indication that electricity imports from the mainland to PEI are not guaranteed during future extreme cold events. Note that the reason for the estimated tight reserve margins in the Maritimes region is electrical load growth, which is driven by the rapid transition of buildings to electrical heating (and electrification in general) and commercial / industrial load.

In addition, on May 15, 2023, NERC released a Level 3 Essential Actions Alert titled *Cold Weather Preparations for Extreme Weather Events III.*[4] The alert was issued to "increase the Reliability Coordinators' (RC), Balancing Authorities' (BA), Transmission Operators' (TOP), and Generator Owners' (GO) readiness and enhance plans for, and progress toward, mitigating risk for the upcoming winter and beyond." For reference, a Level 3 Essential Actions Alert is the <u>highest</u> severity level that NERC issues and this is the <u>first time</u> a Level 3 Essential Actions Alert has ever been issued by NERC.

[2] https://www.texastribune.org/2022/01/02/texas-winter-storm-final-death-toll-246/
[3] https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2022.pdf
[4]https://www.nerc.com/news/Pages/NERC-Releases-Essential-Action-Alert-Focused-on-Cold-Weather-Preparations.aspx

Figure ES-6 — NERC Reliability Assessment for Extreme Cold Events[5]



UPDATED RECOMMENDATIONS FOR MECL

Due to the shortage in dependable resources seen during the February 2023 event, S&L has revised its previous recommendation to MECL of installing a minimum of 85 MW of new RICE/CTs with biofuel compatibility to a higher range of 125 to 150 MW of the same technology. This recommendation is based on the record peak load of 395.7 MW experienced on February 4, 2023. S&L continues to recommend the integration of both onshore wind and solar photovoltaic to help meet MECL's decarbonization goals but notes that these non-dispatchable resources may not be able to provide reliable generation during an emergency event (as was observed during the event between February 3 and 5, 2023). In addition, S&L continues to note that a new BESS demonstration project could help identify the BESS functions/use cases that offer the maximum benefit for the island. As is shown in Figure ES-7, an additional 125 to 150 MW of dispatchable capacity (RICE/CTs) would help to keep the ratio of dispatchable capacity to system peak

[5] https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2022.pdf

load, and thus risk of future load shed in the event of mainland electricity import shortages, near consistent with historical levels.

Figure ES-7 — Outlook of Dispatchable On-Island Capacity versus Peak Load

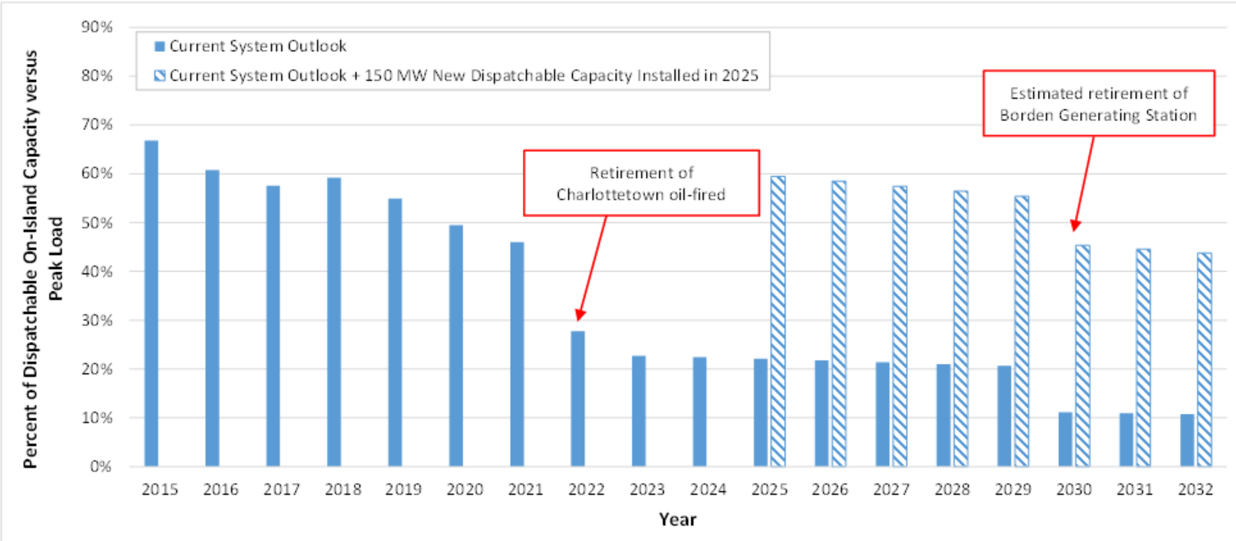


Table ES-1 summarizes the key operating details and levelized costs for CT and RICE options. A more detailed estimate of the CT design is included in Appendix A with the RICE details included in the previous report. Note the manufacturer and type of CT/RICE unit are chosen for comparison purposes only—many other manufacturers make similar units.

Table ES-1 — Estimated Costs for New CTs/RICE

Title	CT – Aeroderivative		RICE	
	GE LM6000 PF+ SPRINT		Wartsila 20V32	
Fuel Type	Diesel Only	Biodiesel Compatible	Diesel Only	Biodiesel Compatible
Winter Output (MW)	57.1 per turbine	57.1 per turbine	10.6 per engine	9.4 per engine
Net Heat Rate (Btu/kWh)	9,000	9,500	8,400	8,400
Levelized Install Cost (CAD/kW)	1,744	1,817	1,845	2,074
Synchronous Condenser Cost	Included	Included	Not included	Not included

There is also a need on PEI for additional electrical system support to maintain voltage levels and system stability, which is an ongoing challenge on PEI as additional wind generation is added to the electrical system. The 2020 MECL Integrated System Plan noted that after island load exceeds 350 MW, additional system voltage support (i.e., a synchronous condenser) will be needed on PEI[6]. Previous forecasts of island load estimated that levels higher than 350 MW would not be reached for a number of years; however, given PEI's load nearly reached 400 MW on February 4, 2023, additional system voltage support is needed today. For reference, both RICE and CTs can operate as synchronous condensers, which would help to improve the system's electrical performance; however, CTs are much more commonly used as synchronous condensers than RICE in the electricity industry. As a result, S&L recommends MECL pursue CTs over RICE if it is determined that a unit with synchronous condenser capability is required.

Finally, due to the unavailability of many of the wind generators on PEI during the February 3 to 5, 2023, event (as a result of equipment shutdowns caused by both the extreme cold and strong/turbulent winds), S&L recommends further information sharing and/or a technical conference, between MECL, the wind operators, and the wind generator original equipment manufacturers to fully understand what transpired and find solutions to prevent a repeat of the challenges experienced between February 3 and 5, 2023.

[6] Maritime Electric 2020 Integrated System Plan, page 44 and 47

1. INTRODUCTION AND EVENT DESCRIPTION

On December 9, 2022, Sargent & Lundy (S&L) issued the *Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company,* report number SL-017203. The report was developed for the purposes of evaluating a variety of different electricity capacity resource technologies, developing cost estimates, and recommending technologies well suited to help Maritime Electric Company, Limited ("MECL" or "Maritime Electric") cost-effectively achieve its most critical goals and needs, which are described as follows:

1. Meet both its capacity and energy obligations
2. Improve its ability to serve load during interruptions and/or curtailments in electricity imported from the mainland
3. Achieve sustainability targets

The report ultimately concluded that a portfolio of reciprocating internal combustion engines (RICE) / combustion turbines (CTs), onshore wind, and solar photovoltaic was best suited to help Maritime Electric meet these goals and needs. Based on a review of Maritime Electric's forecasted peak load at the time the report was written, S&L originally recommended that a minimum of 85 MW of new RICE/CTs with biofuel compatibility should be installed on Prince Edward Island (PEI) as soon as possible to reduce the probability of load shedding and rolling blackouts in the event of electricity import limits and/or interruptions from the mainland. Since the PEI system is winter peaking (i.e., the highest annual electricity demand occurs in the winter due to the demands of electric heating), in addition to the fact that winter in the Maritimes region can be particularly harsh, any load shed or rolling blackout events on PEI in the winter could have serious consequences both in terms of property damage and resident safety.

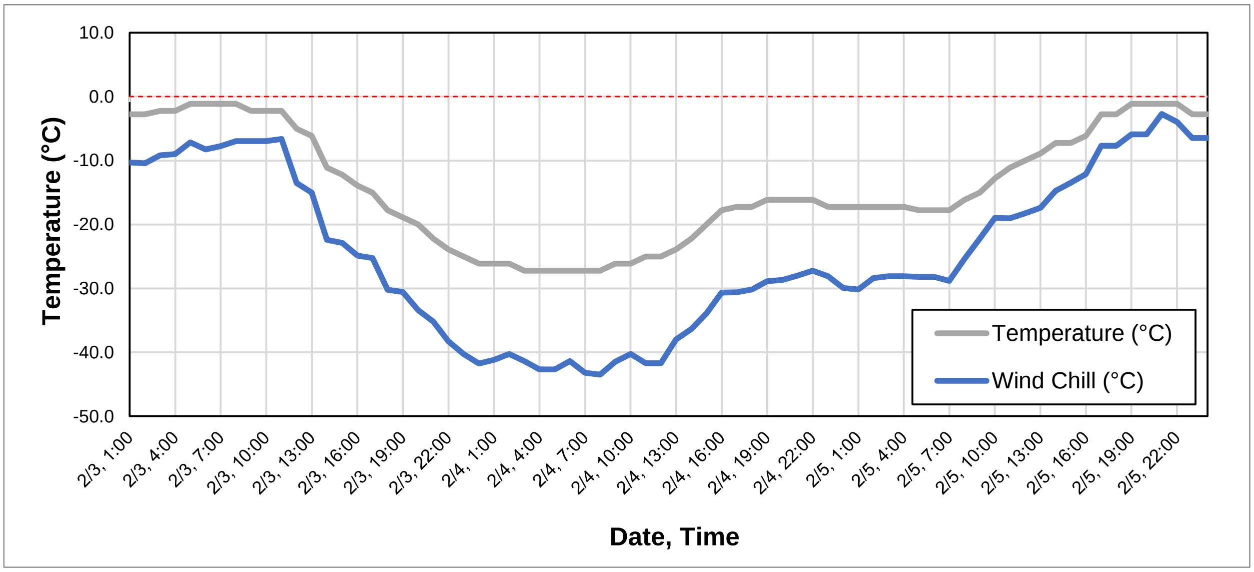
In addition, while S&L's report did not recommend a new battery energy storage system (BESS) as part of the recommended portfolio, S&L noted that a new BESS could provide some benefits for MECL and PEI. As a result, S&L's report suggested that a new BESS demonstration project could be pursued, potentially in coordination with interested PEI stakeholders, to better assess the BESS functions/use cases that offer the maximum benefit for the island.

