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Achieving a Net-Zero Canadian Electricity Grid by 2035

Principles, benefits, pathways

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Summary

The Government of Canada has committed that, by 2035, the country's electricity grid will produce net-zero greenhouse gas emissions. This document sets out the Pembina Institute's understanding of what constitutes a net-zero grid; the environmental, economic and social benefits net-zero electricity can offer to Canadians; and some of the key milestones that must be met by governments and industry to facilitate the creation of a truly net-zero grid by 2035. If Canada achieves this objective, it will have a significant and enduring downward impact on the carbon footprints of all Canadians, and allow Canada to position itself as an international leader in clean electricity.

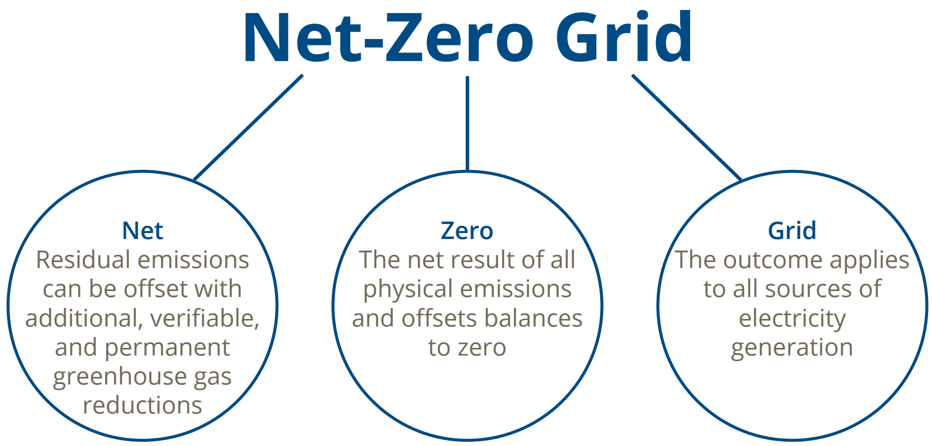
What does a "net-zero grid" in Canada mean?

First principles

A net-zero grid, by definition, should have no additional emissions released into the atmosphere overall as a result of electricity generation and supply. It should consist only of non- or low-emitting electricity generation supply, with any remaining emissions fully offset. It is only once this is achieved that the electricity system can reliably and affordably support the decarbonization of other energy end-uses through electrification (such as the move to electric vehicles). In short: we must achieve a net-zero grid if we are to bring down emissions across the board, and ultimately achieve a net-zero economy overall.

A net-zero grid should utilize as much non-emitting power as possible. Where it is clear achieving absolute-zero emissions would be technologically and/or economically prohibitive, the remaining emissions from the limited emitting forms of generation should be fully offset.

While reliance on offsetting is most justifiable at the beginning of the net-zero transition, the use of offsets must decline rapidly thereafter, eventually to elimination of all flexibility mechanisms by 2050. This is essential to free up offsets for other sectors in the economy that are harder to decarbonize than electricity.



To credibly claim a "net-zero grid", as the federal government has committed to establish, policymakers must give effect to the plain meaning of each of the three words: "net" as a qualifier that allows flexibility in attaining "zero" emissions resulting from electricity generation that is used to supply the interconnected systems known as the "grid".

"Net": how can emissions in the grid be negated?

In the early stages of the net-zero grid, flexibility in meeting the zero outcome ("netting") will be necessary, alongside carbon-abatement technologies for emitting sources of power generation. This will help existing emitting technologies to be gradually phased out. To credibly claim that a grid is net-zero, any residual emissions must be fully offset. Clear criteria and a process for making this determination must be set to ensure the use of offsets is not abused, and that actual emissions (that require offsetting) are as low as feasible. Offsets must be:[1]

- **Additional**. Offsets must be generated from real emission reductions (relative to a credible baseline) or carbon removal (from the atmosphere) that would not have taken place were it not for the offsetting activity.
- **Verifiable**. Verifying offsets ensures accurate accounting for the emissions reduction or carbon removal. Where offsets are generated against a business-as-usual baseline, extra scrutiny must be applied to ascertain the veracity of the baseline.

