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Barriers to innovation in the Canadian electricity sector and available policy responses

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Introduction

The electricity sector is a cornerstone of Canada's current and future energy system. It has been over a century since the first mass market electricity service was rolled out in 1881, and the role of electricity has grown dramatically in that period. Yet in many ways, the underlying structure of the electricity system remains unchanged—the majority of generation is provided by large, centralized generators from a mix of hydropower and fossil resources, and generation is actively managed to meet demand.

While the role of the electricity sector will expand as Canada moves towards a net zero energy system, it will also need to evolve in order to meet two primary requirements. The first is serving new demand patterns and/or increased demand resulting from electrification of end uses, including in the transportation, buildings, and industrial sectors. The second is to reduce emissions from generation to enable Canada to meet its 2030 and 2050 greenhouse gas (GHG) reduction targets.

Decarbonizing electricity systems in Canada will therefore require a mix of innovative solutions that tackle both requirements, specifically technologies and approaches that:

- Increase zero emissions supply (such as wind, solar, hydro, nuclear, and geothermal);
- Manage and shift supply (for example, through storage and transmission);
- Reduce and shift demand (such as strategic demand reductions); and
- Support advanced grid management (using both software and hardware) to balance supply and demand.

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There are a number of initiatives in place at all orders of government in Canada that support electricity system decarbonization, with each order of government using a different set of tools and authorities depending on their respective jurisdictional powers.

With electricity grids in Canada largely organized along provincial boundaries, provinces maintain jurisdiction over most responsibilities, including electricity generation, transmission, and management within provincial boundaries, intra-provincial trade, environmental impacts, and conservation and demand response policies. Examples of initiatives at the provincial level include renewable energy and decarbonization targets, as well as programs targeting distributed generation with solar incentives.

Federal jurisdiction is more limited. It applies to interprovincial and international trade; resource management on frontier lands; nuclear safety; codes and standards; labeling relating to consumption and demand; and other policies of national interest. Initiatives at the federal level include technology-specific policies and regulations (such as the coal-phase out), transmission build-out, innovation research and deployment, and broad-based measures, like carbon pricing.

Municipalities are even more limited in their direct jurisdiction over electricity. However, they retain important powers to facilitate innovation, such as through municipal bylaws, programs, subsidies, and targets. Local governments across Canada have adopted ambitious targets and provided support for new technologies.

Indigenous governments and communities are also playing a major role in advancing electricity sector decarbonization, in particular by leading the deployment of clean energy projects.

Despite many initiatives underway and significant progress from these various orders of government to date, multiple challenges are preventing greater deployment of technologies and adoption of approaches to decarbonize the electricity system. This paper examines those challenges, discusses approaches to overcome them, and outlines high-level policy options for Canada.

Non-technical challenges to deploying innovations in Canadian electricity systems

Today, real challenges are impeding the decarbonization of Canada's electricity system. In particular, the electricity sector faces strong path dependency, whereby infrastructure, network effects, and institutions create challenges to innovation even when alternative solutions are available and economically viable. The highly centralized and regulated nature of electricity generation and system management further amplifies these challenges.

Deployment in particular is critical for two reasons. Beyond the obvious point that emissions reductions happen only when the solutions are implemented, deployment is a necessary step in the innovation process. Processes such as learning by doing drives down the cost of technology as more is deployed, while system operators become more comfortable with new technology through continued use. Without direct action and policy to address challenges in deployment, progress towards the goal of decarbonization will be slow at best. As a result, policies must be implemented to target key challenges and drive the necessary change. This section inventories some of the key challenges.

Misalignment of goals, incentives, and mandates

Within the utility system, regulations and policies give clear direction to the utility commission, utility, and system operator. The need to follow explicit directions limits the ability of these players to pursue mandates they have not been explicitly given, even if individuals within the system believe it would be prudent.

In most cases in Canada, the system operator or utility lacks the clear mandate and necessary incentives to pursue decarbonization or long-term climate resilience of the electricity system. This, in turn, limits the ability and incentive to deploy new or innovative technology. Instead, there is a laser focus on providing reliable electricity at the lowest cost. While this mandate remains critical, it becomes a challenge when it is the only goal.