The purpose of this addendum is to revisit and revise some of the recommendations made in the prior report based on the observations made during a recent extreme cold event that transpired in the Maritimes region between February 3 through 5, 2023. The recent event highlighted both that (1) PEI is more susceptible to mainland electricity import interruptions or curtailments than originally estimated when the prior report was written and (2) Maritime Electric's peak load is higher than what was previously forecasted. S&L is of the opinion that the events that transpired on February 3 to 5, 2023, should serve as an early warning example of the challenges PEI faces with respect to potential electricity disruptions during future extreme weather events.

1.1. EXTREME COLD WEATHER BETWEEN FEBRUARY 3 AND 5, 2023

During the period between February 3 and 5, 2023, large areas across Eastern Canada and the Maritimes provinces experienced extreme cold. Figure 1-1 illustrates the temperature and wind chill experienced in Charlottetown, PEI, between February 3 and 5, 2023. During the event, temperatures and wind chill values dipped significantly, with wind chill values falling to under -40°C. The high winds experienced across Eastern Canada and the Maritimes provinces drove the very low wind chill values, which also resulted in record electrical demand (as is shown in Figure 2-1) as residents heated their homes.

Figure 1-1 — Temperature and Wind Chill, Charlottetown (Feb. 3 to 5, 2023)[7,8]

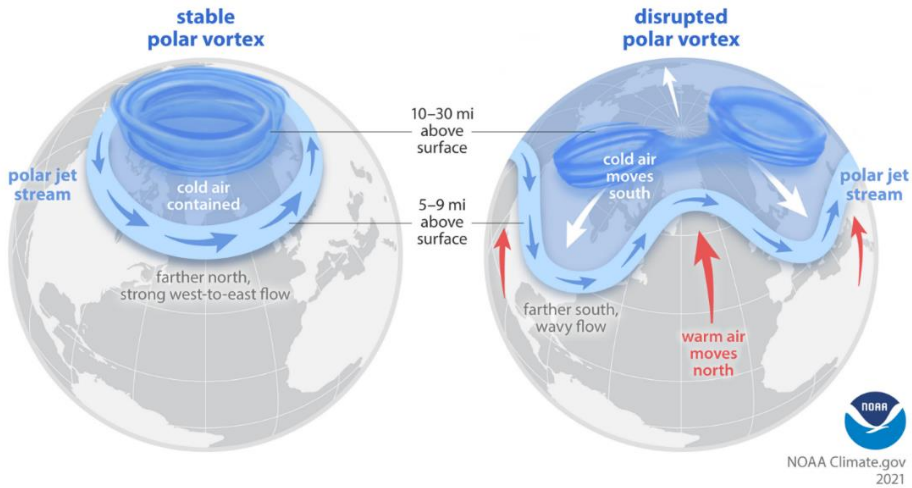


1.1.1. Extreme Cold and the Atmospheric Polar Vortex

The extreme cold in Eastern Canada that occurred between February 3 and 5, 2023, was the result of a disrupted polar vortex, which resulted in extremely cold air over the North Pole migrating southward. For reference, the polar vortex is a circulating mass of frigid air that is typically centered over the Earth's poles, held in place by strong jet stream air currents. In the event the jet stream air currents holding the frigid air over the Earth's poles weaken or fluctuate, the polar vortex can become disrupted and migrate towards the equator. Figure 1-2 helps to illustrate both stable and disrupted polar vortex atmospheric conditions.

[7] https://www.wunderground.com/history/daily/ca/charlottetown/CYYG/date/2023-2-3
[8] https://www.wpc.ncep.noaa.gov/html/windchill.shtml

Figure 1-2 — Polar Vortex Illustration[9]



As a result of the overall warming trend of the Earth, there is significant research ongoing by atmospheric and climate scientists as to whether more frequent and/or pronounced disruptions in the polar vortex will occur in the future, which could result in more extreme cold temperatures at southern latitudes during winter months. Some evidence suggests that frequent disruptions could be expected in the future. In S&L's opinion, regardless of whether global warming is found to increase the rate and/or severity of polar vortex disruptions in the future, extreme cold weather events already occur with sufficient regularity that proper planning and cold weather hardening of the electrical system is essential, especially when considering the growth of electric heating throughout the Maritimes region and Canada.

Listed below are notable recent extreme cold weather events for illustrative purposes. As can be seen, these events occur regularly.

- February 2023: The most recent extreme cold weather event and the subject of this report.
- December 2022: During the end of 2022, storms and a cold weather snap gripped much of North America, resulting in many record low temperatures across the continent and power outages across Canada and the United States.
- February 2021: This extreme cold event resulted in significant damage and loss of life across North America, with the state of Texas' electrical system suffering from widespread outages. This recent event, specifically what transpired in Texas, is discussed in detail in the following subsection.
- January 2019: This significant cold weather event struck Canada bringing both record snowfalls and cold weather to many provinces. Wind chills in parts of Ontario (both Toronto and Windsor), Manitoba, Saskatchewan, Alberta, and British Columbia approached -40°C during this event. Extreme cold temperatures also stretched into the United States, with the state of Michigan declaring

[9] https://www.climate.gov/news-features/understanding-climate/understanding-arctic-polar-vortex

a state of emergency due to the record cold temperatures and wind chills in the city of Chicago, Illinois, dropping to nearly -50°C.

- January 2014: Extreme cold weather and winter storms hit much of Eastern Canada and the United States, resulting in significant damage. High electrical demand as a result of the low temperatures, in addition to electrical equipment failures, resulted in the collapse of the electrical system in Newfoundland, where many residents were left without power for days. This event is described further in the following subsection.

1.2. ELECTRICAL SYSTEM FAILURES FROM EXTREME WEATHER

As is further described in Sections 2 and 3, the extreme cold weather event experienced in the Maritimes region between February 3 to 5, 2023, very nearly resulted in significant load shed across Eastern Canada, including on PEI. Two previous events where cold weather contributed to the failure of electrical systems are described below.

1.2.1. 2021 Texas Electrical System Failure

The 2021 Texas electrical system failure occurred as a result of a severe winter weather polar vortex event that pushed south into Texas for several days in February 2021, resulting in widespread power outages, water shortages, and other disruptions. The crisis was caused by a combination of factors, including extreme cold temperatures, high demand for electricity, insufficient electrical equipment winterization, and disruptions in the supply of natural gas.

Temperatures in the state dropped to a low of -19°C during the event,[10] which was the coldest temperature reached in over seven decades in some parts of the state, and the freezing temperatures lasted for up to eight days in some areas. The event had a significant impact on the state's electric grid, which is managed by the Electric Reliability Council of Texas. The extreme cold caused a surge in demand for electricity as people tried to keep their homes warm, while at the same time the extreme cold resulted in many power plants and natural gas facilities failing to operate. Much of the electrical and natural gas equipment in Texas was not winterized sufficiently, which resulted in frozen wind turbines, mechanical failures at natural gas plants, as well as fuel supply shortages, all of which crippled the generation capacity of the Electric Reliability Council of Texas.

The effects were far-reaching and profound. Approximately 4.5 million homes and businesses were left without power.[11,12] Many Texans were without power for days, and some were forced to resort to unsafe

[10] https://www.dallasnews.com/news/weather/2021/02/16/thousands-still-without-power-as-north-texas-reaches-record-low-temperature/
[11] https://www.nbcnews.com/news/weather/knocked-out-texas-millions-face-record-lows-without-power-new-n1257964
[12] https://time.com/5940232/millions-without-power-texas/

methods to stay warm—approximately 246 people lost their lives during the event, of which two-thirds died from hypothermia.[13] The freezing temperatures also caused water pipes to burst, leading to water shortages in some areas. Some residents had to boil water or rely on bottled water for drinking and cooking. It is estimated that the event caused nearly $200 billion in damage.[14]

While PEI did not experience load shed during the recent February 3 to 5, 2023, extreme cold event, PEI came extremely close to being unable to meet load; thus, it is instructive to consider the many parallels between Texas and PEI, highlighted below.

- The Texas's power grid (Electric Reliability Council of Texas) is designed to operate independently from the rest of the grid in the United States, effectively making the Electric Reliability Council of Texas an "island" that has very limited access to additional generating resources from other states in the United States during times of crisis. This resulted in Texas being unable to import emergency power from its neighbors during the 2021 polar vortex event. Because PEI is an island with both (1) a limited interconnection to the mainland (via New Brunswick) and (2) an insufficient amount of dispatchable on-island generating capacity to fully meet its own electrical load, PEI nearly was unable to fully meet electrical demand during the cold weather event between February 3 and 5, 2023. As is further described in Sections 2 and 3, PEI's mainland neighbors were nearly unable to meet their own load; thus, there was a significant risk that New Brunswick would have been forced to curtail electricity exports to PEI between February 3 and 5, 2023.
- The high demand for electricity in both Texas and recently on PEI (see Section 2) during the cold events was driven primarily by home heating, highlighting the need to plan for higher winter demand as in-home electric heating demand increases.
- Texas experienced the shutdown of many wind generators due to the freezing temperatures, stressing a need to further examine potential weatherization solutions to prevent turbines from freezing in future. As is discussed in Section 2, PEI also experienced a similar drop in wind turbine generation during the recent extreme cold event between February 3 and 5, 2023.

