

eBook



# Smart Grids and Energy Storage Solutions for Canada's Provinces: Enabling the Net-Zero Grid by 2035

Actionable strategies for grid modernization and renewable energy integration in Canada

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# Executive Summary

## Overview of Canada's Renewable Energy Targets

Canada is striving to achieve a net-zero electricity grid by 2035, supported by the federal government's Clean Electricity Regulations. This ambitious, yet achievable goal demands an accelerated transition to renewable energy sources like wind and solar. However, achieving this milestone will require tackling significant challenges, including some ageing grid infrastructure, integrating intermittent renewable energy, and scaling up energy storage solutions.

## The Role of Grid Modernization and Energy Storage

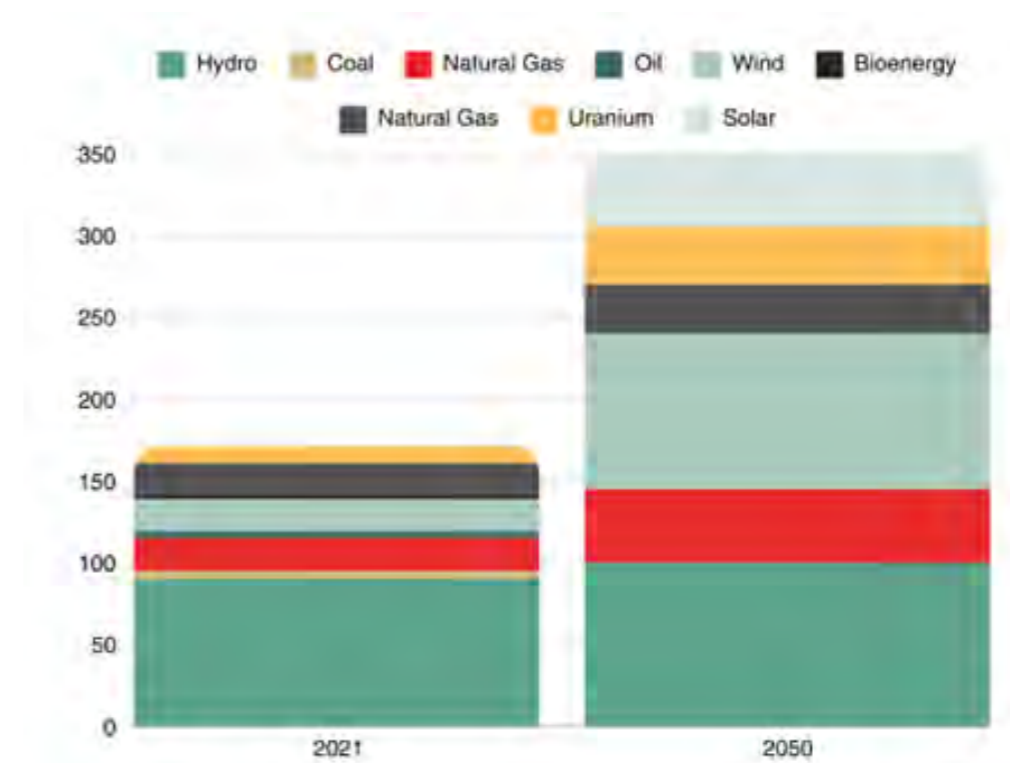
While parts of Canada's grid were built in the mid-20th century and face modernization needs, many provinces maintain well-functioning, robust systems. However, upgrading aging components is important to meet the increasing complexity of modern energy demands and to fully integrate renewables. The introduction of renewable energy sources has further exposed these limitations, with supply variability from wind and solar creating challenges for grid reliability. Energy storage systems, such as lithium-ion batteries and pumped hydro, are critical to balancing supply and demand while mitigating the risk of outages during peak periods.

With electricity demand in Canada projected

to rise 44% by 2050 due to population growth and electrification of industries, it is essential that plans for grid modernization are put into place and actioned.

## The Role of Energy Storage in a Net-Zero Future

Energy storage is a critical component of Canada's net-zero roadmap. These systems balance supply and demand by storing excess energy generated during peak production periods and deploying it during high-demand or low-generation intervals. For example, in Ontario, a pilot project by the [Independent Electricity System Operator \(IESO\)](#) demonstrated how battery storage reduced curtailment of renewable energy and ensured stable grid operations during peak usage. Such solutions show the importance of scaling storage capacity across Canada.



Data from [Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050](#) (energy generation predictions in line with Canada's Net Zero goals in gigawatts)

