ieso
Independent Electricity System Operator

IESO-N-0061233

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1. Introduction

The electricity sector is in a state of transition. Some even anticipate an evolution at the scale of deregulation in the 1990s, but now focused on the distribution level of the grid. As discussed in the 2015 edition of the Reading of the World, this change is being instigated by the rapid and steady cost decline trend for solar photovoltaics (PV). Customer-sited rooftop solar PV is already at retail grid parity in jurisdictions with high solar irradiance and high electricity prices. Projecting continued decline in PV prices, rooftop solar is expected to achieve retail grid parity in many more jurisdictions in the coming years. The adoption of solar and other distributed energy resources (DER), such as batteries, poses both economic and technical challenges for the sector broadly and for distributors particularly.

While the aim of this report is to update the IESO Board of Directors on current discourse in the industry in general, the above notion of fundamental change is an overarching theme. Change is afoot across every macro-environmental factor:

- **P**olitical - Globally, regionally, nationally and provincially, climate change policy became more definitive in the past year. Additionally, in the aftermath of Hurricane Sandy, the state of New York has gained a strong political mandate to institute change in their electricity sector, potentially leading the way.
- **E**conomic - The cost of DER continues to decline and its adoption is threatening the distribution utilities' volumetric business model. The industry is exploring how to refine how DER and the distribution grid are valued and compensated. Additionally, investor sentiment is shifting towards a cleaner, smarter grid.
- **S**ocial - Increasingly, customers have options for how to meet their energy needs. Digitally-enabled customers expect more information and control. Even customers' service expectations have risen, with resiliency becoming a focus in recent years.
- **T**echnological - A variety of DER technologies are emerging, including demand response aggregation, distributed batteries and microgrids. Hardware and software technology is being developed to allow visibility and control of the distribution grid in order to enable DER and better extract their value.

1.1 Scope and Methodology

As an element of an environmental scan, this report's focus is external to the IESO and Ontario. However, for each topic explored, the report will briefly tie the issue "back to home". In some areas this is in more depth and in others less so, as deemed appropriate. Given the intent to summarize recent industry events and debates, sources used include conferences, reports, articles, podcasts and blogposts. By its nature, industry discourse is generally forward-looking and focused on the extra-ordinary. As such, this report is as well.

2. Greenhouse Policy, Regulations and Markets

2.1 COP21: Finally a ("Binding") Global Agreement

Since 1992, parties to the U.N. Framework Convention on Climate Change (UNFCCC) have been meeting with the aim to create an international framework to stabilize the concentration of greenhouse gases in the atmosphere. While discussions have progressed over the years, the Paris Agreement, reached by the 196 parties attending the 21st Conference of the Parties (COP21) in December 2015, is considered to be a "turning point" in the global effort to address climate change. The agreement establishes a goal of limiting the global average temperature to "well below" 2°C above pre-industrial levels, while urging countries to make efforts to keep warming below 1.5°C.

Flexibility was a key aspect of the Paris Agreement. As part of the "binding" agreement, countries individually establish Nationally Determined Contributions (NDCs) towards the global emissions reduction goal. Parties are required to pursue domestic measures towards achieving the NDCs and will report back on realized contributions, which are subject to third party verification. NDCs are to be resubmitted every five years, allowing for course-corrections. This flexibility to self-determine contributions is considered to have made it possible for countries to commit to the Paris Agreement. Past agreements were unsuccessful partly because they lacked this. For instance, the United States (US) was unable to accept the 1997 Kyoto Protocol given that establishing binding emissions targets would have required congressional approval, which was not received [1].

Despite generally being considered a success, the Paris Agreement has been criticized for being "no actions, just promises" and for not having "teeth". While some aspects of the agreement are binding, some are not. Parties to the agreement must submit NDCs, report back on progress, and submit to review. However, what NDCs are set at is voluntary and even if the voluntary goals are not achieved, there are no penalties. The thinking is that countries will be kept on track by public pressure given that they would want to avoid being "named and shamed" [85].

