WHITEPAPER

Managing the energy transition by **creating the grid of the future**

Author: Faisal Kazi, President and CEO, Siemens Canada

Date: October 1, 2020

siemens.ca

SIEMENS

Summary

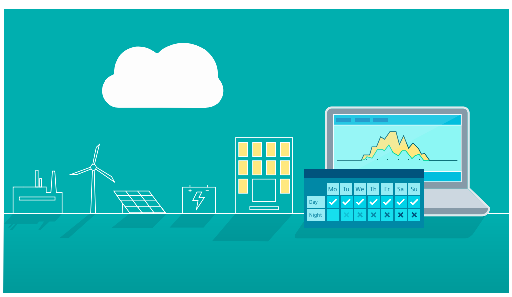
This whitepaper addresses some of the trends, challenges and opportunities associated with the energy transition from fossil fuels to renewables, and how the "grid of the future" is a potential solution. By leveraging the energy landscape's digitization, this grid can enable an efficient and cost-effective transformation to a greener energy future.

Trends and challenges of the energy transition

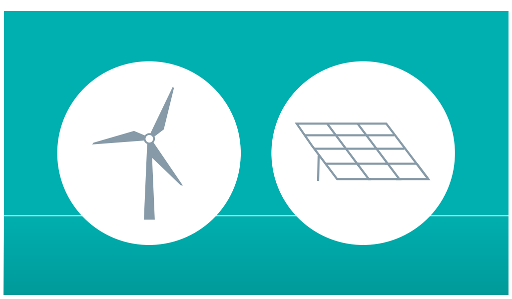
Energy systems around the world are undergoing a massive transition. In Canada and in many regions, there has been a continued commitment to reduce greenhouse gases combined with steep price reductions of renewable energy sources like solar and wind. Solar and wind are rapidly gaining share in the capacity mix and over the past few years have already grown to account for more than half of net capacity additions*. With the entry of multiple energy sources, the energy system is fundamentally changing from one-way, centralized generation to multi-directional, distributed generation. It also brings many new challenges like balancing supply and demand due to the natural intermittency of renewable energy sources and a requirement to upgrade existing grids that were not designed for these sources. Along with these many new challenges it also brings the great opportunity to de-carbonize the global energy sector for our future generations.

It is a massive, highly complex undertaking and can only succeed with careful planning, close alignment amongst a variety of stakeholders, and regulatory reforms, backed by the right technologies and a systematic approach underpinning the entire transition.

An analysis of energy systems around the world has shown jurisdictions struggling with four particular challenges:



1. **Management of peak loads**
   Due to the intermittent nature of renewable energy sources, system operators can be forced to buy expensive peak and back-up power to manage demand, which in turn results in increased energy prices for consumers. Therefore, storage of energy and back-up power combined with demand response are essential for supply to be able to meet demand. Storage can refer not only to batteries, but also to hot water and other forms of energy. Load flexibility must be achieved in parallel through processes that can run intermittently as needed.

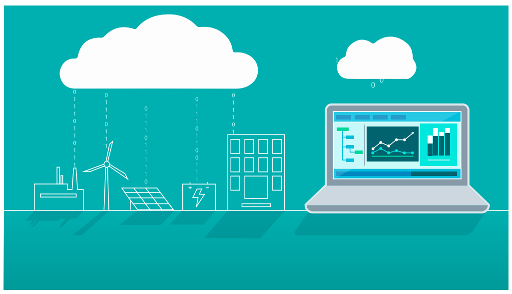


2. **Intermittency of renewables**
   If excess renewable capacity is available at a time of low demand, prices could drop to negative for base-load providers, impacting their return on investment or stranding their assets, because renewables are usually given priority in the system due to their low marginal cost of production. At the same time, prosumers with their own energy assets might only be able to maximize those investments by partnering with aggregators and utilities, which would take the prosumers' generated energy or grid service to the market. This, in turn, requires system transparency and reliable generation forecasts.

*Source: McKinsey Global Energy Perspective 2019.

3. **Decline in system reliability**

   Due to fundamental structural changes, there could be a decline in system reliability, accompanied by increasing grid upgrade expenditures, which would further increase energy prices. These dynamics could be even more acute in jurisdictions where resiliency is already a problem because of aging transmission and distribution equipment, or where there has been a demonstrable increase in extreme-weather events. Therefore, geographically-focused investments in renewables and storage, whether at the customer level or grid-wide, are in many cases more cost-effective than conventional upgrades. In fact, local solutions to generate renewable energy that are available today are far less costly for serving specific customers (particularly in remote areas) than traditional poles and wires.



