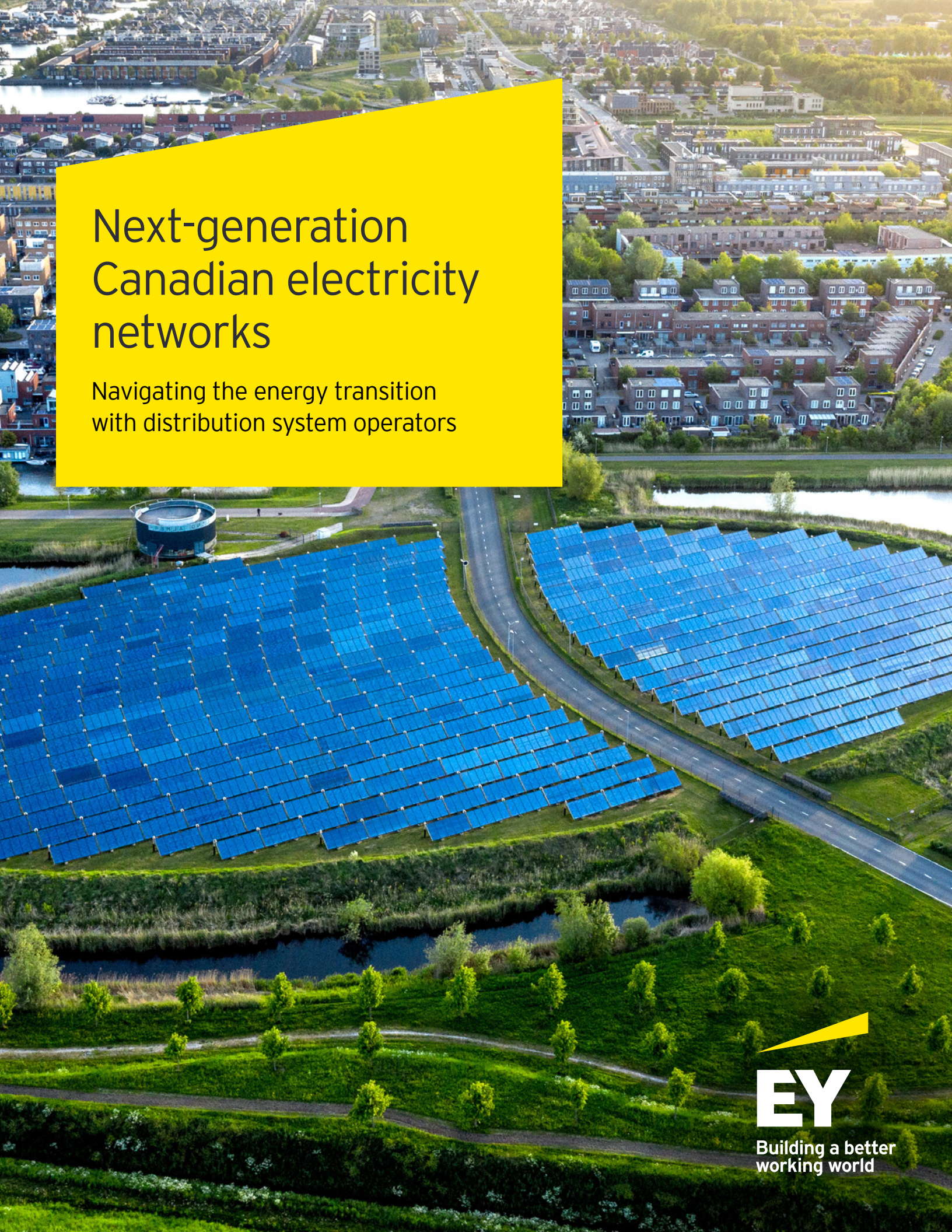

Next-generation Canadian electricity networks

Navigating the energy transition with distribution system operators

EY
Building a better working world

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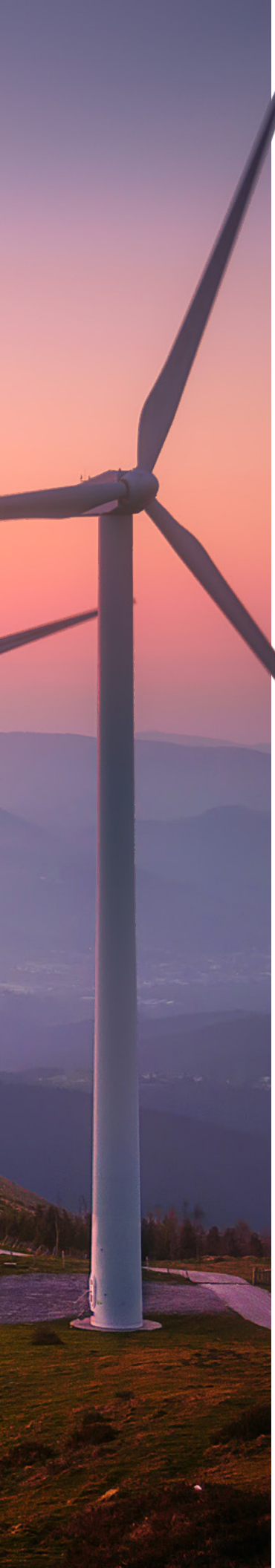


Letter from EY Canada

The evolving electricity ecosystem presents many opportunities and challenges in the energy transition. This industry has been traditionally viewed as predictable and static, but rapidly is becoming more dynamic, innovative and disruptive. The fundamental approach to generating, transmitting and managing electrons is being transformed by new technology deployments across sectors and customers.

