ENERGY STORAGE CANADA

ENERGY STORAGE

A Key Pathway to Net Zero in Canada

October 2022

A report by Power Advisory LLC. Commissioned by Energy Storage Canada

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Energy Storage Canada

Energy Storage Canada (ESC) is a not-for-profit organization and the only national trade association in Canada dedicated solely to the growth and market development of the country's energy storage sector as a means of accelerating the realization of Canada's ongoing energy transition and Net Zero goals through advocacy, education, collaboration, and research. ESC's technology-agnostic approach allows for a diverse membership of 85 members (and growing!) representing the end-to-end value chain of the country's energy storage industry.

For more information visit www.energystoragecanada.org

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Power Advisory is an established electricity market-focused management consulting firm. We specialize in market analysis, market design, policy development, business strategy, power procurement, regulatory and litigation support, and project development and feasibility assessment in North American electricity markets. We offer considerable experience advising industry associations, generators, energy storage providers, transmitters, distributors, technology providers, investors, financial institutions, customers, regulators, government agencies, and governments on a wide range of matters across North American electricity markets, with robust and in-depth experience in Ontario.

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EXECUTIVE SUMMARY:

Energy Storage Canada (ESC) retained Power Advisory to prepare this report demonstrating the pivotal role energy storage resources will play in reducing greenhouse gases (GHG) emissions and securing Canada's achievement of net-zero by 2035. A primary objective of the report is to estimate the potential installed capacity of energy storage necessary to achieve net-zero goals. As a secondary objective, this report will also highlight the importance of removing barriers to the implementation of energy storage within each Canadian jurisdiction.

Canada is committed to an ambitious target to transition the electricity sector to net-zero GHG emissions by 2035. This will require changing supply mixes across the country in the various provincial electricity markets. Energy storage resources, as a versatile and evolving group of technologies, are expected to be a critical component of achieving a net-zero Canadian electricity system. The potential for energy storage resources within each province is determined by two factors.

1. First, growing electricity consumption due to the electrification of other economic sectors, in order to meet their own net-zero objectives, is expected to result in the need for a significant number of new resources between now and 2035. Electrification is foreseen in transportation (e.g. electric vehicles), space heating (e.g. air source heat pumps), industry, as well as in residential and commercial applications.

2. Second, existing carbon-intensive generation units (e.g. coal-fired and natural gas-fired generation) will need to be replaced or converted to lower carbon intensity fuels to remove emissions from the Canadian electricity supply mix.

The reduction of carbon-intensive generation is driven by a combination of government policy; corporate environmental, social and governance (ESG) objectives; non-emitting supply resource economics (i.e. renewable generation is in many jurisdictions the lowest cost new supply resource option); as well as general support among Canadians. While these are compelling and already highly impactful considerations, it must also be borne in mind that in many jurisdictions, carbon-intensive generation units play a critical role in the operability of the electricity grid. Energy storage has a role to play in this regard as well, in that it can provide services to wholesale energy markets, grid infrastructure, and directly to customers.

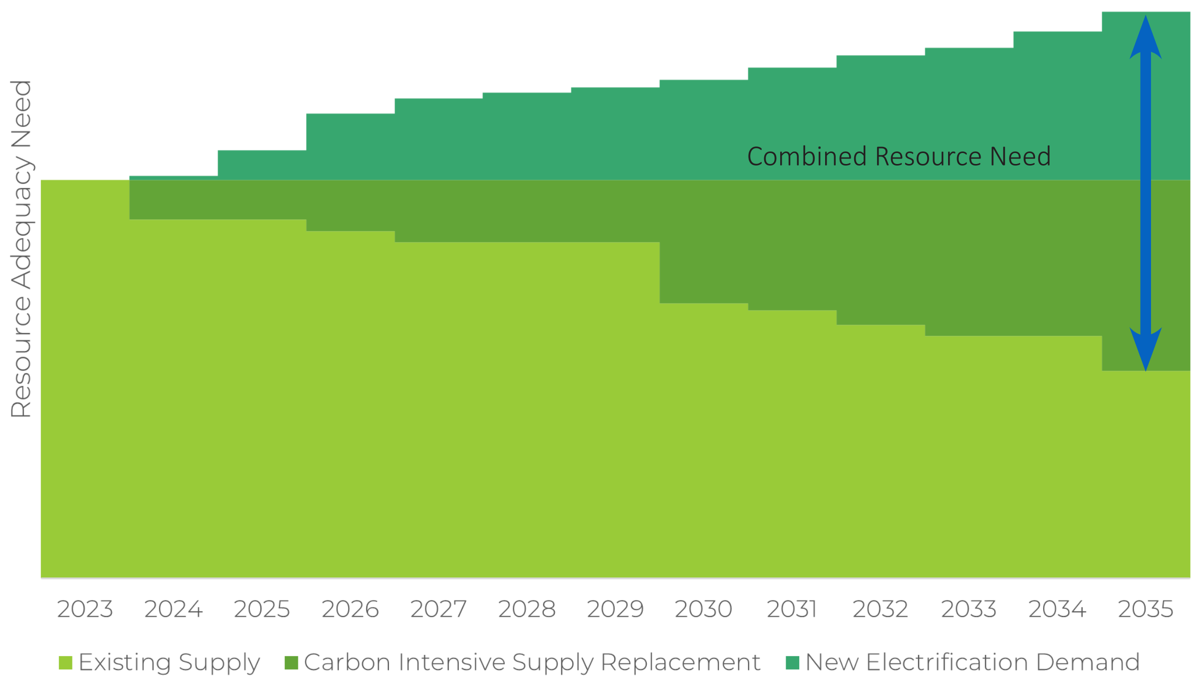

Figure 1: Illustrative Example of Resource Need for Net Zero

Together, growing electricity consumption and the reduction of carbon-intensive generation, determine the potential for new non-emitting generation resources such as nuclear, hydroelectric, wind and solar. There are strengths and weaknesses to each resource that must be balanced within the unique existing electricity market and supply structure of each province. However, energy storage resources can play a critical role in balancing the different supply mixes in each province, meeting electricity demand needs, while also maximizing the efficiency and effectiveness of existing generation, transmission, and distribution assets for the benefit of all customers.

In total, somewhere between roughly 8-12 GW of energy storage potential would optimally support the net-zero transition of the Canadian electricity supply mix by 2035. At the low end, this is equivalent to the installed generation capacity of Manitoba in 2020. Ontario has the largest potential, given existing and growing electricity demand, and the need to replace or repurpose roughly 10 GW of gas-fired generation by 2035 to reach net-zero objectives. Many Canadian jurisdictions with expansive hydroelectric generation resources can also utilize energy storage resources to serve locally constrained power systems and support system stability.