[1] University of Oxford, *The Oxford Principles for Net Zero Aligned Carbon Offsetting* (September 2020), 5. https://www.smithschool.ox.ac.uk/sites/default/files/2022-01/Oxford-Offsetting-Principles-2020.pdf

- **Permanent**. Emissions reductions must not be at risk of reversal, for example through subsequent re-release via leakage or decomposition.
- **Avoid unintended negative consequences**. Offsetting activities should reduce the risk of unintended negative consequences, such as the risk of nature-based solutions impacting biodiversity and other ecological and social resilience factors.

In a net-zero grid, these offsets — if generated within the electricity sector — would have to be negative emissions, from technologies such as direct air capture. The use of offsets in the electricity sector should be limited and should be nearly eliminated past 2035 in order to allow other sectors that are harder to decarbonize to avail themselves of these offsets.

"Zero": what does generation supply look like in a net-zero grid?

A net-zero grid has to be primarily based on renewable energy, supplemented by other non-polluting solutions such as transmission interties and demand-side measures. There may be grids in some parts of Canada where there may be a limited role for emitting technologies (but only where those emissions are fully offset or captured).

Non-emitting technologies may include:

- **Wind and solar energy.** Renewable energy costs have declined precipitously as economies of scale have grown. Costs are projected to continue decreasing, making renewable energy sources some of the cheapest available. Wind energy costs decreased by 72% from 2009-2021, and solar energy costs decreased by 90% during that time.[2] A Lawrence Berkeley National Laboratory cost analysis predicts wind costs will decrease further, by as much as 35% by 2035 and 49% by 2050.[3] Because of these cost declines, market subsidies have become less valuable for scaling up renewable energy developments. Moving forward, establishing policy certainty that encourages investor confidence will be central to creating a net-zero grid.
- **Conventional, run-of-river, and marine hydropower.** Canada has a large supply of hydropower. Maintaining these resources and building hydropower facilities and infrastructure (in a manner that minimizes impact on the environment and Indigenous

[2] Lazard, *Lazard's Levelized Cost of Energy Analysis – Version 15.0* (2021), 9. https://www.lazard.com/media/451905/lazards-levelized-cost-of-energy-version-150-vf.pdf

[3] Ryan Wiser, et al., "Expert elicitation survey predicts 37% to 49% declines in wind energy costs by 2050," *Nature Energy*, 6 (2021). https://doi.org/10.1038/s41560-021-00810-z

communities) will allow clean power supply to complement the increasing shares of wind and solar energy.[4]

- **Geothermal energy.** Geothermal electricity generation uses the heat from the earth to generate power. Canada's geothermal potential has yet to be tapped into.
- **Green hydrogen.** Green hydrogen, produced by electrolysis through low- or non-emitting electricity sources, can provide the same firm power supply and grid-balancing services as blue hydrogen, but with a lower rate of emissions.[5,6]
- **Nuclear energy and small modular reactors (SMRs).** New nuclear energy resources such as SMRs may provide valuable grid services. While some progress has been made in addressing public concerns around nuclear waste, costs, and timelines for deployment, SMRs still face challenges in competing with other readily available low-cost options in the short and medium term.
- **Transmission.** Investing in transmission interties, particularly between provinces with high fossil fuel use and those with abundant clean energy, can deliver large benefits at low costs.[7] Upgrading transmission infrastructure also allows clean electricity to flow to load centres that may not be located in the sunniest or windiest regions.
- **Demand flexibility.** Increasing the share of renewables on the grid will flip the system operations model from "forecast demand and dispatch supply" to "forecast supply and dispatch demand."[8] This will require development of pricing signals that encourage consumer behaviour changes (e.g. use outside of peak times), which in turn allow system operators to optimally dispatch energy resources.
- **Energy storage.** Battery storage can provide a cost-effective solution for short-duration renewable energy variability.[9] For longer duration needs, hydroelectric reservoirs can be utilized — underscoring the importance of better transmission interties. Other storage technologies continue to evolve.

[4] Blake Shaffer, *Technical pathways to aligning Canadian electricity systems with net zero goals* (Canadian Institute for Climate Choices, 2021), 9. https://climatechoices.ca/wp-content/uploads/2021/09/CICC-Technical-pathways-to-aligning-Canadian-electricity-systems-with-net-zero-goals-by-Blake-Shaffer-FINAL-1.pdf

[5] Chris Bataille, Jordan Neff and Blake Shaffer, "The role of hydrogen in Canada's transition to net-zero emissions," *School of Public Policy Research Paper*, 14, no. 30 (2021), 4. https://doi.org/10.11575/sppp.v14i1.72334

[6] Jordan Neff, Chris Bataille and Blake Shaffer, "The role of hydrogen in decarbonizing Alberta's electricity system," *School of Public Policy Research Paper*, 14, no. 31 (2021), 6. https://doi.org/10.11575/sppp.v14i1.73208

[7] Jan Gorski, Binnu Jeyakumar and Spencer Williams, *Connecting provinces for clean electricity grids: Regional collaboration to unlock the power of hydro, wind and solar to decarbonize Canada's economy* (Pembina Institute, 2021), 5. https://www.pembina.org/pub/connecting-provinces-clean-electricity-grids

[8] *Technical pathways to aligning Canadian electricity systems with net zero goals*, 11.