From EY's perspective, the catalysts of change are fuelled by the growing need to balance the energy trilemma — security, sustainability and equity. In our previous publication, Energy Transition in Canada – Pathway to the 2050 Energy System, we provided a detailed overview of the concept. The trilemma is again the driver behind expanding societal expectations, electrification, net-zero ambitions and policy changes.[1]

The combined developments place additional pressure on the electricity sector to deliver and effectively manage a significantly larger energy load while operating in a more complex environment. Canadian generation capacity must be 2.2 to 3.4 times greater to meet 2050 electricity demand projections.[2] Widespread electrification, introduced through distributed energy resources (DERs) and grid-edge technologies, will bring decarbonization, flexibility and cost-reduction benefits across the entire energy system and beyond.

However, if electric utilities are to appropriately capitalize on these innovations and associated value streams, new and enhanced capabilities will be required. Conventional utility cost-of-service business models may be unable or unfit to effectively address DER deployment, interconnection and management in legacy regulatory contexts and structures. That's where distribution system operators (DSOs) may play a vital role in using innovation to optimize technology adoption for the benefit of customers and grid operators. DSO goes beyond the boundaries of a traditional power grid. It takes into account the relevance of DERs, grid-edge technologies and advanced platforms in shaping the future of electricity distribution.

In the following pages we explore the birth of a new energy system, shedding light on the transformative technologies and innovations that exert pressure on the grid. We also delve into the reasons for their emergence, the complexities they introduce, and the core challenges and opportunities they pose to utility businesses. We aim to guide utilities toward a more agile, proactive and sustainable energy future through insightful analysis and practical strategies.

Dr. Lance Mortlock

Managing Partner,
Industrials & Energy,
EY Canada

Moz Salim

Partner, Power and
Utilities Sector Leader,
EY Canada

Introduction

Canadian energy systems are undergoing a profound and disruptive transformation in the 21st century. In the past, electric utility value chains were predictable and stable, whereby market players relied on long-term planning, significant capital project investments and a one-way electricity delivery from generation to customers.

Traditional distribution models, commonly referred to as distribution network operators (DNOs),[3] are gradually becoming insufficient and inappropriately equipped to manage traditional issues. Centralized and one-way directional power and communication systems inherently clash with today's innovative, distributed and ubiquitous customer DER requirements.

Modern electricity distribution is increasingly customer driven, bidirectional and dynamic. It forces utilities to enhance their service delivery models and employ a more targeted local energy market approach to accommodate evolved customer needs. Market players are actively looking for solutions to effectively manage increased load growth, DERs and grid-edge technologies while maintaining the integrity and reliability of existing distribution systems.

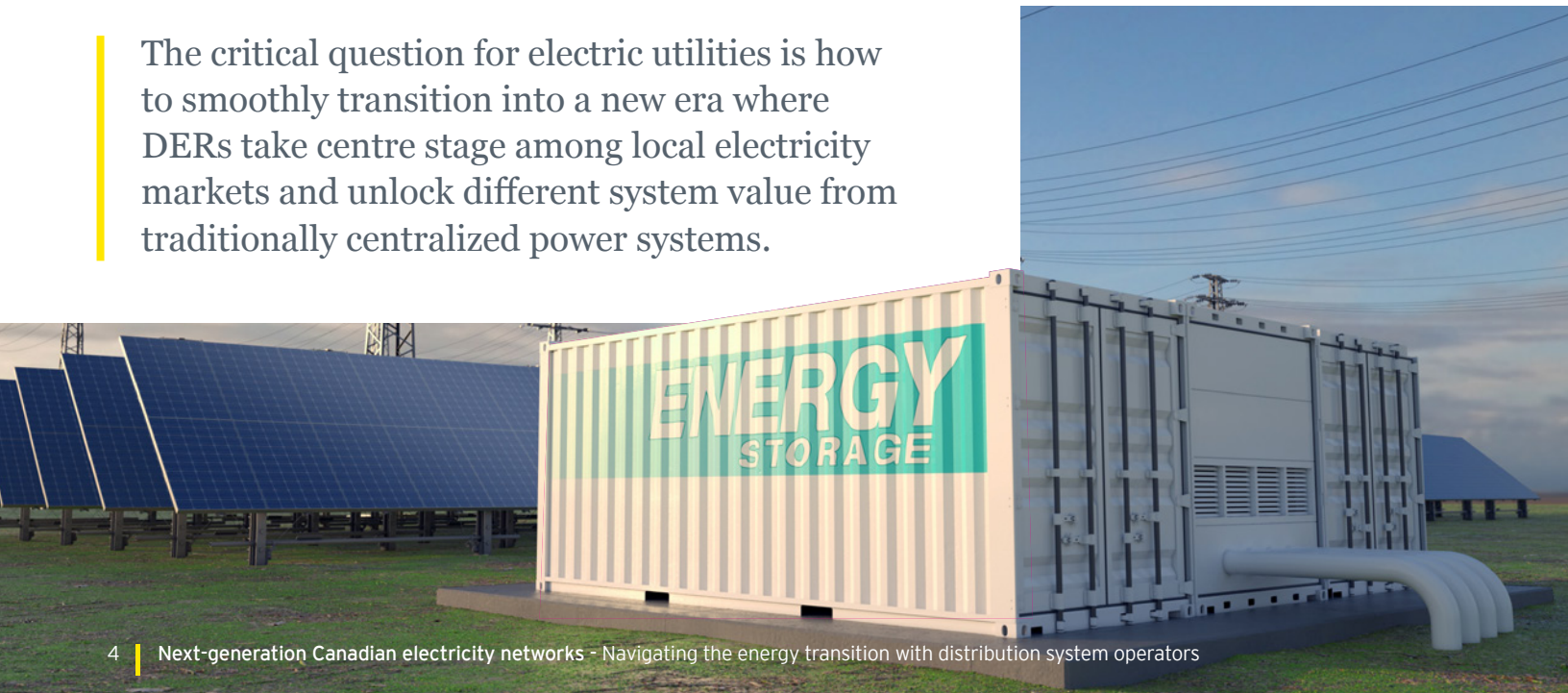
Currently, Canadian DNOs are in the early maturity stages of adopting widespread and standardized practices for interconnecting and managing DERs at a large scale. Some DNOs already embody some of the DSO functions, but those might be either insufficient in addressing multifaceted challenges or operationally siloed. Hence, a more fulsome framework is required.