## Section One

### The Promise of Smart Grids

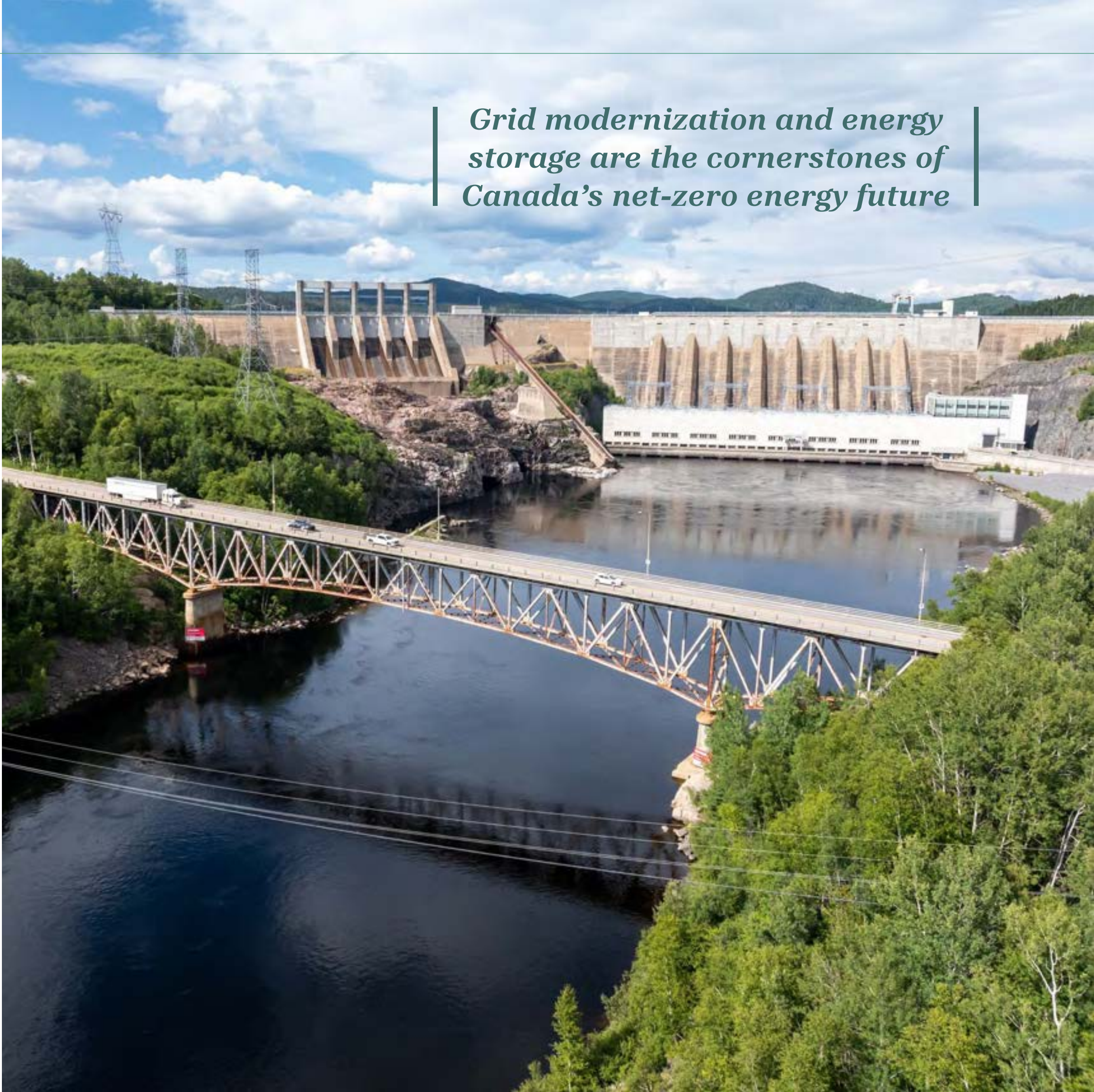
Smart grid technologies will revolutionize energy management by enabling real-time monitoring, AI-driven decision-making, and enhanced two-way communication between producers and consumers. These advanced systems optimize energy flow, reduce losses, and improve reliability. The [IEA](#) estimates that digitally enabled demand response could reduce the curtailment of variable renewable energy systems by more than 25% by 2030, increasing system efficiency and reducing costs for customers.

### A Roadmap to Grid Modernization

Achieving Canada's net-zero target requires a multi-faceted approach. Smart grid technologies must be implemented to improve energy flow and reduce inefficiencies. Energy storage systems, such as lithium-ion batteries and pumped hydro, need to be scaled to manage renewable variability. Decentralized energy systems, including microgrids, can bring clean energy to remote regions while enhancing overall grid resilience. This roadmap is critical to ensuring Canada's energy future remains reliable, sustainable, and resilient.

### Transforming Canada's Energy Future

Grid modernization and energy storage are foundational to Canada's renewable energy goals. Together, these technologies will enable the country to move away from fossil fuels, fully integrate renewables, and ensure that electricity generation meets the growing demand. By adopting these solutions, Canada is paving the way for a cleaner, more efficient, and reliable energy system by 2035.



*Grid modernization and energy storage are the cornerstones of Canada's net-zero energy future*