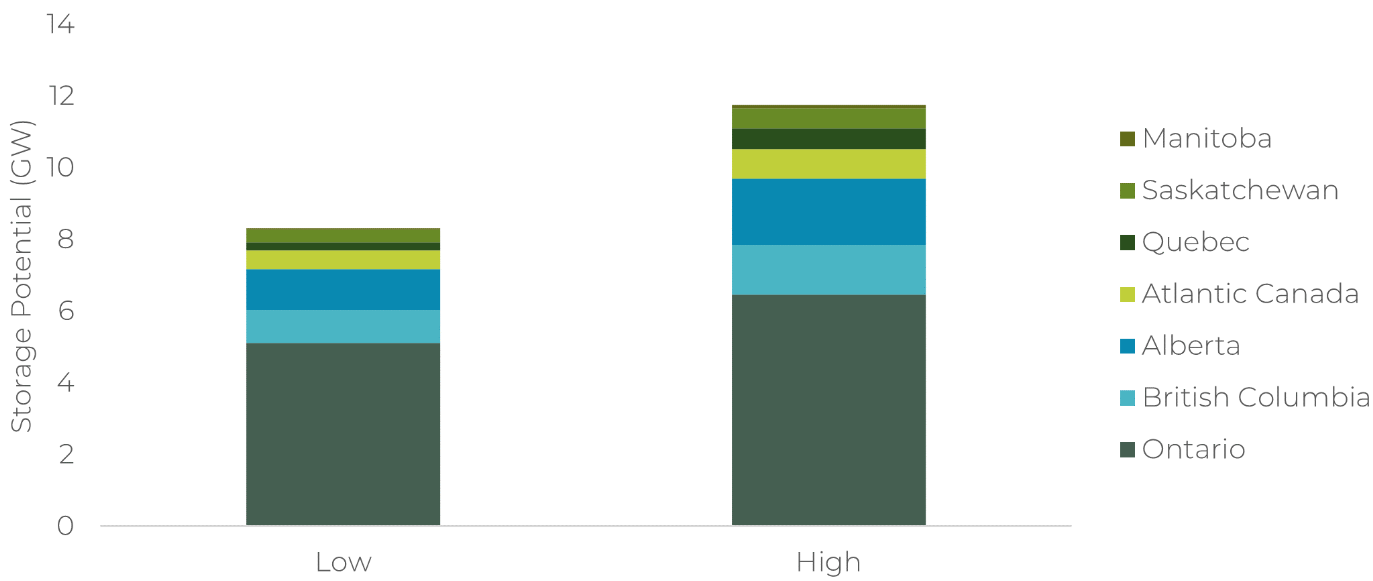

Figure 2: Energy Storage Potential Range for Net-Zero Electricity System

Key Take-Aways

- The versatility of energy storage resources will be a critical component for Canada's ambitious net-zero electricity system objective by 2035

- The potential for energy storage resources is determine by two factors
  - New supply resources required to serve growing electricity demand including electrification
  - Replacement of existing carbon-intensive generation resources (e.g. coal-fired generation)

- Power Advisory estimates energy storage resource potential of 8-12 GW by 2035, with Ontario being the leading province for development

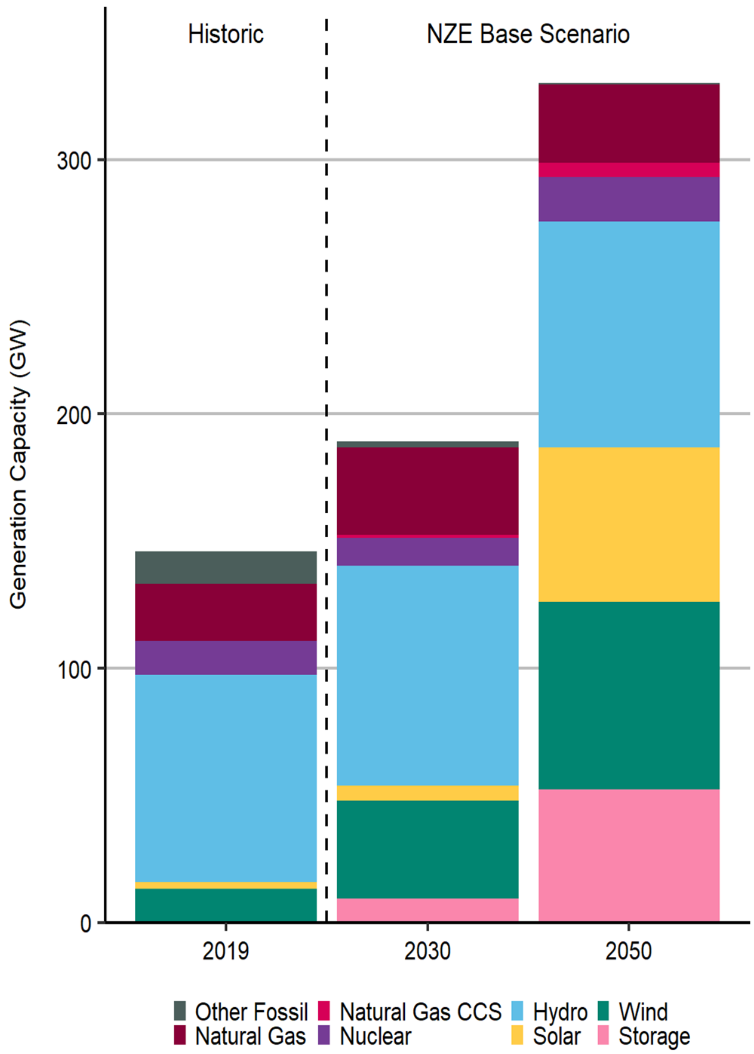

Figure 3: Installed Electricity Generation Capacity in Canada in the NZE Base Scenario

INTRODUCTION:

Energy storage resources are expected to play a significant role in supporting the decarbonization of the Canadian electricity system which in turn will help other economic sectors reduce their emissions. Each provincial electricity system is unique and the potential for energy storage resources to support the reduction of carbon emissions will vary. The Canada Energy Regulator's (CER's) recent report, Canada's Energy Future, outlined multiple possible electricity scenarios in line with achieving a net-zero future.[1] As shown in Figure 3, energy storage significantly increases once more variable renewable energy is integrated into the supply mix. By 2050, CER's Net-Zero Electricity (NZE) Base Scenario includes 52 GW of storage, reflecting an annual growth rate of 1.7 GW/year. However, due to assumptions in CER's model, this only reflects battery storage capacity with four-hour duration and does not include distributed electricity resources (DERs).

In addition to government policy, ESG objectives are also driving climate action and investment. The participation of the corporate sector, along with broad public support for action on climate change, means carbon emissions reduction will be broadly embedded as a goal across the global economy. With continued technological advances and declining costs, energy storage is well positioned to be a critical enabler of Canada's net-zero economy.

1 Towards Net-Zero: Electricity Scenarios: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/towards-net-zero.html

Energy Storage Resource Types and Attributes

Energy storage resources are a versatile, robust, and evolving group of technologies that can offer a range of different services to electricity systems. Their capabilities are well documented in academic literature, research reports, and studies across multiple jurisdictions. Energy storage can provide services to wholesale energy markets (e.g. real-time energy, capacity, and ancillary services), grid infrastructure (e.g. reliability services and capital expenditure deferment), and directly to customers (e.g. grid consumption optimization and outage management).

Storage technologies can also offer different services over different time periods. For example, short response times can be used to supply ancillary services (e.g., regulation) or to maintain system stability during outage events. Over long durations, energy storage can provide peaking capacity and support bulk system operations. It is the variety and versatility of energy storage resources that makes them a critical component of a net-zero electricity grid. Optimizing them requires recognizing the unique attributes of each provincial electricity grid. Future designs and services in electricity markets will likely provide new areas of participation for energy storage.