Providing the ability to consider innovation is important, but even the ability without a clear direction and incentive is insufficient to drive action at the pace and scale required. Rather, a clear mandate is necessary given the understandably conservative nature, culture, and mindset of utility system operators. This path dependency is not unique to Canada but rather a characteristic of utility systems around the world.

While not infeasible to manage, high levels of variable renewable resources do require a change to some approaches to grid management, representing an additional unknown. As a result of the uncertainty around new grid management approaches and the risk-averse environment of the utility system, there may be reluctance to make these changes proactively. The same concerns arise at the distribution grid level, where the regulated monopoly is first and foremost in the business of reliability. Two-way flows of power create additional risks, but ones that are manageable and can even be advantageous if designed for.

As a result of this mandate and mindset, there is little appetite for individuals within the utility system to make changes to integrate new technology. This leads to preferences for the same types of resources that have been historically used and are well understood, meaning large fossil, hydro, or nuclear generation.

Vested interests to maintain the status quo

Lack of direct incentives is not the only issue. Utilities, regulators, and system operators can face pressure from existing asset holders to block or slow integration and large-scale development of new resources that may compete with existing assets. For example, new resources that reduce peak demand in deregulated markets will lead to lower price capture for the existing asset base. Storage, demand response, and solar will all tend to reduce the number of high-price hours and therefore reduce the revenues for existing assets operating in those times. In the case of vertically integrated Crown corporations, these new resources can threaten the economics of previous investments even if they reduce overall system costs.

Existing asset holders can exert political powers by, for example, creating unequal playing fields through more significant involvement in consultation and regulatory processes. In the case of markets controlled by Crown corporations, the decision not to pursue new resources can be made directly.

In some cases, the reluctance to make change extends beyond the culture and biases to direct financial incentives, such as investor-owned utilities operating in a regulated rate of return market. The regulated rate of return structure gives utilities a bias toward capital investments because deploying more capital leads to larger returns, typically without any value assigned to the carbon impacts or consumer costs. Even in cases where a carbon price applies to the sector, costs may be passed through, so the bias remains.

Siloed planning

Planning across the Canadian energy system is highly siloed—between energy types, provinces, and ministries. The lack of federal authority over electricity further hinders coordination and collaboration. Historically, the negative implications of this siloed planning have been limited, as the crossover between areas in practice was minimal and each silo could be optimized in isolation.

However, innovation in the electricity system is increasingly creating crossover between energy types, between supply and demand, and across regions. The lack of integrated resource planning becomes a challenge in designing and implementing an efficient system when planning can only consider half of the issue and when no mechanisms exist to standardize codes and practices. This lack of integrated planning leads to lower welfare overall.

Lack of up to date information

The fast pace of technological innovation in zero-carbon resources and enabling technology leads to misconceptions within the sector around the supply and costs of these resources. These misconceptions can be seen, for example, in the inflated cost estimates for wind and solar in long-term planning documents, over-estimates of integration costs, and concerns from system operators about the ability of resources to deliver reliability.

In the case of wind and solar, for example, costs have fallen dramatically (Shumacher et al., 2020), reflected in the prices observed in Alberta. In 2017 and 2018, the Alberta Electric System Operator (AESO) entered into contracts for wind power from the REP program (AESO, 2021a) of $37-$40/MWhr, while in 2019, the Government of Alberta entered into contracts for solar power for $48/MWhr (Government of Alberta, 2019). However, the most recent long-term outlook from the system operator published in 2021 (AESO, 2021b) uses renewable cost estimates prepared in 2018 (AWS Truepower, 2018) of over $60/MWh for wind and $120/MWh for solar projects to be built in 2021–2025.

Information gaps also exist for geothermal and small modular reactors. However, whereas the challenge in the case of solar and wind is maintaining up-to-date information about costs and value, much deeper uncertainties exist around the technological readiness and cost trajectories for geothermal and small modular rectors. The lack of robust, clear data for analysis and evaluation of resource options slows progress.

These information gaps can also slow deployment by creating challenges in accessing capital. While this challenge is largely addressed for the most mature technologies being deployed globally like solar PV and wind, broader information gaps continue to limit the deployment of many generation and storage technologies.