Industry leaders, academics, regulators and other stakeholders are interested in further exploring this subject to create a viable roadmap for electric utilities to navigate DER and grid-edge technology challenges while improving operations, lowering customer costs, ensuring service safety and reliability, and tackling climate change. This transformation will require various initiatives and fundamentally challenge business models and cultural mindsets that have defined utilities for more than 100 years.

What is a DSO?

A real-time system operator for an active distribution network that manages and coordinates distributed generation at the local level, acts as a neutral facilitator to open markets, and enables easy access to the grid.

> The critical question for electric utilities is how to smoothly transition into a new era where DERs take centre stage among local electricity markets and unlock different system value from traditionally centralized power systems.



The birth of a new energy system

As previously mentioned, the energy transition is creating opportunities and challenges for electricity market stakeholders, whereby an introduction of DERs and grid-edge technologies is the primary concern for utilities. DERs are small, modular energy generation and storage technologies that provide electric capacity or energy, including electric vehicles, wind turbines, photovoltaics (PV), fuel cells, microturbines and more.[4] Grid-edge technologies are further enablers of DERs that extend their usefulness and application, such as automated metering infrastructure (AMI), smart home management software and many others.

In Canada, each province has its own initiatives to encourage DER adoption and profiles due to jurisdictional boundaries. For instance, Ontario's IESO found that at least 5,000 MW of DERs have already been deployed in the province and there is potential for substantial growth in the future.[5]

Below are select recent DER and grid-edge technology developments across the country that can help you contextualize the progress to date:

Distributed Energy Resources (DERs) and adjacent technologies developments by province

British Columbia

The Province of British Columbia passed the Zero-Emission Vehicles Act (ZEV Act) on May 30, 2019. The ZEV Act requires automakers to meet an escalating annual percentage of new light-duty ZEV sales and leases, reaching 100% by 2035.[6]

Québec/Hydro-Québec

Hydro Québec offers business customers a Demand Response (DR) Option to reduce their electricity bills and help optimize the system.[12] According to Propulsion Québec, DR initiative cut business hydro use by more than 443MW in 2022 or an equivalent of supplying 63,000 homes.[13]

Alberta

Travers Solar Project was completed in 2022, whereby one of the largest solar projects in North America is capable of producing 465MW of power.[7] Amazon is the primary benefactor of the produced energy under the power purchase agreement announced in June 2021.

Atlantic Canada (PEI, NS, and NB)

Atlantic Canada has significant opportunities to harness offshore wind energy and become a leader in renewable energy generation according to Public Policy Forum.[14] The Sable Island Bank alone could accommodate at least 1,000 offshore wind turbines or 70,000GWH.[15]

Saskatchewan

The Canada Infrastructure Bank (CIB) is investing $173 million towards a 200MW Bekevar Wind Farm, providing more than 100,000 homes with clean, sustainable electricity.[8]

Manitoba

EV drivers claim that there is a lack of charging stations in the province.[9] The government is funding numerous initiatives to build new EV charging stations, such as a $176,000 provincial grant for installing the equipment at three fast-food restaurants.[10]

Ontario

A microgrid Altona Towns community in West Pickering is providing new homeowners with an opportunity to choose and control their electricity production and consumption through a coordinated use of solar panels, EV chargers, and energy storage.[11] The initiative is partly funded by IESO's Grid Innovation Fund.

Note: Yukon, Northwest Territories, Nunavut, and Newfoundland and Labrador aren't mentioned due to relatively small population sizes.

The initiatives were primarily driven by a confluence of evolving technologies, customer preferences, environmental protection needs, resource availability constraints, regulations and public policy priorities, ultimately indicating the growing need to balance the energy trilemma.

Some of the most notable DERs and grid-edge technologies deployed in the market include:

Electric vehicles (EVs) are automobiles powered by electricity, replacing traditional combustion engine vehicles, to reduce greenhouse gas emissions and offer customers a cost-effective, eco-friendly mode of transportation.

Vehicle-to-grid (V2G) infrastructure enables bidirectional energy exchange between EVs and the electrical grid, allowing EVs to both draw energy for charging and discharge stored electricity back into the grid when needed, typically during peak demand hours.

Micro-wind are installations of wind turbines that capture wind energy to generate electricity, contributing to a cleaner energy mix and creating economic benefits in local regions.

EV supply equipment (EVSE) comprises charging infrastructure and equipment that provide EVs with the necessary electricity, offering EV owners convenient and accessible options to recharge their vehicles at home or in public spaces.

Solar solutions consist of solar panels and associated equipment that convert sunlight into electricity, allowing customers to reduce their electricity bills, lower carbon emissions, achieve energy independence, and potentially earn financial benefits by selling excess energy back to the grid.

Battery storage stores excess energy for later use or during power outages, enhancing grid reliability, providing backup power and optimizing energy use for customers.

Electric heat pumps provide energy-efficient heating and cooling for homes, reducing energy consumption, improving indoor comfort, and offering versatile heating and cooling options.

Electric utilities must adapt to the changing landscape to remain relevant and to continue providing value to customers. Distribution utilities may supply some or all of the new services and product offerings, depending on their regional environments, customer needs, target business models, strategies and objectives.