4. **Business model disruption**

   With more cogeneration as prosumers generate and consume their own electricity, utilities around the world are facing load defection and a deterioration of their historic business model. Without a thoughtful regulatory framework and the utilities engaging with their changing customer base, there is a risk of end-users only optimizing for themselves, thereby missing out on the efficiencies of sharing risk and assets from across the energy system.

While the magnitude of these issues could potentially limit stakeholder support and stall the transformation, not moving forward would be even more costly in the long term. Therefore, the focus needs to be on meeting these challenges. Fortunately, there is a positive path forward. It is centred on using the innovative technologies and power of digitalization that is at our fingertips.

This will, however, be a massive and highly complex undertaking. It can only succeed with careful planning and sensible regulatory reforms – all underpinned by a holistic, systematic approach and close alignment among all stakeholders, which include governments, policymakers, leading corporations, and universities and other research institutes.

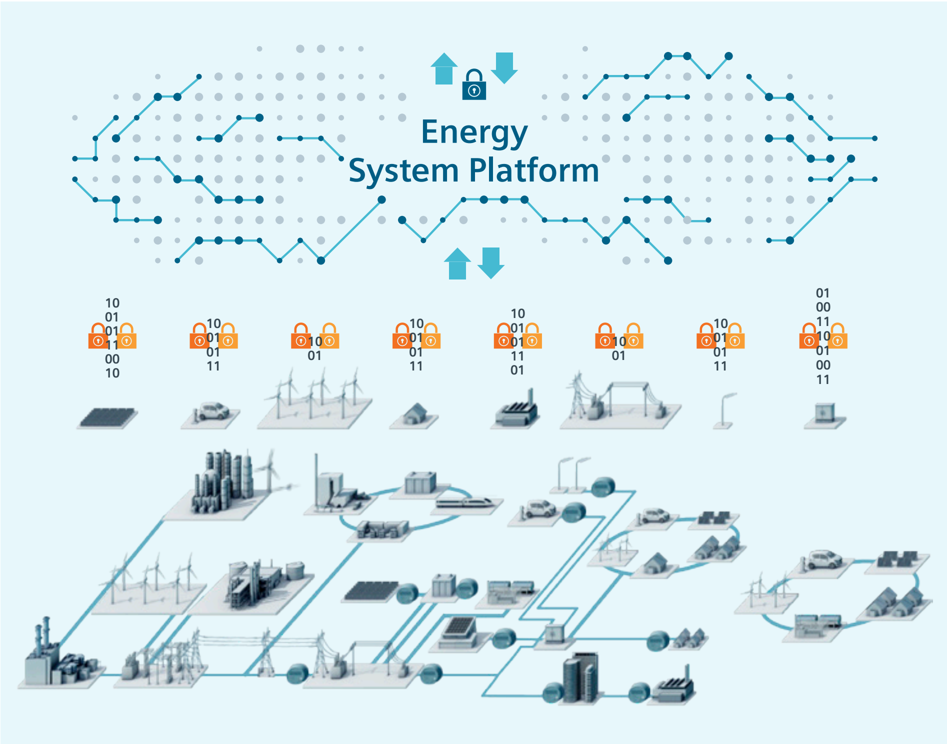
In the Atlantic region of Canada, a consortium of leading stakeholders has come together to lead the way and demonstrate how to do this. The federal government, the utilities New Brunswick Power and Nova Scotia Power, and Siemens are collaborating on an ambitious initiative called Smart Grid Atlantic. The goal is to enable an efficient and cost-effective energy transition by creating and showcasing the grid of the future using real-life assets in a collection of smart energy communities. At the heart of this is an Energy System Platform (ESP) developed and deployed by Siemens.

Grid of the future: The Energy System Platform (ESP)

The ESP is a cloud-based platform equipped with the latest technologies, including artificial intelligence, to help a utility converge and manage all the distributed resources across its system. Smart energy communities connected to the ESP promise to be an integral part of the energy system, as the platform can connect to a wide array of energy resources. This includes solar photovoltaic (PV) and other generators, battery storage, commercial and industrial loads, smart water heaters, electric vehicle chargers, and even entire microgrids.