1.2.2. 2014 Newfoundland System Outages

During the period of January 2 to 8, 2014, Newfoundland experienced significant power outages following a winter storm and associated very cold weather. Investigations on the cause of the outages determined that they stemmed from two primary reasons:[15]

- An insufficiency of generating resources to meet customer demand
- A series of untimely system disruptions (electrical equipment failure, etc.)

[13] https://www.texastribune.org/2022/01/02/texas-winter-storm-final-death-toll-246/
[14] https://www.austintexas.gov/sites/default/files/files/HSEM/2021-Winter-Storm-Uri-AAR-Findings-Report.pdf
[15] http://www.pub.nf.ca/applications/IslandInterconnectedSystem/index.htm, Liberty Report - addressing Newfoundland and Labrador Hydro

During the event, the shortages in available generation required the province's utility to implement unprecedented rotating power outages. At the height of the event, nearly 200,000 customers in total were without power,[16] with some areas remaining in the dark for several days. The outages also affected critical infrastructure such as hospitals and water treatment facilities, leading to concerns about public health and safety. The storm also resulted in damage to power lines on the island, which further contributed to outages in Newfoundland. Thankfully, despite the severity of the storm and the cold temperatures, there were no deaths or serious injuries reported as a result of the power outages.

The assessment of the event showed that insufficient generation capacity, combined with both a peak load that surpassed the forecast and untimely system equipment failure, resulted in major system disruptions and blackouts. PEI is in a similar position to Newfoundland due to the fact that both islands have limited interconnections to neighbors. In addition, similar to Newfoundland, PEI is unable to fully meet its own electrical load with dispatchable on-island generation. As a result, it is not unlikely that the events that transpired between January 2 to 8, 2014, on Newfoundland could occur on PEI.

[16] https://www.theglobeandmail.com/news/national/newfoundland-closes-schools-as-power-outage-enters-fourth-day/article16203471/

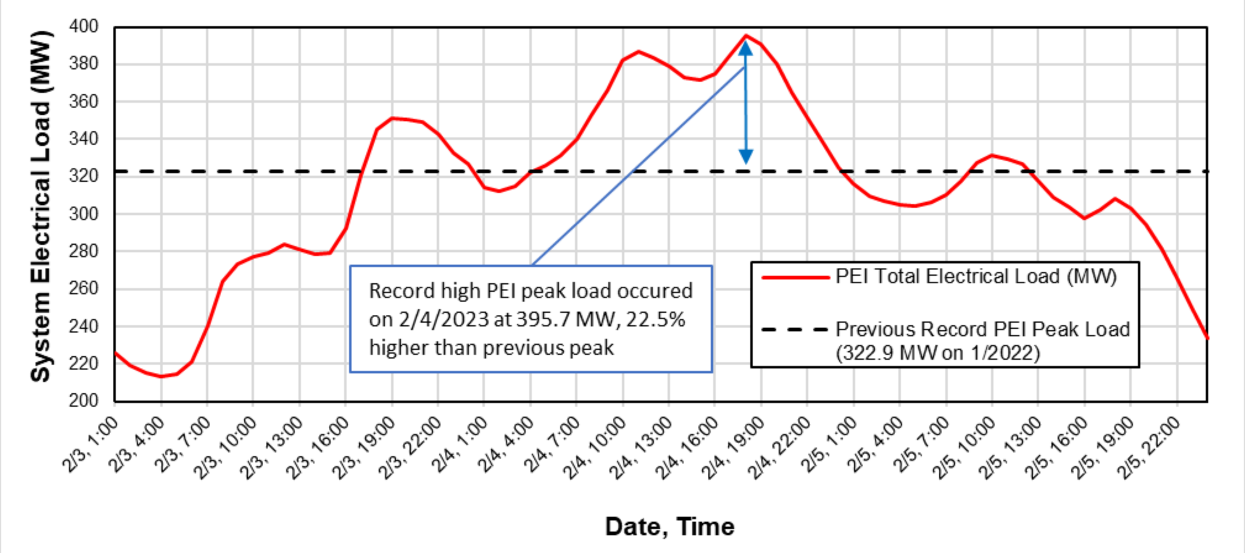
2. ELECTRICAL SYSTEM IMPACT – PEI

The extreme cold that hit Eastern Canada between February 3 and 5, 2023, resulted in a significant amount of stress on the electrical system both on PEI and throughout Eastern Canada in terms of high system load, generation disruptions, electricity import limitations, and load shed. This section focuses on the impacts to PEI, followed by a more general assessment of what transpired at the regional level in Section 3.

2.1. SYSTEM ELECTRICAL LOAD

The extreme cold weather experienced on PEI drove system electricity consumption levels to all-time records due to extremely high demand for electricity to heat homes and other buildings. Both PEI and MECL experienced record peak electrical load. Peak load for PEI soared to 395.7 MW (average between hours ending 17:00 and 18:00 on February 4, 2023, 399.2 MW instantaneously) and peak load for MECL hit a record high of 357 MW. Figure 2-1 illustrates the electrical load profile for PEI between February 3 and 5, 2023. As can be observed in Figure 2-1, the peak load experienced on February 4, 2023, was 22.5% higher than the previous peak set in January 2022.[17]

Figure 2-1 — Electrical Load on PEI (Feb. 3 to 5, 2023)



In the *Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company* issued by S&L on December 9, 2022, the electrical load that MECL serves was expected to increase in the coming years; however, peak load levels were not expected to rise to the levels experienced by MECL between February 3 and 5, 2023, for several years. As such, the recommendation for dispatchable capacity

[17] The previous peak load for PEI was 322.9 MW experienced between the hours of 17:00 and 18:00 on January 11, 2022.

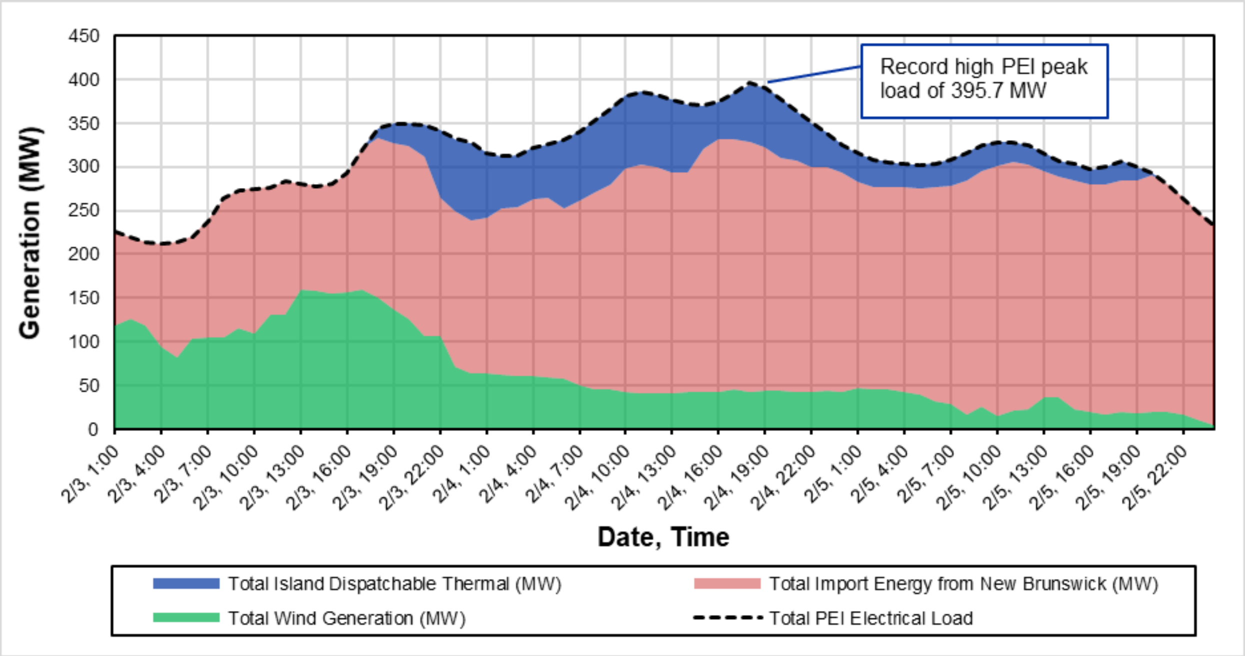
that MECL should install in the near future has been revised upward from the previous recommendation of 85 MW to a range of 125 to 150 MW, depending on the peak load forecast. A further discussion of this recommendation is provided in Section 5.1.

2.2. SYSTEM DISPATCH

Figure 2-2 illustrates total system dispatch by source during the period from February 3 through February 5, 2023. As is illustrated in Figure 2-2, electrical load on PEI was primarily met via imports from New Brunswick during the event. Wind generation was initially high on February 3, 2023; however, wind generation fell significantly throughout the event due to the extreme cold and high wind speeds experienced. Since the contract with New Brunswick is for a maximum of 300 MW, MECL chose to operate its dispatchable thermal generation installed on PEI to stay under this limit or risk curtailments from New Brunswick (New Brunswick did have to partially curtail imports to PEI by 50 MW on the evening of February 3, 2023). MECL's CTs also provided additional benefits such as voltage control and transformer offloading that enabled higher grid stability during this time. The peak imported power from New Brunswick was approximately 290 MW on February 4, 2023, at approximately 16:00.

As is discussed further in Section 3.3, due to the challenges of operating its own system through the extreme cold temperatures, there was a significantly high risk that New Brunswick was not going to be able to export any electricity to PEI. The fact that New Brunswick was able to provide PEI with between 200 and 300 MW of imports through the event (with minimal curtailments of 50 MW) was very fortunate and saved PEI from having to shed firm load. It is also worth noting that PEI's peak occurred during the evening of February 4, 2023, while some of the other provinces had peaks that occurred earlier in the day. Thus, it is a reasonable conclusion that if PEI had a coincident peak with the other provinces, New Brunswick may not have been able to provide PEI with this critical imported power.