Although these transformative technologies may offer a strong potential for a cleaner, more resilient and more customer-focused energy system, they also pose significant operating model gaps and uncertainties that electric utilities must address. Large-scale growth of DERs and increased peak demand in a relatively short timescale will challenge the grid's future ability to operate safely and reliably.

Canadian utilities face the following five key challenges

1. How can electric utilities adapt their business models to effectively integrate DERs and grid-edge technologies and transition to a more customer-centric energy system?
2. What grid infrastructure and advanced technology investments are necessary to ensure grid resilience and reliability in the face of increasingly complex bidirectional energy flows and decentralized systems?
3. How can electric utilities enhance energy security in the face of evolving technologies and more frequent extreme weather events?
4. What regulatory and policy changes should electric utilities advocate for to accommodate the shift directed at more distributed energy generation and active customer engagement?
5. Why should electric utilities consider evolving their current business models towards a DSO?

The transformation of the electricity distribution system creates a more risk-laden environment for utilities. The traditional methods of running an electric utility business, marked by long-term and one-way energy delivery, are no longer sufficient. So DERs and other transformational influences warrant a new approach, and that's precisely where innovative market models, such as DSO, may come into play.

Why DSO?

A DSO model represents a fundamental shift in managing and optimizing energy distribution, offering a range of critical value elements that differentiate it from the traditional approach. Most utilities in Canada operate under conventional market structures.

For example, Ontario currently employs a DNO model, whereby utilities own electric distribution grids — physical distribution assets that move power between the transmitter, distribution-level DERs and customer load — in a defined service territory, coordinate outages and receive control signals from limited distribution company (LDC) operations.[16] In contrast, some provinces have vertically integrated utilities, such as British Columbia, whereby BC Hydro is mandated to generate, manufacture, conserve, supply, acquire and dispose of power and related products.[17]

Although each Canadian jurisdiction is different, most apply similar characteristics to a DNO at the distribution level and the customer interface. The DNO model is currently not equipped to face the growing DER integration, bidirectional flow and grid complexity challenges at scale and speed. Long connection queues, large connection volumes, timeline constraints, limited management of congestion and network reinforcement deferrals are the common issues that plague traditional utilities in the energy transition.

In contrast, DSO is a real-time system operator for an active distribution network that manages and coordinates distributed generation locally, acts as a neutral facilitator to open markets and enables easy access to the grid. DSO reduces complexity for grid operators in the era of decentralized and customer-driven energy systems, further combining asset and service value propositions. In its advanced and mature stages, DSO might be able to collaborate with other system stakeholders outside of current license concessions, such as microgrids and smaller utilities, to deliver DER solutions and electricity.

DSO could yield the following benefits:

Foster electrification and decarbonization: DSO can act as an intermediary between DER owners and the grid, facilitating a seamless and controlled integration of solar panels, wind turbines and other solutions. This enables efficient and coordinated DER utilization while ensuring grid stability, enhancing renewable energy adoption and reducing the overall carbon footprint.

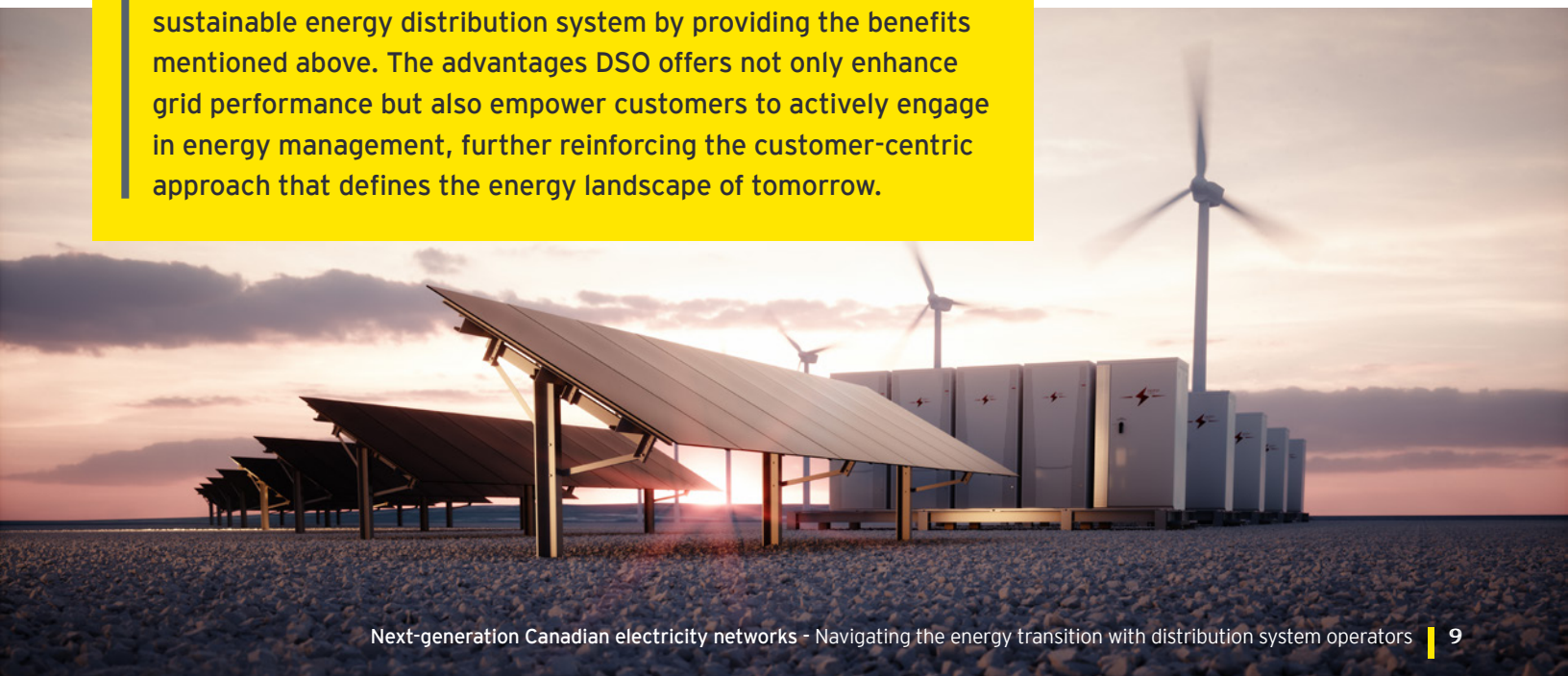
Introduce flexibility: DSO can allow the grid to swiftly respond to variations in energy supply and demand and manage constraints and congestion by integrating advanced monitoring and control systems, dispatching resources where and when needed. This real-time adaptability ensures grid stability and minimizes service disruptions that occur due to a lack of capacity for new connections, constraints, congestion, intermittent renewable energy sources and unexpected demand spikes.