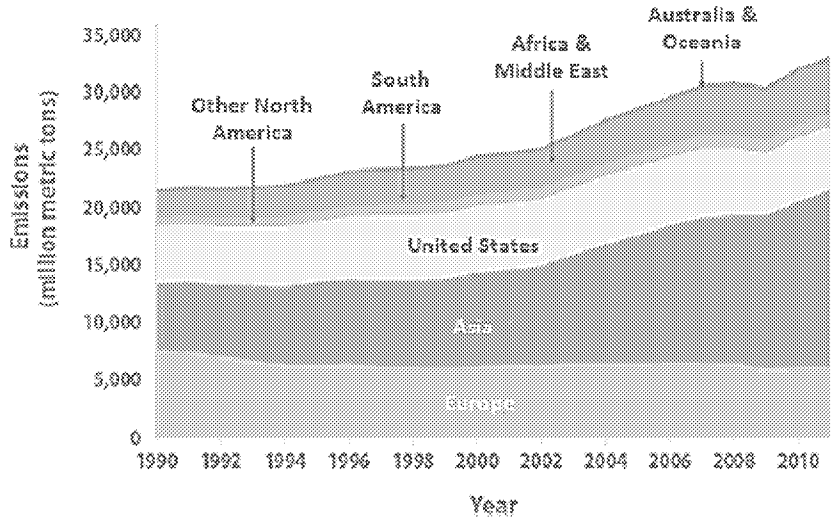


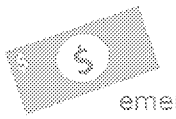
Figure 1: Historical emissions broken down by continent [2]

In addition to the Paris Agreement, COP21 spurred the creation of various new joint initiatives.

Mission Innovation, announced by Bill Gates, is an initiative to accelerate global clean energy innovation. At the COP21 launch, 20 countries committed to double their clean energy R&D investment over the next 5 years. The countries represent 80% of current R&D spending and include Canada [56].

The Breakthrough Energy Coalition – a related initiative – was also announced. The coalition is a group of 25 global high net worth individuals who have committed to finance startups emerging from Mission Innovation's efforts. The list includes Jeff Bezos, Richard Branson Jack Ma, Mark Zuckerberg and of course Bill Gates.

The Paris Agreement also further addressed the divide between the OECD and developing countries. At COP15 in Copenhagen, parties pledged to mobilize US$100 billion per year until 2020 to support the adoption of clean energy in developing countries. Some of this support has actually materialized, but not all of it. In 2014, the developed countries only provided an estimated US$62 billion [3]. Regardless, the Paris Agreement extended the pledge of $100 billion per year to 2025 [1].



to support emerging countries:

$2.7B CAD from **Canada** over the next **5 years**

from **UK** at least **£5.8B** between **2016** and **2021**

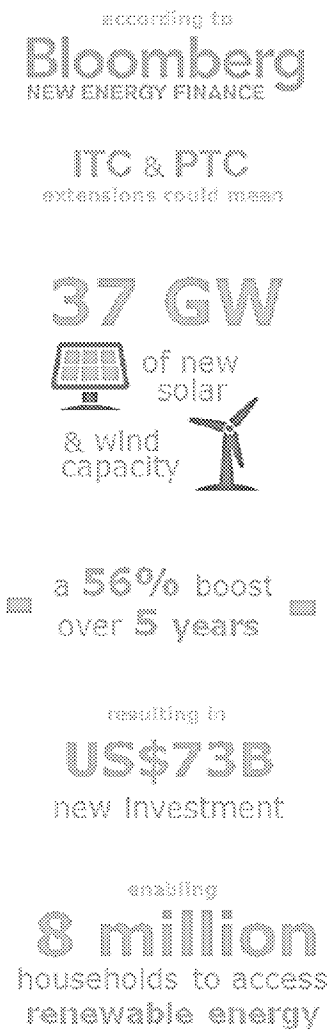
$800M USD **per year** from **U.S.** until 2020 [4]

Although parties adopted the Paris Agreement in December, it is not expected to come into effect until 2020 or later. The groundwork needed to make the agreement a reality will take years. The agreement, which will be open to signatures until April 2017, must be ratified by at least 55 of the 196 parties representing at least 55% of global greenhouse emissions [1]. As part of the Paris Agreement, countries are required to obtain domestic approval.

2.2 ITC Extension & CPP: the US Carrot and Stick

In the US, two major federal clean energy policies moved forward in 2015. One was the Investment Tax Credit (ITC) for renewable energy projects, which is characterized by some as "the carrot". The other was the Clean Power Plan (CPP), which will regulate carbon emissions from fossil fuel power plants, and is characterized by some as "the stick".