# Understanding the Current Challenges in Canada's Electricity Grid

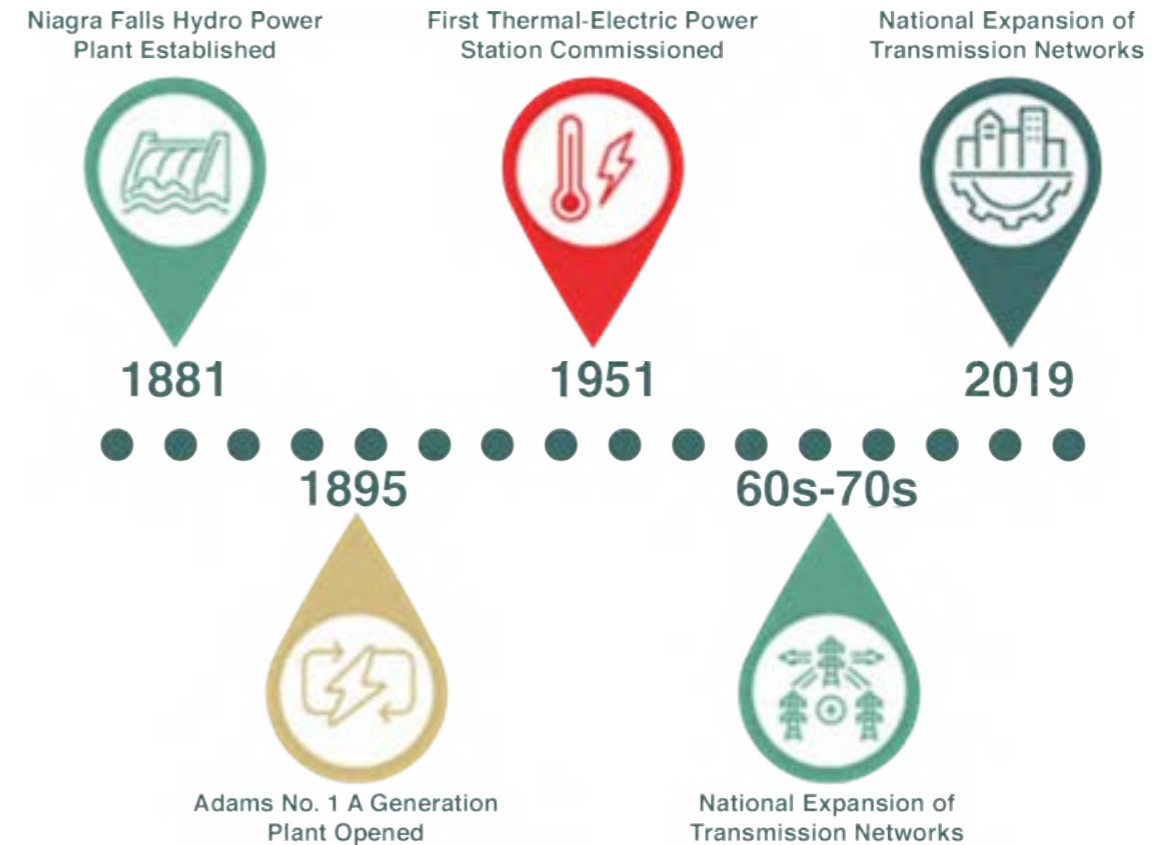
## Aging Grid Infrastructure

Canada's electricity grid, a product of decades of development and innovation, has supported the country's industrial growth and energy needs for years. However, certain components, particularly those built in the mid-20th century, require upgrades to support the transition to renewable energy and to meet the evolving demands of a modernized energy system. According to

the Canada Energy Regulator, significant portions of the grid are approaching the end of their operational lifespans, making reinvestments essential to avoid reliability issues and costly outages.

This aging infrastructure not only increases maintenance costs but also limits the grid's ability to support the growing use of renewable energy sources, further highlighting the urgent need for modernization.

## A History of Canada's Electricity Grid



Canada's electricity grid has evolved significantly since its beginnings in 1881, when the Niagara Falls Hydraulic Power and Manufacturing Company established one of the first hydroelectric facilities to supply power to nearby areas. This milestone marked the start of Canada's grid development, focused on small-scale, localized energy generation.

In 1895, the Adams No. 1 Alternating Current (AC) Generation Plant, developed with contributions from pioneers like George Westinghouse, became the world's first large-scale AC generation plant, paving the way for widespread electricity distribution. By 1951, Canada's first coal-fired thermal-electric station in Toronto signaled the country's shift toward centralized, fossil-fuel-based power generation, with an installed capacity of 1 million kW. However, transitioning from these centralized systems

to distributed renewable energy networks now requires modernized transmission lines and energy storage solutions.

In the 1960s and 1970s, Canada saw massive investments in expanding transmission networks, connecting remote hydroelectric projects to urban areas. While this infrastructure supported industrial and economic development, much of it has now aged significantly and lacks the capacity to handle intermittent renewable energy.

This aging infrastructure presents a significant bottleneck for renewable energy integration, as it cannot efficiently manage distributed energy generation or the two-way energy flows required for a modernized, decentralized grid. Addressing these limitations is essential for Canada to fully transition to a renewable energy future.



## The Integration Challenge for Renewable Energy

The shift to renewables, such as wind and solar, has introduced additional complexities to Canada's grid. Unlike traditional power generation, these sources are weather-dependent and intermittent, which means their output can vary significantly. Balancing this variability is critical to maintaining grid stability, especially as Canada's electricity demand continues to grow.

Electricity consumption is projected to increase by 44% by 2050, driven by factors such as population growth, the electrification of transportation, and industrial shifts toward clean energy. These trends further strain the grid, making it difficult to integrate new renewable energy capacity effectively.

Without systems to store excess renewable energy and manage demand fluctuations, valuable clean energy is often wasted. For example, periods of high solar or wind generation can overwhelm the grid, resulting in renewable energy curtailment, whereas

excess energy is discarded because the system cannot accommodate it.

## Resilient Grid

Canada's grid modernization journey is foundational to achieving its net-zero goals. By addressing aging infrastructure, scaling energy storage, and bridging regional disparities, the country can create a resilient and reliable energy system capable of supporting its renewable ambitions. Modernization is not just an upgrade; it is a necessary transformation for Canada's energy future.

## The Energy Storage Gap

Energy storage systems are vital for addressing these challenges, yet Canada's capacity remains insufficient. Storage technologies such as lithium-ion batteries, pumped hydro, and emerging innovations enable excess renewable energy to be saved during periods of high generation and deployed during peak demand or low output periods.

Globally, the need for energy storage is clear. The International Energy Agency reports that storage capacity must increase sixfold by 2030 to effectively integrate renewables and support global energy systems. Canada's current infrastructure lags behind this target, highlighting the need to expand storage solutions to stabilize renewable output. ([IEA Batteries Report](#))

## Regional Disparities in Grid Modernization

Canada's diverse geography and decentralized energy policies offer unique opportunities and challenges in grid modernization. While some regions, such as Quebec and British Columbia, benefit from strong renewable energy resources like hydropower, others are focused on integrating emerging technologies to support rapid renewable growth.

Each province faces unique challenges: Alberta and Ontario, for example, are experiencing rapid growth in wind and solar energy but lack the necessary infrastructure

to fully integrate these sources. In contrast, Quebec benefits from its reliance on hydropower but faces challenges in maintaining and upgrading its aging grid infrastructure.

These regional differences emphasize the importance of tailored strategies that address specific provincial needs while ensuring national progress toward a modernized, unified energy system.