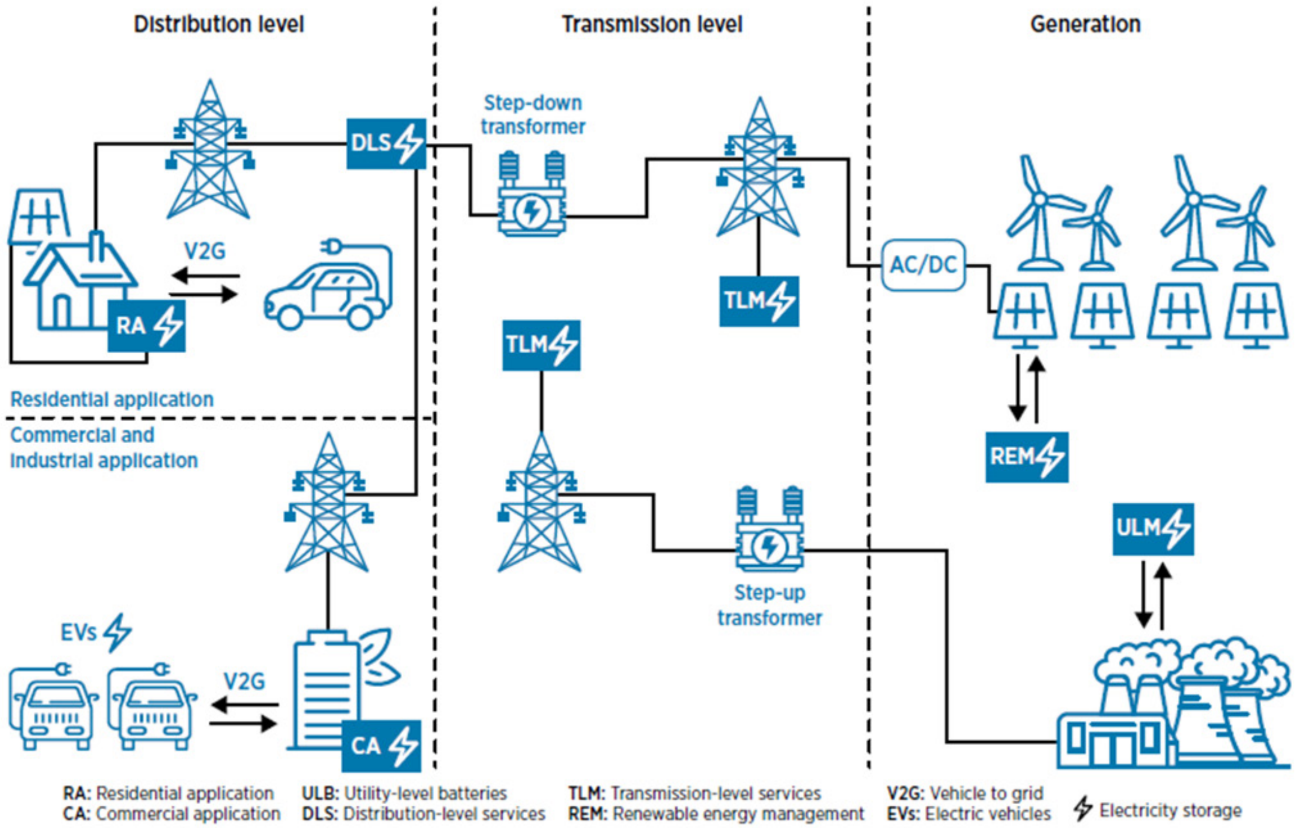

Figure 4: Energy Storage Applications Throughout the Electricity Grid [2]

Federal Government Net-Zero Plans

In December 2020, the federal government announced its intent that Canada would become a net-zero emitter of carbon by 2050.[3] Canada's Parliament has enacted legislation in support of this initiative in the form of the Canadian Net-Zero Emissions Accountability Act,[4] which received Royal Assent in June 2021. In support of this goal, the federal government's "Pan-Canadian Framework on Clean Growth and Climate Change"[5] specifies that 90 percent of electricity generation in Canada will need to come from non-emitting sources by 2030, as a prelude to nation-wide net-zero emissions by 2050. In 2021, the Canadian Institute for Climate Choices suggested that all electricity generation in Canada would need to come from emissions-free resources by 2035 in order to achieve net-zero emissions for Canada by 2050.[6] Furthermore, the mandate letter provided in the same year to the new Minister of the Environment and Climate Change specifies the federal government's desire to achieve net-zero emissions from the electricity sector by 2035.[7]

2 International Renewable Energy Agency, 2020. Electricity Storage Valuation Framework: Assessing system value and ensuring project viability, International Renewable Energy Agency, Abu Dhabi. Retrieved from: https://irena.org/publications/2020/Mar/Electricity-Storage-Valuation-Framework-2020

3 Government of Canada: Net Zero Emissions by 2050: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

4 Canadian Net-Zero Emissions Accountability Act: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050/canadian-net-zero-emissions-accountability-act.html

5 Pan-Canadian Framework on Clean Growth and Climate Change. https://publications.gc.ca/collections/collection_2017/eccc/En4-294-2016-eng.pdf

6 Canada's Net Zero Future: https://climatechoices.ca/wp-content/uploads/2021/02/Canadas-Net-Zero-Future_FINAL-2.pdf

7 Minister of Energy and Climate Change Mandate Letter. https://pm.gc.ca/en/mandate-letters/2021/12/16/minister-environment-and-cli-

More recently, in March 2022, the federal government released a discussion paper to support the achievement of a net-zero electricity sector by 2035 through the development of a Clean Energy Standard (CES).[8] The discussion paper recognizes the need to coordinate with the provinces and to send clear regulatory signals that would both incentivize the investment in emissions-free electricity and dis-incentivize emitting generation. The Clean Energy Regulations would establish a performance standard for emitting electricity generation. The government is continuing to consult on the establishment of these new regulations, and on July 26, 2022, a proposed frame for the Clean Energy Regulations was released.[9]

APPROACH TO ESTIMATING ENERGY STORAGE NEED:

The 2035 net-zero objective for Canada is ambitious and requires solutions in each jurisdiction to reflect the unique conditions and strengths of each provincial electricity grid. The resource need for net-zero is determined based on two primary components.

1. First, new resources will be required to supply electricity consumption growth due to electrification of other economic sectors necessary to meet emissions reduction targets. Transportation (e.g. electric vehicles), space heating, and industrial process adaptation are all expected to result in significant demand growth to 2035 and beyond, even with substantial investment in energy efficiency to reduce conventional electricity demand.

2.Second, the energy output and services provided by carbon intensive resources will need to be replaced or rebuilt with non-emitting resources. In many provinces this transition is already underway. By 2023 for example, coal-fired generation will cease to exist in Alberta as facilities will have either been converted to natural gas or retired.

Non-Emitting Resource Options

The combination of electrification demand growth and carbon intensive supply resource replacement defines the need for new non-emitting supply resources. There are many non-emitting resource options available to supply this capacity need. Each resource has its own advantages and disadvantages including operating capabilities, new capacity potential, development timelines and community acceptance. For example, nuclear generation offers the highest annual energy production on an installed capacity basis compared to all other resources options; however, it requires significant upfront capital spending and extremely long development timelines. Wind generation offers the lowest energy costs and diversified siting opportunities but may require transmission system expansion, and offers low levels of effective capacity to provide supply during system peak consumption hours. Solar generation has the potential to locate in load centres (e.g. roof-top) and aligns relatively well with day-time summer peak loads; however, it is much less effective at serving winter peak loads. Some provinces may have the potential to construct new hydroelectric generation, but this is dependant on local geography.

mate-change-mandate-letter

8 Government of Canada. A clean electricity standard in support of a net-zero electricity sector: discussion paper. https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/achieving-net-zero-emissions-electricity-generation-discussion-paper.html

9 Government of Canada. Proposed Frame for the Clean Electricity Regulations. https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/proposed-frame-clean-electricity-regulations.html