The ITC, first introduced in 2006, allows up to 30% of the capital cost of residential or commercial solar and other renewable projects to be used to reduce federal income taxes dollar-for-dollar (i.e. it reduces taxes payable, not taxable income, effectively reducing the cost of solar PV by 30%) [5]. The ITC was scheduled to step down to 0% for homeowner-owned residential rooftop solar and to 10% for commercial rooftop solar on January 1, 2017 [6]. As would be expected, the US solar developers were apprehensive about this cliff in support, which was expected to significantly cool the market. To the industry's relief, in December 2015, an "omnibus spending bill" was passed by Congress and extended the ITC for solar projects at the current 30% rate to 2020, following which it will be stepped down over a couple of years to 10% in 2022 and beyond [6]. The ITC is expected to be substantially phased out for other technologies by 2019. The spending bill also included an extension to the Production Tax Credit (PTC) to 2020, which is a $/MWh subsidy for wind, biomass, hydro, and other qualifying renewables. Interestingly, the bill was a bipartisan compromise. In return for the ITC and PTC extensions, a ban on the export of American crude oil, that has been in place since the 1970s Oil Embargo Crisis, was lifted [7]. The deal arranged is considered to be a testament to the maturation of the solar industry's advocacy and lobbyists' increasing sophistication.



[8]

The ITC extension is intended as a policy bridge until the Clean Power Plan (CPP) comes into effect in 2022. The CPP will set a national limit on carbon emissions from the power sector and calls for a 32% decrease in emission levels below a 2005 emission benchmark by 2030 [9]. The plan will set targets for emission reductions that are customized for each state. The states are in turn responsible for developing plans and meeting the targets. As discussed further in Section 3.1 of this report, the US is already shifting away from coal generation to natural gas and renewable generation. In fact, CO2 emissions have dropped by more than 15% since 2005 [10]. The CPP is intended to further accelerate this transition.

2015 was the Obama Administrations' biggest year for climate change. The CPP rules were finalized. The Keystone XL pipeline was rejected. A ban was instituted on oil drilling in the Arctic. And the COP21 Paris Agreement was reached. However, there is concern that if the Supreme Court overturns the CPP, it would significantly weaken the US's ability to meet carbon emission commitments and their ability to ratify the Paris Agreement, potentially unravelling all the progress made at COP21.

Addressing climate change is on the Obama administration's to-do-list before leaving office at the end of 2016. Initially attempting to go down the legislative path, President Obama was unable to have Congress pass the 2009 Waxman-Markey bill, which would have created a federal cap-and-trade program. Working around Congress, the CPP is regulation put forward by the Environmental Protection Agency (EPA) under existing legislation, namely the 1963 Clean Air Act, which permits the EPA to develop regulations to address "air pollution, which may endanger public health or welfare" [11]. Not unexpectedly, the plan has received significant opposition with 29 states challenging the EPA's legal authority to carry it out. The issue is now in front of the Supreme Court, which in February 2016 decided to pause the implementation of the CPP until it makes a final ruling expected in 2017 [12].

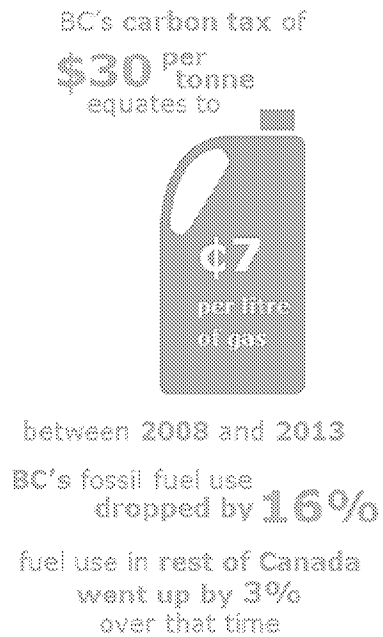
2.3 Provinces take the Lead on Climate Change

Prime Minister Trudeau has committed to reduce Canada's carbon emissions by 30 percent from 2005 levels by 2030 [13]. And similar to the US's federal efforts, the Canadian attempt to address climate change at a national level is not receiving full support. In March 2016, the Prime Minister met with the provincial premiers to work out a plan to meet the commitments made at COP21. The federal government's proposal involved a national carbon tax that would begin at $15 per tonne and would rise over time to $40 per tonne [14]. The summit concluded with provinces agreeing to institute carbon pricing mechanisms, but the notion of a national carbon tax was dismissed by the provinces, despite Trudeau's efforts. Instead, carbon pricing mechanisms will be "adapted to each

province's and territory's specific circumstances". Federal, provincial and territorial government officials will be working together on a national plan which will be discussed at the next summit in October 2016 [15].