## Building a Resilient Grid

Canada's grid modernization journey is foundational to achieving its net-zero goals. By addressing aging infrastructure, scaling energy storage, and bridging regional disparities, the country can create a resilient and reliable energy system capable of supporting its renewable ambitions. Modernization is not just an upgrade; it is a necessary transformation for Canada's energy future.

# Smart Grid Technology in Focus

## What is a Smart Grid?

A smart grid is a modernized electricity network that uses advanced digital technology to monitor, manage, and optimize energy flow in real-time. Unlike traditional grids, smart grids enable two-way communication between energy producers and consumers, allowing for greater flexibility, efficiency, and reliability. Key features include real-time monitoring, AI-driven energy flow management, and demand response systems that adapt to shifting energy needs.

## The Benefits of Smart Grids

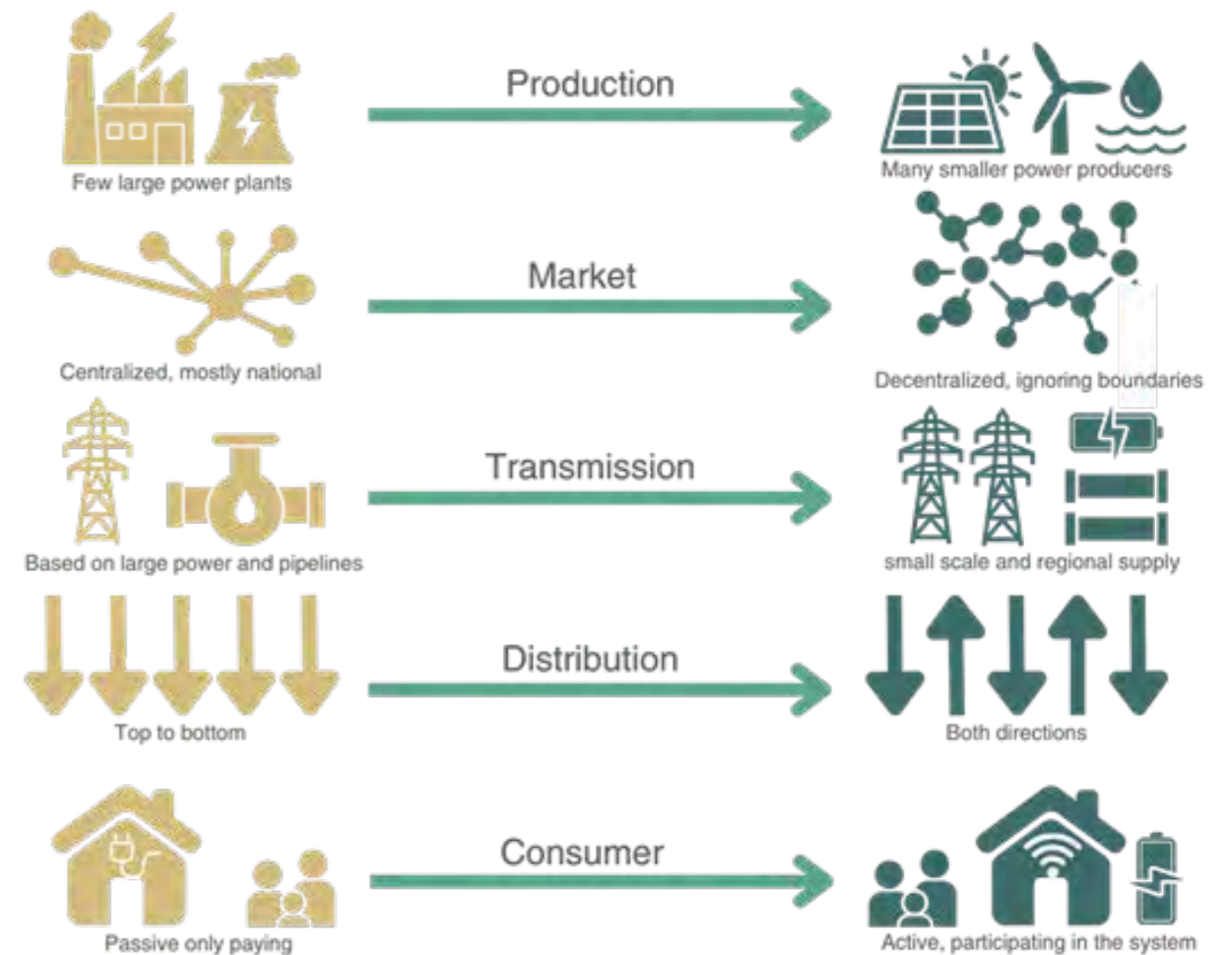
Smart grids provide numerous benefits, particularly for renewable energy integration. By using IoT devices and sensors, they optimize energy flow, reducing waste and preventing power outages. Real-time data enables grid operators to balance energy supply and demand effectively, mitigating the variability of renewable sources like wind and solar. The IEA estimates that digitally enabled demand response could reduce the curtailment of variable renewable energy systems by more than 25% by 2030, increasing system efficiency and reducing costs for customers. Additionally, a study published in Springer indicates that integrating artificial intelligence (AI) and Internet of Things (IoT) technologies into smart grids can lead to a 20% increase in energy efficiency compared to traditional grids.

## Case Study: Ontario's Smart Grid Pilot Project

Ontario has been a leader in adopting smart grid technologies. A recent pilot project demonstrated how smart grids improved the integration of solar and wind power, reducing energy losses and enhancing grid stability. By leveraging AI and advanced sensors, the project enabled operators to predict demand more accurately and optimize the use of renewable energy, reducing dependency on fossil fuel backups.

