

VISION 2050



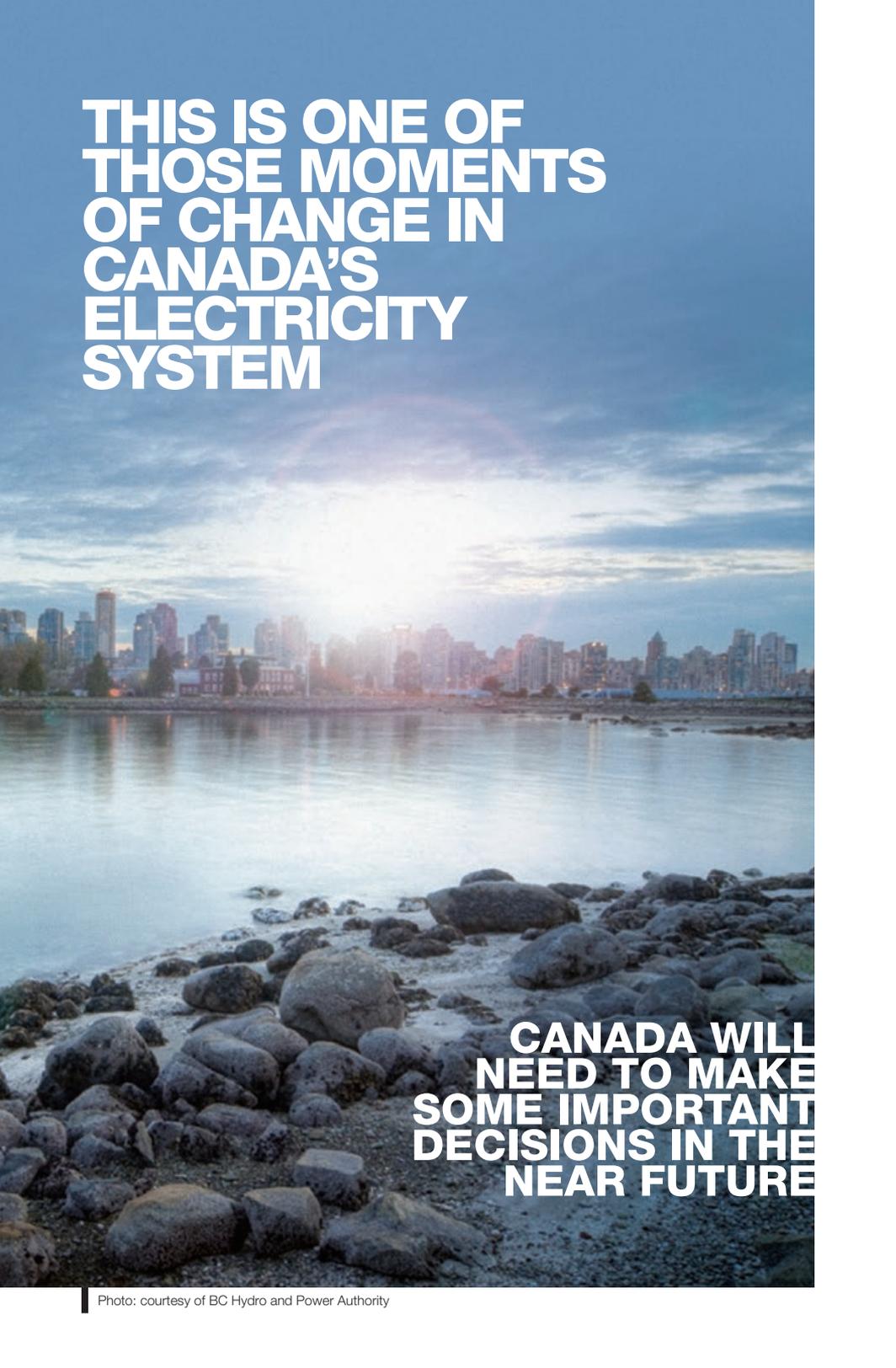
THE FUTURE OF CANADA'S ELECTRICITY SYSTEM

Executive Summary



Canadian
Electricity
Association

Association
canadienne
de l'électricité



THIS IS ONE OF THOSE MOMENTS OF CHANGE IN CANADA'S ELECTRICITY SYSTEM

**CANADA WILL
NEED TO MAKE
SOME IMPORTANT
DECISIONS IN THE
NEAR FUTURE**

ELECTRICITY HAS BECOME SOMETHING WE TAKE FOR GRANTED, NOT ALWAYS UNDERSTANDING THE THOUSANDS OF KILOMETRES OF TRANSMISSION WIRES, GENERATING STATIONS AND DISTRIBUTION SYSTEMS THAT LIE BEHIND THE SWITCH, OR APPRECIATING THE THOUSANDS OF HIGHLY SKILLED PEOPLE WHO HELP DELIVER RELIABLE ELECTRICITY.