Following the meetings, Prime Minister Trudeau noted that the climate change file has had a lack of federal leadership in the past 10 years and that in that vacuum provinces have taken a leadership role. British Columbia, Alberta, Ontario and Quebec either have adopted or are adopting some form of carbon pricing, meaning that about 80 percent of the Canadian population is already subject to a carbon price. Trudeau assures that "the federal government will not undo what the provinces have done, we will add to it" [15].

In 2008, British Columbia instituted a carbon tax of $10 per tonne, which was increased to $30 per tonne in 2012. In March 2016, Premier Christy Clark said her government is considering raising the tax further. The tax is paid by fuel wholesalers, who are then able to pass the cost on to their customers. British Columbia's carbon tax is "revenue neutral" in that the proceeds collected from the carbon tax are matched by cuts in other taxes [16]. Alberta is taking steps towards broadening its hybrid "cap-and-tax" system first introduced in 2007. New regulations will require large emitters to reduce emissions by 20% below baseline levels, up from 12% previously. One of the methods for meeting the target is contributing to a provincial fund for emission-reducing initiatives. The price for this was $15 per tonne previously, was increased to $20 in 2016 and will be increased further to $30 in 2017 [17].



The Western Climate Initiative (WCI) is a collaboration of seven US states and British Columbia, Ontario, Quebec and Manitoba to identify, evaluate and implement measures to reduce greenhouse gas emissions. The WCI has developed tools and provides support for the implementation and, importantly, the harmonization of cap and trade programs across jurisdictions.

In 2013, Quebec implemented a cap and trade program that applies to industrials, fuel distributors and power plants. The program is designed to work within the WCI carbon market and Quebec has linked its system with California's. The most recent joint auction for carbon allowances was held in February and clearing at the reserve price (i.e. minimum price) of $17.64 per tonne [18]. Proceeds from Quebec's cap and trade system are put towards carbon reduction measures via Quebec's Green Fund.

2.4 Ontario Cap & Trade Regulation Released

In April 2015, the Ontario government announced that it will be implementing a cap and trade (C&T) program targeted to be in place by January 1, 2017. Ontario's goal is to reduce its carbon emissions by 37% below 1990 levels by 2030 [19]. The C&T program is expected to eventually link with Quebec and California under the WCI. The program will include emissions associated with electricity production, institutions, transportation, natural gas distribution, industrials and large commercial operators. On February 25, 2016 the draft C&T regulation was released, detailing the proposed point-of-regulation, auction mechanics, and allocation of free allowances in relation to the electricity sector, among other things.

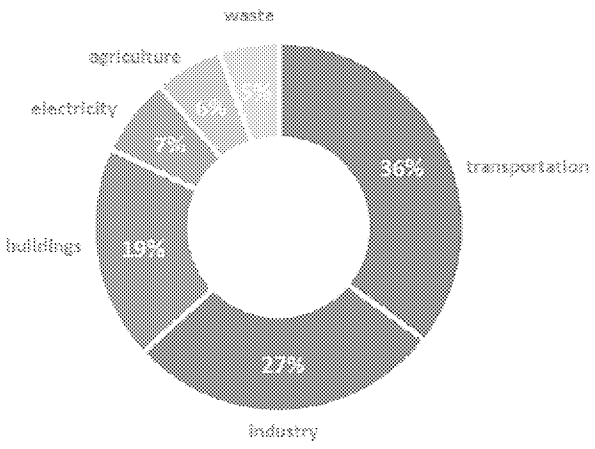


Figure 2: Greenhouse gas emissions in Ontario by sector (2013 data) [20]