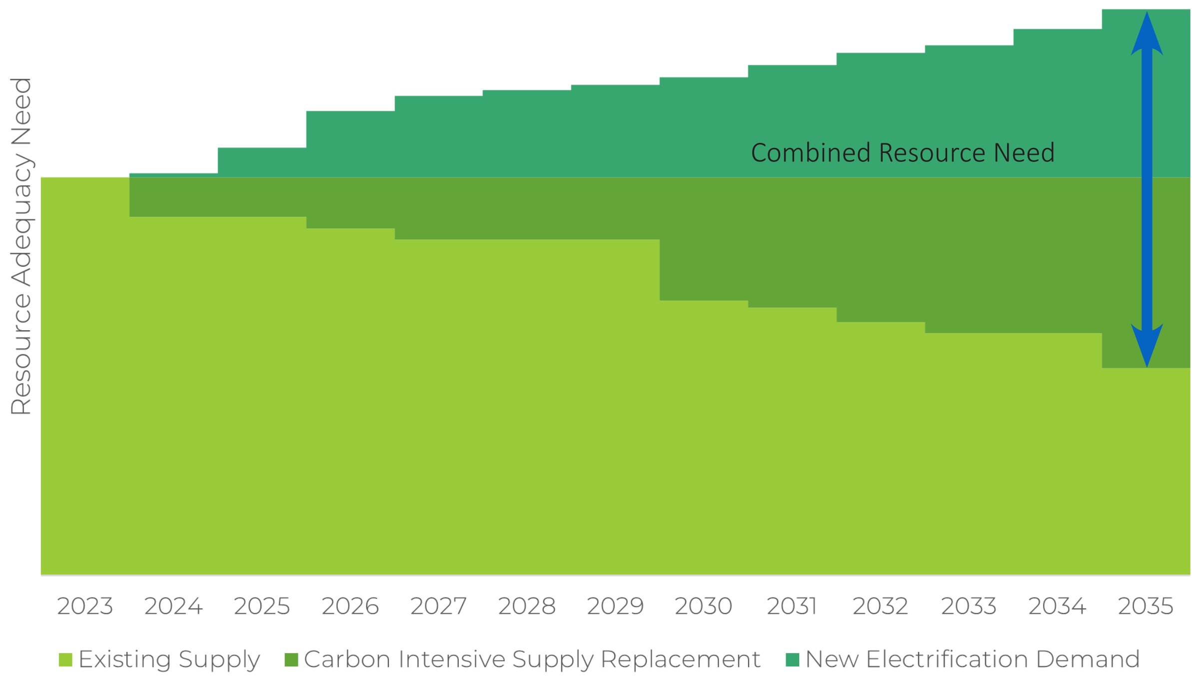

Figure 5: Illustrative Example of Resource Need for Net-Zero

Clearly, a combination of many non-emitting resources will be required to meet the 2035 net-zero electricity supply mix objective. In addition to existing non-emitting resource options, technology evolution and innovation will likely be required to support economy wide achievement of net-zero by 2050. Different energy storage technologies can support each non-emitting resource supply mix in different ways. For example, in a hydroelectric-dependant system with large reservoirs, energy storage resources can be used to support delivery to urban centres and constrained areas, avoiding costly and time-consuming transmission system expansions. In large wind and solar generation buildouts, energy storage can be used to address intermittent output issues and optimize existing and future transmission system operation. Paired with nuclear generation, energy storage can store excess production in low demand periods and deliver it to higher demand hours; allowing nuclear generation to maintain consistent output where it is most cost-effective.

Estimating Electrification Demand Growth to 2035

Power Advisory has estimated the demand growth from electrification in three broad steps. First, it established a baseline demand growth for each province based on published power system planning documents. Next, Power Advisory added energy growth from various electrification sources, namely transportation, space heating, industrial, commercial, and residential appliances (e.g. adoption of induction cooktops). Power Advisory compared its demand forecast against various national and provincial electrification demand forecasts. Some forecasts foresee a fast transition with 30-40 per cent growth by 2035 while conservative forecasts fall in the 15-20 per cent range. Power Advisory's electrification forecast is near the middle of the range, representing a moderate outlook for electrification.

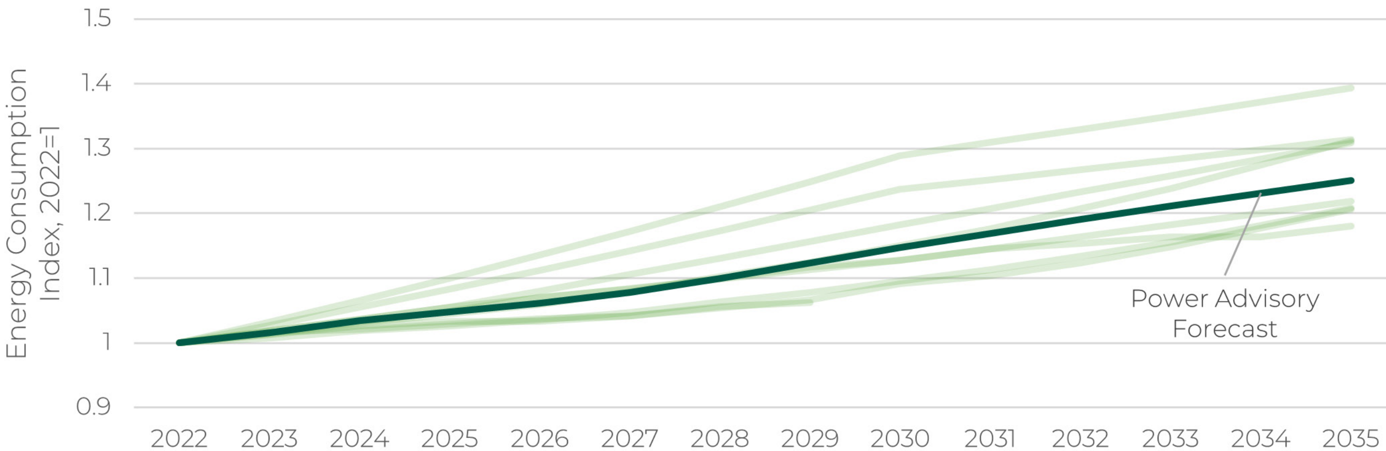

Figure 7: Relative Energy Consumption Forecasts

The final step involved converting the annual energy demand growth (i.e. TWh/year) into a winter peak demand resource requirement (i.e. GW/year). Most provincial electricity systems are winter peaking already. Space heating demand growth is expected to ensure Canadian jurisdictions will be winter peaking under a net-zero future. Power Advisory expects 36-54 GW of winter peak demand growth, leading to a need for new supply resources by 2035 across the studied provinces.