Figure 2-2 — PEI Generation by Source (Feb. 3 to 5, 2023)



2.2.1. Generator Performance During Event

2.2.1.1. Wind Generation

As the extremely cold temperatures hit PEI between the evening of February 3, 2023, and the morning of February 4, 2023, there was a subsequent sharp drop in wind generation. Going into the evening of February 3, 2023, it was reported that approximately 80% of the individual wind turbines on PEI were operational. By February 5, 2023, only about 25% of the individual wind turbines on PEI were operational (i.e., 75% were in forced or planned outage). Figure 2-3 and Figure 2-4 illustrate the historical PEI wind generation along with wind speed and ambient temperature during the cold weather event.

Figure 2-3 — PEI Wind Generation and Wind Speed (Feb. 3 to 5, 2023)

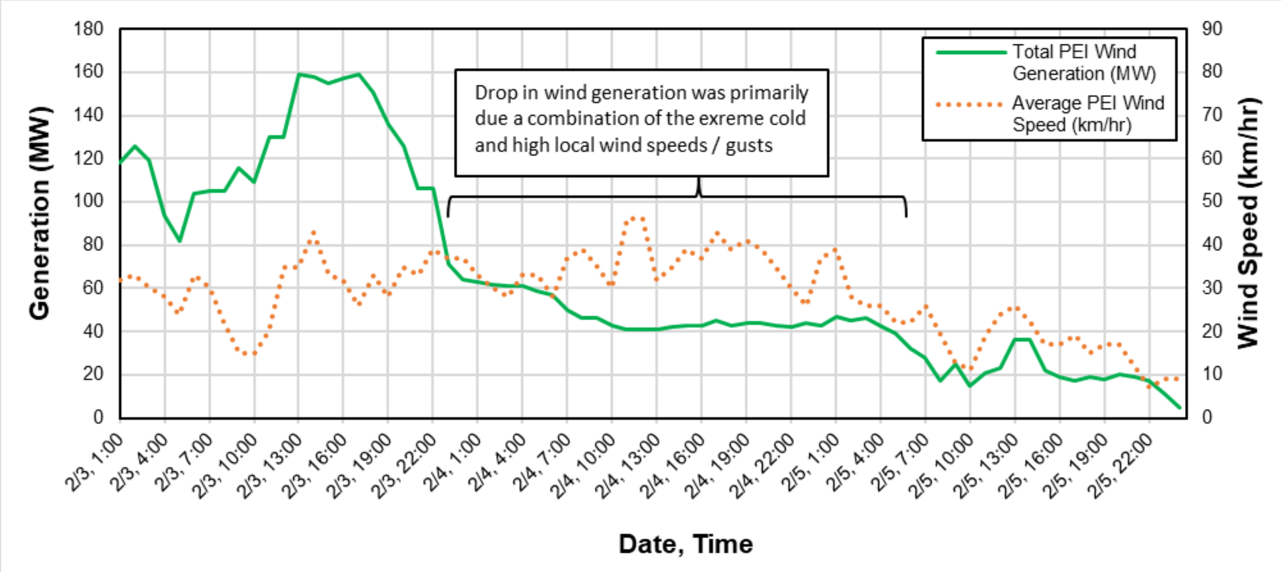
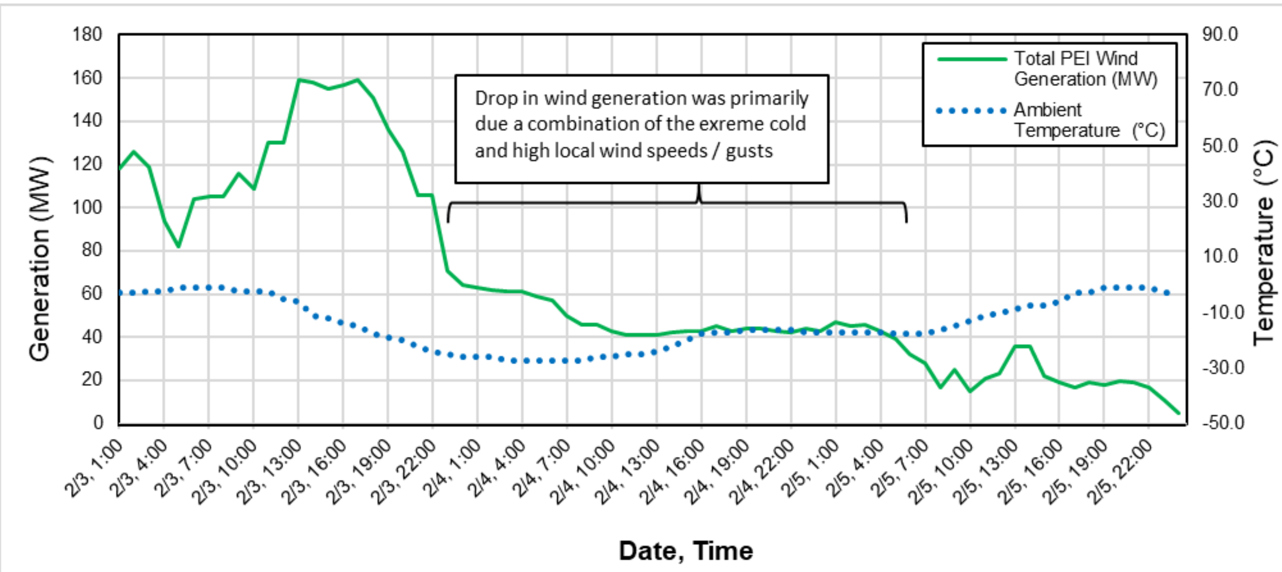


Figure 2-4 — PEI Wind Generation and Temperature (Feb. 3 to 5, 2023)



S&L had the opportunity to speak with the Wind Energy Institute of Canada (WEICAN) regarding the events that took place between February 3 and 5, 2023. WEICAN operates a number of wind turbine generators on PEI, some for research purposes. Per S&L's discussion with WEICAN, the drop in wind generation can be primarily tied to the following reasons:

- **Extreme Cold:** To avoid damage associated with extremely cold temperatures (which can cause equipment lubrication to harden, equipment material properties to change, etc.), wind turbine generators have safe shutdown setpoints that engage when temperatures drop below certain levels. A subset of the wind turbine generators that went offline on PEI experienced cold weather-related shutdowns. WEICAN explained that wind generators can be equipped with cold weather packages that allow the wind generators to operate at lower temperatures; however, the temperatures experienced on PEI were low enough to push the limits of even the wind generators equipped with cold weather packages.

- **Wind Speeds and Turbulence:** During the event, wind speeds (especially gusts) were very high, and the wind was turbulent. To avoid damage because of high wind speeds / high turbulence, wind turbine generators have safe shutdown setpoints that engage when wind speeds and/or turbulence rises above certain levels over a set period of time (i.e., over a 10-minute span). A subset of the wind generators that went offline on PEI experienced wind speed / turbulence-related shutdowns. If a wind generator goes into safe shutdown due to wind speed / turbulence, it is typically relatively easy to restart the generator again, once wind speeds / turbulence fall to levels low enough to safely operate the generator. However, this was not the case during the cold weather event in February because once the turbines went into shutdown, many quickly became too cold to easily restart. As a result, a subset of the turbines that went into shutdown due to high wind speeds / turbulence were unable to quickly restart and operate again because they were too cold.

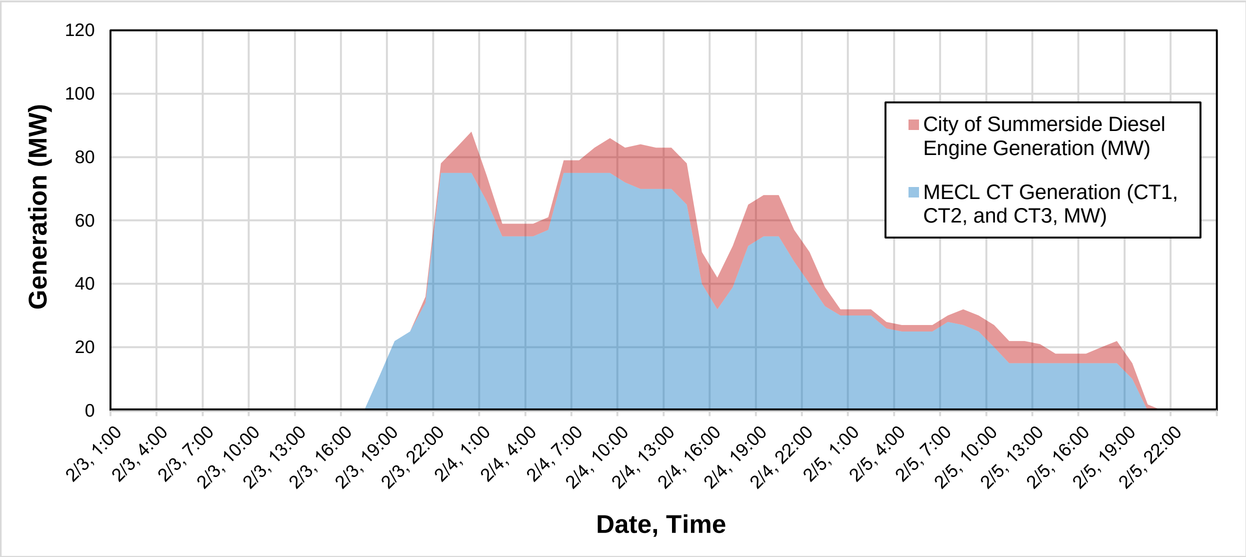
As a result of the large drop in wind generation, MECL was forced to rely even more on imported electricity from New Brunswick, in addition to operating its limited amount of dispatchable thermal generation installed on PEI, to serve load. As is discussed in Section 3.3, there was a significantly high risk that New Brunswick was going to be forced to curtail electricity exports to PEI during the event; thus, the drop in wind generation could have resulted in load shed across PEI.

