Association of Municipalities Ontario

Using Distributed Energy Resources (DERs) to Fight Climate Change and Build Climate Resilience

AMO Climate Change Series Paper

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Executive Summary

The energy landscape in Ontario is changing. Ontario's existing electricity grid is characterized by both centralized generating stations as well as a large transmission and distribution system that stretches across the province. Natural gas distribution in Ontario relies on a large network of similar transmission pipelines and distribution infrastructure. New technologies, a changing climate, and a broad push to reduce carbon emissions are pushing energy production, transmission, distribution, and consumption in new directions. As frontline service providers, electricity consumers, and economic drivers, municipalities are at the forefront of these new trends.

In contrast to the existing large, centralized systems, Distributed Energy Resources (DERs) offer opportunities for smaller-scale, localized energy production, storage, and distribution. The IESO defines DERs as "a resource that… is directly connected to the distribution system, or indirectly connected to the distribution system behind a customer's meter; and… generates energy, stores energy, or controls load."

These technologies may:

- help save costs associated with traditional infrastructure investment models;
- increase the pace of energy infrastructure deployment;
- give communities a say in their energy system;
- provide economic benefits; and
- fight climate change and make energy systems more resilient to extreme weather events.

However, like many emerging technologies, DERs also present challenges to existing systems and practices in the energy sector. DERs may challenge existing energy sector actors (including local distribution companies), create reliability issues on the grid, and push the limits of current regulatory frameworks.

While some DER technologies are pushing the limits of what is practical and economically feasible, other DERs are already commercially viable. Many more will become so as costs continue to decrease. Therefore, it is important for municipalities to develop a clear understanding of DER technologies and their applications now so that they are prepared to navigate the rapid changes in Ontario's energy systems.

This paper recommends the following:

Municipal Governments

- Explore the role of DERs in supporting municipal climate change and climate resilience goals
- Consider the potential impacts and opportunities of DERs on Municipal Energy Plans and Climate Change Action Plans, and where feasible, collaborate with Local Distribution Companies (LDCs) when developing these plans
- Participate in relevant consultations at the Independent Electricity System Operator (IESO) and the Ontario Energy Board (OEB) related to DERs and other alternative energy sources, including but not limited to the DER roadmap and the Framework for Energy Innovation

- Work and collaborate with LDCs to engage with and leverage DER technology to realize potential new revenue streams, provide consumers more choice, while keeping LDCs whole

Regulators

- Conduct meaningful engagement with municipal governments in DER consultation and implementation programs
- Ensure through rate structures that LDCs and other local utilities are not subject to the "utility death spiral" by the widespread adoption of DERs
- Improve consultation, communication, and collaboration with municipalities and LDCs
- Make clear, detailed, and plain-language information about the energy system, energy initiatives, and energy planning processes readily available to municipalities, municipal residents, and other municipal stakeholders
- Collaborate with municipalities as full partners in energy planning processes
- Work in partnership with the Association of Municipalities of Ontario (AMO) to address energy issues of relevance to Ontario's municipalities

Provincial Government

- Encourage research and investment into renewable DERs with a particular focus on energy storage
- Consider how DER technology can increase the share of renewable and non-emitting energy in Ontario's energy mix
- Facilitate the active and meaningful participation of municipalities in energy planning initiatives
- Consider the role of DERs and municipal energy needs while creating the next Long Term Energy Framework
- Provide municipalities with dedicated funding to support energy planning, DER integration, and access to required capital costs related to the adoption of renewable energy initiatives

Federal Government

- Consider how renewable DERs could facilitate the transition of remote communities and First Nations away from diesel generators and other nonrenewable energy
- Provide dedicated funding to municipalities to support energy planning, DER integration, and required capital costs related to the adoption of renewable energy initiatives

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1.0 Introduction

The energy landscape in Ontario is changing. Ontario's existing electricity grid is characterized by both centralized generating stations as well as a large transmission and distribution system that stretches across the province. Natural gas distribution in Ontario relies on a large network of similar transmission pipelines and distribution infrastructure. New technologies, a changing climate, and a broad push to reduce carbon emissions are pushing energy production, transmission, distribution, and consumption in new directions. As frontline service providers, electricity consumers, and economic drivers, municipalities are at the forefront of these new trends.

In contrast to the existing large, centralized systems, distributed energy resources (DERs) offer opportunities for smaller-scale, localized energy production, storage, and distribution. These technologies may allow municipalities to generate and store their own electricity, transform emissions from landfills and sewage treatment facilities into useful energy, encourage economic development, and make Ontario's energy grid more resilient to extreme weather events. However, like many emerging technologies, DERs also present challenges to existing systems and practices in the energy sector.

While some DER technologies are pushing the limits of what is practical and economically feasible, other DERs are already commercially viable. Many more will become so as costs continue to decrease. Therefore, it is important for municipalities to develop a clear understanding of DER technologies and their applications now so that they are prepared to navigate the rapid changes in Ontario's energy systems.

1.1 Project and Scope

This paper explores the role of DERs in reducing the environmental impacts of energy production and in making energy infrastructure more resilient in the face of a changing climate. DER is a broad category. Its focus is limited to smaller-scale DERs involved in electricity and heat generation, production, storage, transmission, and management. This paper outlines the risks and opportunities that DER technology represents for the municipalities of Ontario.