Lack of market access

Challenges facing market access are a common challenge in innovation beyond the electricity system, but the highly regulated nature of the electricity grid can amplify the issue. These challenges can take many forms. They are not necessarily direct prohibitions to new technologies or approaches but rather emerge from a lack of framework, market, regulation, or even a department or person responsible for evaluating the innovation within the regulatory body.

Access to the generation, transmission, and distribution markets is limited in all systems in Canada, regardless of regulatory model or level of public versus private ownership. In the case of new zero-carbon generation, access to the generation market in most provinces is highly controlled by a Crown corporation, meaning that independent power producers (IPPs) have no default ability to sell it to the market. This prevents new generation from being deployed, even in cases where it may be the best option.

When IPPs do have a channel into the market (e.g., through calls for new generation) there are additional challenges that create an uneven playing field. In particular, the vertically integrated utility creates a monopsony situation with a number of standard market failures. For example, limited information about transmission capacity and access creates challenges for developers to identify sites for development. Moreover, IPPs are in effect competing against the Crown corporation that may decide to build other generation, limiting the size and location of future calls. Rather than creating a long-term, stable market for IPPs, the channels have historically been short-term, uncertain, and small—all challenges to creating a robust market.

And even where markets do exist (e.g., in the deregulated generation markets of Alberta and Ontario), rules and structures may limit participation, particularly for new technology categories. Small markets like Alberta can suffer from a concentration of market power and limited liquidity in the markets that renders them less competitive and efficient.

Access challenges are also found in the highly regulated transmission and distribution sector. Non-wire alternatives, such as storage and strategic demand reductions, are at best granted limited opportunity to compete with conventional offerings and in many processes are simply not considered. At the same time, multiple challenges exist to developing additional transmission for integration of variable renewables over a broader geography between provinces.

The case of energy storage illustrates the issues that can be faced by new resource types that are seeking to enter a market that wasn't designed with their potential in mind. In a system that categorizes each resource as either generation, load, or transmission and distribution infrastructure, energy storage can't be placed neatly in any one category. Within the wholesale market it acts as both a generation and load, but market rules are different for each type of resource and become prohibitive to operation if combined. Addressing the challenge requires creating a new resource type with a unique set of rules—a significant regulatory undertaking.

But simply fixing the wholesale side of electricity generation is also insufficient. The same energy storage project that participates in the generation market can also act as a transmission and distribution resource, for example by storing power that can be used to meet local demand over a short period of time. The current market design completely separates generation from transmission and distribution, forcing the storage resource to operate with only one function, thus limiting the full potential of the resource and making it less competitive. Addressing this challenge requires even more significant regulatory and market changes.

Missing price signals and wrong metrics

Markets rely on price signals to drive behaviour. The absence or muting of price signals, on both the demand and supply side, are a challenge facing innovation. Similarly, in regulated systems, the wrong metrics are a challenge in pursuing innovation.

On the demand side, price signals in the market are muted through inefficient rate design when electricity rates do not reflect the true cost of service. Rates that reflect cost of service can incentivize users to shift their demand profiles, and they also create opportunities for companies to offer products and services that shift demand. However, most retail rates across Canada do not reflect real-time cost. While time-varying rates are better than flat rates at capturing the true cost of electricity generation, they are underutilized by utilities and regulators.

The situation is similar on the supply side. A failure to value the full or latent potential that new resources can deliver leads to under-deployment of the resources. When resources are not adequately compensated for the value they provide to the system, they face challenges in building a successful business case for deployment.

The compensation gap arises from the market structure design, which is based on the properties and value of historical resource. These historical resources have a different set of values they bring to the system, and while there is some overlap, values like the faster ramping capabilities of inverter-based generation (e.g., wind and solar) are not captured by the market rules designed for large fossil resources. As a result, new resources are only compensated for part of the value they provide, creating challenges for deployment.

The same dynamic plays out with respect to metrics. Metrics for evaluating the electricity system were designed around historical assets. For example, during a period of transition in an industry with very long-term assets, the option value of a decision is increasingly important. Being able to delay investments in long-term assets until there is more information about what the grid needs by paying slightly higher prices in the short term may be more efficient in the long run. For example, projects like coal-to-gas conversions can play an important role in the transition by providing shorter-term capacity as a bridge to building more zero-carbon resources at lower cost to the system as compared to build-out of new long-term gas assets. Metrics such as internal rate of return are good for finding the lowest cost over long periods of stability but do not capture this option value. Another important example is the value of climate resilience in infrastructure, which may cost more upfront but leads to lower costs over time.