Leverage load management: DSO can optimize the allocation of electricity across the grid through load distribution. By actively managing peak demand and load patterns, DSO can enhance grid reliability, support more efficient energy distribution, and reduce the use of costly and polluting peak suppliers.

Use energy storage and reserve capacity: DSO can facilitate the integration of battery energy storage systems (BESS) into the grid infrastructure that can efficiently capture and store excess energy during periods of low demand and release it during peak demand or outages, enhancing grid resilience, cost efficiency and clean energy use.

Reduce infrastructure spending: DSO can reduce some costly grid infrastructure upgrades by satisfying customer energy needs with more localized solutions and optimizing existing asset usage (i.e., non-wires alternatives (NWA) approach). Note that exact financial benefits will vary between utilities.

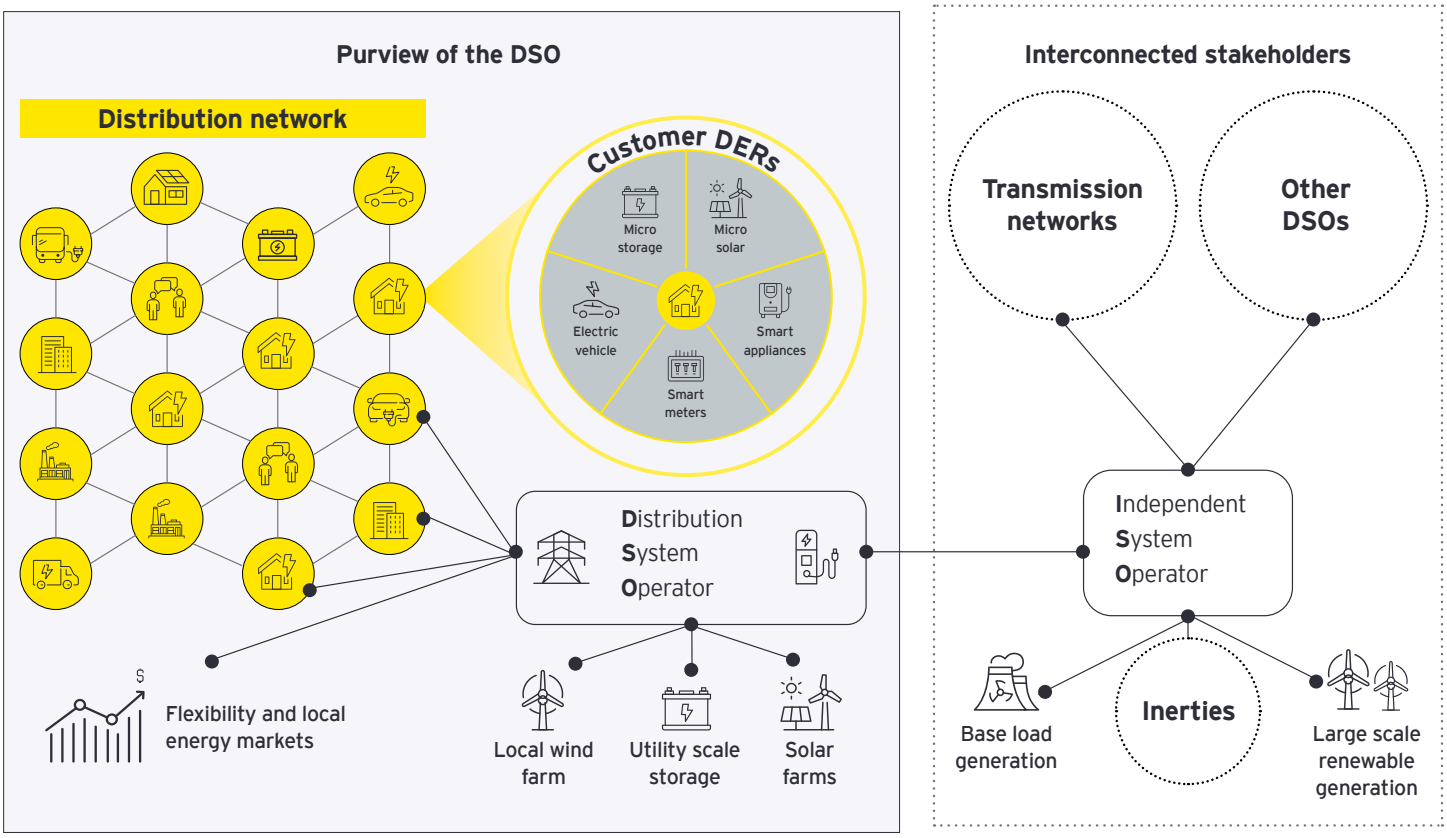
> **DSO could be pivotal in building a more adaptive, efficient and sustainable energy distribution system by providing the benefits mentioned above. The advantages DSO offers not only enhance grid performance but also empower customers to actively engage in energy management, further reinforcing the customer-centric approach that defines the energy landscape of tomorrow.**



DSO core capabilities and requirements

Given the interprovincial and electricity distribution business differences across the country, some utilities will be more conducive to DSO transformation. In contrast, others could maintain their grid modernization efforts without expansive DSO capability investments (e.g., procurement of flexibility markets). With that said, suitable candidates for DSO will require a unique set of competencies to be built based on their market conditions.