When Thomas Edison lit the single incandescent lamp more than a hundred years ago, we could not have imagined how our electricity systems would have changed and grown, or the ever-evolving range of electronic devices that would populate our lives today.

The industry that provides the critical power for our lives and economy is designed to be conservative, delivering reliability and necessary redundancy through its systems. Its planning horizons are measured in the decades.

Today, we're witness to demanding and important new moments in the timeline of electricity in Canada:

- Many electricity assets are approaching their end of life and must be replaced;
- Developments in information technology and automation raise exciting possibilities for a reconfigured electricity grid;
- Extreme weather reminds us of our reliance on critical electricity infrastructure;
- Many stakeholders are advocating greater forms of regional integration in North America.

It's time to modernize our electricity system for the next generation.

As we consider options for the future, we need to remember **the journey** that created the system we have today.

When the electricity industry started in the late **19th century**, it was made up of a number of independent operations, city by city; what we might now call micro-grids.

It became apparent early on that both cost and reliability could be improved when these municipal systems were linked through major investments in larger generating stations and transmission lines. The price of electricity tended to drop with economies of scale. Reliability improved with transmission that enabled large movement of electricity from one place to another. Together these factors drove the development of the industry as we know it.

In the **mid-20th century**, consideration of environmental impacts began to grow in importance. By the **21st century**, environmental sustainability of the electricity system evolved to a social imperative. This gave rise to the growth of new renewable technologies such as solar, wind, biomass and tidal. These “new” renewables complement the long-established renewable hydroelectricity Canada has been relying on for over a hundred years.

Today, the electricity industry has a commitment to limit its carbon footprint and operate in an environmentally-responsible way. More than three-quarters of Canada’s electricity generation comes from non-emitting sources, largely from hydro, which is still the most efficient renewable technology. Across the country, more non-hydro renewables are being added to the grid and the industry continues to find new ways to reduce the environmental impact of natural gas and coal. The industry is also working throughout the country to create a culture of energy conservation.

Over the years, **the role of the customer has evolved** as well. Early on, the customer received what others thought best. However, the paradigm has shifted and, by the end of the 20th century, deregulation of industries accelerated, leading to increasing competition, which in turn created opportunities for lower prices and ultimately gave “customer choice” a foothold in the electricity industry.

More recently, changing technologies have shifted the role of the customer, increasing the impact of consumers in shaping the

electricity system. Fortunately, the same technologies that give the customer a central role also create opportunities to better manage the new complexities as the system evolves. Customization to meet consumer need will become a key attribute of our electricity system, allowing for efficiencies from production to end-use.

CUSTOMERS WANT TO HAVE MORE OF A ROLE NOT ONLY IN CONTROLLING THEIR DEMAND, BUT ALSO IN CONTRIBUTING THEIR OWN SUPPLY TO THE GRID

The journey to present-day reflects a balance among three pillars that have shaped the industry over the last hundred years:

- Affordability;
- Reliability;
- Sustainability.

It is not an exact science – the three attributes cannot be specifically measured and put into an equation. In fact, the dynamics are often different in each region of the country. Finding the right balance is largely done through a process that involves legislation, regulation and often, politics of the day.

The electricity industry is more than the individual companies that produce and deliver power – it comprises the largest interconnected machine in North America. And the impact of that machine reaches beyond today; inherent in its management is an obligation to leave a functioning and reliable system to our children, an essential part of our legacy to them. People and governments look to the industry to operate in the public interest and provide value for the money Canadians spend on power. That means working to earn the public's trust beyond producing power reliably. The industry must increase efficiency, eliminate waste and provide transparency about decisions it makes.

These are all important moments in the evolution of Canada's electricity system, helping us understand our history in preparation for choices about our future.