## The Role of Smart Grids in Achieving Net-Zero Goals

Smart grids are essential to Canada's vision of a net-zero electricity grid by 2035. They enhance grid flexibility, support the decentralized generation of energy through microgrids, and empower consumers to participate in energy management. With aging infrastructure posing significant challenges, smart grids offer a pathway to modernize the grid while meeting the growing demands of electrification and renewable integration.



Structural changes to energy grid structures that are enabled by smart technologies such as real-time monitoring, AI-driven energy flow management, demand response systems and IOT sensors.

# Energy Storage as the Missing Link



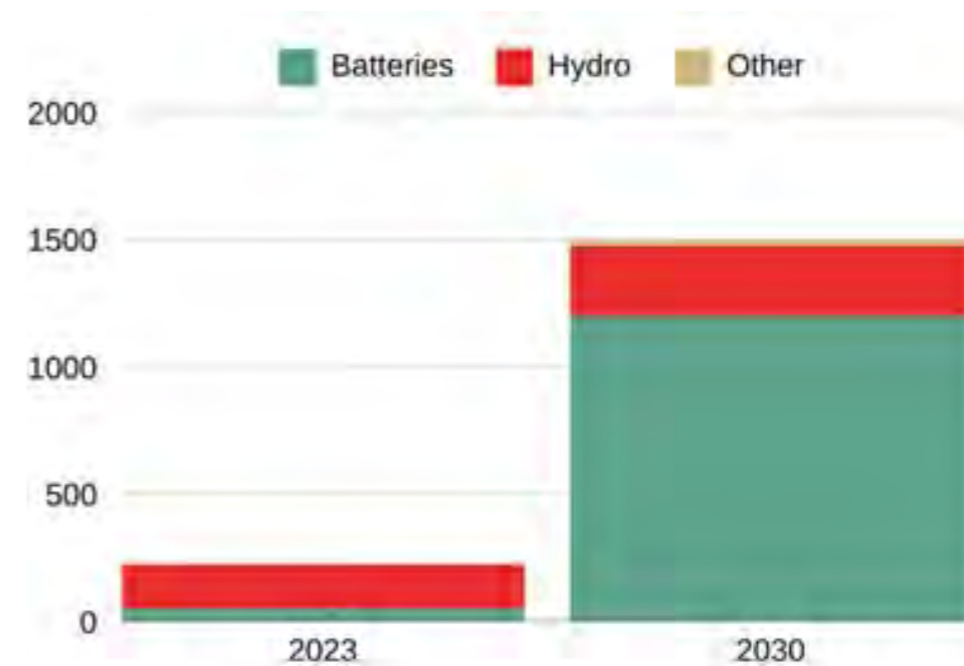
## The Role of Energy Storage

Energy storage systems are critical for managing the variability of renewable energy sources like wind and solar. These technologies store excess energy generated during periods of high production and release it during peak demand or low generation times, ensuring a steady and reliable energy supply. Energy storage is essential to maximizing the potential of renewable energy. By investing in storage solutions, Canada can further strengthen its energy system and ensure that clean energy is effectively utilized to meet demand.

Battery storage systems play an important role in stabilizing grids and addressing renewable energy curtailment. Curtailment,

which is the deliberate reduction of renewable energy generation to maintain grid balance, occurs during periods of surplus generation when the grid cannot accommodate the excess energy. Battery systems store this surplus energy, ensuring it is not wasted and can be deployed during peak demand or low generation periods.

Additionally, battery storage enhances Demand Response which involves adjusting energy consumption patterns to balance supply and demand. Batteries act as a buffer, storing excess energy when demand is low and supplying it during peak periods. This dual capability reduces reliance on fossil fuel backups, improves grid efficiency, and supports the integration of variable renewable energy sources like wind and solar.



According to the [IEA](#), achieving global climate goals necessitates a x6 increase in energy storage capacity by 2030, with battery storage contributing 90%.



## Section Four

### Types of Energy Storage Technologies

There are several types of energy storage systems, each with unique applications:

**1 Lithium-Ion Batteries:** Widely used in grid-scale storage, lithium-ion batteries offer flexibility, scalability, and efficiency. These systems are critical for short-term energy storage and are increasingly paired with renewable energy projects in Canada.

**2 Pumped Hydro Storage:** This well-established technology stores energy by pumping water to a higher elevation during low demand and releasing it to generate electricity during peak times. Canada's vast geography offers significant potential for expanding pumped hydro capacity.

**3 Emerging Technologies:** Innovations such as solid-state batteries, flow batteries, and hydrogen storage are gaining traction, offering longer-duration storage and addressing scalability challenges.

### Case Study: Alberta's Energy Storage Pilot Project

In Alberta, a recent pilot project integrated lithium-ion battery storage with wind farms, reducing curtailment and ensuring stable energy output during fluctuating wind conditions. This project demonstrates how energy storage can enhance grid reliability and maximize the use of renewable energy.

### The Path Forward

To fully realize the potential of renewable energy, Canada must invest in scalable and diverse storage solutions. These systems will not only stabilize the grid but also reduce reliance on fossil fuel backups, paving the way for a cleaner, more reliable energy future.



# Regional Approaches to Modernizing Canada's Grid

Canada's vast geography and decentralized energy policies create unique challenges and opportunities for grid modernization across provinces. Tailored strategies are essential to address these regional disparities and ensure progress toward a unified, net-zero energy future.

## Alberta: Balancing Renewable Growth and Grid Integration

Alberta has experienced rapid growth in renewable energy, particularly wind and solar, driven by its abundant natural resources. However, integrating these renewables into the grid remains challenging due to the province's reliance on fossil fuels and aging transmission infrastructure. Initiatives such as the Fluiditi

Battery Storage Project, developed by [TERIC Power](#), aim to enhance grid reliability and reduce greenhouse gas emissions. This pilot project integrates battery storage into Alberta's distribution grid and has received support from Emissions Reduction Alberta's Reshaping Energy Systems program.