At a high level, a Canadian DSO ecosystem for a utility could look like the following illustration that demonstrates the potential connection points between DERs, grid-edge technologies and stakeholders:



Note: This DSO schematic is illustrative of leading DSO systems. It is not representative of Canada's proposed DSO landscape.

Note that market players such as system operators, aggregators and utilities will employ varying responsibilities depending on prevailing market structures. Thus, the capabilities and requirements must be determined on a case-by-case basis. However, most will be required in some capacity to sufficiently address increasing DER challenges and rapidly changing customer expectations.

DSO requires nine core capabilities

1 **Stakeholder information and insights**	▸ Stakeholder strategy will be transformed to align stakeholder objectives with new DSO service offerings and NWAs. ▸ Information and data sharing will become more transparent to allow developers and customers to identify opportunities and new services more easily.
2 **Data and systems**	▸ New masses of data will be collected and analyzed to enable novel operational capabilities and service offerings. ▸ Data requirements, strategy and policies will be revised to accommodate the increased magnitude and type of data collected and will need to be aligned organization-wide.
3 **Customers and experience**	▸ Customer engagement will be central to socializing new customer programs and service offerings, as customer benefits will be critical to success. ▸ Customer support, communication and experience will be enhanced to manage customer participation in markets, validation and settlement.
4 **Flexibility market and services**	▸ Flexibility programs will be developed to offer customers and service providers compensation according to their ability to meet real-time network needs. ▸ Network needs will be identified to inform the design of flexibility programs for the most critical NWA opportunities. ▸ Identifying flexibility service providers and managing procurement and bidding of capacity will be foundational to building more sophisticated flexibility markets.
5 **System coordination**	▸ Coordination with independent system operators (ISOs) and other DSOs/DNOs will be essential to compromise on an aligned approach for the whole system operations. ▸ Channels will be built to coordinate service delivery with new and existing stakeholders. ▸ Aggregators, system operators, regulators and other stakeholders will need to establish a clear set of rules and requirements for delivering services.
6 **System operations**	▸ Active operation of the network to dispatch DER generation and demand response can be used to mitigate capacity constraints and congestion. ▸ Accurate model-based system studies across all voltage levels will be performed on a week-ahead, day-ahead, hourly and sub-hourly basis across the distribution network to optimally schedule DERs. ▸ Network visibility will allow outages to be more accurately pinpointed, reducing truck rolls and optimizing work management processes.

7

Investment planning

- Along with traditional planning studies, newer methods will be required, such as NWAs, to address network congestion.
- Accurately forecasting load growth, DER adoption and identifying congested areas will be critical to addressing the rapidly evolving landscape.
- Coordinating directly with regional players and customers will bring about solutions that can align new connections with network needs.

8

Connections and connection rights

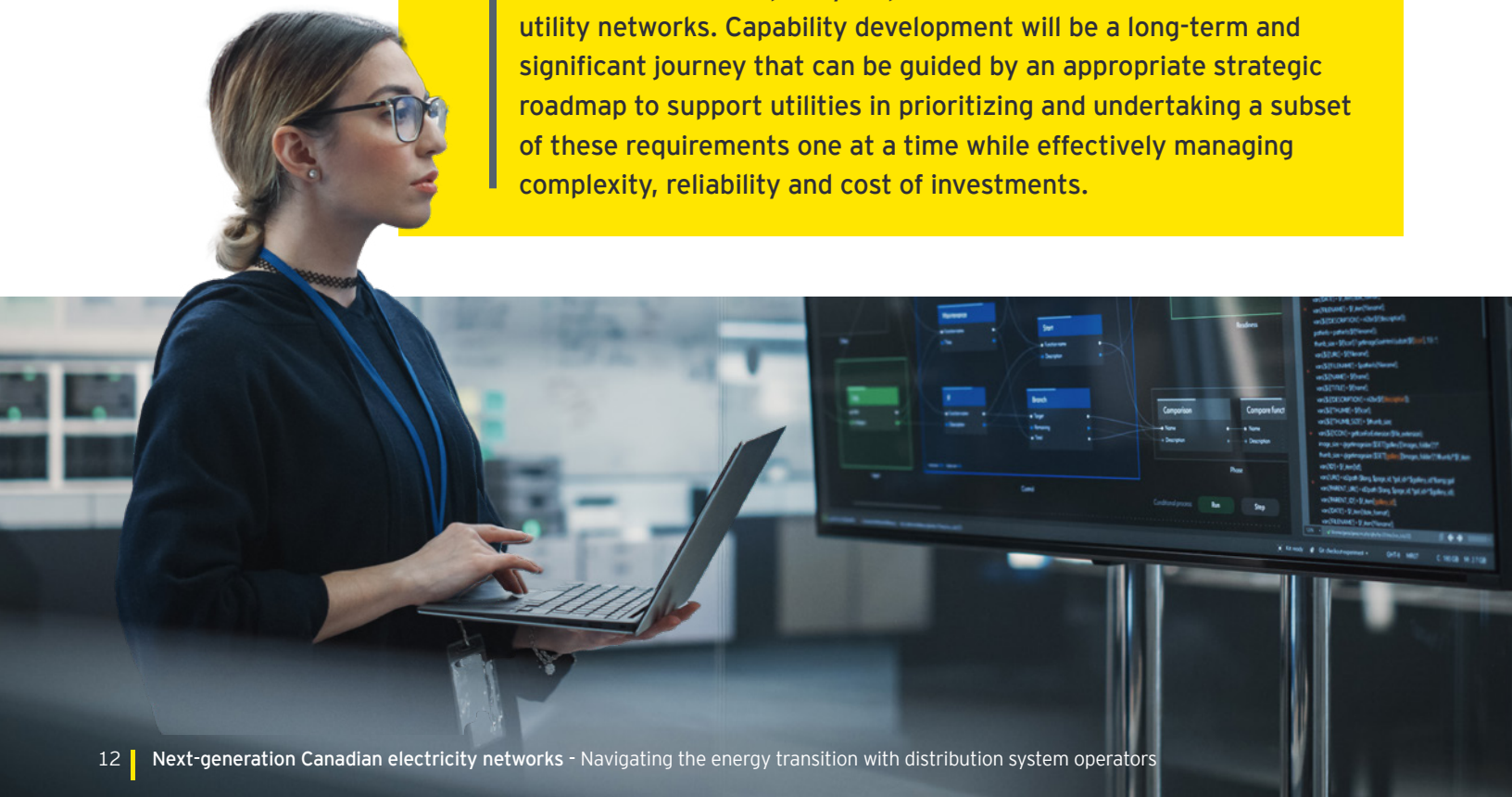
- Commercial arrangements for addressing constraints will need to be defined and aligned with new regulations and competitive frameworks.
- Connection agreements, access rights, curtailment principles and information sharing will need to be managed in a manner that is beneficial to both customers and network operators.
- Market-participating DER interconnections will need to be logged, managed, queued and prioritized for dispatch and settlement.