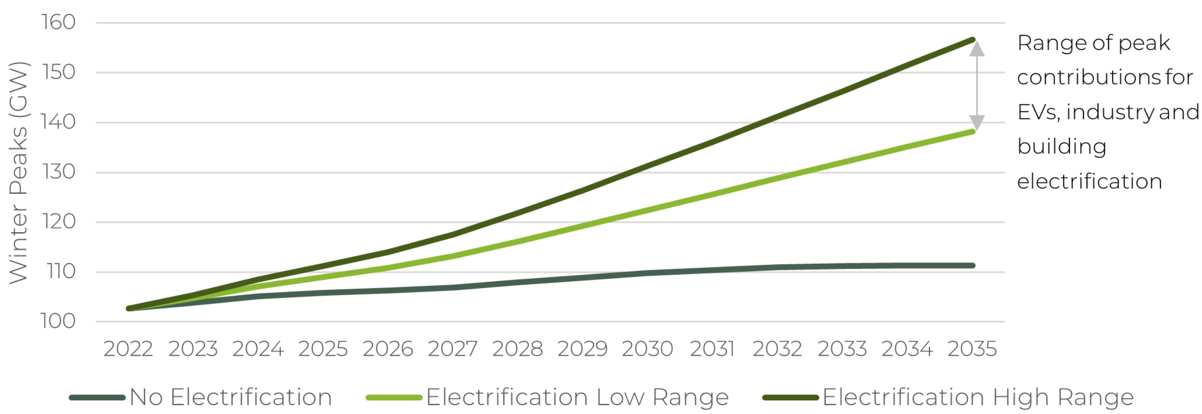

Figure 8: Sum of Provincial Winter Peak Forecasts

Overall, our energy demand growth from electrification varies by province depending on existing demand, the current level of electrified heating, anticipated industry-sector mix, and population growth. The largest electrification growth will take place in Quebec and Ontario, followed by Alberta and British Columbia. This aligns with population centres in the country.

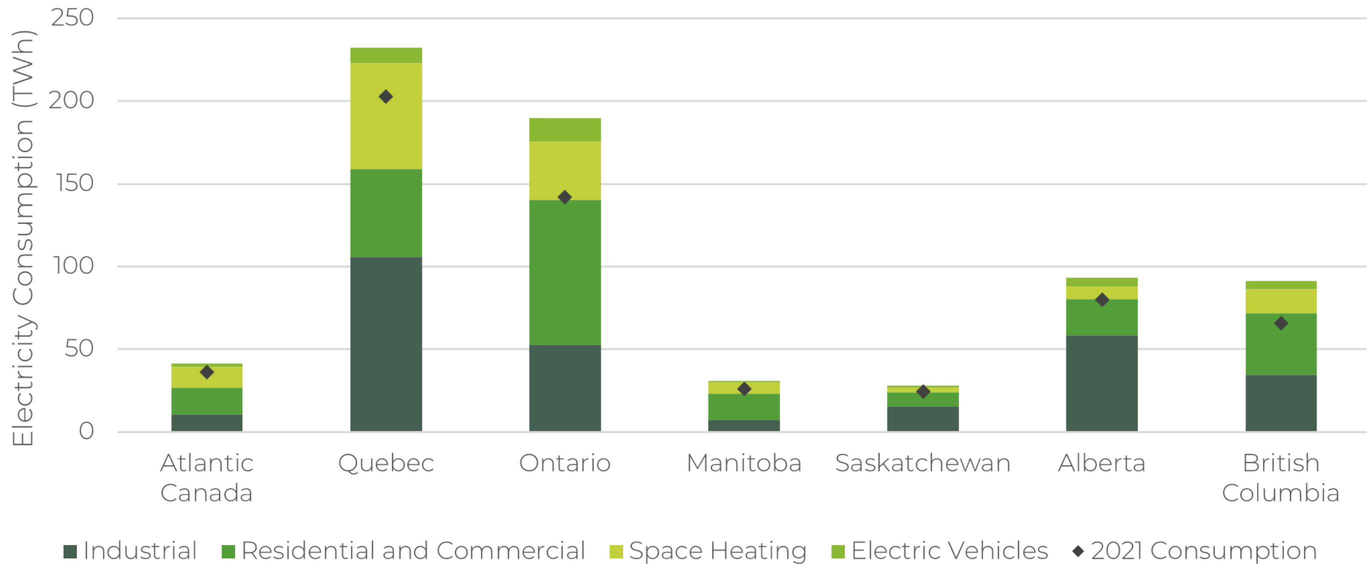

Figure 8: 2035 Energy Consumption Forecast Growth by Province[10]

Replacement of Carbon Intensive Resources

The number of carbon-intensive resources varies by jurisdiction. In addition, the role of these resources varies, thus requiring different combinations of resource replacement to maintain power quality and planning standards. The amount of energy production from carbon-intensive resources also varies by province. Power Advisory's calculations assume that no new carbon-intensive resources will be developed between now and 2035 beyond those already under construction or in late-stage development.

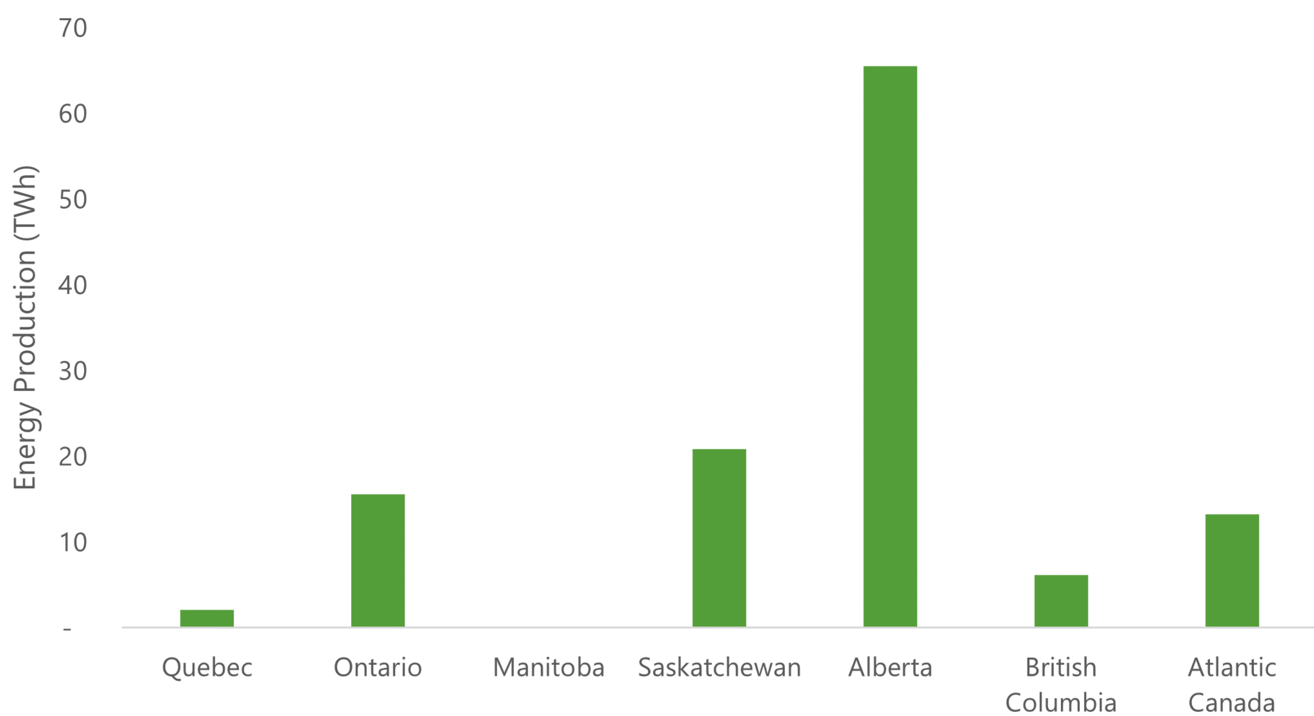

Figure 9: Total Energy Production from Combustible Fuels, 2021

10 2021 Consumption based on StatsCan table 25-10-0016-01

For each province, a non-emitting resource portfolio was created. Planned procurements or rate-regulated supply outlooks were used as a starting point. For example, Ontario's Independent Electricity System Operator (IESO) has launched multiple procurements to secure between 4,000 MW to 6,000 MW of effective capacity by 2030.[11] Depending on the resource mix, this could result in 5,000 MW to 8,000 MW of new installed renewable generation development.