DER technology has potential benefits for municipalities through localizing electricity and heat generation, transmission, storage, and distribution. Despite these net positives, the potential benefits must be weighed against the challenges associated with emerging technologies. For example, their ambiguity under existing regulatory frameworks and the need to maintain a reliable electricity supply. This paper provides key contextual information about DERs to equip elected municipal officials with the tools they need to make informed energy choices as municipal governments take action against climate change.

2.0 Energy in Ontario

Energy in Ontario is a broad category which includes electricity and carbon-based fuels like gasoline or natural gas. Much discussion around DER is focused on electricity, but the entire electricity sector in Ontario only accounts for 16% of total provincial end-use energy demand.[1] Refined petroleum products and natural gas each make up 48% and 28% of total end-use demand respectively.[2]

2.1 Ontario's Electricity System

The electricity system in Ontario is made up of a complex web of actors. These actors can be grouped into a few broad activity categories: generation, transmission, distribution, and regulation.

In 2018, approximately 60% of all electricity in Ontario was generated by nuclear sources.[3] Hydroelectricity accounted for another 26% of generation. Wind, natural gas, and solar made up for 7%, 3%, and 2%, respectively.[4] The vast majority of existing generation in the province comes from sources which do not emit greenhouse gases (GHGs). Generating electricity accounts for just over 1% of Ontario's total GHG emissions.[5]

The province's generation mix will change in coming years as the Pickering Nuclear Generating Station is retired. Nuclear power provides most of Ontario's "baseload" power, which is a steady, constant, and reliable flow of electricity.[6] Other, more flexible forms of generation like natural gas plants are used to meet the province's peak power demands. These peak demand periods are the times in the year where electricity usage is highest in the province, such as on hot summer days when many households are running air conditioners. The provincially-owned power corporation Ontario Power Generation (OPG) produces approximately half of Ontario's electricity,[7] and private generators supply the rest.

Electricity produced in Ontario's generating stations must be transmitted over large distances to end users. Hydro One is the dominant transmitter of electricity in Ontario. This corporation is responsible for 98% of transmission capacity in the province.[8] Hydro One transmits high voltage electricity from generators directly to 82 large industrial consumers, as well as to various LDCs throughout the province.[9] The corporation also functions as a LDC in a number of municipalities in the province. Other municipalities are served by regional and municipal LDCs. There are some private-sector LDCs in Ontario, but many municipalities are partial or sole shareholders in distributors.

2.2 Roles of Different Agencies

While Ontario has competitive energy markets, the unique and essential nature of energy commodities requires some intervention on behalf of the public. The Ontario Energy Board (OEB) and the Independent Electricity System Operator (IESO) are two such bodies relevant to this discussion of DERs. The OEB is an independent regulatory body which oversees energy in the

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[1] Canada Energy Regulator, 2021
[2] Canada Energy Regulator, 2021
[3] Canada Energy Regulator, 2021
[4] Canada Energy Regulator, 2021
[5] Canada Energy Regulator, 2021
[6] While nuclear energy does not emit GHGs, it does create waste which remains hazardous indefinitely. This waste must be safely stored for thousands of years. The Nuclear Waste Management Organization is currently exploring sites for an underground waste storage facility. This facility will likely be located in Ontario.
[7] Ontario Power Generation, 2021
[8] Hydro One, 2021, p. 10
[9] Hydro One, 2021, p. 10

province. The OEB is mandated by the provincial government to set electricity and natural gas rates, license energy system generation, transmission, retail, and local distribution companies; create and enforce energy system rules; and license and set fees for the IESO.[10]

The IESO coordinates and operates Ontario's electricity system and electricity market. The IESO ensures that electricity supply matches demand in a predictable and reliable manner. It does this in both real-time by matching daily electricity needs to supply, and over the long term by procuring generating (as well as demand response, conservation, and storage) resources.[11] In Ontario's competitive electricity market system, the IESO determines the price of electricity by accepting the lowest-cost bids from suppliers until the system needs are met.[12]

2.3 Other Energy

As discussed above, only a portion of Ontario's end-use energy is electricity. Most of the energy used in the province comes from refined petroleum products and other fossil fuels like natural gas. Refined petroleum products are used in a variety of applications in Ontario. The most relevant to this paper is their use as vehicle fuel. The transportation sector is responsible for 35% of Ontario's GHG emissions.[13] The anticipated widespread adoption of electric vehicles (EVs) in Ontario (and around the world) could significantly reduce the transportation sector's GHG emissions, provided that the electricity used to power EVs comes from non-emitting sources.

Natural gas is used in Ontario for heating residences and commercial buildings, a source of fuel and as a material input for industry.[14] It is also used to generate electricity for peak demand periods. Much like the electricity system, the natural gas system relies on extensive infrastructure networks to transport it from the site of extraction to end users.

Large pipelines, owned by a variety of private operators, carry natural gas to Ontario from producers in the United States and Western Canada. A large quantity of natural gas is stored in the Dawn Hub storage facility near Sarnia, Ontario, from which it is distributed to meet seasonal demand.[15] LDCs use a series of smaller pipelines to deliver natural gas to end-users. While natural gas currently plays an important role in Ontario's energy mix, it does contribute to GHG emissions. DERs can help utilize natural gas more efficiently and may be useful in a larger transition away from fossil fuels.