9

Field operations and visibility

- Increased penetration of intelligent electronic devices will be required to unlock the full potential of participating DERs.
- Remote terminal unit (RTU) design for visibility, control systems and failsafe operation of DERs will need to be optimized for network requirements.
- Automatic visibility and control of participating DERs and other flexible loads will require end-to-end management for continued reliable operations.

All market players will need to consider the nine foundational DSO elements in some capacity as part of the inevitable evolution of utility networks. Capability development will be a long-term and significant journey that can be guided by an appropriate strategic roadmap to support utilities in prioritizing and undertaking a subset of these requirements one at a time while effectively managing complexity, reliability and cost of investments.



Key takeaways from DSO case studies in other countries

In many jurisdictions around the world, the DSO journey has already begun. Some utilities are more mature in regard to deploying DSO capabilities and requirements, while others are less advanced. The evidence suggests that DSO models could provide tangible results and allow utilities to deliver more reliable, affordable and cleaner energy for their customers if appropriately implemented. At the same time, DSO undertakings continue to be risky and potentially capital intensive, leading to opportunity costs or even failed initiatives.

To this day, DSO is still highly conceptual, but numerous market players are trying to define their roles and responsibilities in this evolving ecosystem. EY teams emphasize that DSO models should be viewed as one of several tools in managing today's market pressures, rather than as a singular solution. Some jurisdictions may embody some elements of DSO while lacking others. Nevertheless, Canadian utilities can reflect on global learnings and leverage insights in their future endeavours.

Below are some case studies and relevant takeaways from Australia, Ireland and the UK:

The following case studies illustrate the successful outcomes of the following organizations implementing DSO models in their respective geographics. EY Canada does not claim any role in the success of those outcomes through a business or service relationship with any of the organization.

Australia

Overview

Western Power is a government-owned corporation in Western Australia responsible for building, maintaining and operating the electricity network that connects 2.3 million customers through traditional and renewable energy sources.[18] Australia responded to a rapid deployment of solar solutions and system reliability issues by bringing together utilities, regulators and governments to collectively undertake Project Symphony.

DSO strategy

The initiative allowed DERs to be orchestrated via a virtual power plant (VPP) to enable more effective coordination and integration of DERs with the wholesale electricity system and market stakeholders.[19] In this approach, the Australian Energy Market Operator (AEMO) acted as the distribution market operator (i.e., ISO); Synergy, Western Australia's largest energy provider, acted as an aggregator platform; and (WP) acted as a DSO. WP was responsible for developing capabilities to identify the distribution system's maximum demand levels and renewable energy hosting capacity. In the future, WP will continue testing DSO capabilities and eventually create its complete strategic DSO vision.

Key takeaways

The social findings from the project indicated that enrollment in flexibility markets largely depended on customer engagement activities.[20] Hence, strong customer advocacy and public relations are critical to securing wider societal buy-in for DSO adoption.

Lack of visibility on the local distribution network presented challenges for AEMO in coordinating DERs.[21] This example highlights the importance of grid monitoring infrastructure for effective management of flexibility resources.

The study revealed several key requirements that must be further improved before full-scale deployment of VPPs, such as process standardization, data sharing and analytics, cost-reflective pricing and others.[22] Although DSOs may be seen as highly beneficial for electric utilities, they also pose their own unique risks that must be carefully assessed and tackled.

Ireland

Overview

ESB Networks DAC, a ring-fenced subsidiary of ESB Group, is the licensed operator of the electricity distribution system in the Republic of Ireland.[23] The country's long-term climate and energy policy objectives placed additional pressure on ESB to secure the distribution grid and develop flexibility markets.