Limited new nuclear generation is anticipated in Ontario, Saskatchewan, and New Brunswick for the 2035 supply mix based on small modular reactor (SMR) projects. For provinces with abundant hydroelectric generation, such as Quebec and British Columbia, continued development of hydroelectric generation resources is assumed as a baseline with other resources added where appropriate. For example, Hydro-Quebec is procuring 3,000 MW of wind generation to supplement an expansion of 2,000 MW of existing hydroelectric generation. A summary of the unique assumptions for each province/region is provided below.

For the remaining provinces, demand growth is met with a mix of wind, solar and dispatchable low carbon generation. The dispatchable low carbon generation is modelled as natural gas subject to a $200/tonne carbon cost representing the cost of carbon capture and/or offsets. Biomass, renewable natural gas and hydrogen are other options under consideration to provide the necessary dispatchable low carbon energy in Canada's net-zero supply mix. The installed capacity of wind and solar generation in each portfolio was increased until the projected value of these resources in the hourly model (described below) fell below their anticipated levelized cost.

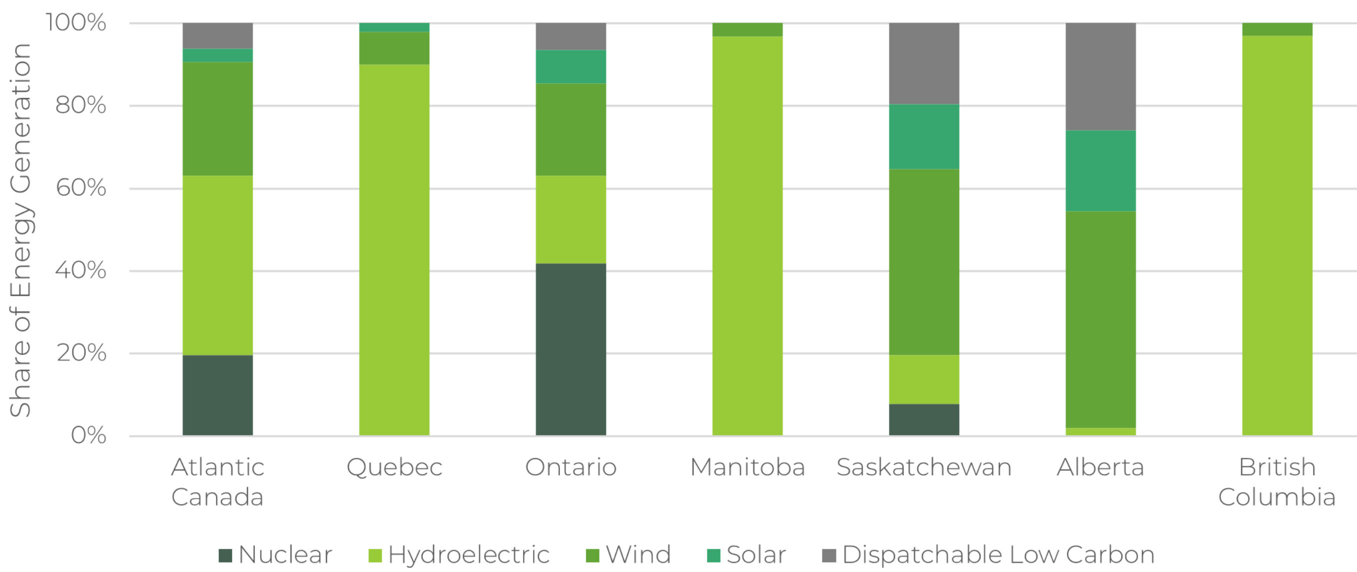

Figure 10: 2035 Net-Zero Provincial Supply Mix

Hourly Energy Modelling

Combining the electrification demand growth projections with the supply outlook in 2035 provides a foundation to assess the potential for energy storage resources in each province. Electricity demand and supply resources must balance in real-time grid operations, requiring consistent scheduling and dispatch of resources to manage for normal and abnormal operating conditions. Power Advisory created an hourly model for each province. Separate load shapes were developed for electric vehicle, space heating, industrial, and residential/commercial

11 Effective capacity, which is equivalent to unforced capacity or UCAP, is the amount of capacity that is expected to be available on average during periods of system stress. It is lower than installed capacity (i.e., the maximum output of a resource in normal conditions) due to uncertainties like equipment failures and weather. Effective capacity is often used to measure resources in planning assessments and technology-neutral procurements.

demand growth. Weather-sensitive inputs (e.g. space heating, wind output) were based on locationally appropriate and correlated data sets.

In some periods, energy output from inflexible generation[12] (i.e. wind, solar, nuclear, and some run-of-river hydroelectric generation) creates periods of excess supply that can be absorbed by energy storage resources. In periods of high demand and/or low inflexible generation output, additional energy is needed from dispatchable hydroelectric generation, other flexible low carbon generation (e.g. hydrogen), and energy storage.

Energy storage in the model operates to reduce the need for dispatchable low carbon capacity by charging during periods of surplus and discharging when the demand for dispatchable generation is greatest. The challenges of a net-zero electricity supply mix became increasingly clear through our analysis. For example, in provinces with limited long-term energy storage from hydroelectric reservoirs, as well as daily and seasonal imbalances between demand and wind/solar supply, it is challenging to cost-effectively reduce the need for flexible, dispatchable generators below about 20 per cent of total energy. This is a scenario where long-duration energy storage technologies may be critical to meeting net-zero objectives.

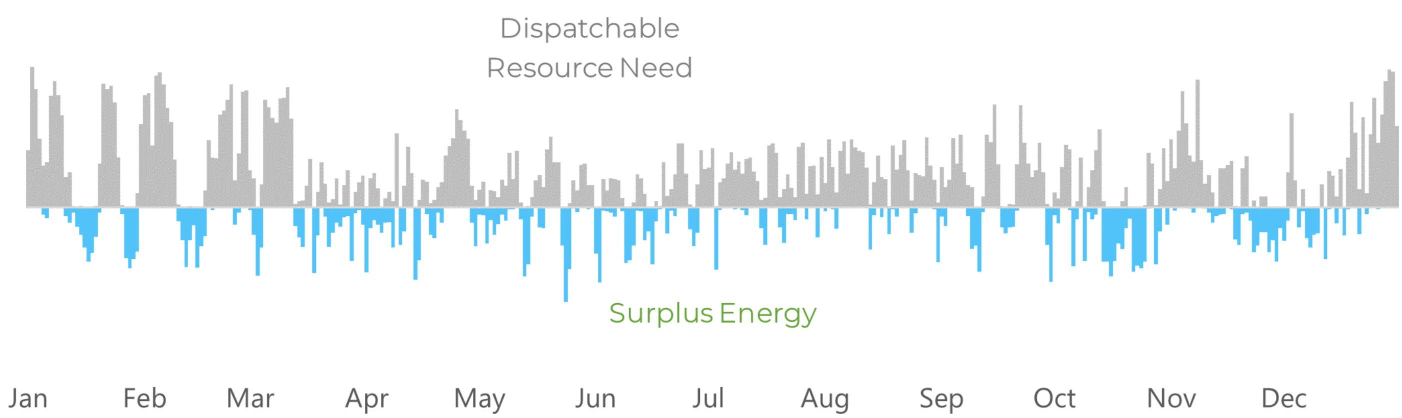

Figure 11: Example of Daily Energy Imbalance Analysis

CANADIAN ENERGY STORAGE POTENTIAL IN NET-ZERO FUTURE:

As expected, the analysis and forecast for each jurisdiction varied depending on the unique electricity sector situation and expected outlook to 2035. This influenced the range of potential for energy storage.

