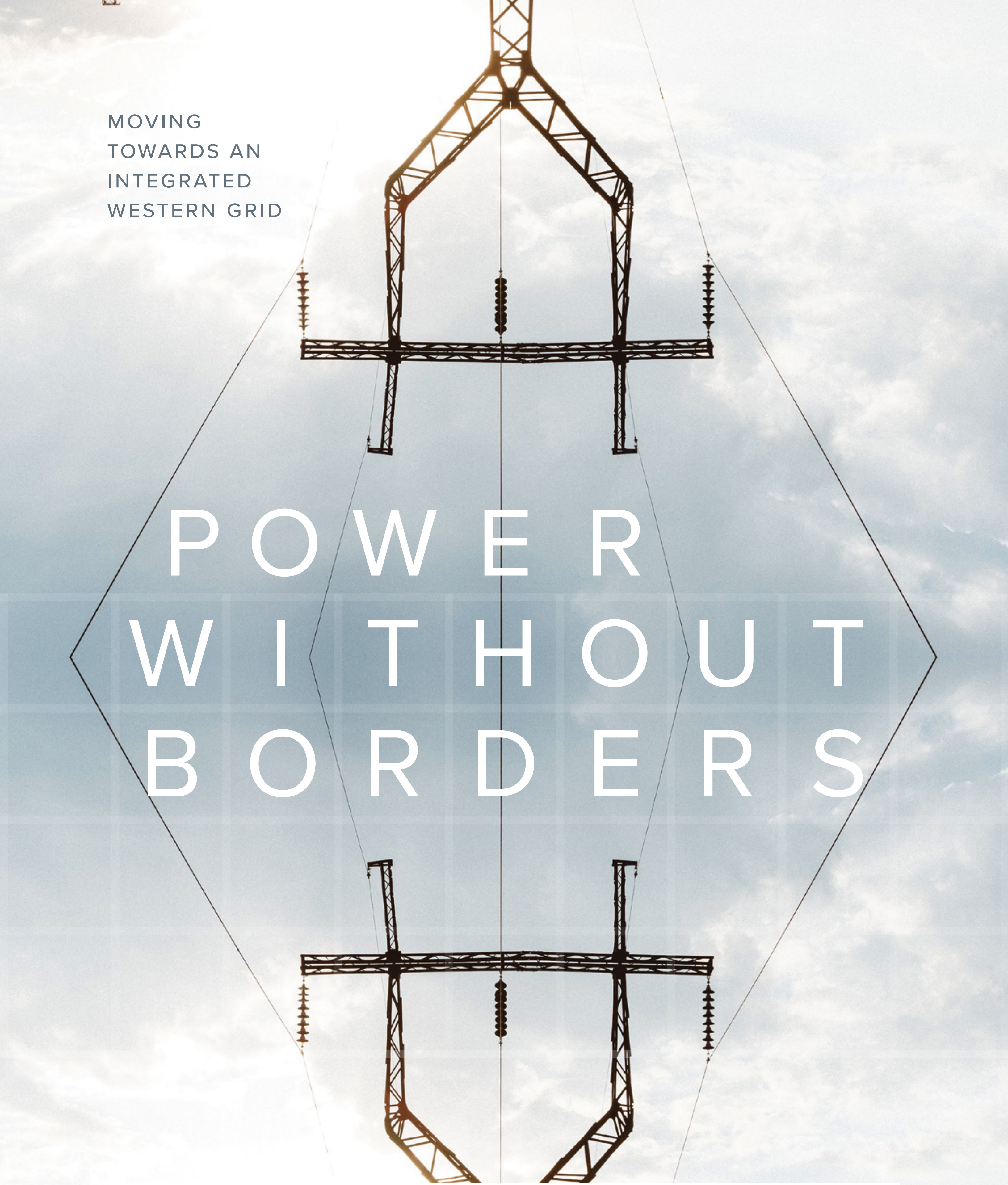

MOVING TOWARDS AN INTEGRATED WESTERN GRID

POWER WITHOUT BORDERS

CANADA WEST FOUNDATION
NATURAL RESOURCES CENTRE

NOVEMBER 2018

Nick Martin

CANADA WEST FOUNDATION

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The Canada West Foundation focuses on the policies that shape the West, and by extension, Canada. Through our evidence-based research and commentary, we provide practical solutions to tough public policy challenges facing the West, and Canada as a whole, at home and on the global stage.

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Executive
SUMMARY

Western Canada's electricity grid is poorly integrated. The way the provinces' markets are structured, regulated and planned makes it difficult to trade electricity across provincial borders – even if there were adequate infrastructure in place to do so, which there is not.

For more than 50 years, many Canadian politicians and energy leaders have championed a more integrated electricity grid. But political inertia and economics have entrenched the status quo.

That situation is changing. The sense of urgency to reduce greenhouse gas (GHG) emissions while maintaining affordable and reliable energy supplies is growing. At the same time, the costs for technologies such as wind and solar electricity generation – two technologies enabled by an integrated grid – are falling. An integrated grid, especially in the Western provinces, has more value than ever before.

Even as the business case for a more integrated grid makes more sense, the political debate lingers. Moving towards a more integrated grid requires provincial political buy-in; Canada's Constitution requires it. But the perception of creating "winners" and "losers" due to shifting electricity-related economic activity from one province to another, provincial treatment of electricity as a political tool, and provincial desires for electric self-sufficiency remain. Whether or not the need to lower emissions and changing power generation options can influence the political case as well as the economic one remains to be seen.

Moving to a more integrated grid faces other issues including how to:

- Fairly share the costs and benefits associated with developing a more integrated grid
- Harmonize regulatory and market rules to enable interprovincial electricity trade
- Address the social and environmental impacts associated with transmission infrastructure
- Ensure an integrated grid drives real emission reductions.

Canada's energy future will require significant changes to the ways Canadians produce and use energy to reduce emissions. The transformation will include widespread electrification – using electricity in place

> If entire countries such as the Nordic nations can surmount political and logistical hurdles, Western Canada can too.

of fossil fuels where possible. But for electrification to reduce emissions, Canada will need to produce much more clean electricity than it does today.

A more integrated grid can be a key tool to produce abundant clean electricity in a cost-effective way. When it comes to electric grids, bigger is often better. By creating geographically larger and more interconnected electricity systems, more integrated grids enable the cost-effective development and integration of high-value clean electricity resources. A more integrated grid increases the value proposition of clean electricity by enabling areas with substantial and low-cost clean electricity resources to access distant demand centres that would otherwise have to rely on more expensive electricity options.

A more integrated grid in Western Canada can also:

- Make it easier to manage large amounts of variable renewables like wind and solar on the grid by reducing the overall variability of these resources over the entire system. When the wind is not blowing in one place, it is probably blowing somewhere else.
- Increase the diversity of electricity resources, bringing together complementary resources that work better together. In the West, hydroelectricity and wind generation work synergistically.
- Share the infrastructure needed to meet peak demand and maintain reliability. Sharing these resources reduces waste and lowers overall costs for consumers.

We recommend that the Western provinces pursue a more integrated grid as a key tool to produce the abundant, reliable, affordable clean energy needed for their energy future.

A more integrated grid – particularly in the West where most of Canada's existing electricity emissions are created and some provinces have abundant and complementary clean electricity resources – can help achieve Canada's energy future at the lowest cost.

While a more integrated grid may require spending up front, it will save significant costs in the near- to long-term. If entire countries such as the Nordic nations can surmount political and logistical hurdles, Western Canada can too.

One way to overcome political barriers is by taking smaller, incremental steps towards a more integrated grid. A more integrated grid is not an all-or-nothing deal. While smaller steps may leave some of the benefits of a more integrated grid on the table, they are a positive move forward – and will cause less disruption to the status quo making them more politically palatable.

We recommend that the Western provinces:

- Participate in energy imbalance markets (EIM) – real-time markets that enable neighbouring grids to help each other balance short-term fluctuations in electric demand and supply. EIMs are key tools in cost-effectively integrating variable renewable generation. British Columbia and Manitoba already participate in EIMs with grids in the U.S. Alberta and Saskatchewan should follow suit.

- Strengthen regional transmission planning. The provinces already work with neighbouring grids to ensure their transmission systems deliver reliable power, but they do not place much emphasis on delivering low-cost power. The provinces should follow the example of European countries and many U.S. states to establish an organization, or formal co-operative agreement, to co-ordinate regional system planning with a mandate to develop transmission infrastructure that is reliable and economic on a regional basis.

- Build new transmission infrastructure. The Regional Electricity Cooperation and Strategic Infrastructure Initiative (RECSI) identified several transmission infrastructure projects that will reduce electricity costs and emissions under current system conditions.[1] The provinces should invest in these projects – and the federal government should help. Infrastructure projects that improve trade and those that reduce emissions fall under the Canada Infrastructure Bank's mandate.

- Put electricity on the interprovincial trade agenda. The provinces should stop exempting electricity from internal trade agreements and include electricity in the next workplan for the Regulatory Reconciliation and Cooperation Table – a body formed under the Canadian Free Trade Agreement to address regulatory trade barriers between provinces.

Canada's energy future will arrive no matter what. The choice Western Canada has now is how much it wants to pay for that future. A more integrated grid is a key tool to ensure the bill is as low as possible.

[1] GE Energy Consulting. "Western Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Study." Natural Resources Canada, August 2018.

— WE RECOMMEND —

The Western provinces pursue a more integrated grid as a key tool to produce the

abundant, reliable, affordable clean energy

needed for their energy future.

CANADA'S ENERGY FUTURE

All options on the table

Canada's energy future will be much different than what exists today.

As part of the Paris Agreement, Canada has committed to reducing greenhouse gas (GHG) emissions by 30 per cent (compared to 2005 levels) by the year 2030. Additionally, Canada's long-term climate strategy seeks to reduce GHG emissions by 80 per cent by 2050. Achieving these climate goals will require significant changes in the ways Canadians produce and use energy.

It is difficult to predict the future with absolute certainty, but trends, expert analysis and governmental policy objectives point to an energy future that relies on significant electrification – using electricity in place of fossil fuels where possible – as a key strategy to reduce emissions.[2,3] Promising examples include electric vehicles, space heating in buildings and low-heat processes in industry.[4]

To reduce emissions, however, the electricity that powers an electrification strategy needs to be clean. Using high-emitting sources of electricity will erode (or even reverse) the emission benefits of electrification (see text box, page 7).

Luckily, Canada has a head start. Eighty per cent of the country's electricity comes from zero-emission generation such as hydroelectric and nuclear generation.[5] But in the long term, this will not be enough. In 2016, Canadian electricity generation emitted 78 megatonnes of CO_2 equivalent.[6] Analyses of the least-cost pathways to achieve Canada's emission reduction goals suggest the electricity sector will need to reduce emissions to only six megatonnes of CO_2 equivalent by 2050 – a near total decarbonization of the electricity generating sector – while doubling or even tripling electricity supply as electrification takes place.[7,8] This will be an immense undertaking.

Provinces are already taking action. Alberta and Saskatchewan, which together accounted for 77 per cent of Canada's electricity-related GHG emissions in 2016, have committed to ambitious renewable electricity goals.[9] By 2030, Alberta aims for 30 per cent renewable electricity *generation* and Saskatchewan aims for 50 per cent renewable electricity *capacity*. Both provinces have taken other steps as well including carbon pricing and a cap on oilsands emissions in Alberta and carbon capture investments in Saskatchewan.

2 Dennis, Keith, Ken Colburn, and Jim Lazar. "Environmentally Beneficial Electrification: The Dawn of 'Emissions Efficiency.'" The Electricity Journal 29, no. 6 (2016): 52–58.

3 Canada. "Pan-Canadian Framework on Clean Growth and Climate Change." Environment and Climate Change Canada, 2016.

4 It should be noted that electrifying all energy uses is not without limit – many things such as high-heat processes in industry are not as easily amenable to electrification with current technologies.

5 Statistics Canada. "Table 25-10-0020-01 – Electric Power, Annual Generation by Class of Producer"

6 Environment and Climate Change Canada. "National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada." 2018.

7 Bataille, Chris, David Sawyer, and Noel Melton. Pathways to Deep Decarbonization in Canada. Sustainable Development Solutions Network, 2015.

8 Trottier Energy Futures Project. "Full Technical Report and Modelling Results." Canadian Academy of Engineering, April 2016.

9 Environment and Climate Change Canada. "National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada." 2018.

THE IMPORTANCE OF CLEAN ELECTRICITY FOR ELECTRIFICATION

As an example to illustrate the importance of clean electricity for the electrification strategy, consider the emissions benefit of switching from an internal combustion engine (ICE) vehicle to an electric vehicle in Western Canada today. The benefits will vary significantly among provinces due to their widely different generation mixes. In Manitoba and British Columbia, where hydroelectricity is dominant, the emissions associated with an electric vehicle are equivalent to an ICE vehicle with a fuel economy of 0.4 to 0.5 litres per 100 kilometres (approximately 461 to 616 miles per gallon).[10] In Alberta and Saskatchewan, the electric vehicle equivalent is an ICE vehicle with a fuel economy of 5.8 to 6.7 litres per 100 kilometres (approximately 35 to 41 miles per gallon) – more than 10 times worse in terms of emissions – due to the provinces' reliance on electricity generation from coal and natural gas.

KEY ELECTRICITY CONCEPTS

Generation versus capacity. Capacity is the maximum instantaneous output an electric generator (or other resource such as a battery) is *capable* of producing – not just what actually is produced. It is measured in watts (e.g., megawatts, gigawatts, etc.).