DSO strategy

ESB's DSO vision is to deliver a clean electric future through the electrification of heat, transport and industry by operating flexibility markets and connecting renewable generation at scale to the electricity network.[24] ESB's DSO transition consists of two primary focus areas: managing a large increase in connections of renewable generation and low-carbon technologies as efficiently, securely and effectively as possible; and empowering and incentivizing a complete shift in the way customers want to use electricity.[25] In 2021, ESB launched a multi-year and multidisciplinary National Networks Local Connections Programme (NNLC) to conduct DSO, market and customer readiness assessments and create DSO delivery plans.[26]

Key takeaways

Customers must be at the centre of a DSO strategy. Their electrification adoption rates and electricity needs will always dictate utility investments and service requirements.

Adding flexibility, including storage, places additional pressure on the grid. Although DSO could lead to fewer future asset investments via NWAs, these savings may be offset by the necessity of installing flexibility-enabling infrastructure (e.g., cooling equipment designed to be used beyond day-night operating cycles).

UK

Overview

UK Power Networks (UKPN) owns, operates and manages three of the 14 regulated electricity distribution networks in Great Britain, serving 18 million customers.[27] The organization expects to see a substantial rise in domestic electric heat pumps and EVs in their service area by the end of 2030, placing significant risk and pressure on future grid. operations.[28]

DSO strategy

UKPN began their DSO journey in 2010 by engaging with customers on their needs and DER interests. As of April 2023, UKPN had officially launched their DSO to "provide, at lowest cost, enough electricity capacity across London, the East and the Southeast of England to facilitate the transition to Net-Zero."[29] The strategy has four pillars: building trust and confidence in independent distribution system operation; reducing bills through sector-leading DSO operations; providing timely and affordable access to their network by accelerating the connection process; and helping customers play their part in net zero and supporting innovation in energy services.[30]

Key takeaways

Once again, DSO has the potential to reduce future asset investment needs. UKPN has committed to maintaining lower costs by taking a "flexibility and energy efficiency first" approach, whereby an estimated £410m of network investment is expected to be avoided through flexibility tenders.[31]

Streamlining the DER connection process is key for a consumer-grade experience. Customers may get discouraged from adopting electrification solutions if their requests aren't processed in a timely manner, thus potentially jeopardizing DSO advancement efforts.

UKPN's DSO remains as a separate legal entity from the DNO.[32] This unique approach may ignite discussions over how DSO models should be implemented from an enterprise perspective, that is, subsidiary vs. business unit ownership.

Conclusion

The energy landscape is transforming, posing intricate challenges and opportunities for electric utilities. The pressing need to balance escalating demand growth with integrating diverse DERs and grid-edge technologies requires innovative solutions. This complexity makes utilities grapple with novel ideas, regulatory uncertainties and reliability concerns.

Amid this intricate scenario, the concept of DSO emerges as a beacon of hope. Acting as real-time operators for active distribution networks, DSOs can not only manage and coordinate DERs, but also facilitate open markets and ensure easy access to the grid, reducing the need for excessive deployment of poles and wire solutions, all while meeting the increasing energy demand.

DSO capabilities, such as flexibility services and system coordination, will drive utilities to enhance or build out a set of core competencies. While the destination is still unclear and undeniably challenging, lessons can be drawn from other jurisdictions undertaking DSO journeys. With the opportunities and challenges properly understood, embracing the DSO framework can offer a promising pathway for Canadian utilities to successfully navigate the complexities of the energy transition.

However, each utility considering a DSO journey should also recognize that this business model may not be suitable or achievable under certain market conditions. Extensive research, analysis and strategy are the core prerequisites to any DSO transformation and implementation. Canadian utilities should further explore these areas in greater detail to better understand the potential of DSO for their respective businesses.

How EY can help

DSO is a brilliant opportunity for electric utilities to step into the next evolution phase of the energy sector in Canada and globally. EY teams are well aware of the market challenges and the scale of disruption, and we are dedicated to supporting the relevant market players along this new journey.

We help organizations in both the public and private sectors overcome existing barriers and develop strategies to drive implementation with real and tangible results. Some of our competencies include:

Strategy services – Corporate and business strategy, target operating model design, market research and analysis, go-to-market strategy, scenario planning, innovation, integrated planning, project and program delivery, business case analysis, regulatory support, procurement and solutions delivery, and M&A.

eMobility services – Advisory services for transportation electrification journeys from strategy to execution, and optimization across three core areas: fleet electrification, charging infrastructure and customer experience.

Key contacts, authors and references

Key contacts

Moz Salim
Partner, Power and Utilities
Sector Leader, EY Canada
moz.salim@ca.ey.com
+1 416 941 7783

Andy Grainger
Partner, Power and Utilities
Consulting Leader, EY Canada
andrew.grainger@ca.ey.com
+1 519 646 5567

Craig Sabine
Partner, Energy Transition
Infrastructure Leader, EY Canada
craig.sabine@ca.ey.com
+1 416 932 4219

Krista Yates
Partner, Power and Utilities,
EY Canada
krista.yates@ca.ey.com
+1 506 634 2178

Paul Micallef
Partner, EY Global Digital
Grid Leader, EY UK
pmicallef@uk.ey.com
+44 20 7951 4500

Authors

Dr. Lance Mortlock
Managing Partner, Industrials & Energy,
EY Canada
lance.mortlock@ca.ey.com
+1 403 206 5277

Sara Ganowski
Senior Manager,
EY Canada
sara.ganowski@ca.ey.com
+1 416 417-3770

Tyson Denhamer
Manager,
EY Canada
tyson.denhamer@ca.ey.com
+1 587 998 7295

Alexandr Kim
Senior Consultant,
EY Canada
alexandr.kim@ca.ey.com
+1 403 592 9987

Connor McCabe
Senior Consultant,
EY Canada
connor.mccabe@ca.ey.com
+1 416 932 5899

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