Another example is the [Hybrid Hydro Supercapacitor Energy Storage System](#), a collaboration between Atlas Power Technologies and TransAlta Corporation. This innovative project combines supercapacitor storage with hydroelectric generation to create a hybrid system capable of quickly responding to grid reliability needs. As the first implementation of its kind in North America, it represents Alberta's commitment to innovative grid solutions.

## Ontario: Strengthening Reliability with Energy Storage

Ontario has taken significant steps to modernize its grid and integrate renewable energy sources through large-scale storage initiatives. [The Oneida Energy Storage Project](#), developed in partnership with the Six Nations of the Grand River Development Corporation, Northland Power, and NRStor, is poised to become Canada's largest battery storage facility. This 250 MW system will store clean energy during off-peak hours and supply it during peak demand, improving grid efficiency and reducing reliance on fossil fuel backups.

In addition, the Independent Electricity System Operator (IESO) has procured [739 MW of battery energy storage projects](#)—the largest energy storage procurement in Canadian history. These systems will bolster grid resilience, facilitate renewable energy integration, and help Ontario meet its future energy demands.





## Quebec: Leveraging Hydropower as a Grid Stabilizer

Quebec benefits from its vast hydropower capacity, supplying clean and reliable energy to the province and beyond. However, the aging infrastructure that connects hydroelectric facilities to other regions requires modernization to support efficient energy export. Upgrades to transmission lines and interconnections are important to ensuring that Quebec's hydropower can stabilize the broader renewable energy network.

As part of its strategic initiatives, Hydro-Québec plans to increase its power generation capacity by integrating more than 10,000 MW of wind power and adding between 3,800 MW to 4,200 MW of new hydropower generation by 2035. This expansion includes developing new hydropower facilities and a pumped-storage facility to support grid reliability and renewable integration. The utility also plans to invest significantly in grid infrastructure to reduce power outages and enhance service quality for customers.

Hydro-Québec is undertaking significant upgrades to its 735-kV transmission system, the backbone of the province's power grid. This initiative aims to support Quebec's energy transition by enhancing the grid's capacity to integrate new renewable energy sources and meet the growing demand for clean electricity. The project is part of Hydro-Québec's Action Plan 2035, which outlines investments totaling between \$45 to \$50 billion by 2035 to ensure grid



Map of Canada highlighting specific grid modernization and renewable energy strategies by state

reliability and accommodate increased renewable generation.

As Canada seeks to unify its grid capabilities, Quebec's resources will play a vital role in supporting national energy goals. These projects exemplify Quebec's commitment to modernizing its grid infrastructure, integrating renewable energy sources, and enhancing overall grid reliability to support the province's energy transition goals.

## British Columbia: Harnessing Hydropower and CleanBC

British Columbia relies heavily on hydropower, which generates 95% of the province's electricity. Through its CleanBC Plan, BC Hydro is upgrading aging grid infrastructure and integrating distributed energy resources like rooftop solar and community microgrids to enhance grid flexibility.

## Section Five

### Saskatchewan and Manitoba: Bridging Gaps in Renewables Integration

Saskatchewan is transitioning from coal-fired power generation to renewable energy, investing heavily in wind projects and implementing smart grid technologies like automated metering to improve efficiency ([SaskPower](#)). Manitoba, leveraging its hydropower dominance, is upgrading transmission lines to strengthen interconnections with neighboring provinces and export markets.

### The Atlantic Provinces: Exploring Offshore Wind and Interconnectivity

The Atlantic provinces, particularly Nova Scotia and Newfoundland and Labrador, are exploring offshore wind and tidal energy potential. The [Atlantic Loop initiative](#) seeks to connect provincial grids, enabling cleaner energy sharing across the region and reducing dependency on coal.

### The Territories: Empowering Remote Communities with Microgrids

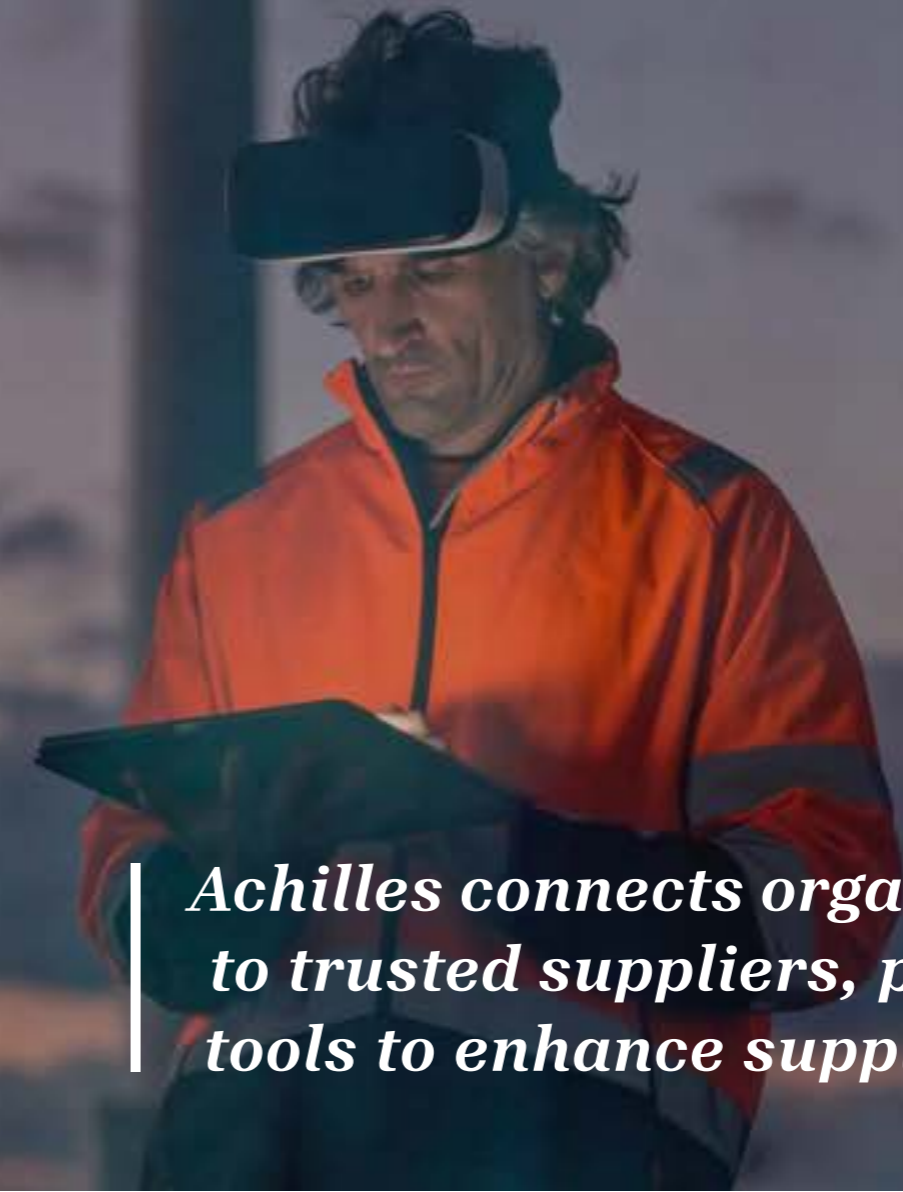
In Canada's northern territories, decentralized energy systems such as microgrids powered by solar, wind, and small-scale storage are reducing reliance on diesel fuel. These projects are essential for improving energy access and reliability in remote and isolated communities.