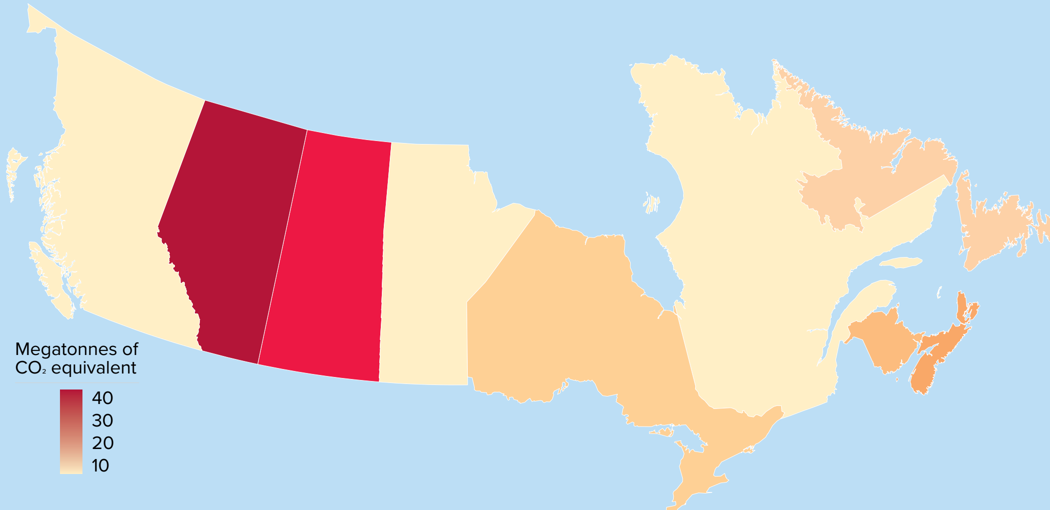
Generation is the amount of electricity an electric generator *actually* produces over a given period of time. It is measured in watt-hours. For example, a one megawatt (MW) generator producing electricity at full capacity for three hours would produce three megawatt-hours (MWh).

Capacity factor. A generator's capacity factor is the ratio of its actual generation to the amount of generation it could theoretically produce operating at full capacity. Generators never consistently run at full capacity. For example, they sometimes must be shut down for maintenance. Wind and solar generators will not run when the wind is not blowing or the sun is not shining. For this reason, actual generation is sometimes far lower than the capacity might suggest.

Levelized cost of electricity. The levelized cost of electricity is the per unit cost (e.g., $ per MWh) of electricity over the expected lifetime of the generating asset including capital costs and operating costs (e.g., fuel, maintenance, capital construction, etc.). It accounts for the expected capacity factor of generation technologies, allowing comparisons between generation types.

10 Logtenberg, Ryan, and Barry Saxifrage. "Comparing Global Warming Impacts of Electric and Gas Powered Vehicles by Electrical Region." 2 Degrees Institute, 2017.

FIGURE 1: PROVINCIAL ELECTRICITY GHG EMISSIONS (2016)



Source: Environment and Climate Change Canada. "National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada." 2018

Most of these provincial renewable goals are likely to be met with generation technologies such as wind and solar. Alberta and Saskatchewan boast some of the country's best solar and wind generation resources – two non-emitting generation technologies with rapidly falling costs. Since 2010, the globally weighted average levelized costs of utility-scale wind and solar have dropped 25 per cent and 73 per cent, respectively, and they are expected to continue declining.[11] Wind generation in Alberta has increased by 25 per cent per year on average since 2008, and the provincial government recently contracted 600 megawatts of wind generation at a weighted average price of 3.7 cents per kilowatt-hour – a record low price for renewable energy in Canada and far below the average cost of electricity in Alberta over the last decade.[12,13]

In the near term, deploying generation such as wind and solar is a cost-effective way to reduce electricity emissions. But over the long term, it will become increasingly difficult. Wind and solar generation are variable, meaning they are not continuously available. They only produce electricity when the wind blows or the sun shines.

Most modern-day electricity systems are not designed to accommodate significant amounts of variable electricity. As large amounts are added to the grid, it becomes more expensive to balance electricity supply and demand on both short (e.g., hourly, daily) to long-term (e.g., seasonal) timescales using traditional tools (see text box, page 9).[14] Grid design and operation must be part of the solution to maintain both affordable and reliable electricity supplies while meeting emission goals.[15] In the West, this means creating a more integrated grid – one that is more interconnected, more optimized and more co-ordinated on a regional (as opposed to provincial) scale.

11 IRENA. "Renewable Power Generation Costs in 2017." International Renewable Energy Agency, 2018.

12 Statistics Canada. Table 25-10-0020-01 Electric power, annual generation by class of producer.

13 The average cost of electricity in Alberta between 2008 and 2017 was 5.3 cents per kilowatt-hour (AESO 2017 Market Statistics Report).

14 Shaner, Matthew R., Steven J. Davis, Nathan S. Lewis, and Ken Caldeira. "Geophysical Constraints on the Reliability of Solar and Wind Power in the United States." Energy & Environmental Science 11, no. 4 (2018): 914–925.

15 Sepulveda, Nestor A., Jesse D. Jenkins, Fernando J. de Sisternes, and Richard K. Lester. "The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation." Joule, September 6, 2018.

MANAGING VARIABILITY ON THE GRID AND THE CHALLENGE OF INTEGRATING LARGE AMOUNTS OF RENEWABLES

Electricity is a "just-in-time" commodity – it must be supplied to the grid at the same time it is consumed. If electricity supply and demand become unbalanced, blackouts can occur as well as physical damage to the grid and the machinery connected to it.

Maintaining this balance is not easy. Over short periods of time, electricity demand can diverge from forecasts, and powerplants and transmission lines can unexpectedly go offline. At all times, grid operators must maintain enough reserve capacity capable of responding to these fluctuations to ensure reliability. Over longer periods of time, grid operators must ensure there is enough capacity to supply peak demand – something that happens only a handful of times per year, meaning much of this capacity can sit idle throughout the year.

Variable generation adds to this balancing act. Like demand, it cannot be perfectly predicted (although forecasting is getting better) so grid operators must have adequate reserve capacity to respond to fluctuations in supply. At low levels of variable renewables on the grid, existing reserve capacity is generally adequate, but the challenge becomes more pronounced at higher levels.

Take California, for example. The state has developed significant solar generation, and in April 2018 set a state record for solar electricity production (one that has subsequently been broken). Figure 2 shows the generation profile for the California Independent System Operator (CAISO) – the state's largest grid operator – for that day. As can be seen, solar electricity floods the grid during daylight hours, which the grid operator accommodates by reducing electricity from other sources (e.g., electricity imports and thermal power generation such as natural gas, biomass and geothermal). At some points, so much solar energy is produced that some must be curtailed – or wasted – because there is too much electricity on the grid. Later in the day when the sun sets, large amounts of resources that sat idle during the day must be quickly brought back online to fill the gap.

Curtailing electricity, rapidly ramping power plants up and down, and having a lot of capacity sit idle is expensive – and these problems only increase as more variable renewables are deployed. But with the levelized costs of generation such as wind and solar becoming so low, grid operators and policy-makers are keen to find the best suite of tools to address these issues.

Traditionally, the tool of choice has been flexible generation – power plants that can be ramped up and down on command. In the California example, thermal generation and imports from neighbouring grids (likely flexible generation as well) fill this role. In general, natural gas, hydroelectricity and geothermal generators are well-suited to perform this role.[16] But the GHG emissions associated with natural gas generation and the locational-dependency of hydroelectricity and geothermal generation has grid operators and policy-makers looking for other options. Hydroelectric dams must be built on rivers where sufficient water is available, the geological structure can support the infrastructure, and the location can sustain an appropriate reservoir. Geothermal electricity generation requires access to sufficiently hot geothermal reservoirs in the Earth's crust that do not exist everywhere.

Other tools include electricity storage and flexible demand. Pumped-storage hydroelectricity is an old storage technology that is used in many places around the world and is the predominant form of electricity storage today. Emerging technologies such as large-scale batteries are becoming less costly.[17] These resources can store electricity and later inject it back into the grid on short notice. While these tools will play an important role in the energy future, they will not be a magic bullet. Electricity storage such as pumped-hydro is location-dependent just like →

16 Coal and nuclear generation can also be ramped up and down but generally suffer from greater inefficiencies and wear-and-tear when operated in this manner. These types of generators are often operated at a constant level.

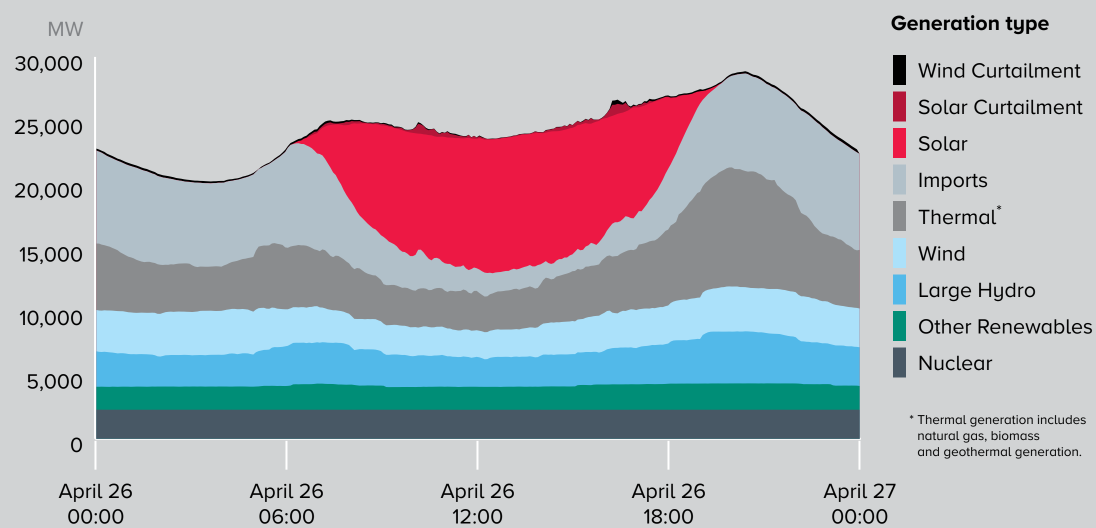
17 IRENA. "Electricity Storage and Renewables: Costs and Markets to 2030." International Renewable Energy Agency, 2017.

hydroelectric dams. Other options, such as batteries, can be costlier than competing options depending on their application.

Flexible demand resources are also becoming more prevalent. They allow grid operators and consumers to work together to adjust electricity consumption in response to grid imbalances. In New York City, for example, households can receive payments for allowing the electricity utility to temporarily reduce their air conditioner output to reduce electricity demand. Flexible demand is valuable, but also unlikely to be enough on its own to solve these problems.

Ultimately, all of these tools will have a role in the future electricity grid, but their limitations underscore the importance of considering all options available to provide affordable, reliable and clean energy. A larger, more integrated grid is one such option.

FIGURE 2: ELECTRIC GENERATION PROFILE FOR CALIFORNIA INDEPENDENT SYSTEM OPERATOR ON APRIL 26, 2018



Source: CAISO Production and Curtailment Report

BIGGER IS BETTER

Why a more integrated grid makes sense

When it comes to electric grids, bigger is better. Most research today suggests that a key component of cost-effectively decarbonizing electricity is by building larger and more interconnected electricity grids.[18]

A seminal study of the U.S. electricity sector found CO_2 emissions from electricity generation in the U.S. could decrease by up to 80 per cent below 1990s levels without increasing the levelized cost of electricity, through the extensive expansion and interconnection of the country's electrical grid, coupled with the development of the country's most high-value clean electricity resources.[19] A study by the National Renewable Energy Laboratory evaluated a number of different scenarios to expand and interconnect the U.S. grid and found every single one reduced electricity costs by more than the cost of added transmission.[20]

These findings hold true in Canada as well where studies have shown increasing transmission capacity between provincial grids reduces the cost of decarbonizing electricity. Researchers at the University of Ottawa modelled the least-cost pathways for decarbonizing Canada's electricity sector and found scenarios with increased interprovincial transmission capacity reduced the overall cost of achieving emission reductions compared to scenarios where interprovincial electricity trading does not increase.[21] Researchers at the University of Victoria found that increasing transmission capacity between Alberta and British Columbia would lead to reduced costs under emissions-constrained scenarios.[22] The Canadian Energy Research Institute (CERI) also modelled the economic impacts of reducing emissions in Western Canada's electricity sector and found the overall cost was lower under scenarios with expanded grids.[23] Most recently, a study commissioned by Natural Resources Canada found that several improvements to transmission capacity in the West could both reduce emissions and electricity costs.[24]

So why are bigger grids better? By creating geographically larger and more interconnected electricity systems, more integrated grids enable the cost-effective development and integration of high-value clean electricity resources.

18 Bird, Lori, and Michael Milligan. "Lessons from Large-Scale Renewable Energy Integration Studies." In World Renewable Energy Forum, Denver, Colorado, 2012.

19 MacDonald, Alexander E., Christopher TM Clack, Anneliese Alexander, Adam Dunbar, James Wilczak, and Yuanfu Xie. "Future Cost-Competitive Electricity Systems and Their Impact on US CO 2 Emissions." Nature Climate Change 6, no. 5 (2016): 526.

20 Bloom, Aaron. "Interconnections Seam Study." TransGrid-X Symposium, July 26, 2018. https://www.nrel.gov/docs/fy18osti/72069.pdf.

21 Dolter, Brett, and Nicholas Rivers. "The Cost of Decarbonizing the Canadian Electricity System." Energy Policy 113 (2018): 135–148.