2.2.1.2. Dispatchable Thermal Generation

The dispatchable thermal generation installed on PEI, which includes the Borden CT1 and CT2 units, the Charlottetown CT3 unit, and the Summerside engines (which are not owned by MECL), ran without incident throughout the event, with units started during the evening of February 3, 2023, and operating until February 5, 2023. The following figure provides the total generation of the thermal generation installed on PEI through the cold weather event.

As discussed above, the generation from the thermal resources was used to help meet record peak loads and offset the drop in wind generation experienced during the cold weather event, which helped PEI to stay below the 300 MW import limit from New Brunswick. During the event, the CTs also provided voltage control and transformer offloading, both of which helped to keep the grid stable.

Figure 2-5 — PEI Dispatchable Thermal Generation (Feb. 3 to 5, 2023)



3. ELECTRICAL SYSTEM IMPACT – REGIONAL

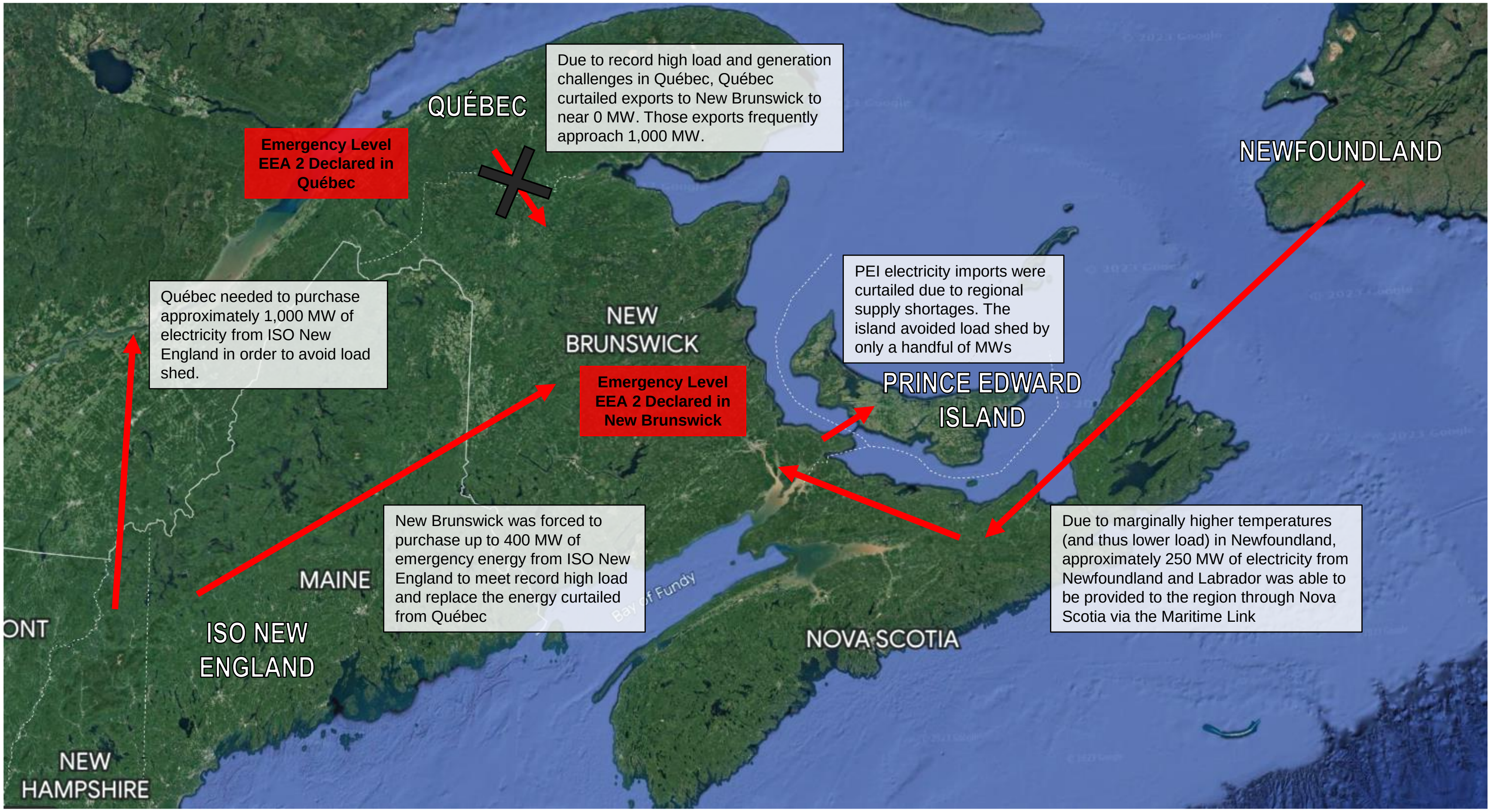
The extreme cold weather experienced in Eastern Canada on February 3 through February 5, 2023, severely strained regional electrical systems to the point that load shedding was a significant risk. To illustrate the severity of what occurred, it is first important to understand the levels at which system emergencies are classified within electrical systems. Below are the different Energy Emergency Alert (EEA) levels, with EEA 3 being the most severe. During the event, both Québec and New Brunswick declared emergencies at an EEA 2 level. The following classifications are provided by the North American Electric Reliability Corporation (NERC)[18].

- **EEA 1:** This is the first emergency level and is defined as "the balancing authority is experiencing conditions where all available generation resources are committed to meet firm load, firm transactions, and reserve commitments, and is concerned about sustaining its required contingency reserves." As part of EEA 1, non-firm wholesale energy sales have been curtailed.
- **EEA 2:** EEA 2 is defined as a situation where "the balancing authority is no longer able to provide its expected energy requirements and is an energy deficient balancing authority." Under an EEA 2 situation, the balancing authority still is able to maintain minimum contingency reserve requirements. A balancing authority experiencing an EEA 2 emergency is at serious risk of having to shed firm load and will take all potential steps possible to avoid firm load shed.
- **EEA 3:** Under an EEA 3 situation, the balancing authority is either currently shedding firm load or firm load shed is imminent. EEA 3 is the most serious of the EEA levels as it means there are or will be power outages / rolling blackouts.

Figure 3-1 provides an overview of the Maritimes region electrical system through the evening of February 3, 2023, and into the morning of February 4, 2023, which was the point at which the risk of load shed became the highest. Additionally, a brief overview of the challenges experienced within each area of the region is provided in the following subsections.

[18] https://www.nerc.com/pa/Stand/Reliability%20Standards/EOP-011-1.pdf

Figure 3-1 — Regional Recap, Evening of February 3 and Early February 4, 2023



3.1. QUÉBEC

The extreme cold drove electrical demand in Québec to record levels. That, in combination with generator operational challenges driven by the cold, resulted in Québec becoming energy deficient and needing to declare an EEA 2 level emergency. To serve its own system and avoid significant load shed, Québec curtailed exports to New Brunswick down to 0 MW. For reference, the export capacity from Québec to New Brunswick is approximately 1,000 MW, and real-time exports rising to this level is not uncommon. In addition, Québec purchased nearly 1,000 MW of emergency energy from ISO New England, in addition to electricity from New York and Ontario. For perspective, Québec is usually a net exporter of electricity to ISO New England and had not purchased energy from New England since 2016.[19] Since Québec is a very large and relied-upon producer of electricity in the region, the challenges experienced in Québec reverberated throughout the region.

During this time, Québec did not have excess generation capacity to spare and was thus unable to export any electricity to New Brunswick, even though the existing intertie is approximately 1,000 MW.

3.2. NEWFOUNDLAND AND LABRADOR

Newfoundland and Labrador is intertied to Nova Scotia via a sub-sea electrical cable system known as the Maritime Link. This linkage allows for the export of up to 500 MW of electricity from Newfoundland and Labrador to Nova Scotia. Between February 3 and 5, 2023, Newfoundland and Labrador was able to export over 200 MW of electricity to Nova Scotia, which helped to alleviate the electricity shortfalls throughout the region. One of the key reasons that Newfoundland and Labrador was able to export this electricity was because temperatures in Newfoundland and Labrador did not fall to the record lows experienced to the immediate south; thus, electrical demand in Newfoundland and Labrador was relatively lower than the record electrical demand levels experienced in Québec, Nova Scotia, New Brunswick, and PEI.

Throughout the event, a key concern related to Newfoundland and Labrador's ability to export electricity to Nova Scotia was the availability of the Labrador Island Link (LIL), a transmission line that connects Labrador, where the 824-MW Muskrat Falls hydroelectric generating station is located, to the island of Newfoundland. Availability of the LIL is essential to allow electricity generated in Labrador to flow to Newfoundland, where it can then be exported south into Nova Scotia. The island of Newfoundland alone does not have enough excess generation capacity installed to support significant export to Nova Scotia; if

[19]https://isonewswire.com/2023/04/06/winter-2022-2023-recap-wholesale-prices-drop-during-warm-season-marked-by-cold-snaps/

the LIL is out of service, generation from Labrador cannot flow into Newfoundland to be exported to Nova Scotia.

Historically, Newfoundland and Labrador Hydro, the operator of the Muskrat Falls generating station and the LIL, had estimated the forced outage rate of the LIL to be 0.0114%.[20] However, in late 2022, Newfoundland and Labrador Hydro issued a report titled *Reliability and Resource Adequacy Study Review; Reliability and Resource Adequacy Study – 2022 Update*, in which the previously estimated forced outage rate of the LIL was revised from 0.0114% to a range of between 1% and 10% (to be more precisely quantified at a later date), which equates to a reliability level that is approximately 100 times to 1,000 times less than previously estimated. Fortunately, the LIL was in service between February 3 and February 5, 2023. Had it been out of service during this time, the result would have been an increased likelihood of load shed on PEI during the coldest part of the event.