3.0 Municipal Interest in Energy

Municipalities in Ontario are closely watching the changes occurring in the energy system. There are a number of areas where the proliferation of DERs are aligned with municipal interests. While many DER technologies present exciting opportunities to municipalities, it is important to remember that

[10] Ontario Energy Board, 2021
[11] IESO, 2021e
[12] IESO, 2021b
[13] Canada Energy Regulator, 2021
[14] Government of Ontario, 2019
[15] Government of Ontario, 2019

"not all, and perhaps not many, proposed DER installations will present system value when compared to conventional system investments."[16]

3.1 Climate

It has become exceedingly clear that the global climate is changing. Seasonal weather patterns are changing, and extreme weather events are happening more frequently, and in new areas. As this paper is being written, fatal heatwaves have afflicted western North America, unprecedented flooding has devastated parts of Europe, and a powerful tornado destroyed homes in Barrie, Ontario. The safety and stability of Ontario's electricity system will be tested by these new conditions.

The massive power outage which occurred amidst an uncharacteristic winter storm in Texas in early 2021 demonstrates the risks extreme weather poses to energy systems. The power outage left millions of people without electricity, and more than 110 deaths have been attributed to the storm. While Ontario's electricity system is built to withstand cold weather and has been modified in response to previous blackouts and extreme weather, changing conditions must be accounted for. The IESO has identified recent extreme weather events in Ontario as an ongoing risk to the grid.[17] As evidenced in the massive 2003 blackout that impacted Ontario and the northern United States, the resiliency of the electricity system must not be taken for granted. DER technology can contribute to energy system resilience through its decentralized nature.

Energy production and consumption in Ontario also has an impact on climate change in the form of GHG emissions. While most of the electricity produced in Ontario comes from non-emitting sources and renewable sources, DERs can help continue to reduce the emissions caused by electricity in Ontario through the more efficient use of renewable electricity. Increasingly, the use of renewable energy is a consideration in international trade agreements and processes, so Ontario's continued transition to a clean electricity grid is both environmentally and economically necessary.

3.2 Keeping up with Growth

Energy infrastructure is essential to support the continued residential and economic growth of Ontario's municipalities. New industries and changing consumption patterns are having an impact on the legacy electricity system, while existing industries are scaling up and require more electricity to continue growing.

In Windsor-Essex, the greenhouse sector has been growing faster than can be supported by the existing electricity system. The continued expansion of this industry is dependent on a reliable and plentiful electricity supply, and greenhouse operators have threatened to expand elsewhere if this supply is not available. In some cases, operators have expanded locally by building their own generation and distribution infrastructure for electricity. The province should look for ways to integrate these supplies with the existing system to help reduce the infrastructure buildout requirements and keep large consumers a part of the connected grid.

[16] Sommerville, 2019, p. 2
[17] IESO, 2019

Meeting this region's projected power needs will require major infrastructure investments.[18] Traditional electricity systems require large investments in generation and transmission capacity to meet these peak needs. In some situations, smaller and more flexible DERs may be able to replace or defer these large investments. Energy prices, policy,[19] and often demand are beyond the control of municipalities. By engaging with emerging DER technologies, municipalities could mitigate this vulnerability.

3.3 Community Energy

The modern electricity system predominantly consists of large generating stations and long transmission systems that connect generators to end users of power. However, there is an increasing acknowledgement of the benefits of localizing energy use and production. This idea is encapsulated in the concept of "community energy," which is defined as "energy initiatives that emphasize community participation through ownership and control, where through doing so, benefits are created for the local community… [and] by an emphasis on community capacity."[20] In Ontario, many municipalities have already created or are in the process of creating Community Energy Plans, Climate Change Action Plans, and Municipal Energy Plans to align energy with other municipal policy goals. Because of their small-scale and flexible nature, DERs can support these community energy initiatives (e.g. virtual net metering), and may help municipalities capture local economic benefits from energy generation, storage, and distribution.

3.4 Emerging Technologies and System Changes

Many DER technologies have existed for some time. However, falling prices and the emergence of new technologies have accelerated the pace of change in Ontario's energy system. In a survey of Ontario electricity industry experts, new and increasingly affordable battery technologies were cited as the most "influential driver of change" in the system. Low-cost storage options allow for the more efficient use of intermittent power sources like wind and solar.

The coming wave of electric vehicles (EV) and the more general phase-out of carbon-emitting energy sources will mean new applications for electricity while also changing patterns of electricity use. The federal government has set a target of 2035 for 100% of light-duty vehicle sales to be zero-emission.[21] As these various technologies become economical, adoption is likely to become more widespread.

In recognition of this, Ontario's IESO has begun a series of consultations and reports on the role of DERs in the province's current and future electricity system. Given the speed at which change is occurring, it is imperative that municipalities begin preparing now. Furthermore, many municipalities in Ontario are partial or sole shareholders in LDCs. The changes occurring to the energy system will have an impact on LDC operations, and LDCs are well-positioned to take advantage of DER technologies to realize potential new revenue streams and provide community-based energy solutions.