Lack of enabling infrastructure

Some enabling infrastructure is required for deploying new technologies, and gaps in this type of infrastructure can slow innovation. Examples include transmission capacity for zero-carbon resources and smart meters for some grid management approaches. In the case of transmission capacity, physical access is limited when there is insufficient transmission capacity within a province to connect zero-carbon resources because these resources are not necessarily located in the same places as the fossil generators they replace. The slow process of transmission build-out within a province can serve as a challenge in the deployment of zero-carbon resources. In many cases, transmission build-out requires declaration of a need coming from a project, but the risks of investing in project development without certainty of transmission availability deters project developers. Similarly, processes for deploying enabling technologies like smart meters may also add challenges.

The build-out of enabling infrastructure faces its own challenges. Within a province there can be issues around the source of funding for infrastructure or responsibility for its development, while interprovincial infrastructure such as transmission is complicated by the need for collaboration between multiple orders of government (federal/provincial) and multiple provincial governments.

Small grid-balancing regions

One of the most cost-effective ways to integrate larger fractions of non-dispatchable resources is via larger grid-balancing regions that can take advantage of geographically diverse renewable resources, along with differences in demand patterns (National Renewable Energy Laboratory, 2015).

As wind generation increases, there are benefits to a more highly integrated grid such that wind can be balanced with other resources, like hydropower or geothermal, and across larger geographies with more diverse wind regimes, as proposed between Quebec and New England (CBC News, 2019).

The provincially aligned electricity system in Canada is a challenge in creating large grid balancing regions, both physically and in the management of the grid. Many of the higher-carbon grids across Canada are relatively isolated, with limited interconnections. Challenges with interprovincial trade extend into the electricity system creating challenges in market integration, while market integration with U.S. states requires international collaboration.

Policy approaches to align electricity systems with net zero goals

In order to align electricity systems with net zero goals, policies and approaches must target the challenges identified: misalignment of goals, incentives, and mandates; vested interest in maintaining the status quo; siloed planning; lack of market access; missing price signals and metrics; insufficient up-to-date information; lack of enabling infrastructure; and limitations arising from small grid-balancing regions.

These challenges are not insurmountable. Many of the challenges are well understood and similar to those faced in electricity systems in other countries, as well as more generally in the deployment of new technologies. As these challenges are not unique to Canada, or to the electricity system, there are a number of proven approaches and tools that can be used in combination to transition to a low-carbon electricity system that is resilient, reliable, and affordable.

Enable and equip the electricity sector to work towards mandated goals

SYSTEM-WIDE MANDATES

A critical pre-condition to overcoming challenges is for governments to set a clear decarbonization objective for all of the players in the electricity system, including regulators, system operators, and, where applicable, utilities. Decarbonization must be mandated as a high-level objective for the electricity system, on par with reliability and cost, as a pre-condition for other solutions to be effective. Moreover, rather than simply focusing internally on reducing emissions in the electricity system as it exists today, the mandate should be broad enough to capture the future role of electricity in a net zero economy—charging the electricity system participants with the imperative to consider future demand growth, energy efficiency, and energy systems that will need to be electrified to meet net zero targets.

SYSTEM-WIDE TARGETS AND STANDARDS

Targets and standards that encourage innovation are critical to driving decarbonization in the electricity system. Electricity system policies that mandate specific targets, including Renewable Portfolio Standards (RPS), emission caps, and Clean Electricity Standards (CES) have been key drivers of electricity system decarbonization to date and can continue to play a role in the future. Targets enable a longer-term planning horizon and serve as an effective mechanism to set clear goals by sending a signal to the market about demand for technology. As technology matures, CES are replacing RPS and can provide additional flexibility to allow for innovation by mandating an outcome as opposed to a specific technology pathway. They are also sufficiently flexible to allow for deep decarbonization while still preserving some fraction of fossil generation in systems in the medium term where this is the most efficient approach.