The ESP offers various integration options for utility-controlled as well as privately-owned assets, from direct connection to distributed energy resources (DERs) at the edge of the grid, including those "behind the meter." There is also integration with aggregators of flexible loads and renewable generators, as well as with dedicated clouds established by the manufacturers or vendors of residential energy equipment.

This technology can significantly reduce the cost of maintaining the existing grid. It is an intelligent investment for distribution – integrating digital and operational technologies, enabling advanced forecasting and scheduling functionalities, and using analytics to optimize the system's overall configuration. This includes leveraging DERs for services at both the transmission and local distribution levels, and encompasses active as well as reactive power through smart inverters.



Optimize the overall system using an open cloud platform as a centrepiece of a powerful Internet of Things (IoT) ESP, enabling:

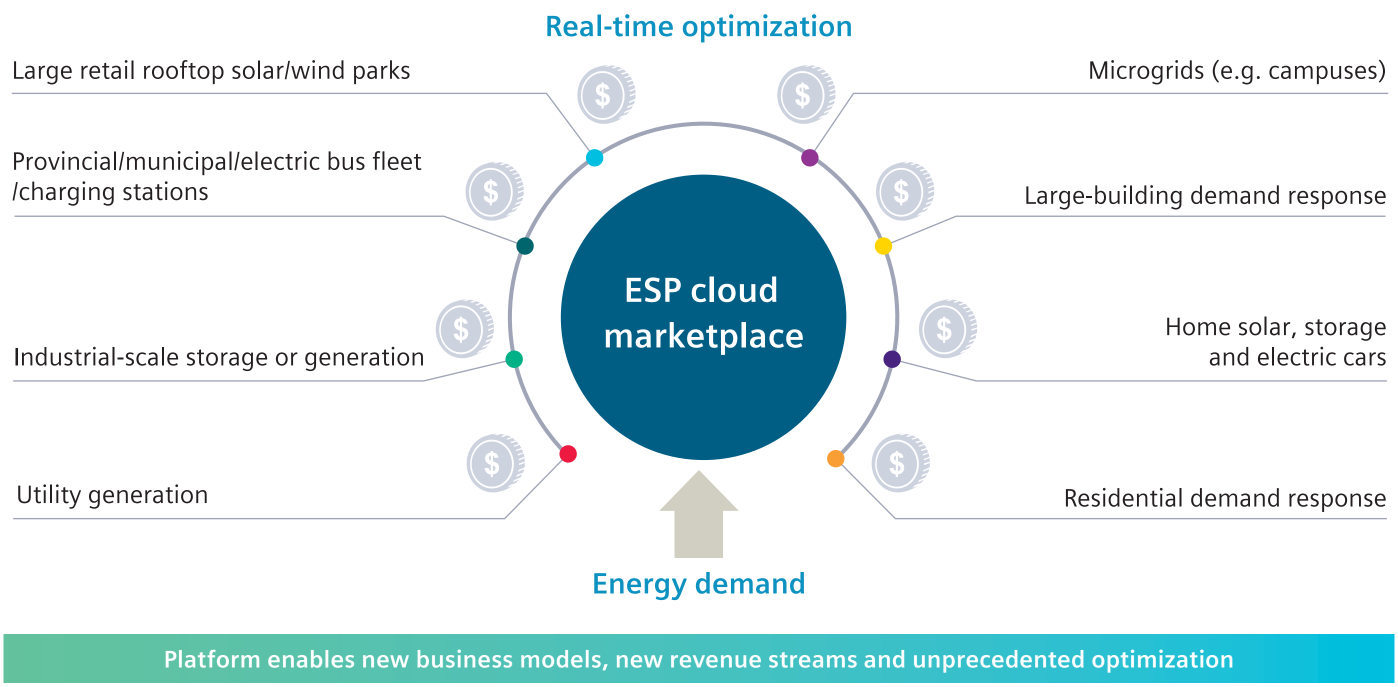
- Real-time optimization
- Advanced network management
- Data analytics and artificial intelligence
- Connectivity capabilities
- Resilient communication
- Cybersecurity in Information Technology / Operational Technology

New business models

- Allow everyone to participate in the energy market
- Peer-to-peer trading
- Electric vehicles to grid, etc.