22 English, J., T. Niet, B. Lyseng, K. Palmer-Wilson, V. Keller, I. Moazzen, L. Pitt, P. Wild, and A. Rowe. "Impact of Electrical Intertie Capacity on Carbon Policy Effectiveness." Energy Policy 101 (2017): 571–581.

23 Doluweera, Ganesh, Hossein Hosseini, and Evar Umeozor. "Economic and Environmental Impacts of Transitioning to a Cleaner Electricity Grid in Western Canada." Canadian Energy Research Institute, 2018.

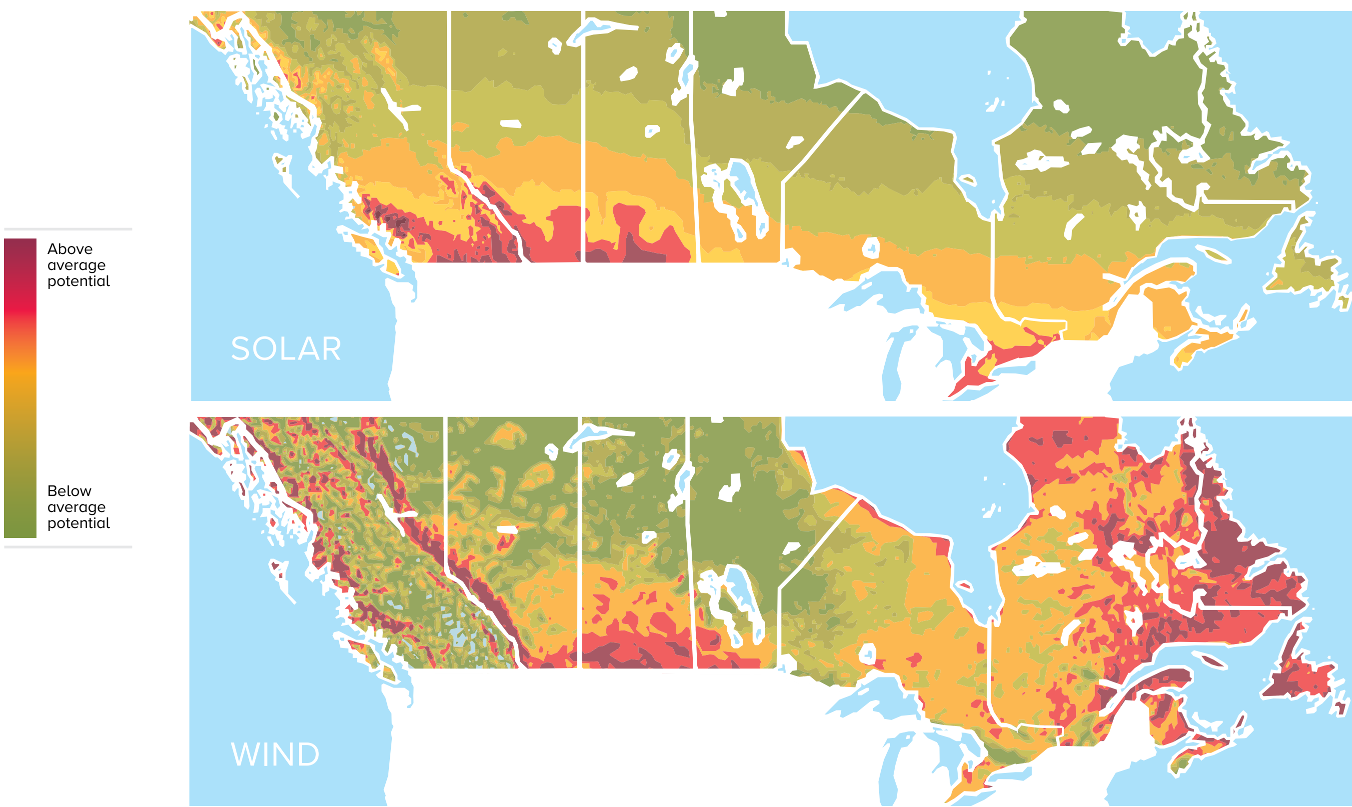
24 GE Energy Consulting. "Western Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Study." Natural Resources Canada, August 2018.

The value of electricity depends on two things – its cost and the cost of the electricity it replaces. The less the electricity costs and the costlier the electricity it replaces, the more valuable it becomes. A more integrated grid increases the value proposition of clean electricity by enabling areas with substantial and low-cost clean electricity resources to access distant demand centres that would otherwise have to rely on more expensive electricity options.

The cost of clean electricity such as hydroelectricity, geothermal, wind and solar is location-dependent – it relies on local geology and weather patterns. The full development of the lowest-cost areas for these sources may quickly overwhelm nearby demand leaving no place for the surplus electricity to go – effectively stranding otherwise low-cost clean electricity resources. With access to more markets, these low-cost options can displace costlier generation. They can also benefit from economies of scale – building more and larger generation units (e.g., turbines, solar panels, geothermal wells) in a given area than would otherwise be possible, making it more economical to connect them to the transmission system among other efficiencies.

In terms of undeveloped clean electricity resources, the southern Prairies offer large areas that are both windy and receive a lot of sunlight (see Figure 3.) British Columbia also has significant wind resources. A more integrated Western grid can ensure these resources are not left stranded in the future.

FIGURE 3: CANADIAN WIND AND SOLAR POTENTIAL



Source: Adapted from the VAISALA Global Wind Dataset 5km onshore wind speed at 80m and the VAISALA Global Solar Dataset 3km with units in Watts per square metre per day

More integrated grids also:

Reduce the variability of renewable resources. Solar and wind generation rely on the weather, which can be highly variable. But over greater geographic areas, the overall variability of weather decreases, which translates to less variability.[25] If it is not windy in one part of the region, it is likely windy somewhere else.[26] With solar, the duration and peak of aggregate solar generation across a larger region is smoothed over a longer period of daylight.[27] Reducing variability lowers the cost of managing large amounts of variable renewables on the grid.

Increase the diversity of electricity resources. Expanding the grid will bring together a more diverse group of electricity resources. This can improve supply security by making the grid less exposed to shortages of a specific type of generation (e.g., hydroelectricity due to low rainfall, solar/wind due to weather, fossil fuels due to fuel supply constraints).

In the West, a more integrated grid would bring together diverse and complementary clean energy resources. For example, in Manitoba wind pairs well with hydroelectricity. Low-cost wind is used when it is available, and flexible zero-emission hydroelectricity fills the gaps. Manitoba is already capitalizing on this synergy with its U.S. neighbours. The Midcontinent Independent System Operator (MISO) – the grid operator covering multiple states in the Midwest U.S. – evaluated the benefits of better integrating Manitoba's hydroelectric generation with extensive wind resources in the U.S. through increased transmission capacity. It found that the diversity helped create billions of dollars in benefits because it reduced U.S. wind curtailment by providing better access to additional markets (e.g., Manitoba) for excess wind energy, and Manitoba's hydroelectricity displaced more expensive options when wind generation was low.[28]

Share peak-demand resources. The need to have enough electric capacity to meet peak demand, something that happens only a handful of hours each year, is expensive. When electricity demand is below its peak, this extra capacity sits idle.

Electricity demand tends to peak at different times across larger geographic areas – especially when these areas stretch east and west over different time zones.[29] By smoothing out the grid's demand profile, grids operating over greater geographic areas allow peak-demand resources that would otherwise sit idle to be shared. This reduces the need to build and maintain peak-demand capacity, which reduces the overall cost of meeting peak demand.

Share grid reliability resources. In addition to peak-demand requirements, the grid must also have enough resources to respond to short-term or unexpected electricity imbalances. And like peak-demand resources, grid reliability resources can also be shared across a wider area thereby requiring less infrastructure and saving ratepayers money. Random fluctuations in energy demand (and variable renewable supply) as well as unplanned power plant outages are generally uncorrelated across large geographic areas, meaning the amount of reserve capacity needed for a grid does not increase proportionally with grid size, and by sharing these resources grid operators are able to split the cost of a smaller pie.

25 Nastrom, G. D., K. S. Gage, and W. H. Jasperson. "Kinetic Energy Spectrum of Large- and Mesoscale Atmospheric Processes." Nature 310, no. 5972 (1984): 36.

26 Handschy, Mark A., Stephen Rose, and Jay Apt. "Is It Always Windy Somewhere? Occurrence of Low-Wind-Power Events over Large Areas." Renewable Energy 101 (2017): 1124–1130.

27 Mills, Andrew, and Ryan Wiser. "Implications of Wide-Area Geographic Diversity for Short-Term Variability of Solar Power." Lawrence Berkley National Laboratory, 2010.

28 Bakke, Jordan, Zheng Zhou, and Sumeet Mudgal. "Manitoba Hydro Wind Synergy Study." MISO, 2013.

29 In some places, peak electricity demand usually occurs on the hottest days of the year when air conditioning use ramps up. In colder climates like Western Canada, peak demand often occurs on the coldest days of the year when electricity for heating and lighting are required (although recent research suggests Western Canada may become summer peaking in the not-too-distant future). See: Rivers, Nicholas, and Blake Shaffer. "Stretching the Duck's Neck: The Effect of Climate Change on Future Electricity Demand," June 12, 2018. Munich Personal RePEc Archive. https://mpra.ub.uni-muenchen.de/87309/1/MPRA_paper_87309.pdf.

Manitoba Hydro has already established agreements with MISO to exchange contingency reserves (a subset of reliability resources needed to operate the grid) with each other – resources required to fill the gap when unexpected generation or transmission outrages occur.[30] For Manitoba Hydro, the cost-saving benefits of its contingency reserve agreement with MISO are estimated at up to $100 million per year.[31] Likewise, grid operators in British Columbia and Alberta both participate in the Northwest Power Pool Reserve Sharing Program.

Reduce negative impacts. A more integrated grid can help reduce the environmental and social impacts of existing and future electricity generation. Access to additional grid resources through an expanded grid can give grid operators more flexibility to reduce negative impacts associated with maintaining electricity supply. For example, the operational choices controlling hydroelectric dams can cause significant downstream impacts due to the cyclical release and impoundment of rivers' natural flows. While these choices are generally made to avoid detrimental downstream impacts, it may not always be possible to avoid all impacts.

In Saskatchewan, for example, the Cumberland House Cree Nation is asking for the reexamination of impacts resulting from the operation of the E.B. Campbell dam, which is located roughly 100 kilometres upstream from their community.[32] Provincial electricity demand sometimes requires the release of water that causes water levels to rapidly increase and decrease, which can have serious effects on the river ecosystem and communities.

A more integrated grid could help mitigate these impacts by providing more seasonal flexibility to the system and allow generation such as the E.B. Campbell dam to operate in a less impactful way. Additionally, a more integrated grid provides more options for future generation needs allowing less impactful generation to be chosen over more impactful options.

The risks of pursuing a more integrated grid

The cost-effectiveness of a more integrated grid is not guaranteed. There are limits to the benefits better integration can create, and costs compared to competing options are not always superior. The studies evaluating these options make many assumptions, including the future costs of electricity resources, which may turn out to be wrong. For example, if transmission costs are higher and/or storage costs are lower than assumed, other options may be more cost-effective. A more integrated grid is one of several options. Advances in electricity storage, distributed generation and other technologies are creating viable non-wired alternatives to many electricity needs.

Yet the best information we have today points towards a more integrated grid being a key, but not the sole component of the most cost-effective path towards decarbonized electricity. New technologies, including those that are unanticipated today, will play a role in decarbonizing Canada's electricity sector. But in the meantime, integrating the grid will enable the more efficient use of current and some new technologies.

[30] FERC. "Order Accepting Coordination Agreement." Docket No. ER10-54-000. Federal Energy Regulatory Commission, December 29, 2009.

[31] Cormie, A. David. "Wholesale Electricity Concepts." MB Hydro, May 2010. https://www.hydro.mb.ca/regulatory_affairs/electric/gra_2010_2012/Appendix%2056-Attachment_3.pdf.

[32] Galloway, Gloria. "Saskatchewan First Nation Demands Consultation in Relicensing of Dams." Globe and Mail, October 30, 2017.

AN INTEGRATED GRID

is more than just transmission lines

While bigger is better, a more integrated grid is not just about building more transmission lines – although these are important. It is about enabling an electricity system that can be optimized and co-ordinated on a larger scale. This will require physical infrastructure, and it will also require a system where electricity resources are traded and generation capacity is developed when and where it makes economic sense – regardless of jurisdictional boundaries.

The studies cited in the previous section generally make this crucial assumption in demonstrating the benefits of a more integrated grid. They show that increased transmission capacity can enable cost-effective emission reductions as long as the region's grids operate together efficiently. In reality, the regulatory and market regimes governing provincial electricity grids create frictions that inhibit the efficient trade and development of electricity resources between jurisdictions. Electricity is a highly regulated commodity with much of the sector operated as a regulated monopoly depending on the province. Many decisions such as when and where to operate and build electricity assets are made administratively or through organized markets.

For these reasons, unlocking the benefits of a more integrated Western grid must address three intertwined issues – regional **interconnectedness**, **optimization** and **co-ordination**. An integrated grid will require transmission infrastructure (interconnectedness) as well as the regulatory and market mechanisms to allow electricity system optimization and co-ordination across provincial boundaries. Under this framework, an integrated Western grid will be:

→ **Regionally interconnected.** The physical infrastructure (i.e., transmission capacity and associated infrastructure) in place to enable the efficient trade of electricity resources between jurisdictions.

→ **Regionally optimized.** Electricity resources *operated* in the most cost-effective manner possible regardless of provincial boundaries. The mechanisms governing the procurement and dispatch of electricity resources select the most economic resources to fulfill electricity demand regardless of their jurisdictional location.