Given the changing dynamics we face, **the electricity industry has developed a vision for a bright future for electricity.**

TIME FOR A VISION

**HEREIN, THE
CANADIAN
ELECTRICITY
ASSOCIATION
PRESENTS THE
ELECTRICITY
INDUSTRY'S VISION
FOR THE EVOLUTION
OF CANADA'S
ELECTRICITY SYSTEM
BETWEEN NOW
AND 2050**

VISION 2050 BEGINS BY FRAMING THE CONTEXT FOR MAKING DECISIONS ABOUT ELECTRICITY, INCLUDING THE ELECTRICITY SYSTEM'S UNIQUE AND IMPORTANT FEATURES, THE LIKELIEST FUTURE SCENARIO AND VARIABLES THAT MAY IMPACT ON IT, AS WELL AS THE IMPORTANT DRIVERS OF CHANGE AND DECISIONS THAT CANADIANS WILL NEED TO MAKE IN THE NEXT FIVE TO 10 YEARS.



Part 1 – fundamental characteristics of the electricity system



Part 4 – the case for the urgency of action



Part 2 – most likely scenario for the mix of power generation



Part 5 – a vision for Canada's electricity future



Part 3 – key variables that will impact the future of the system



Time to decide

Vision 2050 centers on a commitment to renew Canada's electricity system through the optimal evolution of electricity supply and demand, so as to deliver maximum value to customers and citizens, and contribute to a lower carbon economy.



Fundamental Characteristics of the Electricity System

Any vision must accept and build on three fundamental characteristics of the electricity industry that combine to determine its evolution and the constraints under which it operates:

- Its infrastructure is replaced only very slowly;
- Its principal actors are interdependent across borders;
- It manages and delivers a public good.

The electricity industry has a much slower capital stock turnover than most other industries. Coal plants operate for 50 years or more and nuclear plants for 40 years or more. Hydroelectric plants can operate for more than a century. Electricity assets are also slow to turn over because, unlike consumer goods, innovations tend to occur at a slower pace than in many other industries, and truly disruptive innovations – refinements and changes that redefine the entire industry – occur only rarely.

The slow pace of turnover in electricity has a clear implication: while it may seem that we have years to decide on the system we want, 2050 is an electric heartbeat away. Once infrastructure is in place there are significant economic costs to cutting short its very long useful life. In other words, **what we decide to build today will form the foundation for the system for our children and their children.** It will be with us for decades, so it's time for us to choose wisely.

Second, **energy resources are interdependent to a significant extent, especially in terms of the electricity grid and international energy prices.** In 2003, cascading blackouts originating in Ohio led to more than 508 generating units at 265 power plants across Canada and the United States being shut down through the outage. And when Hurricane Sandy hit the East Coast in 2012, Canadian engineers and experts were immediately deployed to help restore power and clean up.

Third, **the electricity system is a public good.** Although electricity companies naturally look to advance their own interests, the industry is also a steward of the public trust. So its effective

functioning leads to significant benefits for society. When the electricity system functions well, it has a meta-role in supporting the stability and growth of other industries and other parts of the economy. Electricity, in developing economies, has driven, or at least been strongly correlated with, human development, and it is equally critical for the sustainability of developed economies. But as well, market failures in electricity often translate into wider crises.

IN THINKING ABOUT THE FUTURE OF ELECTRICITY, WE MUST BE MINDFUL OF ITS BENEFITS AND RESPONSIBILITIES TO SOCIETY AS A WHOLE, AND ACROSS GENERATIONS



Electricity Mix Scenario for 2050

Electricity mix scenarios are tools for combining demand and supply inputs into possible pictures of the future.

Vision 2050 speculates on the National Energy Board's most likely scenario for the mix of power generation in the future, noting some interesting but largely incremental changes in the electricity mix, which is already relatively clean and low carbon, and identifying the underlying factors impacting this base-case scenario.

SCENARIOS ARE EXTREMELY HELPFUL IN DEFINING WHAT IS POSSIBLE AND WHAT IS NOT IN THE 'POSSIBLE WORLDS' WE MAY ENCOUNTER WITH THE EVOLUTION OF CANADA'S ELECTRICITY SYSTEM

It is important to note that scenarios cannot predict with certainty what will shape the path to a low carbon future and they can potentially omit important intervening factors that can dramatically change the longer-term picture.