Utility system integration with Supervisory Control and Data Acquisition (SCADA), Advanced Distribution Management Systems (ADMS), Customer Information Systems (CIS), Meter Data Management (MDM) and Geographical Information Systems (GIS).

The ESP not only optimizes the overall system in real-time but also opens the energy market to everyone, which encourages the entry of new players and drives the introduction of new business models for stakeholders like independent power producers (IPPs), prosumers and flexible commercial and residential consumers.



A staged approach has been deployed to address the challenges of the energy transition. The diagram below outlines the evolution of solutions that have been created over time.

Solutions have evolved over time to address the challenges of the energy transition

From Visibility and Aggregation ...to Network Operation ...to New Business Models

1 Demand Response

Customer benefits:
- Lower rates, peak rebates

Utility benefits:
- Reduced back-up capacity

Demand Response includes load management programs to decrease back-up generation costs, while enabling the utility to spread out the load to reduce peak demand and meet that demand with ample power supply.

Today, these mechanisms are well established and engage customers, who can indicate their flexibility to the system operator. For example, industrial processes, water heaters or electric vehicle chargers can run on lower levels of consumption when renewable energy is scarce. In return, participants can benefit from rebates, incentives or lower rates.

2 Virtual Power Plant

Customer benefits:
- Attractive feed-in tariffs

Utility benefits:
- Transparency into prosumer assets

Renewable power is intermittent. A Virtual Power Plant bundles renewable power generation to ensure reliability. While the output of one renewable generator might be hard to predict, planning and forecasting can be done for thousands of assets managed as one pool of total generation capacity.

By providing visibility into assets behind the meter to the utility, Distributed Energy Resource (DER) owners can participate in markets for energy and grid services. For example, solar and wind can be combined to provide reserve capacity, or batteries used for voltage regulation in the power grid. In return, participants can expect more attractive feed-in tariffs to make the most of their private investments.

3 Distributed Energy Resource Management System (DERMS)

Customer benefits:
- Local resiliency, incentives

Utility benefits:
- Avoidance of grid upgrades

A Distributed Energy Resource Management System (DERMS) can enable real-time optimization of the distribution network by leveraging DERs as a pool for flexibility. This not only improves resiliency of the grid but also allows local demand and supply to be kept in balance, reducing the need for additional grid infrastructure.

Customers in a specific community can engage to promote reliability, resiliency or even self-sufficiency in their area by using flexible processes and loads, distributed generation and storage. Besides incentives for providing their flexibility, this could also lower their network fees.

4 Energy System Platform (ESP)

Customer benefits:
- Trading income

Utility benefits:
- Generate additional revenue

The Energy System Platform (ESP) has the capabilities to do all the previous stages but in addition can also provide consumers with a platform for trading energy in their community, which allows everyone to participate in the energy system.

The vision is to encourage private investment through new transactional business models that benefit prosumers, while lowering the need for capital investments by governments and utilities. In addition, it enables reduced operational and maintenance costs, while providing the opportunity to generate additional revenue streams from transaction fees.