→ **Regionally co-ordinated.** Electricity resources *planned and developed* in the most cost-effective manner possible regardless of provincial boundaries. The aspects of the electric system that are centrally planned and co-ordinated consider and incorporate interprovincial solutions.

These three characteristics are interdependent. The value of regional interconnectedness is influenced by the degree of regional optimization and co-ordination.[33] A more regionally optimized and co-ordinated grid will increase the value of increased interconnectedness on a per-megawatt basis. Likewise, the lack of adequate regional interconnectedness can limit the value of regional optimization and co-ordination. Even with appropriate mechanisms in place, if the transmission capacity does not exist to facilitate optimal electricity trade, then it will not occur. Any one, without the others, will result in failure.

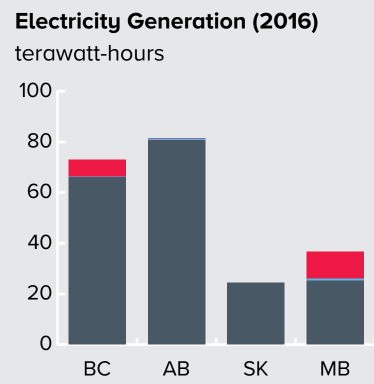
THE WEST'S ELECTRICITY LANDSCAPE

Understanding the benefits, barriers, and implementation of a more integrated grid in the West is aided by understanding the type of electricity currently being generated and how the provinces structure their electricity sectors to provide affordable and reliable electricity.

Total generation

The provinces generate varying amounts of electricity. Most of it is consumed internally, while some is exported.

- exports to other provinces
- net generation
- exports to U.S.

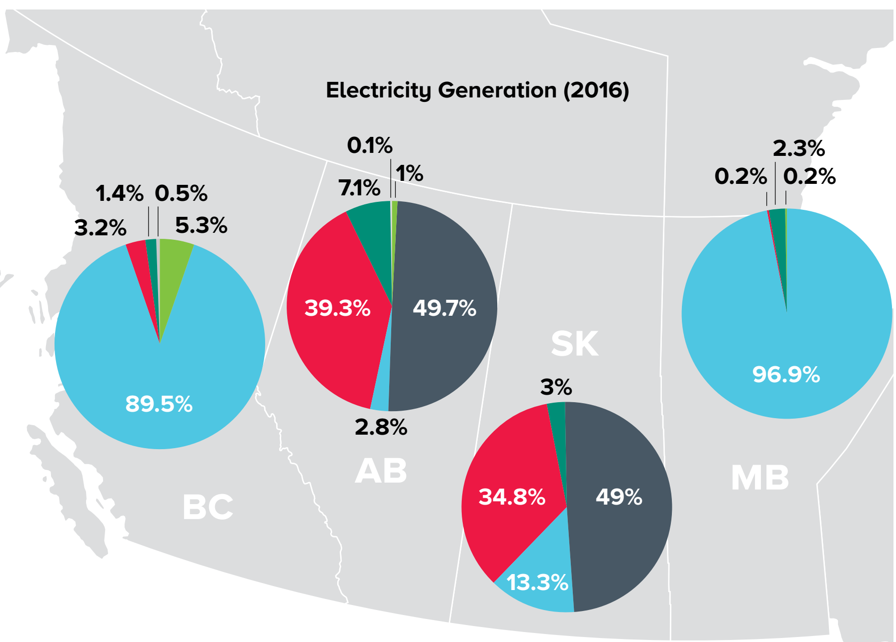


Source: Statistics Canada. Table 25-10-0021

Generation mix

The provinces have varying generation mixes with British Columbia and Manitoba dominated by hydroelectricity and Alberta and Saskatchewan relying on fossil-fuel generation.

- hydroelectricity
- coal
- natural gas
- non-hydro renewables
- biomass
- other



Source: Statistics Canada. Tables 25-10-0020 and 25-10-0028

[33] Carr, Jan. "Power Sharing: Developing Inter-Provincial Electricity Trade." C.D. Howe Institute, July 2010.

Alberta and the rest of the West

When it comes to providing reliable electricity at reasonable costs, the Western provinces are not all alike. Three of them – British Columbia, Saskatchewan and Manitoba – organize their electricity sectors much differently than Alberta. These differences influence how the decisions that ultimately shape each province's electricity sectors are made – making them important to understand in the context of moving the Western provinces towards a more integrated grid.

HOW THE WESTERN PROVINCES ORGANIZE THEIR ELECTRICITY SECTORS		
	ALBERTA	**REST OF THE WEST** (British Columbia, Saskatchewan, Manitoba)
How the electricity sector is organized	**Restructured market model**	**Vertically integrated model**
	Generation is unbundled from electric utilities. Private entities compete to provide electricity generation and other services through organized markets. Alberta currently operates an "energy-only" market where generators compete to deliever energy into the system and are only compensated for the energy delivered. Transmission and distribution services are provided by utilities on a cost-of-service basis.	Electric utilities control all parts of the electricity supply chain including generation, transmission and distribution services. They operate as regulated monopolies. The government gives them sole responsibility and right to procure and sell generation – along with the necessary transmission and distribution infrastructure to deliver the electricity in their defined service territories. In exchange, the government (or its agent) regulates the rates the utility charges on a cost-of-service basis.
Who manages the market?	**Alberta Electric System Operator** (AESO)	**BC: BC Hydro**[ii] | **SK: SaskPower** | **MB: Manitoba Hydro**
	With a restructured market model, the responsibility for providing reliable and affordable electricity generally falls to an independent system operator such as AESO.	Each province is primarily served by a single provincially owned electric utility.
Their responsibilities	AESO fulfills its responsibility by: • Serving as Alberta's balancing authority* • Managing and operating energy markets that deliver reliable electricity to customers at the lowest possible cost • Planning for the future needs of the province's electricity system by developing long-term transmission plans	Each utility is responsible for providing reliable and affordable electricity to its customers. They fulfill this responsibility by: • Serving as their province's balancing authority* [iii] • Planning for future needs by developing long-term resource plans
How they work	Through the energy-only market, private entities are incentivized to build generation capacity if they believe they can make a financial return selling electricity in the future. The goal is to ensure adequate generation capacity over the long-term. However, to provide greater resource adequacy assurance, AESO is transitioning to a capacity market framework. Under this system, generators will also compete and be compensated for their *ability* to supply electricity in addition to actual energy delivered.[i] For transmission, AESO produces a Long-Term Transmission Plan every two years, which outlines anticipated needs for the next 20 years. When AESO identifies the need for additional transmission infrastructure, it coordinates the process of selecting a proponent to build, own and operate the infrastructure.	Long-term resource plans detail how the responsible utility will serve expected future demand. These plans may include conservation efforts, new generation and transmission infrastructure, upgrades to existing infrastructure, and other resources (e.g., demand-side management). Ideally, these plans will consider all possible ways to meet future demand and select the most economically efficient options.
How the electricity sector is regulated	REGULATOR **Alberta Utilities Commission** (AUC)	REGULATOR **British Columbia Utilities Commission**, BC **Saskatchewan Rate Review Panel**, SK **Manitoba Public Utilities Board**, MB
	MINISTRY **Alberta Energy**	MINISTRY **Ministry of Energy, Mines & Petroleum Resources,** BC **Provincial Cabinet and Crown Investments Corporation of Saskatchewan**, SK **Department of Natural Resources**, MB
	The AUC provides regulatory oversight for the AESO. It may review and hear objections regarding rules developed by AESO. The AUC also has jurisdiction over approving specific transmission infrastructure projects and their applicable rates, as well as the rates charged by distribution utilities in the province. Electricity sector stakeholders including AESO, generators, and transmission and distribution utilities are under the purview of Alberta Energy.	Each province has an independent regulator to ensure consumers receive safe and reliable service at fair and reasonable rates. These regulators typically review and approve the utilities long-term resource plans. The utilities are also under the jurisdiction of their provincial governments, which may implement policies and regulations impacting their operations.

* A *balancing authority* ensures electricity supply and demand are in balance at all times, which includes managing the import and export of electricity to and from other balancing authorities.

[i] Notes: Under both competitive market types, AESO also operates a smaller ancillary services market to provide the services necessary to maintain adequate voltage and frequency levels (e.g. operating reserves, black-start services).

[ii] British Columbia has several smaller utilities besides BC Hydro including Fortis BC, which serves over 200,000 customers in the Kootenay region, and some other small municipal utilities.

[iii] Manitoba Hydro shares balancing authority responsibilities with the Midwest Independent System Operator (MISO) through a reliability co-ordination agreement.

THE STATE OF
Western grid integration

The state of Western grid integration is best described as poor.

Previously cited studies all find there is not enough interconnecting transmission capacity among provincial electricity grids to cost-effectively decarbonize the electricity sector. Comparing interprovincial with interjurisdictional electricity trade highlights the issue. The Western provinces have far greater capability to trade electricity resources with neighbouring U.S. states compared to neighbouring provinces. In total, there is three times more province-to-U.S. transmission capacity than province-to-province transmission capacity (see Figure 4, page 19).[34] In 2016, the four Western provinces collectively exported nearly 20 terawatt-hours of electricity to other jurisdictions. Of this amount, 90 per cent was exported to the United States – only 10 per cent went to another Canadian province.[35]

The degree of existing regional optimization and co-ordination in the West is harder to quantify but can be assessed by looking at provincial electricity market structures, regulatory and market rules and electric system planning mechanisms. Carve-outs in interprovincial trade agreements suggest electricity optimization and co-ordination has not been a high priority.

Diverging electricity sector structures

In the West, every province except for Alberta is dominated by provincially owned, vertically integrated utilities. These Crown corporations are responsible for the generation, transmission and distribution of electricity within their service territories, and as regulated monopolies, they do not compete to provide these services. Instead, prices are regulated by the government (or its agent) on a cost-of-service basis. Alberta, on the other hand, operates an open and competitive organized market for electricity generation. Private companies compete to generate electricity. Most transmission and distribution services, however, are still provided on a regulated cost-of-service basis by regulated utilities. The Alberta Electricity System Operator (AESO) manages this market and ensures electricity demand is met with reliable supply.

[34] This was calculated by comparing the sum of the average of the import and export capacity (which is not always the same) between provinces and U.S. states and between provinces and other provinces.

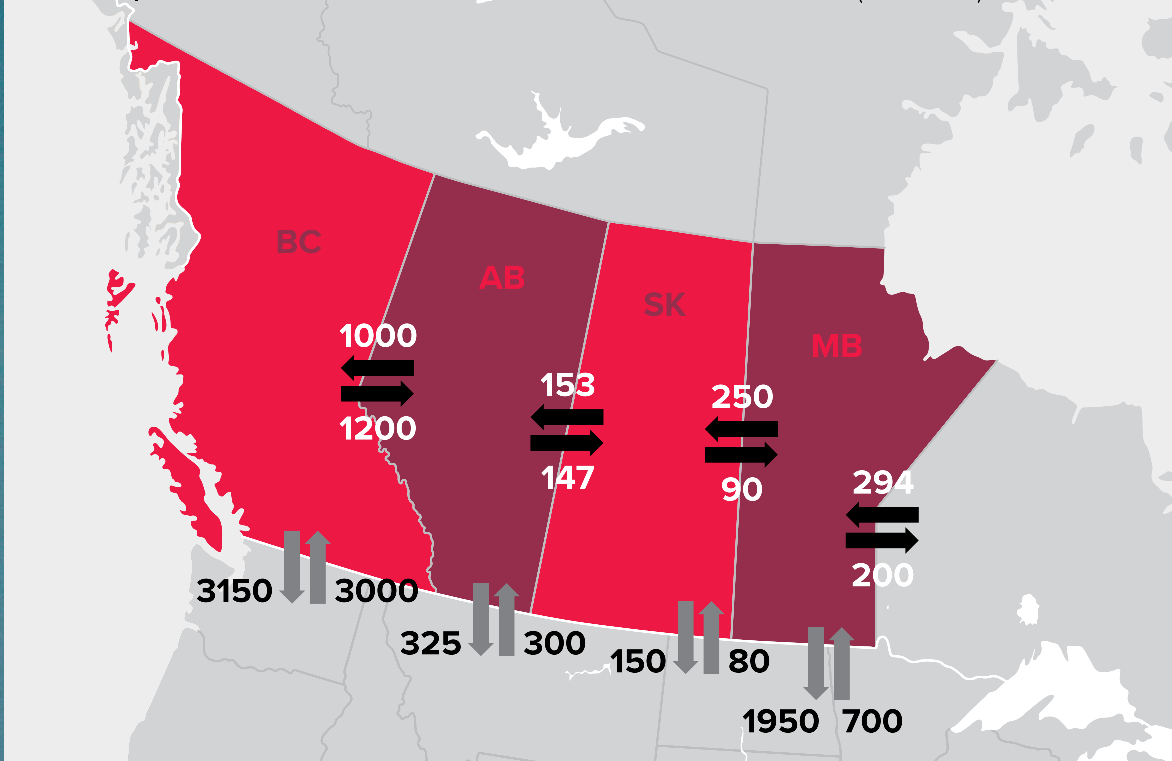
[35] Statistics Canada. Table 25-10-0021-01 Electric power, electric utilities and industry, annual supply and disposition

ASYNCHRONOUS GRIDS, ALTERNATING VERSUS DIRECT CURRENT TRANSMISSION

An important technical consideration in moving towards a more integrated grid is the fact that the provinces on either side of the Alberta-Saskatchewan border are part of different synchronous grids.[36] British Columbia and Alberta are part of the Western Interconnect, while Saskatchewan and Manitoba are part of the Eastern Interconnect. Their grids do not operate synchronously, meaning the generators connected to each system do not operate at the same frequency and speed – a prerequisite for a stable and reliable alternating-current grid.