3.3. NEW BRUNSWICK

New Brunswick saw record electrical load levels between February 3 and 5, 2023, similar to the other Eastern Canada areas. New Brunswick Power indicated to MECL that their peak load hit a high of 3,395 MW on the morning of February 4, 2023, 62 MW higher than their previous peak electrical demand level of 3,333 set in January 2004. It is worth noting that high winds caused approximately 4,000 customers in New Brunswick to lose power on February 4, 2023, which resulted in peak electrical demand being about 20 MW lower than it would have been had those customers not been disconnected. In addition, New Brunswick Power had cut 130 MW of interruptible load. Combined with high load, New Brunswick also experienced similar drop-offs in wind generation to what was experienced on PEI, and some of New Brunswick's generators experienced operational challenges because of the extreme cold weather.

The most significant event that led to New Brunswick having to declare an emergency of level EEA 2 was Québec's need to stop the export of electricity to New Brunswick. The capacity of the interconnection between Québec and New Brunswick is significant at approximately 1,000 MW; thus, the lack of any imports from Québec pushed New Brunswick to the brink of having to further curtail electricity exports to PEI and to also shed load within New Brunswick. Fortunately, New Brunswick only had to curtail exports to PEI by 50 MW. Three of the most significant events that allowed New Brunswick to avoid more significant, or complete, curtailment of exports to PEI were the following:

[20] Link to the recently released *Reliability and Resource Adequacy Study Review*
Reliability and Resource Adequacy Study – 2022, released by Newfoundland and Labrador Hydro in October 2022: UpdateRehttp://www.pub.nf.ca/applications/NLH2018ReliabilityAdequacy/correspondence/From%20NLH%20-%20Reliability%20and%20Resource%20Adequacy%20Study%20-%202022%20Update%20-2022-10-03.PDF

1. **Electricity Imported from ISO New England**: This electricity proved to be essential, and it allowed New Brunswick to continue to export electricity to PEI. It was fortunate that ISO New England was able to provide electricity to New Brunswick because New England also faces challenges (primarily related to fuel supply) in the face of extreme cold weather events. These challenges are highlighted in recent NERC guidance and further described in Section 4 of this report.
2. **Electricity Imported from Nova Scotia and Newfoundland and Labrador:** The electricity that Nova Scotia was able to provide to New Brunswick also helped New Brunswick continue to export electricity to PEI. Part of the reason that Nova Scotia was able to export electricity to New Brunswick was because Nova Scotia was able to import electricity from Newfoundland and Labrador via the Maritime Link, as discussed previously.
3. **Operation of the Thermal Resources on PEI:** The operation of the thermal generation located on PEI (all three MECL CTs and the Summerside engines) helped to generate approximately 80 MW of electricity from late February 3 through February 4, 2023, which were the most critical times during the extreme cold event. The thermal generation on PEI helped to partially offset the failure of the wind generation located on PEI that was experienced during the event. Without the generation from the thermal generators on PEI, the need for imported power would have been greater, increasing the risk from import curtailments.

3.4. ISO NEW ENGLAND

During the extreme cold event, ISO New England was able to serve as an essential import provider to both Québec and New Brunswick as both purchased significant amounts of electricity from ISO New England. Approximately 1,000 MW of electricity exports were sent to Québec and a peak of 400 MW of exports were sent to New Brunswick during the most critical times of the event. Real-time electricity prices soared to $500/MWh on February 4, 2023, (typically prices are in the $20 to $40/MWh range) which is an indication that total electrical demand approached the available supply within ISO New England. ISO New England notes that demand would likely have been higher if February 3 through 5, 2023, had not been weekend days.[21]

3.5. NOVA SCOTIA

Information regarding the electrical system challenges faced by Nova Scotia during the extreme cold weather event that transpired between February 3 and 5, 2023, mirrored much of which was experienced in the rest of the region. Nova Scotia's peak load experienced on February 4, 2023, was 10% higher than the previous peak experienced in 2004. As previously discussed, Nova Scotia was able to import electricity from Newfoundland and Labrador throughout the event, which helped to not only allow Nova Scotia to meet

[21] https://isonewswire.com/2023/04/06/winter-2022-2023-recap-wholesale-prices-drop-during-warm-season-marked-by-cold-snaps/

system load, but also export some excess electricity to New Brunswick (which ultimately helped to avoid New Brunswick from further having to curtail PEI).

3.6. PRINCE EDWARD ISLAND

Fortunately, PEI was able to get through the events of February 3 through 5, 2023, without having to implement load shed due to electricity shortages. However, in many respects, PEI was in the most precarious position of any location within the entire region. This is because PEI does not have enough dependable capacity installed on the island to fully meet peak load and thus required continuous imported electricity from New Brunswick in order to avoid load shed. While the wind generation installed on PEI is an excellent resource from the perspective of lowering carbon emissions for the island, wind generation is not a dispatchable resource in an emergency. This was evident during the extreme cold event that took place as only 25% of the wind turbines were operational (i.e., 75% were in forced or planned outage) during the most critical, coldest time of the event. PEI was fortunate that ISO New England, Newfoundland and Labrador, and Nova Scotia had some small amount of excess electricity to send to New Brunswick during the event—without electricity from these locations, New Brunswick would have been forced to further or completely curtail electricity exports to PEI, which would have resulted in significant load shed on PEI.

In the *Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company*, issued by S&L on December 9, 2022, an important focus was related to a scenario where PEI is electrically disconnected from the mainland. Many of the recommendations in the study were rooted in that specific scenario, which has occurred infrequently in the past. The extreme cold weather event that transpired between February 3 and 5, 2023, illustrates a similar, but fundamentally different scenario—one where the interconnection between PEI and the mainland remains operational, but electricity shortages on the mainland result in the curtailment of electricity imports to PEI. In terms of impact to PEI, this scenario is essentially equivalent to a scenario where the interconnection to the mainland becomes inoperable—both scenarios are likely to result in electricity shortages on PEI and thus load shed.

One important point to note is that when a utility experiences a shortage of electrical generation, its first priority is to serve its own load, which may require the utility to cut exports (for example, Québec cut exports to New Brunswick during the February cold weather event so that it could meet its own electrical load). In the event that PEI's thermal generators and wind and solar power plants are unable to generate a sufficient amount of electricity to support PEI's load, which they did not during the February 2023 event, PEI is dependent on imported electricity from the mainland to serve load. As was demonstrated during the February 2023 event, MECL and the other utilities in the region will attempt to generate and secure enough electricity to fully serve regional load during an emergency event; however, if there is not enough generation in the region to fully serve load, the other regional utilities will first prioritize their own load over exporting electricity to PEI. In this situation, the risk for load shed on PEI is high, which would put the residents of PEI in danger.

4. NERC WINTER RELIABILITY ASSESSMENTS

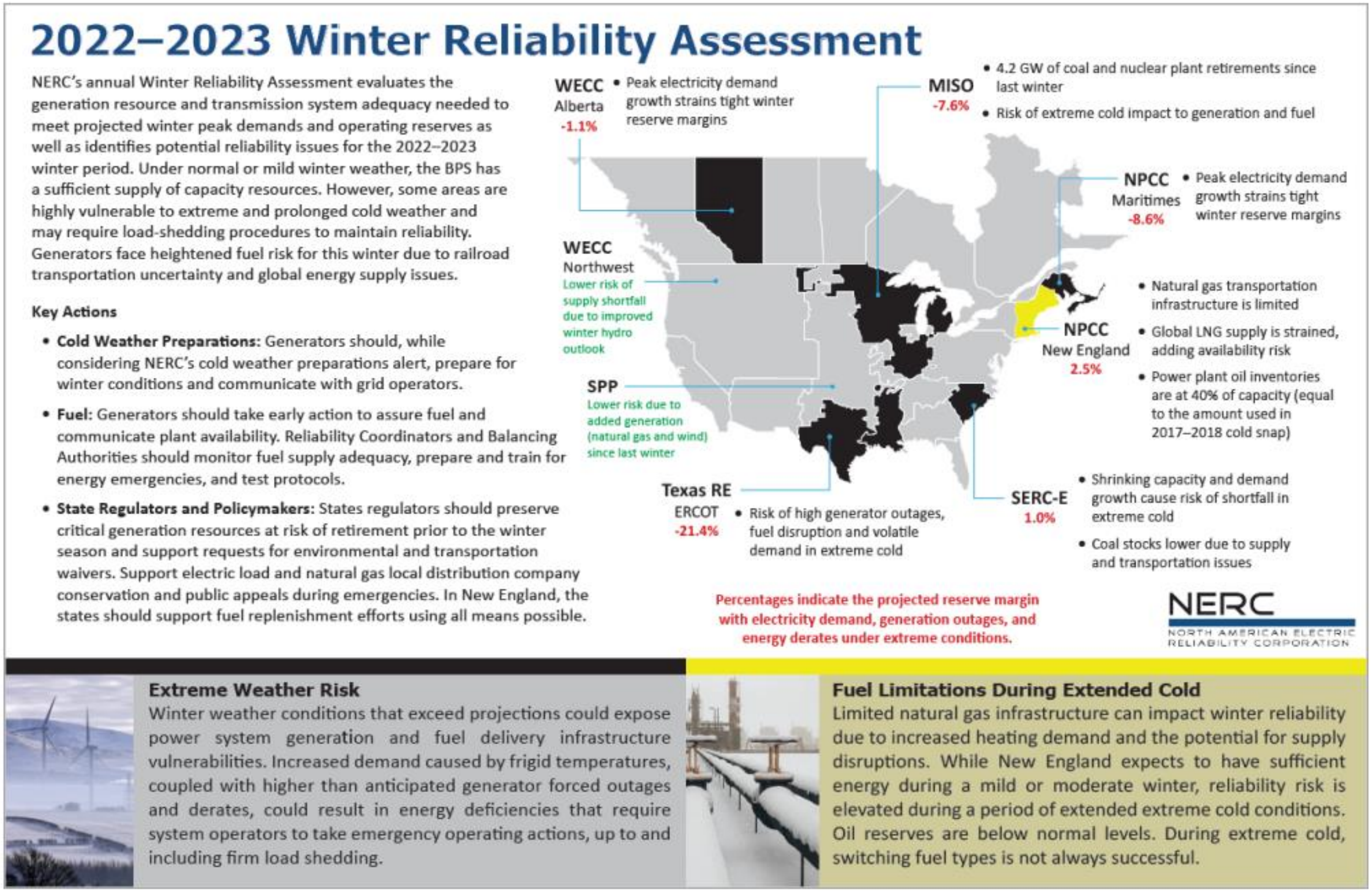
Given the stress recent extreme cold weather events have put on electrical systems, NERC has released a set of planning guidelines and recommendations regarding extreme cold weather events to come. For example, in November 2022, NERC released its *2022-2023 Winter Reliability Assessment,*[22] which highlighted that "some areas [of the bulk power system] are highly vulnerable to extreme and prolonged cold weather and may require load-shedding procedures to maintain reliability." The report is meant to inform industry leaders, planners, operators, and regulatory bodies to take necessary actions to ensure reliability. The guideline notes that during extreme cold events, the Maritimes region is likely to have the second lowest electrical system reserve margins of all the electrical systems NERC oversees (see Figure 4-1 taken from the NERC guideline). Only Texas is estimated to have lower reserve margins. The reason for the estimated tight reserve margins in the Maritimes region is electrical load growth, which is driven by the rapid transition of buildings to electrical heating (and electrification in general) and commercial / industrial load. In addition, NERC also notes that New England faces challenges during extreme cold events, primarily due to fuel supply constraints.