[9] *Technical pathways to aligning Canadian electricity systems with net zero goals*, 15.

Emitting technologies may include:

- **Natural gas generation with carbon capture, utilization and storage (CCUS).** Existing natural gas resources may be used to provide grid-balancing services to ensure system reliability as the net-zero transition gets underway. CCUS can also be employed to facilitate the production of hydrogen from natural gas resources.
- **Blue hydrogen.** Derived from natural gas with CCUS; can be used in place of fossil gas to provide power, storage, and grid-balancing services.[10,11]
- **Cogeneration.** Existing cogeneration facilities may continue to provide heat to industry, while producing electricity as a by-product. Emissions allocated to the electricity output should be zero or netted to zero.

In the context of achieving a net-zero grid by 2035, any new investment in emitting technologies listed runs the risk of committing to "dead ends" that will ultimately become uneconomical and not support a net-zero grid in the long term. Furthermore, the above emitting technologies also have associated with them upstream emissions from natural gas production and transmission (which are considerably higher than the life cycle greenhouse gas impacts of renewables),[12] in addition to any inefficiencies in carbon capture, which would make them incompatible with a net-zero economy. This risk of stranded assets and follow-on investments (retrofitting or replacing generation that is ultimately not reconcilable with a net-zero economy) creates risks of higher ratepayer impacts not only on the generation capital itself, but also the grid infrastructure necessary to connect and integrate that generation.

"Grid": what generating facilities constitute the electricity system?

To create a truly net-zero grid that is recognized as such by investors, Canadians and the global community, there cannot be broad, undue exemptions that result in loopholes for certain generators. As such, all generation that is connected to an interconnected electricity system must be net-zero emissions. That includes behind-the-fence generation[13], even in cases where a majority of the energy generated is also consumed behind the fence.

[10] "The role of hydrogen in Canada's transition to net-zero emissions," 4.

[11] "The role of hydrogen in decarbonizing Alberta's electricity system," 6.

[12] Vincent Morales and Binnu Jeyakumar, *Renewable energy – what you need to know* (Pembina Institute, 2020), 5. https://www.pembina.org/pub/renewable-energy-what-you-need-know

[13] Behind-the-fence generation refers to power plants that are built on-site, specifically to provide power to a load such as an industrial facility, rather than to provide power into the grid. Many such facilities are however still connected to the grid and use it for reliability.

For instance, industrial cogeneration is typically sized to the non-electricity product (e.g., steam or heat) load, so that the amount of electricity produced ends up being substantially greater than the facility's consumption level — not only on a point-in-time basis, but even on a net annual basis. Therefore, excluding industrial cogeneration from the net-zero obligation would create a substantial, unnecessary loophole that would allow for large volumes of grid electricity to be net-emitting, significantly undermining Canada's claim of a net-zero grid. Moreover, the exclusion would perversely incent the further development of a generation source that is less flexible and offers fewer of the attributes and grid services that may be useful to operating a net-zero grid. Instead of exempting cogeneration altogether, it makes more sense to distinguish between the emissions assignable to the electricity system and the emissions assignable to the other industrial product.

Moreover, policy design must also take care not to create a perverse incentive for grid defection and the establishment of off-grid facilities in grid-adjacent locations. A cost-effective net-zero grid outcome is undermined when large volumes of load choose to go off-grid and undermine the economies-of-scale and rate-base dispersion that is possible with larger load densities.

The most sensible exemption could be based on generation size, such as a low capacity, low generation or low emissions threshold. Many facilities below 5 MW are sized to self-generate on a net basis and are also administratively costly to regulate.

The other type of "grid" to consider are remote micro-grids, commonly found in northern and remote Indigenous communities. Indigenous governments and communities should be engaged to determine if and how remote community microgrids should be included in defining and delivering a net-zero grid. Territorial governments should have an opportunity to be consulted, given the fact that all communities in the territories can be classified as remote, with many communities in Yukon and the Northwest Territories connected to territorial regional grids.