Power Advisory estimates that across Canada energy storage potential in support of a net-zero electricity grid could approach 12 GW by 2035. For comparison, the CER analysis estimated between 5 GW and 9 GW of energy storage potential by 2030.

Ontario represents the highest peak demand reduction potential, of between 4,700 MW and 5,500 MW by 2035. In addition to provincial peak demand needs, constrained regional and local transmission systems can offer additional potential for energy storage resources. For example, much of the storage potential identified for British Columbia is as an alternative to transmission expansion.

12 While all of the mentioned resource types can participate and follow dispatch instructions in wholesale markets, their operating capabilities and attributes limit the ability to adjust output to follow system hourly demand profiles.

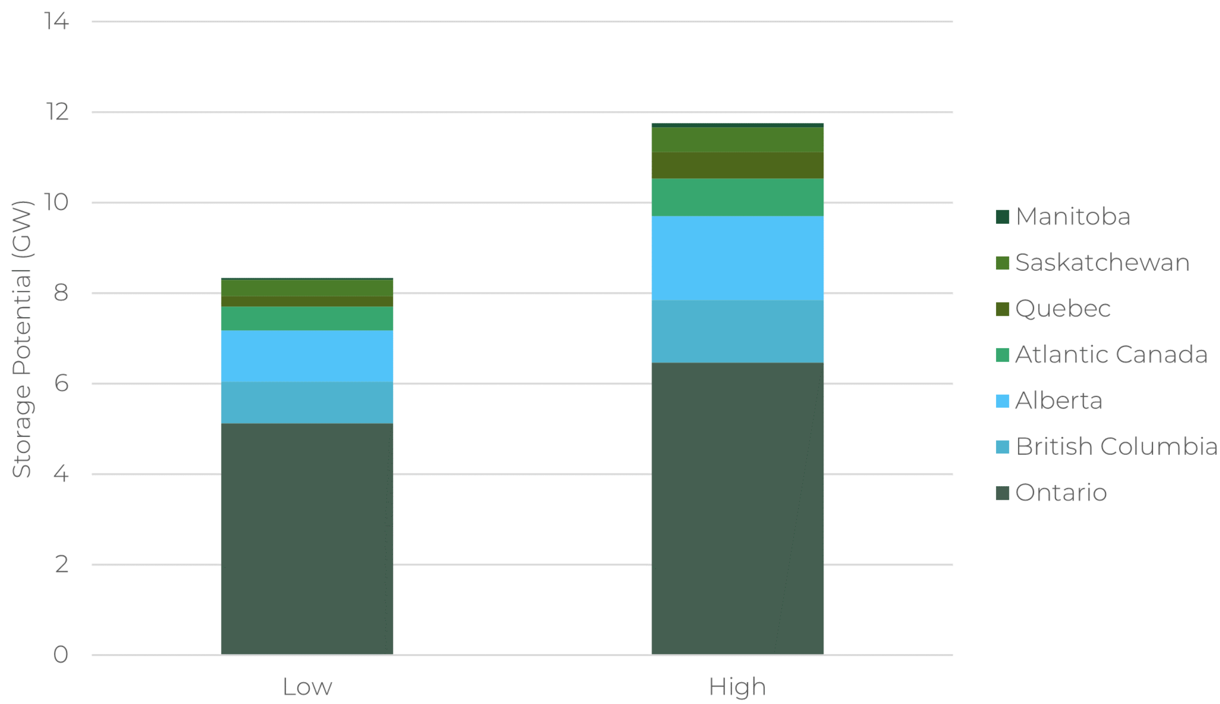

Figure 12: Energy Storage Potential for Net-Zero

The primary driver of energy storage potential by province is the ability to provide capacity by reliably meeting demand when non-emitting resources are not capable or are unavailable. The maximum potential of storage for capacity is limited by the duration of the capacity need and the availability of charging energy; and these vary by province depending on the supply mix, demand flexibility and weather patterns. Figure 13 demonstrates how four- to eight-hour storage might contribute to meeting capacity needs on a peak winter day with relatively low wind output. On days with higher wind output and lower demand, storage would be more likely to use surplus energy to minimize the need for dispatchable low carbon generation.

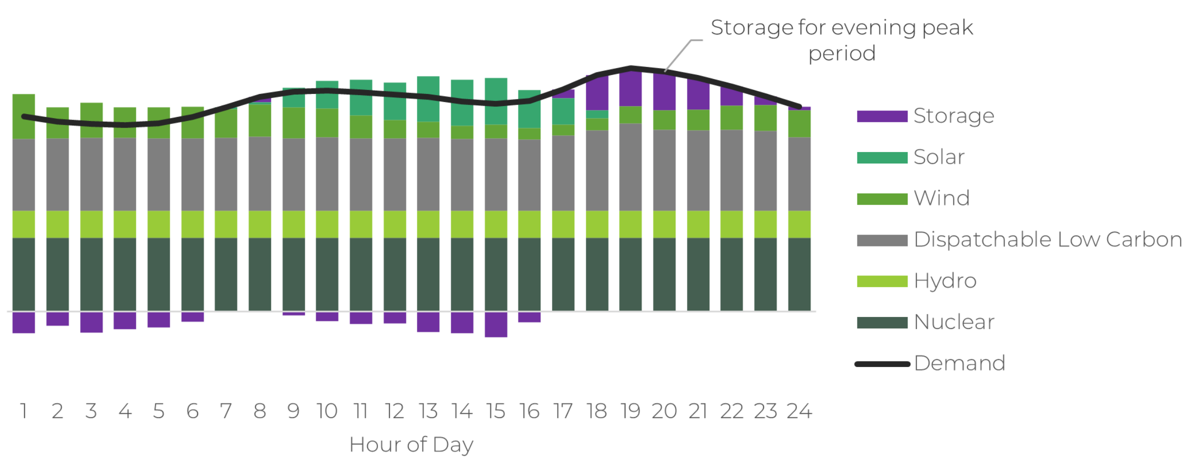

Figure 13: Example of Storage for Capacity on a Winter Peak Day

Peak demand reduction potential for storage durations of up to eight hours were explored for this study. Longer-duration storage, which may shift energy over multiple days, would have additional potential beyond what is identified in Figure 14.

In the near term, storage with a duration beyond eight hours could be used as an alternative to gas generation for certain reliability services. On a day-to-day basis, system operators may keep gas generators online at their minimum loading point so they can be easily ramped up to manage an outage or forecast error. Because it is difficult to predict how long additional energy will be required, operators are hesitant to rely on short-duration storage as an absolute alternative to gas generation. Maintaining fully charged long-duration storage on the system could provide the certainty that is needed to avoid running gas generation unnecessarily.

As electricity systems incorporate a greater share of wind and solar, very long duration storage may also have potential to address multi-day energy needs. Long periods of low wind, or wind droughts, are frequently cited as a challenge for reliability in high-renewables systems. Multi-day storage could be used to mitigate this risk. Ultimately, eliminating fossil fuels from the electricity system would require seasonal energy storage. For example, hydrogen electrolysers may operate between spring and fall to store hydrogen for combustion turbines on cold winter days.

Factors Influencing Energy Storage Potential

Total future demand by 2035 is one of the most important variables in the analysis. Under higher demand outlooks, energy storage potential could exceed 14 GW. Other factors that would increase storage potential by 2035 include wind and solar generation growth that increases the variability of supply to match demand. Energy storage, as expected, could store excess energy and shift to demand shortfalls. In addition, higher transmission and distribution congestion would provide unique opportunities for energy storage to address local power system needs.