Living lab: The Smart Grid Atlantic project

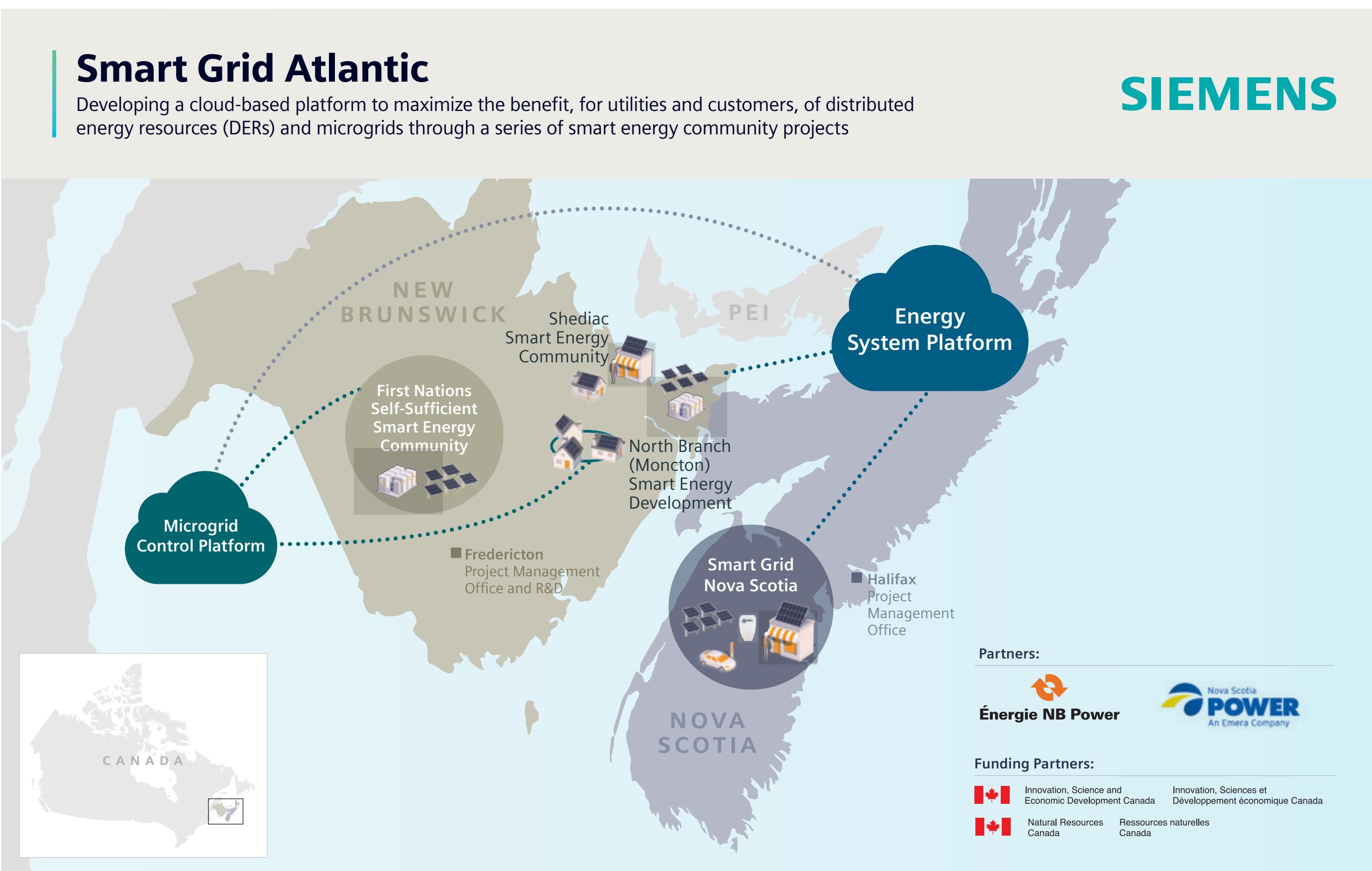
The Smart Grid Atlantic project will develop and deploy the ESP in the two provinces of New Brunswick and Nova Scotia. The benefits of distributed energy resources (DERs) and entire microgrids for utilities and customers will be maximized through a series of smart energy community projects. A wide array of behind-the-meter, grid-edge devices and community and utility-scale assets will be connected. This includes:

- Residential solar, storage, water heaters, heat pumps, etc.
- Fleet and residential electrical vehicle charging
- Building automation systems
- Commercial solar, storage and loads
- Community solar and utility-scale storage

The assets will be leveraged in both the Shediac Smart Energy Community and Smart Grid Nova Scotia load management programs. Energy and grid services will be created, as will new business models, demonstrating the great value of this initiative for the participating jurisdictions.

Two communities will be equipped with microgrids and connected to the ESP. This first will include the development of new “net zero ready” homes in a new Moncton neighbourhood. They will feature roof-top solar, as well as battery storage (decentralized approach), local energy optimization driven by artificial intelligence, and peer-to-peer energy trading mechanisms. The other will be equipped with a solar and battery installation (centralized approach) to provide higher levels of self-sufficiency and resiliency at lower energy costs.

This project will be a living lab for utilities to understand how customers engage with new offerings. It will demonstrate how to design new business models, create value, and analyze how incentive structures can influence behaviour. With all stakeholders involved, it will provide a critical roadmap for an efficient and cost-effective energy transition, leading to a more resilient and sustainable future.



Siemens Canada Limited
1577 North Service Road E
Oakville, ON L6H0H6
siemens.ca