In addition, on May 15, 2023, NERC released a Level 3 Essential Actions Alert titled *Cold Weather Preparations for Extreme Weather Events III.*[23] The alert was issued to "increase the Reliability Coordinators' (RC), Balancing Authorities' (BA), Transmission Operators' (TOP), and Generator Owners' (GO) readiness and enhance plans for, and progress toward, mitigating risk for the upcoming winter and beyond." For reference, a Level 3 Essential Actions Alert is the <u>highest</u> severity level that NERC issues and this is the <u>first time</u> a Level 3 Essential Actions Alert has ever been issued by NERC.

The assessments and recommendations from NERC illustrate that many parts of North America are at risk during extreme cold weather events. Among the locations facing the greatest challenge is the Maritimes region. For PEI, this is an indication that electricity imports from the mainland to PEI are not guaranteed during future extreme cold events.

[22] https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2022.pdf
[23]https://www.nerc.com/news/Pages/NERC-Releases-Essential-Action-Alert-Focused-on-Cold-Weather-Preparations.aspx

Figure 4-1 — NERC 2022–2023 Winter Reliability Assessment[24]



[24] https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2022.pdf

5. RECOMMENDATIONS

The following sections highlight updated recommendations to the *Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company* issued by S&L on December 9, 2022. All recommendation updates are based on lessons learned from the extreme cold weather event that took place between February 3 and 5, 2023. Note that the recommendations in this section supersede those in the previous report, unless explicitly noted.

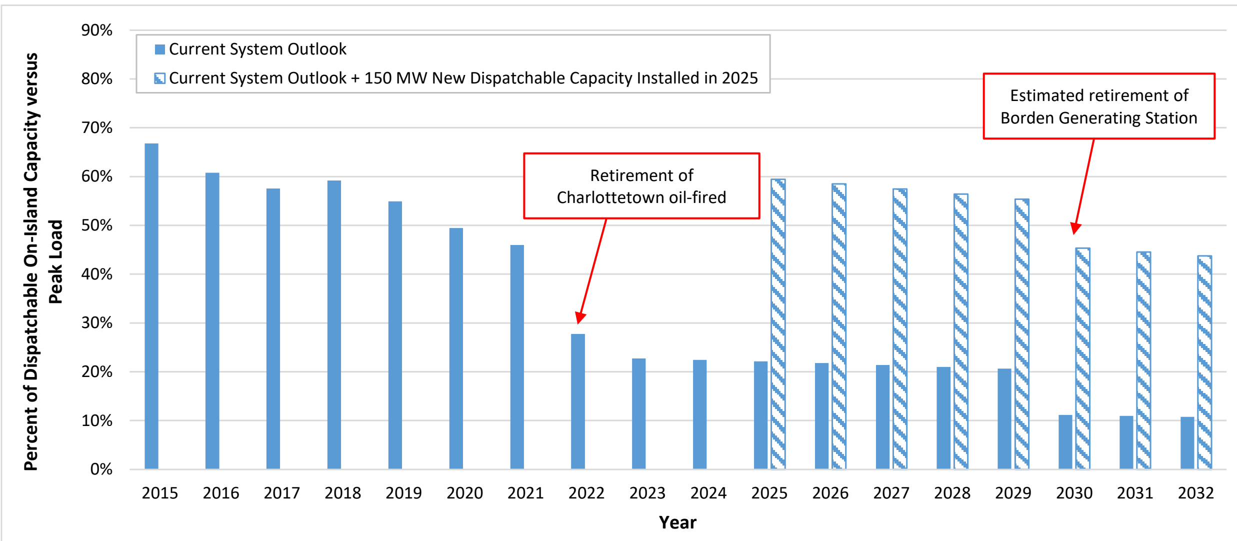
5.1. UPDATED RESOURCE RECOMMENDATIONS

On December 9, 2022, S&L issued the *Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company*. The report ultimately concluded that a portfolio of RICE/CTs, onshore wind, and solar photovoltaic was best suited to help Maritime Electric meet its most critical needs and goals. Based on a review of Maritime Electric's current and forecasted peak load, S&L previously recommended that a minimum of 85 MW of new RICE/CTs with biofuel compatibility should be installed on PEI as soon as possible to reduce the probability of load shed and rolling blackouts in the event of electricity import limits and/or interruptions from the mainland.

The extreme cold weather event that occurred between February 3 to 5, 2023, resulted in record peak load of 395.7 MW, which was over 72 MW higher (22.5%) than the previous peak load of 322.9 MW experienced in January 2022. As a result, S&L has revised its previous recommendation of a minimum of 85 MW of new RICE/CTs with biofuel compatibility to a range of 125 to 150 MW of the same technology, to bring the ratio of dispatchable capacity to peak load back in line with the 50% historical threshold (which would equate the risk of potential load shed in the event of mainland import curtailments to near historical levels). A range of additional capacity was specified because there is uncertainty regarding the future peak load forecast for PEI. The lower end of the recommended range is based on MECL's recently updated internal 10-year peak forecast and the higher end of the range is based on an escalation of the 395.7 MW peak experienced on February 4, 2023. In addition, MECL should continue to prioritize integration of both onshore wind and solar photovoltaic to help meet decarbonization goals, consistent with what was recommended in S&L's original report. Note that even with up to 150 MW of additional dispatchable capacity, there may still be a need for load shed to be implemented if PEI were not able to secure enough electricity imports to fully meet load; however, the additional 125 to 150 MW would help to bring the risk of load shed to be consistent with historical levels.

Figure 5-1 illustrates the ratio of dispatchable on-island generation capacity versus peak load both historically and forecasted through 2032. A second set of data points are included on the figure to illustrate how the ratio of dispatchable capacity versus peak load increases if 150 MW of additional dispatchable capacity is added on PEI in 2025. Note that current estimates for the retirement of the Borden Generating Station (40 MW) is approximately 2030. Additional capacity, beyond the 150 MW assumed in 2025, would have to be added to the system in 2030 to replace Borden's retired 40 MW capacity to maintain a 50% ratio of capacity to peak load. Figure 5-1 does not add any additional capacity to replace Borden; however, it does illustrate the impact of Borden's retirement in terms of the capacity to peak load ratio.

Figure 5-1 — Outlook of Dispatchable On-Island Capacity versus Peak Load



In addition, S&L continues to note that a new BESS demonstration project could help identify the BESS functions/use cases that offer the maximum benefit for the island.

5.1.1. Synchronous Condenser Considerations

Given the large distance between PEI and the large mainland generators, PEI must be self-sufficient in reactive power supply capability, which is necessary for maintaining voltage levels and system stability on PEI. This is an ongoing challenge, especially as more wind generation is added to PEI. A synchronous condenser is an example of electrical equipment than can help improve an electrical system's voltage regulation and overall stability. RICE and CTs have the ability to operate as a synchronous condenser when they are not generating electricity; under this mode of operation, the units use a modest amount of energy from the grid to synchronize (spin), helping to improve the system's electrical performance. The units do not consume fuel when operating as synchronous condensers. The 2020 MECL Integrated System Plan noted that after island load exceeds 350 MW, additional system voltage support (i.e., a synchronous condenser) will be needed on PEI[25]. Previous forecasts of island load estimated that levels higher than 350 MW would not be reached for a number of years; however, given PEI's load nearly reached 400 MW on February 4, 2023, additional system voltage support is needed today.

While both a CT and RICE can be fitted with the appropriate equipment to allow them to function as synchronous condensers when they are not generating electricity, the use of CTs as synchronous condensers is much more common than the use of RICE. In the December 9, 2022, report issued by S&L (*Capacity Resource Study: Evaluation of Various Technology Options for Maritime Electric Company*), S&L considered both CT and RICE options to be virtually equivalent from a technical capability perspective, with RICE being modestly less expensive. However, if MECL wishes to pursue an option with a strong pedigree of synchronous condenser operation, S&L recommends MECL pursue CTs over RICE.

5.1.2. Estimated Costs

Appendix A of this addendum provides a detailed high-level cost estimate of purchasing approximately 170 MW of additional CTs, represented by a 3x0 simple-cycle design with General Electrical LM6000 PF+ SPRINT CT generators (three turbines at a 57.1 MW winter rating each). The estimate includes options for operation exclusively on diesel fuel as well as operation with biodiesel. Other manufacturers make units of similar technical capabilities that MECL could pursue, including varying capacities of CTs and RICE units—the unit types and manufacturers shown in the following table are for illustration and high-level costing comparisons only. S&L recommends biodiesel fuel compatibility to reduce the risk of having a stranded asset in the event government fuel regulations change in the future—biodiesel is considered a renewable fuel by the Canadian government. The cost of equipment related to synchronous condenser operation is also included in this indicative estimate for the CTs (this is not included for the RICE due to the reasons described in Section 5.1.1).