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[18] Similarly large-scale investments will be required to ensure that other municipal infrastructure—including water, waste, and housing, among others—will be able to support increased growth

[19] City of Vaughan, 2016, p. 26

[20] Wyse, 2018, p. 6

[21] Transport Canada, 2021

It is important that as LDC shareholders, municipalities are engaged in this process and that the province look to reduce regulatory barriers that may impede the deployment of these technologies. Ultimately, as one report on DERs argues: "we do not actually know how much time we have, so, we have to start now, because in these exhilarating, accelerating times, the future has a way of arriving more quickly than prudence might prefer."[22]

4.0 DER Technologies

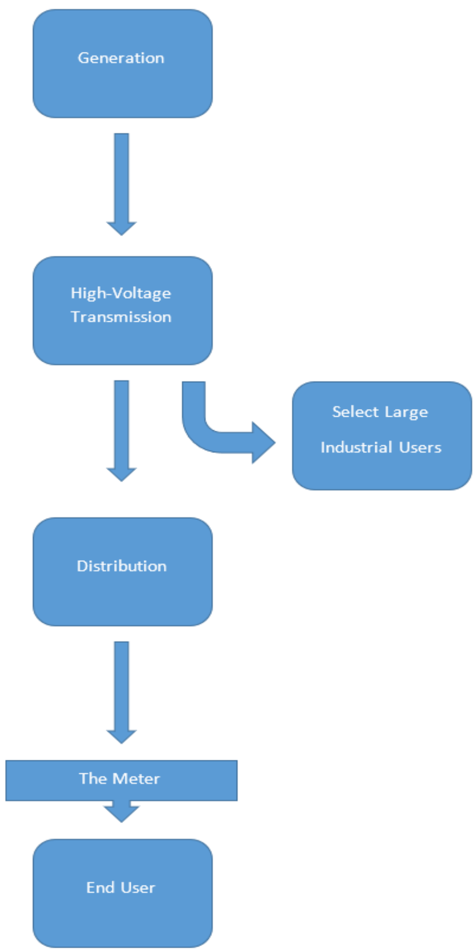

Figure 1: Legacy Electricity System

4.1 Definitions of DER

There are many different definitions of DER. As an emerging set of technologies with varied and geographically-specific applications, DER can mean different things to different parties. As one author states:

"There are virtually as many definitions of distributed energy resources as there are commentators. Different resources present different opportunities, and different challenges. Each technology has its own cost structure, suite of benefits, and locational relevance. These technologies are not interchangeable – what may provide system value in one setting, may present a completely different proposition in another."[23]

Common elements of various DER definitions include their decentralized nature, their position in the energy system and their connectedness in the distribution (as opposed to long-distance transmission) system.[24]

In order to be aligned with existing practice in the Ontario context, this paper will adopt the IESO's technologically-neutral working definition of a DER as being "a resource that… is directly connected to the distribution system, or indirectly connected to the distribution system behind a customer's meter; and… Generates energy, stores energy, or controls load."[25] This input-neutral definition includes a variety of resources that occupy different niches in a system of distributed energy. Notably, unlike some other jurisdictions26 this definition includes controllable loads.

[22] Cameron, 2019, p. 11
[23] Sommerville, 2019, p. 5
[24] Cameron, 2019, p. 12; IESO, 2021a
[25] IESO, n.d., p. 11
[26] AESO, 2020, p. 5

4.1.1 Behind the Meter vs On the Grid

When discussing the electricity system, it is common to hear the terms "on the grid" and "behind the meter." Most legacy electricity systems feature a clear linear path from generation to end user (see Figure 1). Electricity flows through the meter just prior to use by the end user. In this model, electricity flows in a unidirectional manner.

In an electricity system with integrated DERs, the flow of electricity can look very different. DERs can be connected to the electricity distribution system, or even directly to the end user (see Figure 2). In this kind of system, end users of electricity may also become generators or repositories of power, who then provide electricity to the grid as needed. This generation and storage often takes place behind the meter.

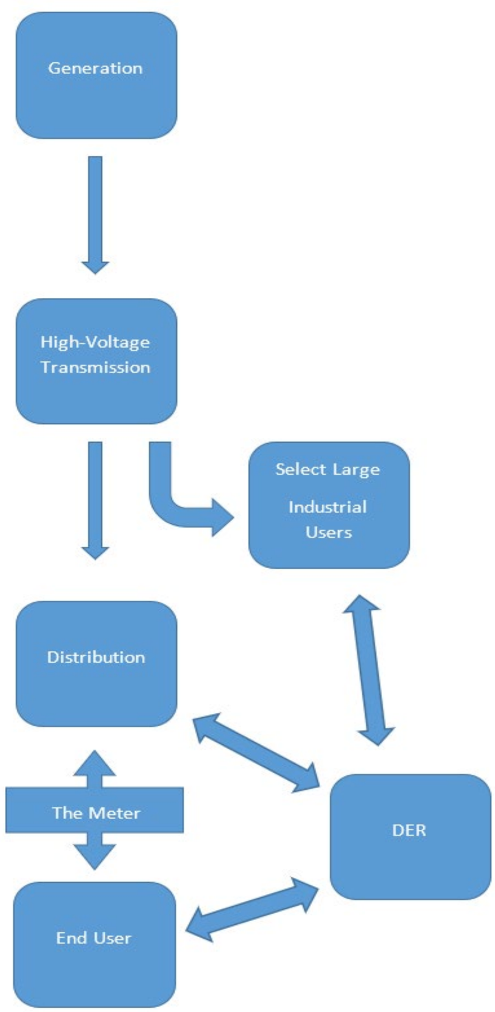

Figure 2: Electricity System with Distribution and User-connected DERs

4.2 Different Types of DERs

While DERs are defined by their function in the energy system, there are a number of technologies that are commonly thought of when discussing DERs. These technologies fall into three main categories: storage, generation, and controllable loads.