Key Variables Affecting the Future of Canada's Electricity System

To inform the discussion about scenarios of the future, Vision 2050 lists a series of variables that may dramatically impact the future of electricity in Canada if they change significantly over time. The variables include:

- **The future size of the system** – the size of electricity supply and demand could be altered by variables such as growth rates for population, gross domestic profit (GDP), electrification of vehicles and electricity exports as well as the effectiveness of energy efficiency and demand management programs at reducing demand.
- **The future composition of the system** – decisions made about the evolution of nuclear, fossil fuel and renewable generation could significantly alter the total composition of the electricity mix. Canada's ability to incorporate the economic, environmental, social and cultural interests of Aboriginal Peoples and communities in the development of renewable and non-renewable energy resources will also be impactful.
- **Changes in management of the system by the industry and customers** – how the system will be managed and designed in the future will be impacted by the effectiveness of energy efficiency and demand management efforts, adoption of new technologies such as electric vehicles and grid modernization, advancement of consumer management of energy, and the ability of the sector to overcome human resource shortages.
- **Economic and financial levers that might be brought to bear on the system** – the ability of governments and regulators to implement and support economic and financial instruments that balance costs, benefits, alternatives, timelines and beneficiaries will impact Canada's transition to a low carbon energy mix.



The Case for Action Now

Despite uncertainty in the many variables that will affect the future of Canada's electricity system, **Vision 2050 sheds light on the urgent need for action both in policy development and infrastructure investment.**

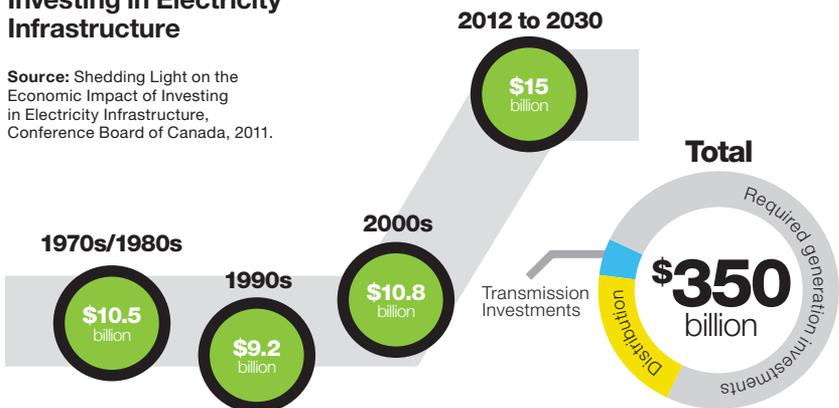
For a start, electricity infrastructure must be maintained and renewed just to sustain the reliability of what we have today. This will require substantial new capital investment at unprecedented levels.

It is in our collective interest to be serious about these issues today, understanding that less-than-reliable electricity would create its own costs through economic losses and opportunity costs, to say nothing of the potential costs of brownouts and blackouts. In addition, the practical reality is that citizens in an advanced economy like Canada expect nothing less than reliable electricity across a wide array of applications.

Furthermore, long lead times for planning for refurbishment and new construction suggest that we do not have the luxury of many years of assessment before making decisions. It can sometimes take up to a decade or more to build large facilities. And looking ahead, we know that most of our current electricity assets will have reached the end of useful life by 2050.

The Economic Impact of Investing in Electricity Infrastructure

Source: Shedding Light on the Economic Impact of Investing in Electricity Infrastructure, Conference Board of Canada, 2011.



Electricity public policy is politically charged. Other than taxation, it is probably the largest area in which public policy impacts directly on consumer spending and disposal income; and virtually all stakeholders are consumers. Power is a significant business input cost and is a large factor in business investment decisions. The blending of energy and environmental policy has significantly complicated the political dynamics, requiring solutions that address both factors.

The net result is a broad coalition of interests that is predisposed to withhold social license and to resist significant price increases, including those that result from capital investment. In times of fiscal constraint and difficult political choices, governments have tended to limit their direct investment and have tried to manage the rate of price increase, with a resultant shortfall in renewal of infrastructure, particularly by public utilities.