Finally, emissions from electricity that is imported to Canada's grid must be accounted for and should not undermine achieving a net-zero grid. Flexibility mechanisms for electricity imports could include a border carbon adjustment or offering offsets for net-zero power exports.

Why is a net-zero grid by 2035 crucial for Canadians?

Achieving a net-zero electricity grid will provide environmental, social and economic benefits for Canada and Canadians.

Reliability and resilience

Creating a net-zero grid is an opportunity to improve the reliability and resilience of Canada's electricity supply. Diversifying the generation mix, investing in energy efficiency, modernizing the grid, and enabling demand-side management will improve grid flexibility and reliability.[14] A successful net-zero grid will be able to provide reliable electricity where and when it is needed, while also being resilient to disruptions, especially those caused by the increasing frequency of extreme weather events.

Affordability

Renewable energy costs have declined dramatically over the last two decades, so that wind and solar are now clearly the lowest-cost electricity generation options available. In addition, the rising carbon price and increased stringency of industrial carbon pricing systems will accentuate the competitive advantage of non-emitting power in the years ahead. As recent steep increases in natural gas prices have brought into focus, consumers can suffer from the price volatility of an electricity grid that is tied to global fossil fuel markets; a grid that is less reliant on gas-fired generation will therefore improve stability for consumer bills. Furthermore, Pembina Institute analyses have found that a clean energy portfolio consisting of renewables, storage, energy efficiency and demand-side management can be cheaper than gas-fired generation, while providing the same energy services.[15,16]

Reducing electricity sector and economy-wide emissions

Canada's electricity sector produces 56 Mt of emissions per year.[17] While emissions in the electricity sector have decreased in recent years as the retirement of coal facilities continues,

[14] Dylan Clark and Anna Kanduth, *Enhancing the resilience of Canadian electricity systems for a net zero future* (Canadian Institute for Climate Choices, 2021), 3. https://climatechoices.ca/wp-content/uploads/2022/02/Resiliency-scoping-paper-ENGLISH-Final.pdf

[15] Jan Gorski and Binnu Jeyakumar, *Reliable, affordable: The economic case for scaling up clean energy portfolios* (Pembina Institute, 2019). https://www.pembina.org/pub/reliable-affordable-economic-case-scaling-clean-energy-portfolios

[16] Jan Gorski and Binnu Jeyakumar, *Towards a Clean Atlantic Grid: Clean energy technologies for reliable, affordable electricity generation in New Brunswick and Nova Scotia* (Pembina Institute, 2022). https://www.pembina.org/pub/towards-clean-atlantic-grid

[17] GHG emissions from electricity sector in 2020, Environment and Climate Change Canada, *National Inventory Report 1990-2020: Part III*, 11. https://publications.gc.ca/site/eng/9.506002/publication.html

current projections show that gas-fired generation will increase by 70% by 2050.[18] This growth in fossil fuel generation must be avoided and all emissions from electricity generation brought close to zero. International Energy Agency (IEA) analysis shows that to meet the Paris commitment of limiting the global temperature increase to 1.5°C, all developed economies must decarbonize their grids by 2035.

A clean grid is also essential for achieving economy-wide net-zero greenhouse gas emissions by 2050. In addition to reducing emissions from electricity generation, it will also facilitate emissions reductions in other sectors that rely on the grid, such as buildings, transportation, and heavy industry.

Jobs and economic development

There is significant potential for jobs growth and economic development associated with the decarbonization of Canada's grid, including investments in transmission, renewable energy, and storage. While jobs in the traditional energy sector will decline, research indicates that job growth in the clean energy economy will outpace those losses. Between 2020 and 2030, an estimated 125,800 fossil fuel-related jobs will be lost, but 208,700 jobs in clean energy will be added during that time.[19] Renewable energy projects can also help generate revenues for communities and municipalities,[20] in addition to attracting investments from companies with ESG and net-zero commitments. The decision by General Motors Canada to locate its new cathode battery plant in Quebec "because of Quebec's low-cost, but zero-GHG electricity system"[21] underscores this trend. Additionally, Canada is the largest source of United States energy imports.[22] As the United States considers its own legislation around clean electricity, Canada will be well-positioned to export affordable and reliable electricity that meets U.S. regulatory criteria.