4.2.1 Storage

Storage technologies allow operators to collect and release energy. Batteries are perhaps the most well-known type of this technology, but other mechanisms like flywheels, fuel cells, underwater compressed air storage, and pumped-storage hydroelectricity also provide opportunities to store electricity.[27] Some people even consider EVs to be a form of energy storage.[28]

EVs can charge at periods of low demand and low price, and some may even be able to feed electricity back into the grid during periods of high demand, much like a conventional battery. Other technologies like heat storage allow for the capture and deployment of non-electrical forms of energy.

4.2.2 Generation

Generation resources are those that have the ability to produce power. This DER type encompasses a wide variety of technologies, including solar, wind, and small nuclear (also known as small modular reactors). Other generation DERs can include technologies like on-site biogas (RNG) generators at landfills and agricultural operations, and combined heat and

[27] Ahmed et al, 2016, p. 8
[28] Cameron, 2019, p. 53

power facilities (CHP) that can address facility needs at large organizations.

4.2.3 Controllable Loads

Controllable loads (also known as demand response) are users of electricity that can adjust their usage based on market or user signals. These can be major industrial users, or small-scale devices like heating, ventilation, and air conditioning (HVAC) systems, smart thermostats, electric water heaters, and other software and building systems.[29] Controllable loads can support intermittent renewable generation technologies like wind and solar.

4.2.4 Other Types

While this paper focuses on the above categories, the broad nature of DERs can also include technologies that are more like the conventional power grid. Microgrids and district energy systems replicate some functions of the traditional grid and power plants, but at a much smaller scale.

A microgrid is a "group of interconnected loads [users] and DERs within clearly defined electrical boundaries," which acts as a "single controllable entity" that be connected or disconnected from the grid.[30] They can be deployed as an alternative or as a supporting measure to the existing grid. Similar to microgrids, virtual power plants are agglomeration of DERs that are collectively controlled by software to function much like a larger, conventional generating station.[31]

5.0 Opportunities for Municipalities

The widespread adoption of DERs presents several potential opportunities for municipalities.

5.1 Community Financial Benefits and Cost Savings

Because of their smaller scale, DER may allow more players to enter the energy market, fostering competition and choice for users.[32] Furthermore, DERs may further allow utilities to defer costly generation and transmission infrastructure investments. DERs can be utilized as Non-Wires Alternatives (NWA), which is a term that encompasses various applications of DERs to avoid building new transmission and distribution infrastructure.[33] This has proven to be particularly useful in situations where projections for electricity usage have overestimated demand.[34]

The use of small-scale DER investments can help avoid or defer major capital outlays, facilitate gradual growth, and more closely match the electricity system to demand.[35] However, it is important to ensure on a case-by-case basis that DERs are, in fact, the most cost-effective option.[36] Under the correct conditions, the use of DERs in this way may help avoid stranded assets and costs in the electricity system.

[29] IESO, n.d.; Sommerville, 2019
[30] Chew et al., 2018, p. 12
[31] Chew et al., 2018, p. 12
[32] AESO, 2020
[33] Chew et al., 2018
[34] Chew et al., 2018
[35] Chew et al., 2018, p. 12
[36] ICF, 2021, p. 43

Some organizations have even proposed DERs like small-scale nuclear reactors (a.k.a. Very Small Modular Reactors) to power remote mining operations quickly and at reduced costs.[37] Unlike the individualized benefits of the FIT and microFIT programs, data from Vaughan, ON indicates that almost half of municipal energy spending goes to Ontario businesses, and nearly one-fifth of energy spending support enterprises (mostly utilities) in Vaughan itself.[38]

Localized energy production, generation, and storage may be able to generate more economic activity by reducing residential, commercial, and institutional energy costs. In turn, this creates jobs and keeps energy dollars in local economies.[39]

5.2 Speed of Development

DERs can offer a way to meet energy needs that avoid the long lead times of traditional energy infrastructure. Electricity usage in Ontario (and in virtually all other jurisdictions) has periods of high and low demand that change by the hour, the day, and the season. For the system to function correctly, there must be enough generating capacity to meet the periods of highest demand.

However, for much of the year this capacity goes unused. Small scale DERs may be able to "flatten demand by reducing peaks and filling in the valleys"[40] by shifting times of use, controlling loads, and storing excess electricity. This can help the entire electricity system avoid the need to engage in the expensive, long timelines involved in generating station construction.[41] DERs can also be quickly deployed to meet unpredicted power needs.[42] In some cases, municipalities may be able to leverage existing assets like legacy water control dams and waste treatment facilities to create small-scale renewable electricity and biogas (RNG) DERs.

5.3 Community Energy

Advances in DER technologies mean that it is becoming increasingly economical for individual users to supply, store, or reduce their electricity usage.[43] This may allow electricity users to become less reliant on the power grid[44] and give these users more control over how their energy is generated and used.