THERE IS A CLEAR NEED FOR SIGNIFICANT ENGAGEMENT BY GOVERNMENTS AND THE INDUSTRY TO BROADEN THE DISCUSSION OF PRICE TO THE LARGER QUESTIONS OF VALUE FOR MONEY AND THE FUTURE REQUIREMENT FOR A RELIABLE, SUSTAINABLE ELECTRICITY SYSTEM

The lead times for planning and construction preclude quick responses to a crisis in supply. Sensible choices will only come when we are able to depoliticize the discussion, but reducing political risk and shoring up social license will take time and disciplined effort.

Principles for Prudent Electricity Investments

As Canadians consider scenarios for future electricity investments that will ensure a safe, secure, reliable electricity system for future generations, **electricity investment decisions should be guided by a set of key principles:**

Reliability is an intangible good that is often taken for granted in our day-to-day life, but it forms part of any cost-benefit analysis around infrastructure renewal.

RELIABILITY

As electricity prices increase, governments will need to protect lower income citizens and ratepayers from 'energy poverty' through social policies and support.

EQUITY

Careful attention must be paid to how incremental and intermittent forms of generation will be integrated into the overall electricity mix.

INTEGRATION

A forward-looking approach to electricity may generate additional revenues through the sale of electricity exports.

GROWTH

Innovative new technologies and applications may deliver significant environmental, social and economic benefits.

INNOVATION

Grid modernization will entail further opportunities for energy efficiency, and households may enjoy returns on efficiency investments through reduced electricity consumption and customization of use (e.g., consumption during non-peak periods).

EFFICIENCY SAVINGS

Energy efficiency is an issue in transportation as much as in electricity. While electrification of transportation will entail some infrastructure switching costs, it will also generate a more efficient mode of transportation, resulting in savings to customers over time.

TRANSPORTATION BENEFITS

For the economy as a whole, resilient infrastructure can generate confidence and stimulate other forms of growth and innovation in the economy.

RESILIENCE BOOSTS CONFIDENCE

VISION 2050



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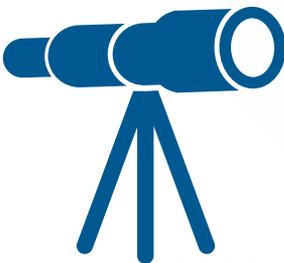
LONG LEAD TIMES IN PLANNING AND BUILDING OUT INFRASTRUCTURE REQUIRE DECISIONS NOW TO ENSURE THAT WE CONTINUE TO HAVE A RELIABLE AND SUSTAINABLE SYSTEM IN 2050.

The Canadian Electricity Association's Vision 2050 proposes practical and proactive strategies and actions aimed at advancing three objectives:

- Renewing the electricity system;
- Delivering maximum value;
- Contributing to a low carbon economy.

Vision 2050 centers on four key recommendations that are likely to produce the greatest transformations. These recommendations are intended for the federal and provincial governments, regulators, electricity companies, and ordinary Canadians in support of the vision.

VISION 2050: The Future of Canada's Electricity System



renew



value



low carbon



RECOMMENDATIONS

VISION 2050 – A SUMMARY OF RECOMMENDATIONS AND STRATEGIES FOR ACTION

Recommendation One – Accelerate Innovation and Customer Management of Energy

Electricity regulations were developed in a different era. Increasing consumer management of energy and grid modernization are blurring traditional distinctions between utilities, the grid and the customer. By 2050, if not much earlier, there is potential to be operating an electricity system in which electric vehicles, energy efficiency, integrated renewables, and energy storage are all in a constant state of dynamic, demand-supply interaction, tailored to the preferences of households and individual customers. Vision 2050 recommends accelerating this transformative innovation and customization.

Federal Government	Provincial Governments	Regulators and System Operators	Utilities
Maintain national research, development and deployment (RD&D) funding via Sustainable Development Technology Canada (SDTC)	Support knowledge sharing, collaboration, and customer-funded innovations related to energy efficiency, low carbon electricity, energy storage and electric vehicles	Support integration of pilots in electricity customization Provide oversight and criteria for evaluation of customer benefits from innovative investments	Assess cost-benefits of grid modernization programs; start with pilots Introduce customized cost-saving options for customers through reduced electricity use Form industry consortia focused on innovation that can pool customer funding from across jurisdictions and enable collaboration
Revise policies, laws and regulations to facilitate two-way electricity flows, micro-generation, emerging forms of generation and flexible demand response	Revise policies, laws and regulations to facilitate two-way electron flows, micro-generation, emerging forms of generation and flexible demand response	Advise governments on regulatory changes needed to facilitate two-way electron flows, micro-generation, emerging forms of generation and flexible demand response	Facilitate two-way electron flows, micro-generation, emerging forms of generation and flexible demand response