### A Unified Path Forward

While provinces and territories face distinct challenges, a unified approach to grid modernization will enable Canada to achieve its national net-zero goals. Collaborative initiatives like the Atlantic Loop and federally funded programs such as the Smart Renewables and Electrification Pathways Program ([SREPs](#)) are helping bridge gaps and ensure progress across all regions.



# Supporting Grid Modernization through Supplier Validation



*Achilles connects organizations to trusted suppliers, providing tools to enhance supply chains*

Modernizing Canada's electricity grid requires collaboration, careful planning, and resilient supply chains to address challenges like aging infrastructure, renewable energy integration, and increased energy demand. Organizations need robust systems to manage suppliers, ensure compliance, and mitigate risks as they undertake grid modernization projects.

## Ensuring Supplier Quality and Compliance

Grid modernization projects depend on reliable access to materials like batteries, transformers, and advanced grid technology components. Ensuring that these materials

come from trustworthy, compliant sources is essential to avoid delays or quality issues. A centralized platform for vetting suppliers and managing relationships can streamline this process and reduce risks. Solutions such as [Achilles Prequalified Supplier Network](#) ensure that partners meet regulatory, safety, and ESG standards before contracts are finalized.

## Mitigate Supply Chain Disruptions

Supply chains for energy infrastructure often span multiple regions, creating vulnerabilities to disruptions from geopolitical events, material shortages, or delivery delays.

Proactively identifying these risks through advanced supply chain management tools can help mitigate potential problems. Platforms such as [MyAchilles](#) that provide visibility into supplier performance and risks enable energy companies to plan ahead and secure their projects against unexpected disruptions.

## Enhance Collaboration and Compliance

Large-scale projects require close collaboration between developers, governments, and utilities. Transparency is essential to ensuring that all stakeholders are aligned on regulatory compliance,

timelines, and sustainability goals. Centralized data-sharing platforms can simplify communication and performance tracking, helping to keep projects on schedule and meeting their goals.

## Building Transparent Collaboration

Grid modernization involves collaboration among various stakeholders, including governments, utilities, and private developers. Achilles' solutions facilitate transparency, risk management and sustainability, ensuring stakeholders are aligned on compliance, timelines, and performance goals.

# Actionable Steps to Modernize Canada's Grid

Grid modernization is a complex process, but a clear roadmap can guide developers and utilities toward success. These actionable steps address the critical areas of planning, collaboration, and technology deployment, ensuring that projects meet both operational and sustainability goals.

## 1 Step 1: Assess Current Grid Capacity and Future Needs

A comprehensive evaluation of existing infrastructure is the first step in modernizing the grid. This includes analyzing transmission line capacity, aging components, and the ability to integrate variable renewable energy sources. Developing detailed forecasts of electricity demand accounting for population growth, industrial electrification, and renewable capacity is important for setting realistic goals.

## 2 Step 2: Strengthen Supply Chain Resilience

Securing access to critical materials and components like batteries, transformers, and grid-monitoring technologies is essential for timely project delivery. Engaging with pre-qualified suppliers through trusted platforms can help developers navigate