[18] Canada Energy Regulator, *Canada's Energy Futures,* 2021 dataset. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/

[19] Clean Energy Canada, *The New Reality* (2021), 4. https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[20] Rocky Mountain Institute, *Powering Rural Economic Development with Renewables* (2021). https://rmi.org/powering-rural-economic-development-with-renewables/

[21] Gabriel Friedman, "Ontario risks losing its auto crown as cheap, green power gives Quebec the EV edge," *Financial Post,* March 11, 2022. https://financialpost.com/commodities/energy/electric-vehicles/ontario-risks-losing-its-auto-crown-as-cheap-green-power-gives-quebec-the-ev-edge

[22] U.S. Energy Information Administration, "Canada is the largest source of U.S. energy imports," June 5, 2020. https://www.eia.gov/todayinenergy/detail.php?id=43995

Equity

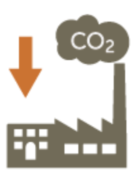
The net-zero grid transition presents an opportunity to address the systemic inequalities that have historically existed in the traditional energy system. Governments can enable equitable participation and access to clean energy jobs by:[23]

- Working with municipal and Indigenous governments to identify, prioritize, fund, and develop local and Indigenous-owned infrastructure projects in affected communities
- Providing equitable access to permanent jobs with good pay and opportunities for advancement, particularly for women, First Nations, Métis, Inuit, and other groups with historically limited participation in the fossil fuel-based energy sector
- Providing accessible and culturally appropriate opportunities for participation in decision-making processes for communities that have been disproportionately impacted by the environmental and health impacts of heavily polluting electricity generation

How do we get to a net-zero grid?

Generators, investors, utilities, cleantech developers, consumers and different levels of government will need to come together in concert to achieve a net-zero grid by 2035. As highlighted above, however, the necessary technologies already exist to meet this goal, particularly with a foundation of renewable energy options that are already the lowest-cost generation available. With the right price signals, regulatory certainty, and supportive programs, we can be confident that market forces, utility planning, and innovation will prompt the capital deployment and operational behaviour necessary to meet this crucial goal.

Government must set the conditions to enable the activation of industry and utility expertise, and market dynamics. This includes coordination and collaboration between different levels of government and between neighbouring provinces, to successfully implement a set of key policy and programming measures:



1. **Regulated emissions standards:** the federal government's forthcoming Clean Electricity Regulations (to be finalized in 2023) will be crucial in setting clear, stable regulatory signals against deploying capital in assets that are not compatible with a net-zero grid, and instead toward investments in non-emitting generation and corollary infrastructure. To provide the certainty needed for the investment environment, the

[23] Grace Brown and Binnu Jeyakumar, *Supporting Workers and Communities in a Coal Phase-out: Lessons learned from just transition efforts in Canada* (Pembina Institute, 2022), 40. https://www.pembina.org/pub/supporting-workers-and-communities-coal-phase-out

standards within the Clean Electricity Regulations must therefore be set early and unambiguously, and be insulated from long-term political uncertainty. In particular, the clear outcomes the Clean Electricity Regulations must ensure are:

   a. an immediate end to new investment in unabated natural gas generation; and
   b. a fully net-zero grid in 2035, with any remaining direct emissions offset.