For this reason, the two grids cannot directly connect to each other through alternating-current (AC) transmission lines. Instead, they must be connected by direct current (DC) transmission links, which require additional infrastructure and costs to convert electricity from AC to DC and back to AC again. However, due to lower per-kilometre costs and lower line losses, high-voltage DC transmission lines can be economical over long distances.

FIGURE 4: INTERPROVINCIAL AND INTERNATIONAL ELECTRIC TRANSMISSION CAPACITY (MEGAWATTS)



Source: Adapted from Natural Resources Canada Submission to House of Commons Standing Committee on Natural Resources, September 20, 2017

Notes: All figures are in megawatts and are approximate.

Due to grid constraints, the simultaneous amount of electricity that Alberta can import from British Columbia and Alberta is limited to 1100MW, despite the higher combined rating.

There is currently a transmission line between Saskatchewan and Manitoba under construction that is expected to increase transfer capability by 300MW.

There is a proposed transmission line between Manitoba and Minnesota that is expected to increase transfer capabilty by 750MW.

36 A synchronous grid is one in which all generators connected to the system operate at the same frequency and speed (e.g., current alternates in the same direction at the same rate).

In 2016, the four Western provinces collectively exported nearly 20 terawatt-hours of electricity to other jurisdictions. Of this amount, 90 per cent was exported to the United States – only 10 per cent went to another Canadian province.

These different market structures can create frictions that hinder efficient electricity trade across provincial boundaries for several reasons.[37] Crown corporations, by virtue of being provincially owned, may face competing priorities that lead to economically inefficient decisions. They have both an economic incentive to maximize revenues and a political incentive to maintain low rates. Additionally, provincial utility ownership can induce other financial distortions that are less common in privately owned utilities. For example, Manitoba Hydro is not allowed by law to include a rate of return on capital expenditures – artificially depressing prices for consumers.[38]

With Alberta's competitive market structure, neighbouring provincial utilities such as BC Hydro can sell electricity into Alberta's market, and private generators in Alberta can sell electricity to their provincial neighbours – if BC Hydro is willing to buy it. Market efficiencies benefit, however, when there are many buyers and sellers of a product. The mismatch in market power between Alberta-based private generators and provincial Crown corporations may lead to inefficient transactions.

Regulatory and market rules

Provincial electricity regulatory and market rules can also diminish the efficient optimization and co-ordination of the region's electricity system. While a full review of all rules is beyond the scope of this report, these are a few examples that highlight current rules that can add to trade frictions:

- British Columbia's *Clean Energy Act* requires BC Hydro to hold "the rights to an amount of electricity that meets the electricity supply obligations solely from electricity generating facilities within the Province."[39] With this resource adequacy requirement in place, British Columbia can still buy and sell electricity when it makes economic sense, but it is limited in the capacity resources it can share with its neighbours – even when it might be more cost-effective. It must maintain enough resources to meet the obligation regardless if external resources could provide it more economically.

37 Pineau, Pierre-Olivier. "Canadian Electricity Structure and Impact on Pricing, Trade and Environment»." Geopolitic of Energy, 2007.

38 Pineau, Pierre-Olivier. "Fragmented Markets: Canadian Electricity Sectors' Under-performance." In Evolution of Global Electricity Markets, 363–392. Elsevier, 2013.

39 *Clean Energy Act*, SBC 2010, c 22, s 6.

→ In Alberta, the Alberta Electric System Operator (AESO) market rules only allow the scheduling of electricity imports and exports on an hourly basis.[40] The schedule begins on the hour, every hour, and electricity that is scheduled is generally not allowed to fluctuate during that hour. This means that generation from outside the province cannot respond to intra-hour fluctuations in electricity demand or supply – something that will become more important as more variable generation is added to the system. Additionally, AESO restricts the types of allowable bids for imports and exports, requiring them to be "price-takers," which could further disincentivize electricity cross-border trade.[41]

System planning

Most of the West's electricity system is centrally planned, yet there is little sustained co-ordination between provincial electricity planning authorities. In Alberta, competitive market forces are the primary driver of generation investment decisions, but transmission investments are still primarily directed through a centralized planning process conducted by the AESO. The AESO develops and maintains a Long-Term Transmission Plan and identifies transmission needs in the province. In the other three provinces, generation and transmission investment decisions are made by the utilities through centrally administered long-term resource plans. The utilities decide what electricity generation and transmission capacity is procured. Regulators usually oversee this process, but in some cases it may be bypassed for political purposes.[42]

While there is a high degree of centralized transmission planning *within* provinces, there is little co-ordination *between* provinces in planning the development of transmission infrastructure beyond ensuring transmission decisions do not impact regional reliability. There is no formal organization or agreement between provincial authorities to optimize investment decisions that reduce electricity costs across provincial boundaries. Provincial organizations responsible for transmission planning generally create plans to optimize the electricity systems within their own territories without significant collaboration with neighbouring jurisdictions. Instead, these organizations fulfill their planning responsibilities with mostly internal measures, which can lead to missed opportunities for economically beneficial inter-regional transmission investments.

Provincial trade agreements

Formal interprovincial trade agreements do not address electricity. In the Canadian Free Trade Agreement (CFTA), electricity is mostly exempted. While there are provisions that address electricity transmission services, these provisions will not enter into force unless Quebec or Newfoundland and Labrador provide such notice.[43] Furthermore, the CFTA creates a framework to address regulatory barriers across myriad industries that are not explicitly included in the agreement. One part of this framework is a regulatory reconciliation process whereby trade barriers can be identified, studied and reconciled between provinces.[44] Provinces submit regulatory issues to the Regulatory Reconciliation and Cooperation Table (RCT) – a "federal-provincial-territorial body established by the CFTA to oversee the regulatory reconciliation process and promote regulatory cooperation across Canada." The 2018-2019 RCT workplan includes 23 different regulatory matters brought by various provinces, but none are related to electricity.[45]

In the West, the New West Partnership Trade Agreement states that "parties shall work toward improving existing arrangement and promote enhanced interjurisdictional trade in energy" but offers no concrete rules or ways to achieve this.[46]

[40] Mascarenhas, Karen. "CERI Electricity Report: Interprovincial Electricity Trade: The British Columbia-Alberta Intertie." Canadian Energy Research Institute, March 2017.

[41] Note: AESO rules require imports and exports to bid at the market's maximum and minimum allowable bid prices, respectively. Generators typically bid into Alberta's market at their marginal cost (i.e., the lowest price they can accept to not lose money when providing electricity). Restricting this ability for imports and exports may reduce their willingness to participate in the market.

[42] *Clean Energy Act*, SBC 2010, c 22, s 7.

[43] Canadian Free Trade Agreement. Annex 309, Section 1(a). 2017.

[44] Canadian Free Trade Agreement. "Regulatory Reconciliation Backgrounder," April 7, 2017. https://www.cfta-alec.ca/wp-content/uploads/2017/06/CFTA-regulatory-reconciliation-backgrounder.pdf.

[45] RCT. "List of Items Included in the 2018-2019 Work Plan." Regulatory Reconciliation and Cooperation Table (RCT), July 20, 2018. https://www.cfta-alec.ca/wp-content/uploads/2018/07/RCT-2018-2019-Work-Plan-List-of-Measures-Final-July-20-2018.pdf.

[46] New West Partnership Trade Agreement. 2010.

THE POLITICS
of a more integrated grid

Moving towards a more integrated grid requires provincial political buy-in. Canada's Constitution explicitly assigns responsibility for intra-provincial resource management – including electricity – to the provinces.[47] While the federal government has some responsibilities including environmental impacts (when those impacts extend beyond provincial borders), interprovincial and international transmission infrastructure as well as authority over anything involving nuclear energy, the federal government ultimately does not have the power to regulate electricity markets and regulatory regimes.[48]

With constitutional control over electricity, the provinces must be at the table to advance a more integrated grid, but provincial political interests have not typically aligned with the idea. These interests include using the development of electricity generation to create jobs and economic activity, and subsidizing electricity consumption in support of other provincial economic goals. Provinces also value electrical self-sufficiency.

These political interests have created the grid Canada has today – largely balkanized with little integration – even though a more integrated grid may have been a more cost-effective way to supply electricity. Studies commissioned by federal and provincial governments during the 1960s through the 1980s repeatedly demonstrated the positive economic benefits of a more integrated Canadian grid (see Appendix 2, page 39, for more information).

Ultimately, however, the provinces did not move forward for two key reasons. First, the estimated benefits of a more integrated grid, while seemingly large, were spread out over decades and predicated on uncertain assumptions (e.g., future fuel prices). And second, the alternative to pursuing a more integrated grid – developing internal resources to meet provincial electricity needs – was also economically viable, while being more politically palatable. Nearly every province had access to low-cost provincial resources to generate electricity (e.g., hydro for British Columbia, Manitoba, Ontario and Quebec and fossil fuels for Alberta and Saskatchewan). For the provinces, these two dynamics meant they could choose the more politically expedient option without the perception they were giving up significant economic benefits.

As this report argues, however, the economics are changing. The need to supply substantially more clean electricity that remains affordable and reliable increases the value of a more integrated Canadian grid – particularly in the West where most of Canada's

[47] See: *Constitution Act*, 1867. Section 92A.

[48] Additionally, while the National Energy Board (NEB) has the authority to regulate interprovincial transmission lines, it has never elected to do so in the past. See: Raphals, Philip, and Richard Hendriks. "The NEB's Role in Electricity Regulation and Energy Information: A Critical Review." Helios Centre, March 2017.

existing electricity emissions are created and the provinces have abundant and complementary clean electricity resources.

While the economics may be changing, the politics are still largely the same. Visible, concentrated negative impacts of a more integrated grid may spur political opposition from electorally significant groups. Provinces also may resist any solutions that require relinquishing control over their electricity sectors, or their "crown" jewels as the Crown power corporations are known. Finally, provinces often place high value on provincial electric self-sufficiency as a driver of economic development.

The visible, concentrated negative impacts of a more integrated grid

The benefits of a more integrated grid are due, in part, to changing when and where electricity resources are developed and operated. A more integrated grid allows the larger system to better use the most cost-effective options available than would otherwise have been possible under a less integrated system. These are the benefits of increased trade in any good or service. In the aggregate, the good or service is produced and consumed at a lower total cost.

Yet not everyone will be left better off from increased trade. Trade can negatively impact domestic producers that are not able to compete with producers from other jurisdictions. Consumers in low price jurisdictions may have to pay higher prices due to increased demand from other jurisdictions. These impacts – particularly on the producer side, which are often more concentrated, more localized and therefore more visible – can create political pressure against increased trade. Resistance to these distribution impacts is a commonly cited barrier to trade liberalization.[49]

In the context of electricity, a more integrated grid may negatively affect existing generators that are costlier or more inefficient. It can also shift the future development of electricity resources from one province to another if it is more cost-effective. This dynamic could lead to a transfer of electricity-related economic activity within a province to another. Combine this possibility with the fact that building and operating electricity resources such as power plants spurs visible, local economic activity and creates well-paying and long-lasting jobs, and you have a recipe for political opposition towards anything that is perceived to negatively affect these things within a province.

It can create the perception that one province "wins" while another province "loses" due to the distribution of economic activity associated with electricity generation from a more integrated grid – even though both provinces would benefit on the whole. No one wants to be perceived as on the losing side. It can also create the perception that potential new jobs are being lost. In many cases, it is more politically salient to say "we want to keep our energy jobs here" than tout the more dispersed benefits of an integrated grid.

Electricity as a political tool

Provinces often treat electricity not as a commodity, but as a political tool for achieving other provincial goals such as economic development and job creation.[50] It has been viewed differently than other natural resources such as oil and gas, where the motivation has generally been to secure the most value possible from developing the commodity by selling to internal or external markets. Instead, provinces have exerted their control over electricity to subsidize electricity consumption to the benefit of other industry and consumers.[51]

This has, in part, led to the dominance of provincially owned electric utilities in many provinces. In Ontario, for example, the development of hydroelectricity on the Canada side of Niagara Falls was first licensed to a private company. However, when provincial leaders realized the company's intentions to sell much of the electricity output to consumers in New York, they chose to take ownership of this electricity resource in order to ensure the low-cost electricity output would flow to Canadian consumers.[52] Ontario formed the Hydro-Electric Power Commission of Ontario to provide electricity province-wide, leading to the first government-owned utility in North America.[53]

49 See: Rodrik, D. (1995). Political economy of trade policy. Handbook of international economics, 3, 1457-1494. | Dollar, D., & Kraay, A. (2002). Spreading the wealth. Foreign Affairs, 120-133. | Mansfield, E. D., & Busch, M. L. (1995). The political economy of nontariff barriers: a cross-national analysis. International Organization, 49(4), 723-749.

50 Froschauer, Karl. White Gold: Hydroelectric Power in Canada. UBC Press, 2011.

51 Pineau, Pierre-Olivier. "Canadian Electricity Structure and Impact on Pricing, Trade and Environment»." Geopolitics of Energy, 2007.

52 Froschauer, Karl. White Gold: Hydroelectric Power in Canada. UBC Press, 2011.

53 Gucciardo, D. (2011). The Powered Generation: Canadians, Electricity, and Everyday Life.

A more integrated grid could threaten provinces continued use of electricity as a political tool.