DERs may also provide remote communities options to implement their own power systems,[45] rather than waiting on the expansion of grid infrastructure. Ownership and control over energy infrastructure is a key element of "energy democracy" or "community energy" frameworks that advocate for local democratic control over energy resources.[46] The current rigid and hierarchical grid system makes achieving true community energy a significant challenge. In the community

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[37] Conference Board of Canada, 2020; Small modular reactors still, of course, create hazardous nuclear waste which must be safely stored for thousands of years. The potential reduction in GHGs this technology offers must be assessed against the perpetual risk and obligation that nuclear waste creates.
[38] City of Vaughan, 2016, p. 21
[39] Laszlo et al., 2016
[40] Cameron, 2019, p. 50
[41] Cameron, 2019, p. 50
[42] Capehart, 2016
[43] Alibhai, 2016
[44] Alibhai, 2016
[45] Capehart, 2016
[46] Hoicka et al., 2021

energy framework, "community ownership is associated with beneficial local impacts," and community-owned DERs may help realize these benefits.[47] Implementing these types of projects on a piloting basis is one way to responsibly deploy DERs in a measured way.

5.4 Local Solutions

As shown in Figure 1, in the current electricity system power must flow through a number of entities and pieces of infrastructure on its journey from generator to user. In Ontario, many of the large baseload generators are located at a significant distance away from end users. As electricity is transmitted, some generated power is lost. In contrast, DERs are often located close to end users, which can reduce this inefficiency in the electricity system.[48]

DERs located near end users can also help mitigate issues of congestion in transmission and distribution infrastructure.[49] DERs can further provide local backup power and defer transmission investments.[50] While LDCs face some risks from changes to the electricity system, these changes also represent an opportunity for LDCs to create new revenue streams, provide customers and shareholders with choice and value, and align local energy practices with the desires of the local community.

5.5 Action for the Climate

DERs can be important supporting infrastructure for municipalities' climate change and resilience goals. Energy storage DERs can support the reliability of the electricity grid by collecting excess power from intermittent renewable sources like wind and solar and releasing it back during periods of low generation. If non-emitting DERs are used to displace natural gas generation, other benefits may be realized through the reduction of harmful non-GHG pollutants like nitrogen oxide and mercury, which threaten the environment and are dangerous to human health.[51]

In the event of a major outage, energy storage DERs can also be utilized for restarting the grid.[52] DERs can further support the reliability of the grid in extreme weather events by providing redundancy in the system and by reducing community demand on the centralized grid. DERs like CHP plants and biogas generators may help reduce the carbon footprint of some existing natural gas resources,[53] however the ability of biogas or RNG to displace significant amounts of conventional natural gas is not clear.[54]

6.0 Barriers to DER Implementation

Despite the current degree of DER penetration in Ontario's energy system, there are still some barriers to the more widespread deployment of DER technologies.

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[47] Hoicka et al., 2021, p. 22
[48] ASEO, 2020
[49] Ahmed et al., 2016
[50] IESO, n.d., p. 8
[51] Bramley, 2011
[52] Ahmed et al., 2016
[53] Canadian Biogas Association, 2019
[54] Roberts, 2020

6.1 Infrastructure

Actors in the energy system have invested in infrastructure, and the widespread adoption of DERs has the potential to strand some existing energy assets before the end of their service lives.[55] To keep up with the evolving sector, many LDCs would be required to make costly infrastructure upgrades and adjust planning processes to accommodate DERs on distribution networks. That is why the province should provide proper tools and expertise to LDCs to allow better integration of DERs in the local system.

Some literature indicates that DERs could challenge the existing business model of LDCs. If existing LDC customers can utilize DER to address their electricity needs, this could lead to a reduction in LDC revenues and customer base.[56] In this situation, LDC costs remain largely the same, but must be spread across fewer customers. This pattern of distribution will lead to higher costs per customer, thus making it more economical for more LDC customers to disconnect from the grid.

The entire self-perpetuating cycle is a process better known as the "utility death spiral."[57] Customers unable to become self-sufficient through DERs would be left to foot the bill.[58] Currently, electricity industry stakeholders in Ontario appear not to be concerned about this phenomenon.[59] However, given that many municipalities are joint or sole shareholders in LDCs, the potential impact of DERs on distributors cannot be ignored.

6.2 Reliability

While there are currently some DERs operating in the Ontario electricity grid, falling costs and technological advances may facilitate a rapid and widespread mass adoption of these resources. This can present problems for the electricity grid, which was designed with a highly centralized and hierarchical organization. There may be challenges for the IESO and LDCs in regard to the "visibility" of DERs in their networks,[60] and appropriate measure will need to be taken to ensure that a high degree of DER penetration does not impact the reliability of the grid.[61]

The operational differences between small DERs and large resources may also impact reliability, as small resources may not remain connected to the system in the event of voltage or frequency variations.[62] The further integration of DERs can create challenges for these organizations in coordinating resources on the grid and may also make long-term reliability planning more difficult.[63]

6.3 Regulatory Barriers

In provinces with competitive electricity markets like Ontario, there will be challenges in integrating DERs into a system designed prior to their widespread adoption. When Ontario's electricity markets

[55] Cameron, 2019
[56] Alibhai, 2016
[57] Alibhai, 2016
[58] Cameron, 2019, p. 19
[59] Young, 2021
[60] ICF, 2021, p. 28
[61] IESO, n.d., p. 16
[62] IESO, 2019, p. 25
[63] IESO, n.d., p. 7

were deregulated, energy resources like storage were not yet feasible enough to be factored into regulations and processes.[64]

This creates a challenge for such resources under the current regulatory framework. As one researcher found, "our legislative regulatory frameworks are not flexible enough and don't easily adapt to change."[65] In other jurisdictions, coordinating market signals, operating the electricity system, and ensuring that system operators are able to accurately forecast and model for DERs in transmission and distribution planning have been identified as key challenges.[66]