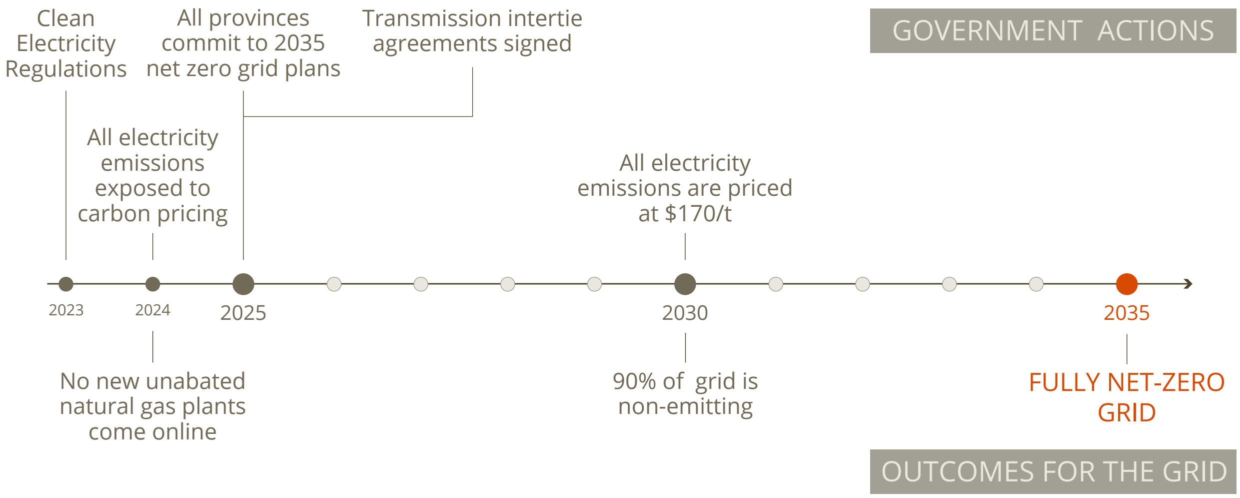
2. **Incentivizing through carbon prices**: en route to a 2035 net-zero grid, governments must codify $170/t carbon pricing by 2030 on *all* electricity emissions, with no free allocations (i.e., zero output-based production standards, output-based allocations, or performance benchmarks) for either new or existing facilities. In terms of federal action, this means not only a federal Output Based Pricing System of zero for electricity, but also rejecting provincial industrial carbon pricing policies that fail to fully price electricity emissions.

3. **Funding**: the provision of immediate funding and financing is essential to encourage both near-term deployment of renewable energy that is already commercially available and lowest-cost, and of energy storage and transmission (both intra- and inter-provincial) infrastructure to integrate that new renewable energy. The immediate deployment is necessary to achieve the federal commitment of 90% non-emitting power by 2030, and to accommodate long development timelines for transmission.

4. **Interprovincial cooperation and energy trade**: the transition to net-zero will prove more cost-effective if interprovincial interties are deployed where they are the most cost-effective option for balancing non-emitting generation and load. At present, the deployment of interprovincial interties to reduce costs to consumers is hindered by regulatory, social, and political dynamics; competitiveness concerns of incumbent generators; and anxiety amongst provinces about being able to guarantee the reliability of their grids. To overcome these barriers, the federal government must offer carrots and wield sticks to promote intertie development where it makes sense. Given transmission development timelines, there is no time to spare.

Key milestones

Canada's path to a net-zero grid by 2035 requires early and bold action by governments as well as industry. The switch cannot be flipped overnight. In particular, the following milestones are key to ensure we are making progress at the pace needed to meet this goal:



Federal government actions set the pace and direction for Canada's net-zero goals. As provincial and territorial governments oversee their own electricity systems, they play a key role in incentivizing the net-zero transition and ensuring national targets are met. Table 1 outlines federal and provincial/territorial roles and pathways for enabling a net-zero grid.

Table 1. Government roles and pathways for enabling the grid transition

Role	Federal Government	Provincial/Territorial Governments
Target-setting	• Commit to national net-zero grid by 2035 *(done)*	• Commit to a net-zero provincial/ territorial grid by 2035
Regulating	• Institute Clean Electricity Regulations	• Offer utility performance incentives and alternative rate structures that align with decarbonization targets • Expand regulator mandates to align with decarbonization targets • Integrated energy planning • Integrated distribution system planning
Incentivizing	• Carbon pricing	• Carbon pricing
Funding	• Transmission • Energy storage • Support for stranded assets • Renewable energy procurement	• Transmission • Energy storage • Support for stranded assets • Renewable energy procurement

	• Incentives for electric homes and appliances	
Convening and coordination	• Support provincial/territorial regulatory reform • Support modernization of grid operations • Coordinate with provinces on expanding transmission	• Convene net-zero grid strategy sessions • Coordinate with regulators on climate accountability
Innovation and knowledge-sharing	• Grid modernization • Support provinces/territories in regulatory reform • Conduct studies on optimizing grid decarbonization	• Grid modernization • Conduct studies on optimizing grid decarbonization

Conclusion

With these concerted actions, a net-zero grid can be achieved by 2035, enabling the cost-effective widescale electrification that will be necessary for a net-zero economy by 2050. With an affordable net-zero grid in 2035, Canada will position itself among the most competitive jurisdictions in the world to attract global capital for investments in industries that need clean power. The key to reaching that cost-effective net-zero grid are the introduction of clear, immediate, unambiguous standards (through the Clean Electricity Regulations), complemented by predictable full carbon pricing, programs to foster early action to deploy non-emitting power, and support for interprovincial clean electricity trade.