CES are technology-neutral portfolio standards that require a certain percentage of utility sales from zero- or low-carbon generation technology, spurring development and deployment of low-carbon technology. While many early portfolio standards targeted specific amounts or types of renewable energy generation (which was important for deployment of what were less commercialized resources at the time), technology-neutral portfolio standards have clear benefits when targets approach 100 per cent. By defining the goal of reducing emissions in a technology-neutral way, targets can allow for innovation without being overly prescriptive. Targets can also be used to encourage innovation in grid management and integration of high levels of renewable energy more quickly.

INTEGRATED PLANNING

Changes are needed to break down siloes in utility management by integrating planning functions between gas and electricity utilities and potentially including new resources like hydrogen. Creating clear planning functions within the utility commission that covers both gas and electricity allows for the systems to be co-managed.

The same type of broader planning can be enabled between provinces by setting processes to standardize codes and approaches to new technology integration. This can be enabled by creating a forum for collaboration encompassing utility commissions and provincial ministries in charge of electricity and natural gas, ensuring that these forums consider both near-term needs as well as longer-term planning. Inter-temporal planning is critical in the context of net zero goals where near-term decisions must be aligned with long-term goals to avoid creating stranded assets or suboptimal pathways.

IMPROVED INFORMATION AND DATA SHARING

Ensuring access to real-time information on costs and performance of new technologies will allow governments, regulators, and system operators to make more informed decisions. This information could be integrated into the federal government's new energy information function and could also be provided at the provincial level. By drawing on the latest cost and performance data from trusted industry sources and then adjusting data for the Canadian context, the federal government can provide a valuable service to provinces.

Peer-to-peer information sharing is critical for innovation in a sector where reliability is so important. Building out Canadian forums such as the Utility Forum and deepening participation across Canada in existing industry groups can enable system operators and regulators to be better informed in the rapidly changing sector and to apply best practices to enabling innovation while maintaining reliability.

Enable market access and improve price signals and metrics

Different approaches are required to create market access and improve price signals and metrics in markets across Canada.

In Crown-controlled markets, for example, access can be created by requiring utilities to provide more information about transmission access and the costs of new generation. All-source procurement approaches allow for different resource types to compete directly (Wilson et al., 2020).

In the United States, the Public Utility Regulatory Policies Act (PURPA) is recognized as having been a key driver in developing new technologies, such as wind power (Union of Concerned Scientists, 2002). The law requires the utilities to purchase power from IPPs when it is cheaper than the alternatives that utilities could deploy. Laws like PURPA enable IPPs to develop projects when they make economic sense, driving deployment of innovative technologies. A similar approach can be applied to transmission and distribution markets, by considering non-wire alternatives like strategic demand response.

In deregulated markets, it is necessary to create rules and market structures that allow new technologies to participate. Mandating the creation of the rules, with a specific timeline, can remove barriers to access.

CARBON PRICING

The cost-focused nature of the approach to dispatch in the electricity system makes it highly responsive to carbon pricing. The impact of carbon pricing at the sector level can be seen clearly in the shift to dispatch lower-carbon sources in the Alberta generation mix following implementation (Shaffer, 2018). The incremental carbon cost, along with some retirement due to the coal phase-out, led to a drop in generation from coal plants. At the same time, the ability to generate bankable revenue streams from renewable energy offsets can lead to increased development of zero-carbon sources by contributing to addressing the financing challenge.

However, improvements can be made to the way carbon pricing is implemented to maximize effectiveness. In particular, the lack of certainty around future carbon prices leads to limited bankability of carbon revenue, while the federal Output-Based Pricing System needs to be applied uniformly across the sector to enable new renewable projects to benefit from their relative emissions advantage. Changes to regulations that provide more clarity on future prices, increase policy certainty (Beugin and Shaffer, 2021), and create revenues for new renewable projects can make the price signals more effective.

PERFORMANCE-BASED REGULATION

Under traditional rate of return (cost of service) regulation, utilities are granted a rate of return on capital deployed, resulting in limited incentive to find ways to provide services a lower cost. Performance-based regulation (PBR) is a form of incentive regulation that gives utilities an opportunity to earn a higher rate of return even if they can lower the cost of providing a service. By defining desired outcomes on the basis of underlying goals for the utility system, PBR can enable and incentivize utilities to innovate (Littell et al., 2017).