DER penetration in Ontario's energy system is not uniform, and impacts will be most acutely felt in "high penetration… pockets."[67] This could present a challenge to regulators, as a consultants' report to the OEB argues "a blanket approach [to OEB action] across the province is likely not appropriate."[68] Furthermore, some researchers have argued that there is not yet a clear understanding of the cost to the broader electricity system that DERs like self-generation present.[69] DERs also may present a security risk to the electricity system by connecting more actors.[70]

7.0 DER Applications in Ontario

DERs of various kinds have already begun to penetrate Ontario's energy systems. A number of agricultural, industrial, landfill, and wastewater treatment operations in the province have installed anaerobic digestion facilities to capture and utilize biogas (methane) for heat and electricity production.[71] According to the IESO, "tens of thousands" of DERs are already connected to distribution systems in the province.[72] These DERs account for approximately 10% of Ontario's capacity.[73] The adoption of DERs in Ontario "has been largely driven by policy," notably through the Feed-In Tariff (FIT) and micro-FIT programs.[74] Other policies and initiatives like conservation programs and net metering have also contributed to this adoption.[75]

The DERs installed through these programs were overwhelmingly for wind and solar generation.[76] The pace of widespread DER adoption will be influenced by factors like infrastructure costs, potential revenue, and government and regulatory body policy, among others.[77] In a 2016 industry conference, solar photovoltaic, energy storage, and CHP were identified as the most promising DER technologies in the Ontario context.[78]

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[64] IESO, 2018
[65] Cameron, 2019, p. 30
[66] AESO, 2020, p. 6
[67] ICF, 2021, p. 5
[68] ICF, 2021, pp. 5-6
[69] Cameron, 2019, p. 15
[70] Cameron, 2019, p. 18
[71] Canadian Biogas Association, 2019, p. 4
[72] IESO, n.d., p. 1
[73] IESO, n.d.
[74] IESO, n.d., p. 6
[75] IESO, n.d., p. 6
[76] London Economics International LLC, 2020
[77] ICF, 2021
[78] Alibhai, 2016, p. 68

Battery technology was further identified as the most "influential driver of change" in the electricity system, closely followed by distributed generation technologies.[79] In recent surveys of residences and businesses, nearly 70% of respondents in both categories identified cost savings as a major reason for installing or considering installing DERs.[80]

As discussed above, DERs have already achieved a significant foothold in Ontario's energy system.[81] To demonstrate the applicability of these technologies at different scales, below are three examples examining the deployment of DERs at the level of the region, the community, and the single institution.

7.1 Region: York Region Non-Wires Alternatives Demonstration Project

DERs are currently being deployed in York Region in an IESO demonstration project. The York Region Non-Wires Alternatives project aims to explore the ways in which DERs can function as alternatives to conventional electricity infrastructure in a real-world scenario. This project, funded by Natural Resources Canada and the IESO's Grid Innovation Fund, encompasses a large part of southern York Region that includes the lower-tier municipalities of Richmond Hill, Vaughan, and Markham.

In the next decade, electricity demand in this area is projected to surpass the system's current capacity, which makes it a useful test region for emerging DER technologies.[82] The demonstration project is operated by Alectra, the regional LDC that is acting as a Total Independent System Operator.[83] In this role, Alectra is not a participant in the DER pilot, and all pilot DERs connect to the distribution system.[84] DERs in the York Region pilot may be aggregated or individually-connected, and must be either storage, natural gas-fired generation, or demand-response resources of between 100kW and 3000kW in capacity.[85]

The IESO will coordinate capacity auctions for interested DER operators. Through this mechanism, DER operators can submit bids to supply capacity through either generation, storage, or demand-response. The pilot aims to demonstrate that the capacity auction and DER integration processes can be quick, efficient, and affordable options for increasing system capacity, can help defer or avoid major traditional infrastructure investments, and can create economic opportunity for local stakeholders.[86]

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[79] Alibhai, 2016, p. 69
[80] London Economics International LLC, 2020, p. 10
[81] While the following sections focus on three specific projects underway in Ontario, there are number of other compelling examples for interested readers. In Halifax, Nova Scotia, turbines have been added to municipal water pipes to generate electricity. A similar in-pipe hydropower project has also been implemented in Portland, Oregon. Hamilton, Ontario has been capturing renewable natural gas from its wastewater treatment plant for over 15 years, and now uses the RNG to generate electricity, to displace conventional natural gas on the grid, and as vehicle fuel. Furthermore, the Ontario Waterpower Association estimates that there are over 2000 non-hydroelectric dams in Ontario, and that these facilities could be retrofitted to also supply power to communities across the province. In Toronto Ontario's LDC Toronto Hydro partnered with a local firm to install an underwater compressed-air storage project in Lake Ontario, and in Goderich, Ontario, a defunct salt mine is being used to provide grid-scale energy storage, also using compressed air.
[82] Alectra, 2021
[83] IESO, 2020
[84] IESO, 2020, p. 7
[85] IESO, 2020
[86] Alectra, 2021

Through the demonstration project, the IESO also aims to gain insights into the applicability of local energy solutions, barriers to DER participation, and the reliability and economics of distribution-connected DERs in order to inform future regulation and policy.[87]

7.2 Community: Kiashke Zaaging Anishinaabek (Gull Bay First Nation)

DER installations have been deployed in Ontario to reduce remote communities' reliance on fossil fuels. Kiashke Zaaging Anishinaabek (KZA) (also known as Gull Bay First Nation) in Northern Ontario, the community, in partnership with Ontario Power Generation, ABB Inc., Hydro One Remote Communities Inc., and the MaRS Advanced Energy Centre, has installed a renewable energy microgrid.[88]

The project includes a microgrid that coordinates solar power generators, diesel generators, and battery storage resources.[89] The microgrid project added over 1000 solar photovoltaic panels to the community's power system, and 81 battery units.[90] KZA is not connected to the broader Ontario power grid, so before the installation of the microgrid the community was reliant on diesel generators for all of its power needs.