The following table provides a summary of the key operating details and levelized costs for the LM6000 option, along with an alternative RICE design. Additional details and assumptions are noted in Appendix A for the CT design with the RICE details included in the previously report.

[25] Maritime Electric 2020 Integrated System Plan, page 44 and 47

Table 5-1 — Estimated Costs for New CTs/RICE

Title	CT – Aeroderivative		RICE	
	GE LM6000 PF+ SPRINT		Wartsila 20V32	
Fuel Type	Diesel Only	Biodiesel Compatible	Diesel Only	Biodiesel Compatible
Winter Output (MW)	57.1 per turbine	57.1 per turbine	10.6 per engine	9.4 per engine
Net Heat Rate (Btu/kWh)	9,000	9,500	8,400	8,400
Levelized Install Cost (CAD/kW)	1,744	1,817	1,845	2,074
Synchronous Condenser Cost	Included	Included	Not included	Not included

The levelized install cost (dollars per kW) for the LM6000 CT shown above is lower than the smaller RICE design (note that the levelized cost values consider economies of scale associated with the purchase of multiple generators to total approximately 150 MW). Furthermore, the cost for the synchronous condenser is already included for the CT option. However, the RICE design may provide more flexible operation due to the smaller unit capacities, as well as the ability to implement a staggered install schedule over time. As described in S&L's previous report, the RICE units also require less modification to operate on biodiesel fuel. At a capacity of 125–150 MW, along with the known synchronous condenser operational benefits of CTs, either the larger CT design alone, or a portfolio of CTs and RICE, are likely the best options for MECL.

5.2. WIND GENERATION LESSONS LEARNED

During the extreme cold weather event that took place between February 3 and 5, 2023, wind generation dropped substantially because of a number of cascading wind generator and system failures related to the cold temperatures and high wind speed / high wind turbulence. The drop in wind generation resulted in PEI having to import a significant amount of energy from the mainland during the event to avoid load shed. Fortunately, electricity imports, generation produced from the dispatchable generators on PEI, and the remaining wind generation on PEI were able to fully meet the record load experienced on the island; however, PEI came very close to having load shed during the coldest part of the event.

As discussed earlier, S&L had the opportunity to speak with WEICAN during the preparation of this addendum on the topic of what transpired between February 3 and 5, 2023. WEICAN operates several wind turbine generators on PEI for research purposes. During S&L's conversations with WEICAN, it became clear that there are several lessons learned that can and should be shared related to the wind generator and grid operation during the cold weather event between MECL, the wind operators, and the wind turbine original equipment manufacturers. These lessons learned will help to identify various improvements and changes to avoid a similar drop off in wind generator production during a future extreme cold event.

Given these considerations, S&L recommends further information sharing, and/or a technical conference, between MECL, the wind operators, and the wind generator original equipment manufacturers to fully understand what transpired and find solutions to prevent a repeat of the challenges experienced between February 3 and 5, 2023.

APPENDIX A. NEW THERMAL GENERATION COST ESTIMATES

Appendix A contains capital and operations and maintenance estimates for 14x0 and 3x0 simple-cycle designs with Wärtsilä 20V32 RICE and General Electric LM6000 PF+ SPRINT CT generators, respectively. The estimate includes options for operation exclusively on diesel fuel as well as operation with biodiesel. All values in CAD.

Technology	**Reciprocating Internal Combustion Engine**	**Reciprocating Internal Combustion Engine**	**Combustion Turbine - Aeroderivative**	**Combustion Turbine - Aeroderivative**
Unit Type (Representative Manufacturer)	Wartsila 20V32 (14x)	Wartsila 20V32 (14x)	GE LM6000 PF+ SPRINT w/ Sync Condenser (3x)	GE LM6000 PF+ SPRINT w/ Sync Condenser (3x)
Cycle Type	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Fuel Type	Diesel Fuel	Biodiesel Fuel	Diesel Fuel Only	Biodiesel Fuel Compatible
Net Plant Output (MW) - Summer (27˚C, 47% RH, 0 m)	148.4	131.2	119.7	119.7
Net Plant Output (MW) - Winter (-26˚C, 60% RH, 0 m)	148.4	131.2	171.3	171.3
Net Heat Rate (Btu/kWh) (HHV) (ISO: 15˚C, 60% RH, 0 m	8,400	8,400	9,000	9,500
Project Costs				
Owner Furnished Equipment				
Prime Mover	$ 82,377,000	$ 82,377,000	$ 92,979,000	$ 101,079,000
Emission Control	$ -	$ -	$ -	$ -
Synchronous Condenser	$ -	$ -	$ 11,138,000	$ 11,138,000
Sales Tax	$ 12,357,000	$ 12,357,000	$ 15,617,000	$ 16,832,000
Total Owner Furnished Equipment	**$ 94,734,000**	**$ 94,734,000**	**$ 119,734,000**	**$ 129,049,000**
EPC Costs				
Other Equipment	$ 16,137,000	$ 16,137,000	$ 22,462,000	$ 22,462,000
Diesel/Biodiesel Infrastructure (Fuel Handling and Stora	$ 6,827,000	$ 7,711,000	$ 4,749,000	$ 5,364,000
Materials	$ 26,958,000	$ 26,958,000	$ 10,440,000	$ 10,440,000
Construction Labour	$ 34,490,000	$ 34,490,000	$ 46,567,000	$ 46,567,000
Other Labour	$ 14,954,000	$ 14,954,000	$ 12,126,000	$ 12,126,000
Sales Tax	$ 6,464,000	$ 6,464,000	$ 4,935,000	$ 4,935,000
EPC Contractor Fee	$ 11,646,000	$ 11,646,000	$ 13,261,000	$ 13,856,000
EPC Contingency	$ 16,045,000	$ 16,045,000	$ 17,681,000	$ 18,475,000
Total EPC Costs	**$ 133,521,000**	**$ 134,405,000**	**$ 132,221,000**	**$ 134,225,000**
Total Project Costs	**$ 228,255,000**	**$ 229,139,000**	**$ 251,955,000**	**$ 263,274,000**
Non-EPC Costs				
Project Development	$ 6,676,000	$ 6,676,000	$ 6,611,000	$ 6,711,000
Mobilization and Start-Up	$ 1,335,000	$ 1,335,000	$ 1,322,000	$ 1,342,000
Non-Fuel Inventories	$ 668,000	$ 668,000	$ 662,000	$ 671,000
Owner's Contingency	$ 10,681,000	$ 10,681,000	$ 10,577,000	$ 10,738,000
Electrical Interconnection	$ 6,210,000	$ 6,210,000	$ 6,885,000	$ 6,885,000
Land	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000
Fuel Inventories	$ 15,290,000	$ 13,514,000	$ 16,058,000	$ 16,951,000
Working Capital	$ 2,003,000	$ 2,003,000	$ 1,983,000	$ 2,013,000
Subtotal - Non-EPC Costs w/o Financing Fees	**$ 45,563,000**	**$ 43,787,000**	**$ 46,798,000**	**$ 48,011,000**
Total Non-EPC Costs	**$ 45,563,000**	**$ 43,787,000**	**$ 46,798,000**	**$ 48,011,000**
Overnight Capital Costs ($)	**$ 273,818,000**	**$ 272,926,000**	**$ 298,753,000**	**$ 311,285,000**
Overnight Capital Costs ($/kW-Winter)	$ 1,845	$ 2,074	$ 1,744	$ 1,817

(1) Costs based on EPC contracting approach.
(2) Interconnection and land costs are assumed values.
(3) Property taxes and insurance costs are not included in the above estimate.

Technology	Reciprocating Internal Combustion Engine	Reciprocating Internal Combustion Engine	Combustion Turbine - Aeroderivative	Combustion Turbine - Aeroderivative
Unit Type (Representative Manufacturer)	Wartsila 20V32 (14x)	Wartsila 20V32 (14x)	GE LM6000 PF+ SPRINT w/ Sync Condenser (3x)	GE LM6000 PF+ SPRINT w/ Sync Condenser (3x)
Cycle Type	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Fuel Type	Diesel Fuel	Biodiesel Fuel	Diesel Fuel Only	Biodiesel Fuel Compatible
Net Plant Output (MW) - Summer (27˚C, 47% RH, 0 m)	148.4	131.2	119.7	119.7
Net Plant Output (MW) - Winter (-26˚C, 60% RH, 0 m)	148.4	131.2	171.3	171.3
Net Heat Rate (Btu/kWh) (HHV) (ISO: 15˚C, 60% RH, 0 m	8,400	8,400	9,000	9,500
Fixed O&M				
Labor - Routine O&M	$ 880,000	$ 880,000	$ 659,000	$ 659,000
Maintenance Materials and Services	$ 190,000	$ 190,000	$ 154,000	$ 154,000
G&A	$ 331,000	$ 331,000	$ 267,000	$ 267,000
Total Fixed O&M ($)	**$ 1,401,000**	**$ 1,401,000**	**$ 1,080,000**	**$ 1,080,000**
Total Fixed O&M ($/kW-year)	$ 9.44	$ 10.68	$ 6.30	$ 6.30
Variable O&M				
Annualized Equipment Maintenance	$ 568,000	$ 568,000	$ 459,000	$ 459,000
VOM (non-fuel)	$ 274,000	$ 274,000	$ 221,000	$ 221,000
Variable O&M - Hours Based ($/MWh)	$ 64.79	$ 73.31	$ 45.34	$ 45.34

O&M expenses assume low utilization (1% capacity factor); thus predominately allocate O&M spend on a variable basis.