Yet while the idea behind PBR is simple, the implementation is not. And if done poorly, it can lead to undesired outcomes (Energy Foundation and Energy Innovation, 2015), such as simply allowing a utility to make a larger return without providing savings. Important principles for success include the need to start by creating an understanding of system goals and the related measurable outcomes with key stakeholders and the need for a sufficiently long time horizon for the utility to truly innovate to meet targets.

RATES

Time-varying pricing improves the price signals for consumers of electricity through rates that vary at different times of day and year. By better reflecting the cost of providing electricity at a given time, this approach can incentivize consumers to shift their demand to lower cost times. The mechanisms for shifting use vary, from basic behaviour change to more advanced demand response management with third-party providers. Alternative pricing relationships between electricity utilities and customers, such as discounted plans in exchange for managed charging of electric vehicles, can also help shift demand and increase system flexibility.

Developing infrastructure and improving integration

FINANCING TRANSMISSION BUILD-OUT

In some markets, there will be a need for additional build-out of transmission capacity to connect low-carbon generation sources. Even within provinces, transmission build-out can face challenges due to the land requirement and the cost of new transmission projects (especially when generation cost savings are not considered in the evaluation of projects). When new transmission is needed to reach deep decarbonization goals, it may be appropriate for the cost of the transmission to be borne by taxpayers rather than ratepayers (since it is being built to meet not just electricity system goals). For example, this could include example federal funding for provincial transmission build-out.

IMPLEMENTATION OF SMART GRID INFRASTRUCTURE

Ensuring that the basic building blocks for smart grid operations, such as smart meters, are in place allows innovators to bring new products and operation to markets (Canadian Electricity Association, 2017). A combination of policy carrots (in the form of funding for smart grid deployment) and sticks (regulatory requirements) can accelerate deployment. But careful planning and oversight is necessary to ensure that deployment of new technology actually delivers benefits to customers and doesn't just create projects for utilities. Performance-based regulations are one way to provide this oversight.

IMPROVED INTEGRATION

With limited investment in the short term, opportunities exist to better utilize existing infrastructure. The use of dynamic (or real time) line ratings can increase the capacity of existing transmission lines, as they allow grid operators to take advantage of increases in transmission line capacity rather than always limiting it to the most conservative rating.[1] Targeted investments can also

1 The amount of power a transmission line can safely carry depends on a number of factors that can vary, such as the ambient temperature. Dynamic line ratings use real-time information to calculate what is safe for a given line in real time rather than limiting the transmission ratings to the lower level that is safe under all conditions. Dynamic rating thus effectively increases the amount of power a transmission line can carry on average.

address bottlenecks in existing transmission lines to increase capacity. And more coordinated planning between separate grids can optimize the use of interprovincial lines.

In the long term, building out new interprovincial transmission lines, along with larger balancing regions, can address the challenges of integrating new resources. Yet recent studies on the potential role of transmission lines have failed to capture the benefits because the potential for additional transmission lines to enable the integration of new generation was not considered (Natural Resources Canada, 2018).

For larger balancing regions, the optimal structure depends on the geography and resource mix across the country. A pan-Canadian grid is not necessarily the most efficient solution. Rather, larger regional grids connecting provinces with significant hydro resources with those who lack them, along with neighbouring U.S. states, could deliver greater benefits.

While this interprovincial build-out faces real challenges, actions can be taken at the federal level to overcome them. There is a clear role for the federal government in negotiating the build-out and operation of more regional grids and providing funds to build them.

Policy options for Canada—drawing on international best practice

Despite the significant differences in provincial electricity grids and markets across Canada, many of the underlying policy solutions that combine the best practices above are the same across the country. And as the challenges facing Canada's domestic electricity systems are not unique, case studies from other jurisdictions offer important lessons.

1. Adopt clear interim targets that encourage near-term action on long-term goals

Province-wide targets for zero-carbon electricity can include multiple levels of stringency that ratchet up over time. Similar targets have been adopted in the U.S., Canada (e.g., coal phase-out and natural gas regulations), and the U.K.