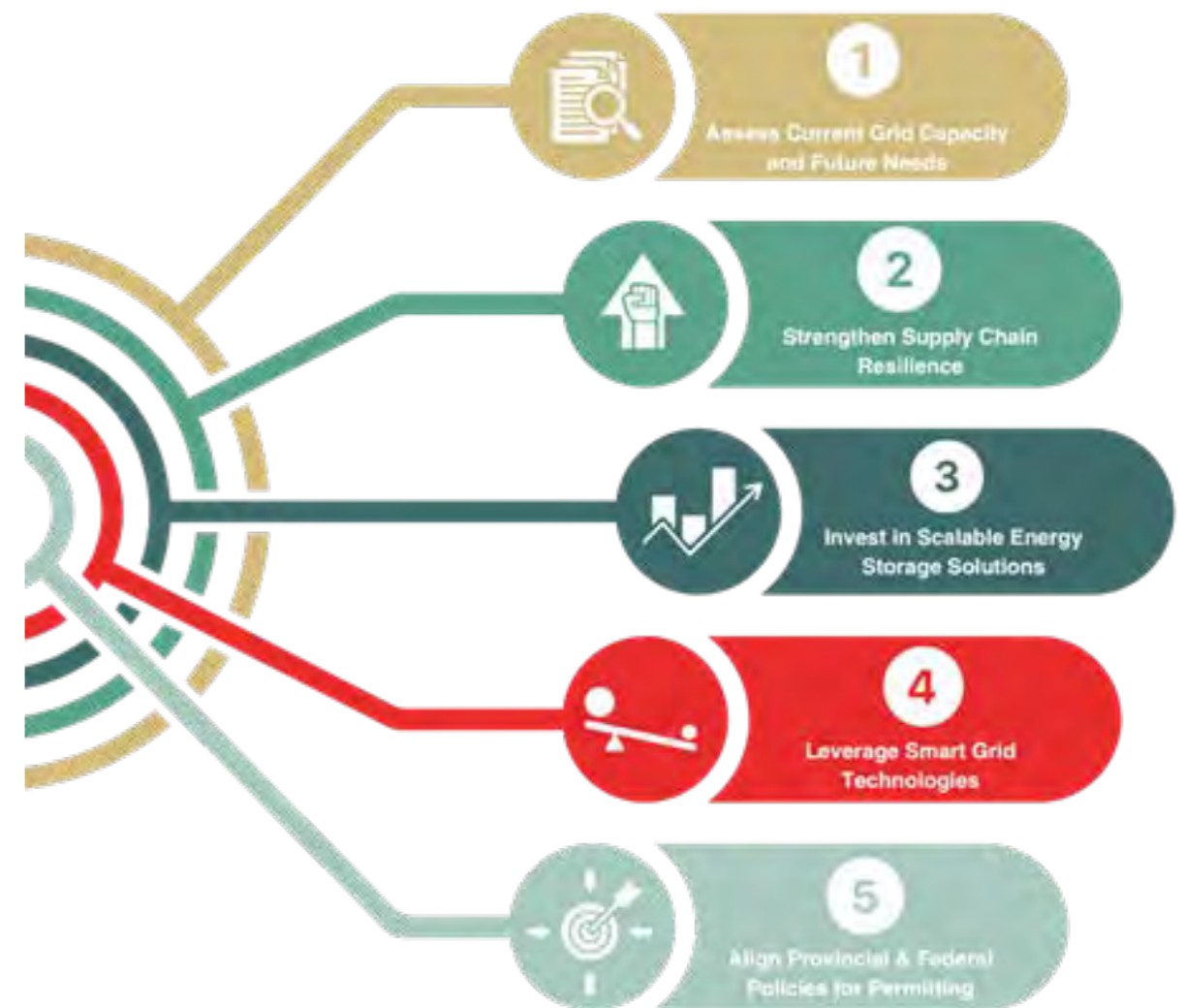
risks such as material shortages and price volatility. Diversifying sourcing strategies and maintaining a robust network of suppliers ensures that projects remain on track despite external challenges.

## 3 Step 3: Invest in Scalable Energy Storage Solutions

Energy storage is key to stabilizing the grid and integrating renewables effectively. Developers should prioritize scalable solutions such as lithium-ion batteries, pumped hydro, and emerging technologies like flow batteries. These systems not only address renewable energy variability but also reduce reliance on fossil fuel backups during peak demand. Identifying locations and projects where storage solutions can deliver maximum impact will optimize returns and enhance grid reliability.

## 4 Step 4: Leverage Smart Grid Technologies

Adopting smart grid technologies enables real-time energy flow management, minimizes losses, and enhances grid efficiency. Key components include advanced sensors, AI-driven analytics, and demand response systems that balance



supply and demand. By implementing these technologies, utilities can optimize renewable integration and future-proof the grid.

## 5 Step 5: Align Provincial and Federal Policies for Streamlined Permitting

Navigating Canada's regulatory landscape can be a challenge, as energy governance varies across provinces. Developers should actively engage with both provincial and federal authorities to align permitting processes with project timelines. Policy incentives for renewables, grid upgrades,

and energy storage can be leveraged to secure financial and operational support.

## Where Achilles Can Assist

Achilles supports organizations by providing the serious analysis and expert supply chain insight necessary to comply with ESG regulations, meet stakeholder requirements and achieve ambitious ethical and sustainability goals. These resources streamline procurement, mitigate risks, and ensure compliance with regulatory and sustainability standards, enabling smoother project execution.

# The Path Forward: Achieving a Net-Zero Grid

Canada's journey toward a net-zero electricity grid by 2035 is ambitious but achievable. Modernizing Canada's grid is an exciting opportunity to build a sustainable and resilient energy system. By addressing aging infrastructure, integrating renewable energy sources, and adopting innovative technologies like smart grids and energy storage, Canada can meet its climate goals while ensuring energy security for future generations.

The key to success lies in collaboration. Developers, utilities, and policymakers must work together to streamline permitting, strengthen supply chains, and deploy scalable solutions that bridge the gap between current capabilities and future needs. Tailored strategies that address regional disparities will ensure that all provinces and territories contribute to and benefit from a unified energy vision.

Achilles is ready to support organizations on this path. By connecting you with trusted suppliers, providing visibility into supply chain risks, and enabling compliance with ESG and regulatory standards, Achilles helps build the foundation for successful grid modernization projects.

## Ready to strengthen your grid modernization efforts?

Contact Achilles today to learn how our supply chain solutions can help you achieve your energy goals while meeting compliance and sustainability requirements.

[Talk to an expert](#)



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