Ontario has moved away from an entirely provincially owned electricity system, but many other provinces still have provincial Crown corporations that dominate their electricity sectors. In the West, electric utility Crown corporations operate in three of the four provinces."[54] Provincial control of these utilities has enabled provinces to lower electricity costs by restricting exports or offering advantageous rates to favoured industries. In British Columbia, for example, BC Hydro must supply a significant amount of energy at below market rates – known as "heritage" energy – for provincial consumption only.[55]

A more integrated grid could threaten provinces continued use of electricity as a political tool. Depending on the degree of integration, it could require provinces to relinquish this type of control. For this reason, provinces – especially ones with provincial Crown corporations – may be less likely to support a more integrated grid. It has happened in the past. For example, attempts in the 1960s to develop a more integrated grid were hindered in part by views that a national grid would reduce provincial control over electricity – especially in Quebec (see Appendix 2, page 39).

The allure of self-sufficiency

An additional political barrier facing a more integrated grid is the allure of self-sufficiency. A more integrated grid is predicated on the idea that providing clean and reliable electricity will be cheaper by provinces working together, instead of on their own. Yet in many provinces, electric self-sufficiency is a highly valued characteristic of provincial electricity sectors. This value is reflected in provincial regulations controlling electricity supply. For example, British Columbia requires BC Hydro to hold the rights to enough electricity to fully supply the province's need for a given year solely from resources within the province.[56]

There are benefits to self-sufficiency, but achieving self-sufficiency is not without cost. It requires provinces to build and maintain enough generation to power their own grids – something a more integrated grid will help reduce. Capturing the full benefits of a more integrated grid may require tradeoffs with provincial electricity self-sufficiency. The degree to which provinces do not want to give up this autonomy will hamper efforts to develop a more integrated grid.

[54] Manitoba Hydro. "News Release: Manitoba Hydro Announces New Corporate Structure and Executive Leadership Changes," February 2017.

Hunter, Justine. "$800-Million in Cuts to BC Hydro Urged." Globe and Mail, August 11, 2011.

[55] *Clean Energy Act*, SBC 2010, c 22, s 6.

[56] ibid

OTHER BARRIERS
to a more integrated grid

Beyond politics, other barriers can also inhibit a more integrated grid. These include:

- Fairly allocating the costs of a more integrated grid
- Harmonizing regulatory and market rules to enable interprovincial trade
- Mitigating social and environmental impacts associated with transmission infrastructure
- Ensuring an integrated grid drives real emission reductions

Who foots the bill?

Transmission infrastructure projects are expensive. Transmission lines can cost between $1.2 million to $2.9 million per kilometre depending on their capacity, and related facilities such as substations and capacitor banks cost millions of dollars more.[57] The "sticker shock" of this upfront cost poses a barrier even with the promise of long-term cost savings.

Additionally, the interprovincial nature of transmission infrastructure to enable a more integrated grid complicates the issue of who pays. Generally, transmission infrastructure is built by a regulated utility, and the cost of the infrastructure is recovered from consumers overtime by charging regulated rates on the electricity that is transmitted.[58] But with multiple utilities involved, it is not clear how costs should be allocated between the various jurisdictions.

Disagreements over allocating the costs associated with a more integrated grid create stumbling blocks. For example, in testimony to the House of Commons' Standing Committee on Natural Resources, Manitoba Hydro's Director of Wholesale Power and Operations stated that "for us to invest half a billion dollars or a billion dollars in more transmission lines to connect to Saskatchewan doesn't bring the province any more value than we already have."[59] In this case, Manitoba Hydro believes the benefits of increased interconnection with Saskatchewan will accrue primarily to Saskatchewan (and not Manitoba), and therefore Manitoba should not be responsible for the costs.

[57] GE Energy Consulting. "Pan-Canadian Wind Integration Study." Canadian Wind Energy Association, 2016. See Tables 7-3 and 7-4.

[58] In some instances, merchant transmission lines may be built by private entities to transfer power without regulated rates, although this arrangement is rare.

[59] Canada. Parliament. House of Commons. Standing Committee on Natural Resources. "Strategic Electricity Inter-ties". September 20, 2017.

Regulatory and market regimes

As previously described, current market structures, regulatory regimes and system planning practices can create frictions that inhibit efficient electricity trade between provinces. The rules governing the production, transmission and distribution of electricity are many and complex, and the financial capital committed based on these rules is large.

Depending on the changes pursued, large transition costs, stranded investments/assets, legal actions, and other issues may arise.[60] In Ontario, for example, policy choices affecting electricity pricing mechanisms have created a system whereby Ontarians subsidize electricity exports to other jurisdictions such as the United States.[61]

Environmental and social impacts

Transmission infrastructure involves large linear projects that cross great distances. They can cause social and environmental impacts spread out geographically, which in turn can lead to significant public opposition. Transmission lines can significantly impact landscapes. A transmission line corridor, especially through wooded terrain, can splinter the scenery. The large towers and related infrastructure associated with transmission lines can also have significant visual impacts. In addition to visual impacts, transmission lines can impact land use involving the use of agricultural machinery – increasing costs and reducing the amount of usable land for agricultural purposes.

Recent controversies in Western Canada surrounding the construction of new transmission lines illustrate the importance of acknowledging and addressing these impacts. In Manitoba, for example, ongoing transmission infrastructure projects have been the subject of significant controversies including allegations of political decisions related to the project route adding significant costs and various actions by groups representing landowners in front of the National Energy Board to reconsider the project's details.[62] In Alberta, the construction of two transmission lines between Calgary and Edmonton was similarly controversial with landowner groups voicing significant opposition.[63] The development of any new transmission lines will need to navigate siting, Indigenous rights, land ownership, compensation and environmental impacts.

Carbon leakage

Creating an electricity system that drives emission reductions cost-effectively is one of the main reasons to pursue a more integrated grid, so it will be important to ensure that it will produce real emission reductions. Recent studies show, however, that without appropriate policy mechanisms a more integrated grid could shift electricity production and associated emissions to the United States – a phenomenon known as "carbon leakage."[64, 65] These studies show that as a more integrated Western grid creates better market access for fossil-fuel dominated provinces (i.e., Alberta and Saskatchewan) to the United States, policies to reduce emissions incentivize replacing in-province emitting generation with imported electricity from the U.S. because the policies do not account for the emissions of imported electricity.

Simply shifting electricity-related emissions from Canada to the United States does not reduce emissions. It only reduces economic activity in Canada – a lose-lose outcome.

60 Woo, Chi-Keung, M. King, A. Tishler, and L. C. H. Chow. "Costs of Electricity Deregulation." Energy 31, no. 6–7 (2006): 747–768.

61 Baden, Greg. "Apples to Apples: Fixing Ontario's Electricity Price Mismatch." Council for Clean & Reliable Electricity, 2015.

62 MacLean, Cameron. "Southeast Manitoba Landowners Want Investigation into Hydro Deal with Métis Federation." CBC, March 28, 2018. https://www.cbc.ca/news/canada/manitoba/manitoba-hydro-southeast-stakeholders-coalition-1.4596264.

63 Cleland, Michael. "A Matter of Trust: The Role of Communities in Energy Decision-Making." Canada West Foundation and University of Ottawa, 2016.

64 English, J., T. Niet, B. Lyseng, K. Palmer-Wilson, V. Keller, I. Moazzen, L. Pitt, P. Wild, and A. Rowe. "Impact of Electrical Intertie Capacity on Carbon Policy Effectiveness." Energy Policy 101 (2017): 571–581.

65 GE Energy Consulting. "Western Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Study." Natural Resources Canada, August 2018.

RECOMMENDATIONS

THE PATH TOWARD A MORE INTEGRATED GRID

We recommend that the Western provinces pursue a more integrated grid as a key tool to produce the abundant clean energy needed for their energy future.

The economics are changing, driven by the urgency to reduce greenhouse gas (GHG) emissions and need to supply substantially more clean electricity in an affordable and reliable way. A more integrated grid – particularly in the West where most of Canada's existing electricity emissions are created and the provinces have abundant and complementary clean electricity resources – can help achieve Canada's energy future at the lowest cost.

The path toward a more integrated Western grid begins with provincial political decision-makers. Provincial control over electricity necessitates it. Actions – big or small – to move towards a more integrated Western grid will only happen if provinces agree to work together. There are two ways to address the politics – by changing them or by crafting solutions that keep them in mind.

Changing the politics of a more integrated grid can be aided by a clear understanding of both the costs and benefits of a more integrated grid, which includes understanding the stakes involved with not developing a more integrated grid and recognizing the long-term benefits of a more integrated grid.

A fully integrated Western grid will require major changes to provincial electricity market structures and regulatory regimes, which will likely remain out of political reach for the foreseeable future. Still, improving grid integration is not an all-or-nothing endeavour. There are incremental and more politically palatable options the provinces can pursue in the short-term that will bring some of the benefits of a more integrated grid. These steps include:

- Participating in energy imbalance markets,
- Strengthening regional transmission planning,
- Building new transmission infrastructure that makes sense today, and
- Putting electricity on the interprovincial trade agenda

A MOVE TO A MORE INTEGRATED GRID HAS MORE VALUE NOW THAN EVER.

We recommend that the Western provinces pursue a more integrated grid as a key tool to produce the abundant, reliable, affordable clean energy needed for their energy future.

The economics are changing, driven by the urgency to reduce GHG emissions and need to supply substantially more clean electricity affordably and reliably. A more integrated grid – particularly in the West where most of Canada's existing electricity emissions are created and the provinces have abundant and complementary clean electricity resources – can help achieve Canada's energy future at the lowest cost.

While a more integrated grid may require spending up front, it will save significant costs in the near- to long-term. If entire countries such as the Nordic nations can surmount political and logistical hurdles, Western Canada can too.

ONE WAY TO OVERCOME POLITICAL BARRIERS IS BY TAKING SMALLER, INCREMENTAL STEPS TOWARDS A MORE INTEGRATED GRID.

We recommend that the Western provinces:

Participate in energy imbalance markets (EIMs).

EIMs are real-time markets that enable neighbouring grids to help each other balance short term fluctuations in electric demand and supply. EIMs are key tools to cost-effectively integrate variable renewable generation. British Columbia and Manitoba already participate in EIMs. Alberta and Saskatchewan should follow suit.

Strengthen regional transmission planning.

The provinces should follow the example of European countries and many U.S. states to establish an organization, or formal co-operative agreement, to co-ordinate regional system planning with a mandate to develop transmission infrastructure that is reliable and economic on a regional basis.

Build new transmission infrastructure.

The Regional Electricity Cooperation and Strategic Infrastructure Initiative (RECSI) identified several transmission infrastructure projects that will reduce electricity costs and emissions. The provinces should invest in these projects – and the federal government should help.

Put electricity on the interprovincial trade agenda.

The provinces should stop exempting electricity from internal trade agreements and include electricity in the next workplan for the Regulatory Reconciliation and Cooperation Table.

> Actions – big or small – to move towards a more integrated Western grid will only happen if provinces agree to work together. There are two ways to address the politics – by changing them or by crafting solutions that keep them in mind.

In addition to these steps, policy-makers also need to consider ways to address the impacts of new energy infrastructure and reduce the potential for carbon leakage resulting from a more integrated grid.

Changing the politics

Understand the stakes. Political leaders need to recognize that reducing Canada's emissions is a long-term challenge that will require fundamental changes to the way Canadians produce and use energy. Some of these changes will be quicker and easier than others, such as deploying relatively small amounts of variable renewables today. Beyond the low-hanging fruit, it will become more difficult to further reduce emissions.

A more integrated grid will be a key tool for enabling deep emission reductions through electrification cost-effectively, but it will not happen overnight. Political leaders need to recognize this now to set the provinces on a path towards a more integrated grid or risk creating an energy future that is more expensive, less clean and unreliable.

At the same time, political leaders also need to keep in mind the stakes for people invested in the status quo. The fundamental changes required of Canada's energy system will create economic upheaval for some parts of our society. For example, plans to phase out coal-fired generation will have concentrated detrimental impacts on communities that rely on these power plants, such as Hanna, Alberta. The Government of Alberta recognizes this reality and has implemented policies to aid these communities.[66] Through altered trade patterns, a more integrated grid may concentrate negative impacts on specific communities. This fact should be recognized and addressed similarly as the negative impacts of other policies.

Recognize the benefits. A more integrated grid is not just about reducing emissions, it is also about continuing to provide affordable and reliable electricity for Canadian homes, businesses and industry. An affordable and reliable electric grid is a bedrock of modern society, and it is a vital input for many businesses and industries. Access to low-cost and reliable electricity can help spur economic growth and job creation.

In the West, a more integrated grid will help Alberta and Saskatchewan manage the significant changes their electricity sectors will undergo over the next several decades, and it will help them fully capitalize on their wind and solar resources by providing better market access for their electricity. For British Columbia and

[66] For example, see the Government of Alberta's Coal Workforce Transition Program and Coal Community Transition Fund.

Political leaders need to recognize that reducing Canada's emissions is a long-term challenge that will require fundamental changes to the way Canadians produce and use energy.

Manitoba, it will mean better access to more markets to sell their plentiful and valuable hydroelectricity. Right now, both provinces rely on markets in the United States for their electricity exports. Given what we have seen recently in trade (e.g., North American Free Trade Agreement [NAFTA] renegotiations), it is clear that diversification is important.

Imagining a fully integrated Western grid

A fully integrated grid would require consolidating the operation and planning responsibilities of the region's electricity grid into a single entity. This would entail existing provincial authorities giving up some degree of control over the systems they currently manage – something provinces are unlikely to do in the near future. It would also likely be the most disruptive option based on the diversity of electricity regulatory and market structures in the West. There are tradeoffs between disruption (and the cost associated with it) and benefits. Regardless, it is instructive to imagine what this might look like in the West.