Recommendation Two – Implement Financial Instruments for Carbon Reduction

Electricity investments in Canada will unavoidably entail significant costs to ratepayers and taxpayers in the coming decades. It is important that economic policies be well-coordinated to ensure costs are considered in the proper context and weighed against the benefits of the investments, in light of the alternatives and over the long-term. A North American carbon price that is implemented across the economy holds potential for very significant carbon reductions at lower cost than alternatives. Vision 2050 recommends implementing financial instruments that support carbon reduction at multiple levels: for households, for the electricity sector, for electricity in conjunction with transportation and for the economy as a whole.

Federal Government	Provincial Governments	Regulators and System Operators	Utilities
<p>Phase out operating subsidies</p> <p>Continue providing R&D and early-adopter capital subsidies</p> <p>Provide loan guarantees for beneficial interprovincial projects</p>	<p>Phase out operating subsidies</p> <p>Continue providing R&D and early-adopter capital subsidies</p> <p>Develop (or maintain) loading order policies for new transmission to give priority to low carbon generation resources</p>	<p>Support technical issues arising from implementation of carbon policies</p>	<p>For generators, develop corporate plans for ongoing carbon reductions in fleets</p>

GRID MODERNIZATION IS NOT AN END IN ITSELF, RATHER, IT IS AN ENABLER OF OTHER INNOVATIONS AND ADVANCES

MILLIONS OF CANADIAN HOMES COULD BE LOAD CENTERS, PEAK SHAVERS AND MICRO-GENERATION UTILITIES

Recommendation Three – Enable Electric Vehicles (EVs)

Electric vehicles may grow to very high levels of market penetration, with corresponding environmental benefits and opportunities for electricity providers, or they may fall far short of their full potential. Vision 2050 recommends proactive steps to accelerate the electrification of the transportation sector through policy support and collaboration, coalition building, and implementation of enabling infrastructure.

Federal Government	Provincial Governments	Regulators and System Operators	Utilities
Develop enabling policies and regulations (e.g., for recharge points)	Develop enabling policies and regulations (e.g., for recharge points)	Advise governments on technical requirements for electric vehicles	Advise governments on technical requirements and commercial models for electric vehicles
Early adoption of electric vehicles in public sector fleet	Early adoption of electric vehicles in public sector fleet	Not applicable	Implement customer-friendly information technology (IT) systems to measure what is being taken from the grid

Recommendation Four – Expand Collaboration Across Borders

The electricity grid is already very much a shared resource between Canada and the United States, yet additional opportunities for integration and collaboration abound. Vision 2050 recommends optimizing electricity assets from a more integrated North American approach and expanding scope for electricity storage and export of low-carbon electricity to the United States.

Federal Government	Provincial Governments	Regulators and System Operators	Utilities
Form an agreement with U.S. on RD&D collaboration areas	Advise federal government on key areas for RD&D collaboration with U.S.	Advise provinces on technical obstacles and enablers for expanded collaboration	Advise provinces on key areas for RD&D collaboration with U.S.
Collaborate with U.S. on new transmission lines	Collaborate with U.S. on new transmission lines	Support new transmission lines for export	Expand clean electricity for export to U.S.



CONCLUSION

THE DECISIONS THAT CANADA MAKES TODAY, AND OVER THE NEXT FIVE TO 10 YEARS, WILL HAVE A HUGE IMPACT ON WHAT OUR SYSTEM WILL LOOK LIKE IN 2050.

Far-reaching, Vision 2050 represents a new, more ambitious role for electricity in Canada. It calls for a new level of leadership, as well as supporting actions from governments, regulators, and utilities. Public understanding and support will be essential. It will evolve with time and through conversations with citizens and stakeholders.

Vision 2050 is also an opportunity. It responds to growing customer expectations for a more responsive and innovative electricity system. It is a chance to strengthen environmental outcomes and generate additional revenues in the process. It is an opportunity to continue delivering the three pillars of a strong electricity system – reliability, affordability and sustainability.

Vision 2050 represents a real choice to pursue a proactive and coordinated approach to shaping our electricity future over a passive and fragmented approach. As with so many choices, it will not be available forever.

It's time to decide.



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