CASE STUDY:
In the U.K., the electricity system operator has put in place a near-term (2025) zero-carbon operation target (Leslie, 2019), recognizing that while the U.K. has made significant progress in decarbonizing the electricity system, reaching zero-carbon operations will require a step change in planning and operation. In particular, the system has identified several specific challenges that will need to be addressed to ensure secure operation without traditional fossil resources (e.g., new supplies for grid management, mechanisms to produce them, and new data management techniques).

Unlike the more commonly used zero-carbon generation targets, which focus on the total generation across a year that is produced with zero-carbon sources and are based on timelines a decade or more into the future, the operation target approach is focused on the ability to run the grid for a short period of time with high levels of zero-carbon generation and encourages action on a shorter, six-year timeline, requiring that concrete actions be taken in the short term.

2. Enable and improve market access by improving price signals and providing financial support

Improving market access and encouraging innovation can be directly supported in a number of ways, for example by requiring market operators to create rules for new resources such as storage and by enabling regulated utilities to share in the benefits from improved systems through PBR. On the customer side, pricing and other creative plans that encourage consumers to shift their consumption from periods of scarcity to periods of abundance can save costs for consumers and the system as a whole.

CASE STUDY:

The U.S. Federal Energy Regulatory Commission (FERC)'s storage mandate offers useful insights into how adjusting market rules can enable market access. Recognizing that market rules designed for traditional generation can create challenges for energy storage, FERC issued Order 841 (FERC, 2018), which requires each grid operator to create new rules to allow energy storage to participate in wholesale markets. The new rules also allow energy storage resources to provide and be compensated for all the services they are technically capable of providing, thereby capturing the full value they bring to the system. Additional requirements were put in place to ensure that participation is as broad as possible, for example by limiting the minimum size requirement specified in new rules to no more than 100 kilowatts. The companion order, Order 841-A, also recognizes the need for market rules to be created in a way that enables investment, requiring that market design bolster investor confidence and encourage development of storage resources. Analysis of a preceding FERC Order (Order 755)—which requires grid operators to compensate ancillary services based on their speed and accuracy—found that changing market rules to better reflect and compensate the value that storage systems provide to the energy system can lift barriers, unlock investment, and increase deployment (Tabari and Shaffer, 2020).

The approach taken by FERC—recognizing the lack of market rules as a challenge and then requiring the creation of non-prescriptive ones—acknowledges the differences in both the physical system and markets and allows for flexibility. It also places a clear requirement that market rules cover the complete set of services energy storage can provide, creating a level playing field for all grid resources. This is an example of a target *or requirement that is both specific in the desired outcome while not overly prescriptive in the approach. While the full impacts of the FERC Order will take some time to become apparent, there are already positive indications that the approach will lead to increased storage deployment (Maloney, 2018).*

Although Order 841 applies to energy storage specifically, it has been suggested that this approach could be extended to other electricity system resources (Ahlstrom, 2018). Such a "universal market participation model" would allow for a true comparison across different resource types.

It is important to note that, in the Canadian context, no federal body exists with equivalent authority to the FERC. Therefore, this approach would have to be taken up by the provinces and territories, and any push from the federal government would be guidance only.

3. Increase integration and build out required infrastructure across the country

Broadening balancing regions and ensuring renewables have access to load centres can lead to robust markets for new resources.

CASE STUDY:

In 2005, the Texas state legislature mandated an increase in renewable energy generation in the state. The creation of the designated Competitive Renewable Energy Zones (CREZ) and build-out of extensive transmission infrastructure to connect the zones to load areas was a key contributor to the success and continued growth of renewable energy in the state (Orrell, 2016; Gould, 2018; ERCOT, 2006; Energy Institute, 2018). However, at the time the CREZ was created, transmission constraints in regions with significant wind potential prevented further development, as much of the best areas for wind development were not well connected to major load centres or to sufficient transmission lines.

To overcome challenges facing transmission development in the region (such as slow build-out and high uncertainty), the legislature mandated that the Public Utility Commission of Texas designate zones for wind development and build out transmission lines connecting the zones to load centres. The approach worked as designed, creating transmission connection capacity that allowed for significant private sector investment in wind development and increased wind generation capacity in Texas from 1,854 MW in 2005 (ERCOT, 2018) to 21,751 MW in 2019 (ERCOT, 2019).

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