There are two primary ways full integration could proceed – consolidation as a vertically integrated utility or consolidation under a restructured market.[67] Under a vertically integrated utility, all components of operating and developing the region's grid would be controlled by a single organization. The framework for this system would be similar to the one Crown corporation utilities in B.C., Saskatchewan and Manitoba currently operate under – it would just be trans-provincial. Under a restructured market, a single Regional Transmission Operator (RTO) would administer a regional competitive market for generation and operate the bulk transmission grid. This framework would be similar to the restructured market currently operating in Alberta under the AESO.

In either scenario, provinces would have to give up substantial control over their provincial electricity sectors – a hard sell, but not unprecedented. In the United States, groups of states participate in single RTOs such as the Midcontinent Independent System Operator, PJM and ISO New England. These RTOs co-ordinate the electricity system across state boundaries and have been successful in providing reliable, affordable and increasingly cleaner electricity. In Europe, multiple countries have come together to form one of the world's first multinational electricity markets. Beginning with Norway, Sweden, Denmark and Finland in the 1990s, a total of nine countries are now part of Nord Pool – a common, integrated market for electricity across national boundaries (see text box, page 31).[67]

[67] Nord Pool. "2017 Annual Report: Investing for the Customer," 2018.

THE NORDIC MODEL

The Nordic countries originally moved towards a more integrated grid because of the complementary diversity between the founding countries' electricity resource mix.[68] Similar to Western Canada, two countries (Norway and Sweden) produce most of their electricity from hydropower, while the other two countries (Denmark and Finland) have traditionally relied on thermal generation for electricity.

The Nordic power market is generally viewed as a successful example of electricity system integration. It has contributed to both stable and low electricity prices, while these countries have reduced their reliance on emitting generation. Over the past two decades, the Nordic region has been able to decrease its reliance on emitting generation such as coal from approximately 18 per cent of generation in 1995 to under 7 per cent in 2015.[69] At the same time, the region enjoys some of the cheapest electricity in Europe for non-household use (see Figure 5, page 32).

The success of the Nordic model derives from two main components:

- **A common electricity market.** By operating a common electricity market across different countries, Nord Pool allows for the optimal dispatch of generation to fulfill electricity demand regardless of where the generation physically resides. This common market has helped the region develop a significant amount of variable renewables such as wind by allowing clean electricity to flow to where it can be used.
- **Regional transmission planning.** The transmission system operators (TSO) in the Nordic countries co-ordinate closely to produce regional transmission infrastructure plans. The Nordic TSOs actively participate in the European Network of Transmission System Operators for Electricity (ENTSO-E) to co-ordinate transmission investments across the continent, and they participate in a Nordic planning group that focuses on regional transmission planning. Through these associations, the Nordic TSOs produce joint scenarios used to study future transmission requirements and identify where investments are needed. Ultimately, investment decisions are made by each individual TSO, but the co-ordination between each TSO ensures these decisions contribute to regional and continental efficiency.

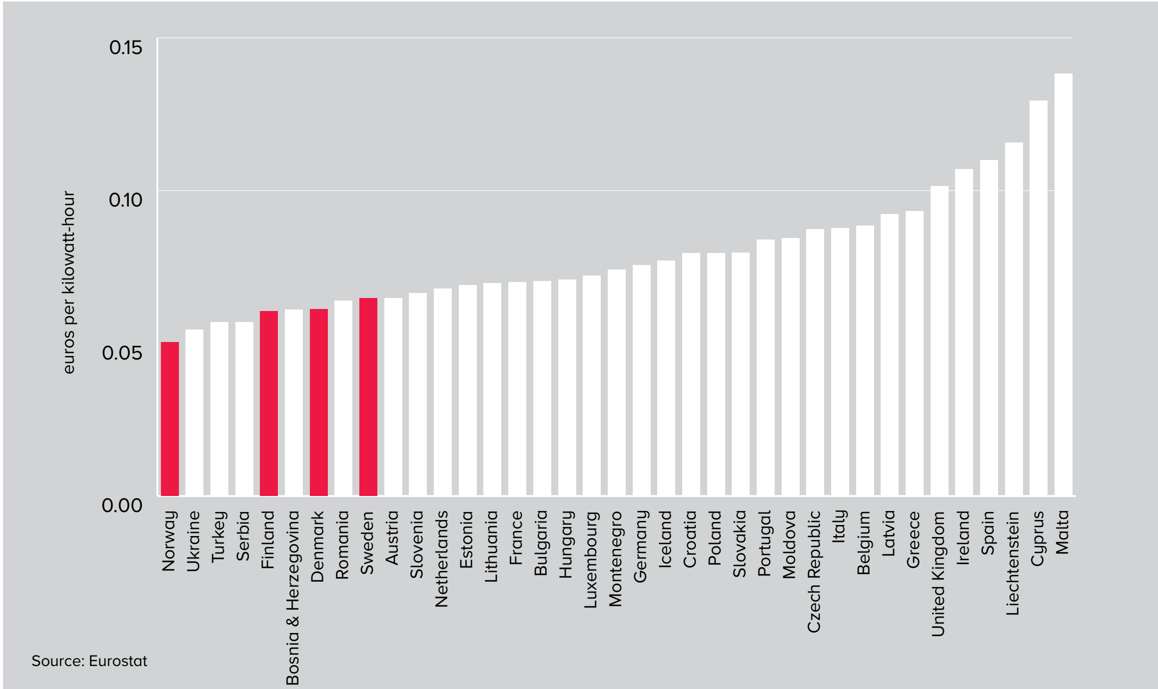
A common market and regional transmission planning has naturally led to a physically more integrated electric system as well. In Europe, interconnection capacity has been a barrier to market integration in the past, but as countries like the Nordics began co-ordinating their systems more closely, more interconnection capacity was built. In many cases, this increased interconnection capacity allowed the region to serve growth in electricity demand without developing new generation – reducing overall costs.[70]

[68] SARI/EI Project Secretariat, IRADe. "Learnings from Nord Pool Region: Power Market Development," September 2016.

[69] IEA. "Electricity Information." International Energy Agency, 2017.

[70] Bredesen, H. "The Nord Pool Market Model." ASEAN Energy Market Integration Forum (AEMI), Singapore, 2016.

FIGURE 5: AVERAGE NON-HOUSEHOLD ELECTRICITY GENERATION PRICES IN EUROPEAN UNION (2017)



INCREMENTAL STEPS TO IMPROVE GRID INTEGRATION

The provinces can improve grid integration in the near term without dramatic changes that loosen provincial control over their own electricity systems. Improving grid integration is not an all-or-nothing endeavour. Some steps have already been taken. Three of the four provinces already engage in contingency reserve sharing agreements with neighbouring jurisdictions. These agreements do not require significant changes to regulatory or market structure or complex financial transactions – but they do create value.

The provinces should not stop here. There are other steps they should take in the near term including expanding participation in energy imbalance markets, strengthening regional transmission planning protocols to enable economic investments, building new transmission infrastructure that will reduce costs and emissions, and putting electricity on the interprovincial trade agenda.

We recommend that the Western provinces participate in energy imbalance markets

Alberta and Saskatchewan should participate in energy imbalance markets (EIM). An EIM is a real-time energy market that optimizes the grid's response to short-term unanticipated fluctuations in electricity supply and demand between different balancing authorities. When demand or electricity generation are not exactly matched, an EIM will dispatch the lowest-cost energy to correct this energy imbalance regardless of its jurisdictional location. For example, if one province produces more wind electricity than forecasted, an EIM would allow this excess electricity to be sold to another province if it can displace more expensive electricity generation. Importantly, an EIM does not require provincial utilities or balancing authorities to give up their grid responsibilities or operational control of their grid assets – it only helps them fulfill these responsibilities more cost-effectively.

THE BENEFITS OF ENERGY IMBALANCE MARKETS: WESTERN EIM

The Western EIM – launched in 2014 by the California Independent System Operator (CAISO) – has brought together numerous grid operators in western North America to better integrate variable renewables such as wind and solar. Prior to this initiative, participating authorities did not have a mechanism to enable electricity trading as a response to short-term energy imbalances on their system even when this may have been the most economical option. Now, the EIM allows cheaper resources to fulfill balancing requirements regardless of where those resources physically reside, reducing the overall cost of providing reliable electricity. In many cases, these resources are surplus renewable energy that would have otherwise been curtailed.

Since inception, the Western EIM has generated US$288 million in cost savings through the more efficient dispatch of generation resources.[72] In addition to these savings, the EIM has also reduced the clean generation curtailment and the amount of additional ramping reserves needed to maintain reliability, which brings further savings.

British Columbia and Manitoba already participate in EIMs (or markets with similar qualities). British Columbia began participating in the Western EIM in April 2018 via BC Hydro's marketing-arm Powerex (see text box for the benefits of the Western EIM).[71] Manitoba also effectively participates in an EIM with U.S. states through Manitoba Hydro's participation in MISO. Alberta and Saskatchewan should follow their neighbours' leads. Since Alberta and Saskatchewan operate as part of the Western and Eastern Interconnects, respectively, it may be more cost-effective for Alberta – through AESO – to join the Western EIM and for Saskatchewan – through SaskPower – to participate in MISO markets that emulate an EIM. Still, the provinces' balancing authorities should evaluate the costs and benefits of a single EIM across all Western provinces.

We recommend that the Western provinces strengthen regional transmission planning

The Western provinces should strengthen regional transmission planning to enable the identification of – and investment in – transmission projects that reduce electricity costs.

Currently, interprovincial transmission planning is mostly limited to investments for reliability purposes. Grid operators' participation in organizations or agreements that ensure reliability is maintained on a regional scale. For example, BC Hydro, AESO and other provincial stakeholders are members of the Western Electricity Coordinating Council (WECC). WECC's purpose is "to assure the public of the reliability and the security of the Western Interconnection's Bulk Electric System."[73] It shares best practices to improve reliability and security, and it provides guidance to entities undertaking transmission planning, but importantly, it does not focus on operating an economically efficient electricity system.

An organization, or formal co-operative agreement, should be established to co-ordinate regional system planning. Similar to what vertically integrated utilities currently do with long term resource plans or AESO with its Long-Term Transmission Plan, a regional planning mechanism would identify the regional system's short-term and long-term needs for both reliability and economic purposes. Planning at this larger scale would avoid building duplicative infrastructure that could instead be shared and better provide for the consideration of more cost-effective solutions to system needs (e.g., building new transmission instead of new generation if it is less expensive).

71 California ISO. "News Release: Western EIM Welcomes New Participants – Idaho Power & Powerex," April 4, 2018.

72 California ISO. "Western EIM Benefits Report: Fourth Quarter 2017," 2018.

73 WECC. "Strategic Direction Outline." Western Electricity Coordinating Council, December 2016.

A more integrated grid is not just about reducing emissions, it is also about continuing to provide affordable and reliable electricity for Canadian homes, businesses and industry.

In Europe, countries and grid planners have recognized the benefits of regional system planning for a long time. The Nordic countries established Nordel in the 1960s to promote international co-operation in establishing an efficient electricity system between countries. Today, most of the continent participates in the European Network of Transmission System Operators for Electricity (ENTSO-E), which co-ordinates transmission planning and other activities across 43 transmission system operators and 36 countries.[74]

We recommend that the Western provinces build new transmission infrastructure

The provinces should pursue interprovincial transmission infrastructure improvements where it makes sense, and the federal government should help finance these improvements.

The Regional Electricity Cooperation and Strategic Infrastructure Initiative (RECSI) – a study evaluating the costs and benefits, including emission reductions, of electricity infrastructure projects commissioned by Natural Resources Canada – identified several transmission infrastructure projects that would reduce costs and decrease emissions.[75]

RECSI found that an additional transmission interconnection between Saskatchewan and Manitoba could decrease electricity costs by nearly $17 million annually while reducing emissions by enabling lower cost zero-emission hydroelectricity from Manitoba to displace higher cost emitting generation in Saskatchewan. For British Columbia and Alberta, RECSI found that incremental improvements to existing transmission interconnections – somethings the two provinces are already working on – would similarly reduce costs and emissions. Based on these findings, both infrastructure projects would reduce costs while saving money, and they should be pursued.

RECSI also evaluated new transmission inter-connections between Alberta and British Columbia. While the study found that new interconnections would induce emission reductions, it also concluded that they would increase electricity costs (when the cost of the new infrastructure is included). As a result, the two evaluated options would reduce emissions at an effective cost between $58 and $65 dollars per tonne of CO_2. While these options do not appear to be “win-win,” the effective emission reduction cost is near the federal government’s 2022 carbon price of $50 per tonne. In the context of this carbon price, the investment becomes more attractive.

[74] ENTSO-E. “Who Is ENTSO-E.” Accessed August 3, 2018. https://www.entsoe.eu/about/inside-entsoe/objectives/.

[75] GE Energy Consulting. “Western Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Study.” Natural Resources Canada, August 2018.

Additionally, the study did not incorporate many benefits of a more integrated grid including avoiding the capital costs of redundant generation resources, greater reserve sharing, or short-term balancing services such as would be provided by an EIM. Including these benefits could make new transmission infrastructure between Alberta and British Columbia more attractive. At a minimum, the two provinces should conduct further evaluation of these options that considers these additional benefits.