Key take-aways from the analysis for the provinces is provided in the table below.

Table 1: Summary of Provincial Electricity System Take-Aways

Jurisdiction	Potential	Comment
British Columbia	920 – 1,380 MW	Supply needs emerge closer to 2035; limited additional hydroelectric generation capacity remains. Capacity needs emerging on the South Coast (i.e. Lower Mainland) area; BC Hydro Integrated Resource Plan (IRP) anticipates using 480 to 800 MW of energy storage to defer transmission expansion.
Alberta and Saskatchewan	1,130 – 1,850 MW 360 – 540 MW	Significant wind and solar generation growth expected to reduce emissions. After full retirement of coal-fired generation, remaining fossil-fueled generation must be mitigated. Current options under consideration include energy storage resources (both long and short duration), carbon capture/offsets, and conversion to a low carbon fuel (e.g., hydrogen). High share of industrial demand could lead to higher electrification depending on technology evolution. Some interest in nuclear generation (e.g., SMRs); however, limited installed capacity until late 2030s due to development timelines.
Manitoba	40 – 90 MW	Abundant exploitable hydroelectric generation and reservoir storage available for system-wide needs; some potential for energy storage as a non-wires solution to defer new transmission to the Winnipeg area.

Quebec	230 – 580 MW	Energy and capacity needs emerging in 2027 and 2028; Hydro-Quebec planning new wind generation (i.e. 3,000 MW) and expansion of existing hydroelectric generation (i.e. 2,000 MW) to address medium-term needs. Long-term; Quebec expected to explore further resource development, including energy storage, to meet peaking needs and defer transmission development.
Ontario	5,120 – 6,470 MW	Capacity needs emerge and grow from mid-2020s reaching 4,000 MW to 6,000 MW by 2030. Current procurement process expected to result in significant new energy storage capacity. Over 10,000 MW of gas-fired generation capacity will need to be mitigated; either replaced with new resources (e.g., energy storage) or converted to low carbon fuels by 2035.
Atlantic Canada New Brunswick and PEI Nova Scotia Newfoundland and Labrador	250 – 350 MW 270 – 440 MW 10 – 40 MW	Transmission availability (i.e., Atlantic Loop) is a key uncertainty for resource development in the region. Storage has potential to both mitigate transmission congestion and enable carbon-intensive generation retirements.

RECOMMENDED CHANGES TO SUPPORT ENERGY STORAGE PARTICIPATION:

This paper has described an approach to estimate the potential for energy storage resources to support a net-zero electricity grid across Canada on a province-by-province basis. To support energy storage development and participation in electricity markets, there are many regulatory framework changes that should be considered by policy makers. Regulatory framework includes legislation, regulations, market design, codes, and standards that support the electricity sector in each province. Each framework is distinctive and represents the roles and responsibilities of key entities as well as the structure of market participation in each province. Changes suggested below recognize the differences between provinces and reflect firm first steps to supporting energy storage participation.

Unique Energy Storage Definition and Treatment in Regulatory Framework

Energy storage resources are unique resources that have capabilities and attributes similar to loads and generators, but which require separate participation models to be appropriately integrated into system planning, wholesale markets, and real-time operation.[13] A common starting point for supporting energy storage participation across all provinces consists of updates to legislation, regulation and market rules to include a definition and treatment for energy storage resources. The existing regulatory framework in most provinces does not currently contemplate the full integration of energy storage resources. Many provinces have started to make changes to incorporate energy storage resources; however, a coordinated effort between policy makers and government agencies is required to ensure the entire regulatory framework is overhauled to include energy storage. In particular, power system planning and procurement approaches must evolve to ensure that investment incentives are aligned the positive benefits of energy storage.

Clarity on Siting and Interconnection Requirements

Further clarity is needed for energy storage siting requirements and interconnection processes.

For siting, energy storage resources will require treatment and oversight that reflects space requirements and environmental impacts associated with the specific energy storage technology. Like generation assets, different energy storage technologies will require different oversight processes. Clarity and transparency on those requirements will support investment and development.

For interconnection processes, system planners and operators will need to consider how energy storage will connect and participate in the electricity system and market. Fair and appropriate treatment is required to ensure energy storage is not unduly restricted by overly conservative assumptions and analysis. Depending on the energy storage technology and local power system constraints, an energy storage resource may be able to address the issues while continuing to provide services to the broader electricity grid. For example, inverter-based energy storage resources can offer reactive power support to pockets of the power system where stability issues may exist.

Compensation Structures for Energy Arbitrage

A primary service from energy storage is energy arbitrage, shifting excess energy from low demand hours to high value hours, increasing the efficiency of the electricity system and effectiveness of existing generation. In provinces with wholesale markets (i.e. Alberta and Ontario), there are real-time energy prices that can be used to determine the energy arbitrage opportunity and compensation. In jurisdictions with vertically integrated utilities,

13 Federal Energy Regulatory Commission (FERC) Order 841 provides a clear explanation of the uniqueness of energy storage resources in wholesale markets. https://www.ferc.gov/media/order-no-841

there is no price signal for energy storage to determine investment opportunities or receive compensation for services. These jurisdictions should explore how to compensate energy storage for the energy arbitrage service, under either special rate design or contractual arrangements.

Long Duration Storage Compensation Structures

Unique consideration should be explored for long duration energy storage that can provide direct capacity replacement for existing carbon-emitting resources. The compensation structures should consider the potential sporadic usage of long duration energy storage, as influenced by weather years and seasonal climate variations. Long duration energy storage technologies may require alternative legislation, regulation and market participation compared to short and medium duration energy storage resources.

Pursue Non-Wires Solutions

In addition to supporting system peak demand, energy storage resources sited in constrained areas can defer or avoid new transmission and distribution investments. The use of energy storage resources as non-wires solutions increases the efficiency of the existing transmission and distribution network. Power system planning and regulatory processes must evolve to appropriately consider the value proposition of energy storage as a non-wires solution. The value stacking capability of offering system peaking capacity and local power system relief is an important optimization process for all jurisdictions to consider. For vertically integrated utilities, this means incorporating non-wires solutions into integrated resource plans. For jurisdictions with open wholesale markets, this means ensuring the ability to receive multiple funding sources for the provision of services to different entities.

Conclusion:

Canada has set an ambitious goal to achieve a net zero electricity system by 2035, the success of which depends on energy storage. As our report notes, energy storage technologies of all durations will play a pivotal role in reducing Canada's GHG emissions and meeting Canada's net zero objectives. Each province has its own unique supply mix of electricity generation to meet their demand needs and their own unique pathways to net zero.

However, whatever the supply mix in each province, energy storage resources of varying technologies and duration will play a critical role in meeting provincial electricity needs while maximizing the effectiveness of new and existing generation, transmission, and distribution assets for the benefits of all customers. Energy storage resources are a versatile, robust, and evolving group of technologies that offer a range of different services to electricity systems, with a potential of installed capacity between eight and twelve gigawatts of energy storage Canada-wide

To ensure this potential is realized and to unlock the value that energy storage can provide, a coordinated effort between policy makers and government agencies is required to ensure the entire regulatory and legislative framework is overhauled to include energy storage. In particular, provincial power system planning and procurement approaches must evolve to ensure the investment incentives are aligned with the positive benefits of energy storage.

It is the unique variety and versatility of energy storage resources that makes them a critical component to a net zero electricity grid, without which, Canada will not reach its net zero goals by 2035.