The renewable energy DERs installed in the community will reduce diesel consumption by approximately 30% (130,000 litres) annually.[91] According to Ontario Power Generation, this will reduce the community's carbon emissions by over 400 tonnes each year.[92] The project also provides revenue to KZA and created jobs in site preparation and facility maintenance.[93]

7.3 Institution: John Paul II Catholic Secondary School

DERs are also being deployed at small scales as energy solutions for individual public institutions. John Paul II Catholic School in London, Ontario is the site of a retrofit to eliminate GHG emissions from the facility. The project is being carried out by Ameresco Canada Inc. in partnership with the London District Catholic School Board, Natural Resources Canada, and the IESO. The school is 12,555 square metres in area, and prior to the retrofit relied on a combination of heat-pump and natural gas boilers for temperature control.[94]

According to the project proponent, the school is the first in the country to be retrofitted to be carbon neutral.[95] The project features a geothermal system, a large solar panel array, EV charging stations (including one for busses), and a battery storage system all connected as a microgrid.[96] The microgrid will be able to operate in islanding and transmission-connected manners.[97] The retrofit will eliminate approximately 277 tonnes of GHG emissions annually.[98] The DER installation will be

[87] IESO, 2020
[88] Natural Resources Canada, 2021
[89] Natural Resources Canada, 2021
[90] Ontario Power Generation, 2019
[91] Ontario Power Generation, 2019
[92] Ontario Power Generation, 2019
[93] Kiashke Zaaging Anishinaabek, n.d.
[94] Natural Resources Canada, 2019b
[95] Ameresco, 2021
[96] Ameresco, 2021
[97] Natural Resources Canada, 2019b
[98] Ameresco, 2021

paired with a specialized school curriculum designed to teach students about energy.[99] The project aims to provide insights into microgrid applications, and demonstrate the potential of demand management and DER technologies.[100]

8.0 Recommendations

8.1 Municipal Governments

- Explore the role of DERs in supporting municipal climate change and climate resilience goals
- Consider the potential impacts and opportunities of DERs on Municipal Energy Plans and Climate Change Action Plans, and where feasible, collaborate with LDCs when developing these plans
- Participate in relevant consultations at the Independent Electricity System Operator and the Ontario Energy Board related to DERs and other alternative energy sources, including but not limited to the DER roadmap and the Framework for Energy Innovation
- Work and collaborate with LDCs to engage with and leverage DER technology to realize potential new revenue streams, provide consumers more choice, and keep LDCs whole.

8.2 Regulators

- Conduct meaningful engagement with municipal governments in DER consultation and implementation programs
- Ensure through rate structures that LDCs and other local utilities are not subject to the “utility death spiral” by the widespread adoption of DERs
- Improve consultation, communication, and collaboration with municipalities and LDCs
- Make clear, detailed, and plain-language information about the energy system, energy initiatives, and energy planning processes readily available to municipalities, municipal residents, and other municipal stakeholders
- Collaborate with municipalities as full partners in energy planning processes
- Work in partnership with the Association of Municipalities of Ontario to address energy issues of relevance to Ontario’s municipalities

8.3 Provincial Government

- Encourage research and investment into renewable DERs with a particular focus on energy storage
- Consider how DER technology can increase the share of renewable and non-emitting energy in Ontario’s energy mix
- Facilitate the active and meaningful participation of municipalities in energy planning initiatives

[99] Natural Resources Canada, 2019a
[100] Natural Resources Canada, 2019b

- Consider the role of DERs and municipal energy needs while creating the next Long Term Energy Plan
- Provide municipalities dedicated funding to support energy planning, DER integration, and required capital costs related to the adoption of renewable energy initiatives

8.4 Federal Government

- Consider how renewable DERs could facilitate the transition of remote communities and First Nations away from diesel generators and other nonrenewable energy
- Provide municipalities dedicated funding to support energy planning, DER integration, and required capital costs related to the adoption of renewable energy initiatives

9.0 Conclusions

Advances in technology, falling costs, and government policy have encouraged the adoption of DER over the past decade, and increasing attention to climate change and climate resilience are pushing further DER integration. As the closest level of government to most Ontarians, municipalities are well-positioned to take advantage of these changes.

Navigating the shifting landscape will undoubtedly present unique challenges to municipalities of all sizes and locations, which is why it is important for municipalities to consider their energy needs and aspirations now. The widespread adoption of DERs offers potential opportunities for municipalities to make meaningful progress on their climate, social, and economic policy goals. Working with the support and cooperation of other levels of government, regulatory bodies, and industry stakeholders, municipalities are positioned to be an important site of change in Ontario's emerging energy future.

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