These projects will cost money, but they will engender savings in the long-term. The issue of efficient and fair allocation of costs and savings will need to be addressed. Cost-allocation is a complex subject that many jurisdictions in North America are grappling with as the need for more interjurisdictional transmission becomes more important. The provinces should evaluate new and innovative methodologies for determining cost-allocation. In the United States, grid operators are implementing novel cost allocation mechanisms for multi-state transmission projects that may serve as a model for Canada.[76]

To the extent that additional interprovincial transmission infrastructure enables emission reductions and beneficial electricity trade, the federal government should provide financial support. This can be accomplished through a mechanism such as the Canada Infrastructure Bank. Established in 2017, the infrastructure bank's initial capitalization included $5 billion for green infrastructure projects. Federal support for these projects would help address some of the political issues hampering a more integrated grid by reducing the financial "sticker shock" facing political entities.

We recommend that the Western provinces put electricity on the internal trade agenda

Western grid integration could be improved by chipping away at the various regulatory barriers that inhibit the economic transfer of electricity between provinces. Electricity is not the first or only industry to suffer from these issues, however. To rectify these issues in other industries, the provinces adopted the Canadian Free Trade Agreement (CFTA) – but unfortunately exempted electricity from most of its provisions. The provinces should add electricity to their interprovincial trade liberalization efforts. A key step would be adding electricity to future iterations of the RCT workplan through the CFTA to address regulatory barriers. Such a step would formally put these barriers on the trade agenda, and allow the provinces to make progress on reducing them.

[76] Fink, Sari, Kevin Porter, Christina Mudd, and Jennifer Rogers. "Survey of Transmission Cost Allocation Methodologies for Regional Transmission Organizations." National Renewable Energy Lab.(NREL), Golden, CO (United States), 2011.

CONCLUSION

A more integrated Western grid will be a vital component to achieve Canada's emission goals in a cost-effective way, while providing reliable and affordable electricity. But it will only work if provinces work together; if entire countries can do it, Western Canada can, too.

Long-term thinking and recognizing the stakes of going it alone can change the political will. Once the political will exists, the provinces will need to take concrete steps to improve the integration of their grids. This report provides some steps the provinces should consider but is by no means a comprehensive action plan. Moving forward will require a sustained effort among the provinces to identify the best steps and take them as needed.

Canada's energy future will arrive no matter what. The choice Western Canada has is how much it wants to pay for that future. A more integrated grid is a key tool to ensure the bill is low.

APPENDIX 1

How did we get here? A brief history of Canada's electricity industry

To understand the factors and pressures that will influence the development of Canada's electricity industry in the future, it is important to understand its history. The early development of Canada's electricity system can be broadly described as the provincial pursuit of economic development opportunities through the exploitation of domestic electricity resources.

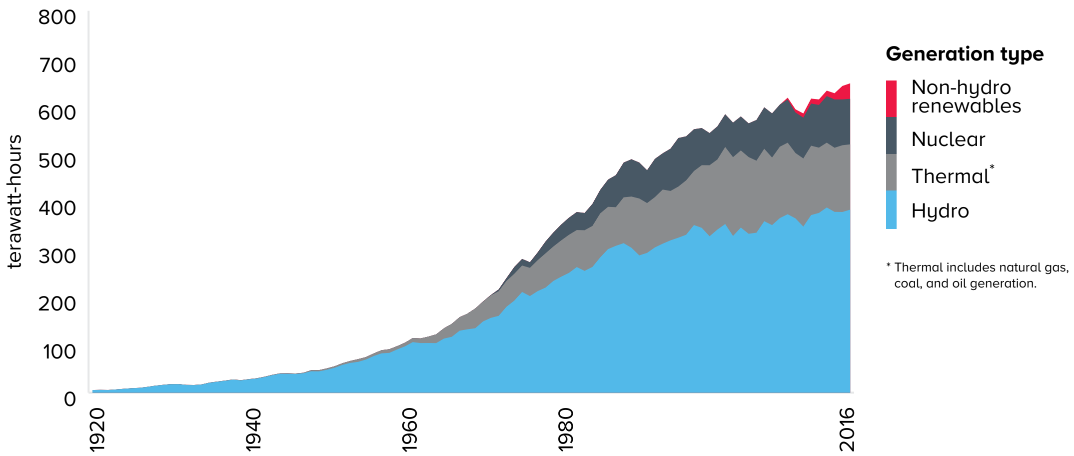
In the late 1800s, electricity generation and distribution began with generally isolated fossil fuel power plants located near where electricity was demanded, due to technological constraints. The world's first commercial centralized power plant was built by the Edison Illuminating Company in New York City, which served lighting needs within a short radius around the plant. As technology advanced, the ability to transmit electricity over longer distances became available. In Canada, this made possible the exploitation of well-suited hydroelectric resources located away from where the electricity was needed.

Through the 1900s, Canada first saw the rapid expansion of hydroelectric generation followed by thermal generation (e.g., coal and natural gas), nuclear, and finally non-hydro renewable sources (see Figure 6, page 38). In general, the provinces pursued electricity development in order to meet their own internal demand and spur industrial development. After initial forays into private and municipal development, many of the provinces chose to give responsibility for electricity development to large provincially owned and vertically integrated utilities with the goal to supply reliable electricity to provincial customers at least cost.

As electric transmission technology continued to improve, provincial utilities began to look outside their borders for opportunities. Through interconnections with other jurisdictions, utilities saw opportunities to find additional markets for surplus energy as well as ways to bolster the reliability of their own systems, among other benefits. Generally, these interconnections were one-off bilateral deals between neighbouring utilities that rarely involved the co-ordinated development of resources, and more often than not, they were with the United States. Overall, provincial utilities generally chose to pursue the construction of their own generating facilities rather than purchase electricity from neighbouring jurisdictions in a co-ordinated or long-term basis, with some exceptions.[77]

[77] One significant and notable exception is Hydro Quebec's purchase of most of the output from the Churchill Falls hydroelectric dam built in Labrador

FIGURE 6: CANADIAN ELECTRICITY GENERATION (1917 TO 2016)



Source: Historical Statistics of Canada Series Q85-91; Statistics Canada Table 25-10-0001-01; Statistics Canada Table 25-10-0020-01

This trend was not without its detractors, however. Since the late 1950s, various federal and provincial leaders have put forward the idea of developing a nationally or regionally integrated electricity grid. These proponents argued that co-ordinating electricity development on a national or regional scale, as opposed to provincial, would allow the country to capitalize on its hydroelectric resources to a higher degree and at a faster pace, avoid exposure to expensive and volatile fuel prices, and share other resources to reduce overall costs of electricity generation.

Ultimately, these efforts failed for a multitude of reasons. Some provinces resisted the idea because they feared federal overreach into a sector viewed as entirely within the provincial domain. In some cases, provinces favoured the short-term economic advantages such as the additional jobs of developing electricity generation sources within the province and saw greater opportunity in exporting electricity to the United States than neighbouring provinces. In other instances, provinces could not agree on how to distribute the benefits of an integrated grid, or the estimated benefits were too uncertain to drive decision-makers towards a definitive decision to pursue an integrated grid.

APPENDIX 2

Past attempts at national and regionally integrated electricity grids

1960s

Prime Minister John Diefenbaker and his government pushed the idea in the early 1960s as a way to capitalize on the significant untapped hydroelectric potential in the country. The Diefenbaker government co-ordinated a process that culminated with a study evaluating the costs and benefits of a national grid. The study envisioned a national grid that developed hydroelectricity in British Columbia, Manitoba, and Quebec in lieu of coal-fired power plants in Alberta, Saskatchewan, and the Maritimes. Compared to building and operating separate systems, the study "estimated that a national power network could save $644 million [$4.6 billion in 2017 dollars] within a thirty-year period."[78]

The initiative never moved forward. First, there was never full buy-in from all of the provinces. Quebec boycotted meetings related to the issue, protesting the federal government's involvement in an issue it viewed as entirely within the provinces' domain. Second, while the technical studies suggested a national grid would create large economic benefits, the uncertainty inherent in such a study, coupled with the capital-intensive nature of investing in a national grid, was too much for the provinces to move forward politically. Instead, provinces favoured the short-term economic and political advantages of developing their own generation sources and saw exporting to markets in the United States as easier and more lucrative than a national grid.

1970s

The idea of a national grid gained traction again in the 1970s as oil prices rose steeply during the energy crisis, increasing electricity costs for regions relying on oil-fired generation. This time, the provinces took the lead and formed a group within the Interprovincial Advisory Council on Energy to study the concept. Specifically, the provinces evaluated a "conceptual plan" that significantly increased east-west electricity transfer capacity that would allow oil-fired generation to be replaced with hydroelectricity as well as allow utilities to share generating reserves, thus reducing each utility's need to procure their own reserves.

The study found that a national grid would create significant benefits if fuel (i.e., oil) prices continued to increase relative to other costs – but the benefits were highly sensitive to these fuel cost assumptions. The provinces were also concerned about whether pursuing an interprovincial grid would be subject

[78] Froschauer, Karl. White Gold: Hydroelectric Power in Canada. UBC Press, 2011.

to additional federal intervention than standalone provincial grids. They consulted an expert who advised that no assurances could be made against the possibility of federal governmental involvement in an interprovincial grid.[79]

Ultimately, the interprovincial committee decided not to move forward with the idea. Like the 1960s study, one cited reason was that the uncertainty of the net benefits of such an initiative could not justify the costs. Fears of federal government overreach also reduced interest in this provincially led national grid initiative.

Regional Initiatives (1970s-80s)

While the idea of a truly national grid received attention but never got off the ground, groups of provinces periodically explored the idea of developing regional grids as well.

At the 1978 Western Premiers' Conference, the Western provinces announced that a Western grid "could produce significant economic advantages for the provinces in meeting their future electrical needs".[80] The provinces funded a feasibility study evaluating interconnecting British Columbia, Alberta, Saskatchewan and Manitoba and found significant benefits from such a plan.[81] In general, provincial utilities were skeptical of the idea, while provincial politicians were more in favour. In 1979, British Columbia, citing insufficient benefits from a regional grid, opted to forego continued participation in the idea.

The other three provinces remained optimistic and agreed to fund a Western Electric Power Grid Study in 1980, which looked at linking the three provinces to enable Manitoba to sell hydroelectricity to the other two provinces in lieu of expanding coal-fired generation. Again, this study found net benefits from linking and co-ordinating the three provinces' electricity grids to the tune of $150 million in 1980 dollars ($425 million in 2017 dollars). Additionally, the study reported environmental benefits from the displacement of coal-fired generation with hydroelectricity. On socioeconomic metrics, the study found large increases in employment and income in Manitoba due to increased development of hydroelectric resources, with decreased employment and income in Alberta and Saskatchewan since these provinces would no longer develop as many coal-fired power plants.

At the time, the job impacts were politically palatable because labour shortages were forecast in both Alberta and Saskatchewan due to significant growth in the oil sector, while Manitoba was suffering from a sluggish economy.

The idea never progressed, however. Negotiations between the provinces stalled due to disagreements over how the costs and benefits of the project would be shared between the provinces. The election of a new government in Manitoba in the midst of negotiations further complicated matters. By the summer of 1982, an agreement had still not been reached and recession had hit both Alberta and Saskatchewan as the oil industry stalled. This change meant the job impacts of the regional grid initiative were a lot less politically acceptable in Alberta and Saskatchewan. An agreement was never reached.

79 Froschauer, Karl. White Gold: Hydroelectric Power in Canada. UBC Press, 2011.

80 NEB. "Inter-Utility Trade Review: Inter-Utility Cooperation." National Energy Board, 1992.

81 ibid

APPENDIX 3

Electricity-related climate policies
The provinces and the federal government are implementing a number of electricity-related policies aimed at reducing emissions.

	ELECTRICITY-RELATED CLIMATE POLICIES
Federal	**Phasing out emissions from coal-fired electricity**. Proposed regulations will require significant emission reductions from all coal-fired power plants by 2030 that will likely restrict any coal-fired power plants without carbon capture technology (unless an equivalency agreement is reached between the federal government and an interested province). **Reducing emissions from natural-gas fired electricity**. Proposed regulations will impose emission standards on new and significantly modified natural gas-fired power plants. **Carbon pricing**. The federal government plans to impose a carbon pricing scheme on provinces that do not implement their own by 2019.
British Columbia	While British Columbia's electricity supply is overwhelmingly zero-emitting already (98 per cent), the province's Climate Leadership Plan commits to supplying 100 per cent clean or renewable electricity (with allowances for reliability) by 2025. Other aspects of British Columbia's Climate Leadership Plan could drive significant electrification including policies promoting electric vehicles and the use of electricity in natural gas production.
Alberta	**Coal phase-out**. The province will phase out all emissions from coal-fired electricity production by 2030. **Renewable generation target**. Alberta has committed to having 30 per cent of electricity generation be from renewable sources by 2030. **Carbon pricing**. The province has implemented a carbon tax on combustible fuels. Electricity generation is regulated by the Carbon Competitiveness Incentive Regulation, which creates an output-based allocation system to incentivize emission reductions while minimizing negative competitiveness impacts.
Saskatchewan	**Renewable capacity target**. The province, via SaskPower, has committed to having up to 50 per cent of its electricity capacity be renewable by 2030. **Cap on electricity-related emissions**. As part of a proposed equivalency agreement to extend the life of several coal-fired power plants, the province has implemented regulations capping electricity sector emissions. **Carbon capture and sequestration (CCS)**. Saskatchewan, through SaskPower, has invested in CCS technology resulting in the world's first commercial-scale, coal-fired power plant equipped with CCS at Boundary Dam near Estevan, SK.
Manitoba	Manitoba's electricity supply is overwhelmingly non-emitting. Accordingly, it does not have any major policies in place that will cause significant alterations to the current situation. The Made-in-Manitoba climate plan includes discussion on policies that may drive additional electricity consumption such as electrifying Winnipeg Transit.

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