Table 1: Expected cost impact as per the 2016 Ontario budget [21]

electricity	
commercial & industrial	$0/month
residential	- $2/month
transportation	
gasoline prices	+ ¢4.3/liter
home heating	
natural gas prices	+ ¢3.3/m³
natural gas cost	+ $5/month

Based on the draft C&T regulation, the program is expected to apply to both domestic carbon-emitting electricity generation and imported electricity. For domestic generation, the point of regulation for most facilities is proposed to be upstream at the fuel distributor level, i.e., with the natural gas distribution companies. For imports, the point-of-regulation is proposed to be where the electricity enters the province on our interconnection lines with neighbouring jurisdictions and the associated emissions are proposed to be estimated based on the marginal power plant emissions in the exporting point-of-origin jurisdiction.

For domestic natural gas-fired generators, the cost of carbon allowances is expected to be passed down from the natural gas distribution companies, who have the direct compliance obligation and are subject to regulatory oversight by the Ontario Energy Board (OEB). It is expected that generators would subsequently reflect this added cost in their offers into the

IESO's wholesale electricity market, resulting in a higher Hourly Ontario Energy Price (HOEP) when natural gas generation is on the margin. The increase in the HOEP will drive a partially offsetting decrease in the Global Adjustment (GA). The resulting impact on ratepayer's bills will vary depending on their allocation of GA and whether proceeds from carbon allowance auctions are recycled back into the electricity sector. The government has committed that ratepayers will not see an increase in the cost of electricity. However, details regarding how this will be achieved have yet to be announced.

3. Energy Resources and Supply Mix

3.1 Shift from Coal to Gas: Have We Reached Peak Coal?

Contrary to common wisdom that China and India will continue to drive global demand for coal, the International Energy Agency (IEA) stated in its 2015 Medium Term Coal Market Report that coal consumption has stalled [22]. A global decrease of 0.9% in 2014 marked the first decline in demand following a decade of aggressive growth. This reversal is primarily driven by China. Given slower economic growth, a shift to less energy intensive industries and efforts to fight air pollution, China may have passed peak coal in 2013 according to the IEA. The only major economy that continues to see strong growth in coal demand is India.

"Peak coal is coming sooner than expected"

Goldman Sachs
September 2015
Research Note [80]

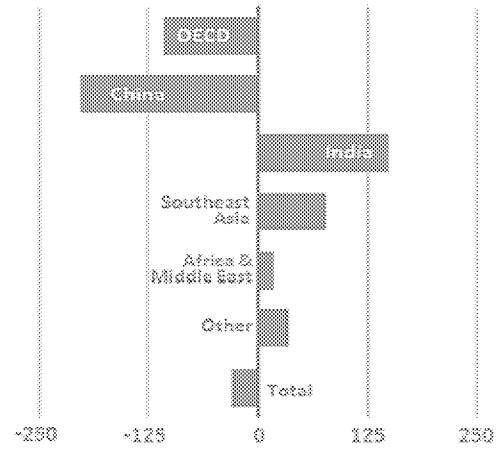


Figure 3: Change in demand 2014-2020 (million tonne) under IEA's "China Peak Coal" scenario [23]

[24]

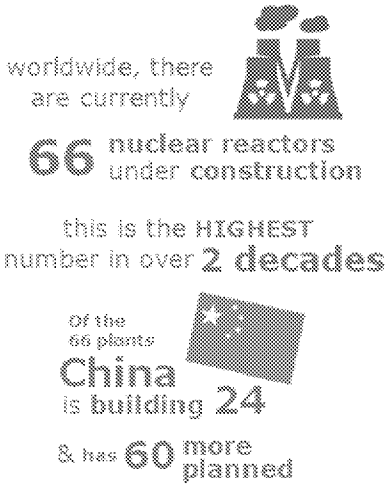
In April 2015, the US Energy Information Administration (EIA) reported that electricity generation from natural gas surpassed generation from coal in the US for the first time ever [25]. In light of low coal demand, low natural gas prices and newly proposed regulations, such as the CPP, American coal production companies are collapsing en masse. Across North America, approximately 47 GW of coal-fired generating units have been retired since 2009, and an additional 27 GW are scheduled to close by 2025. Moreover, remaining coal plants may increasingly shift from baseload to peaking operations, further reducing generation output and emissions. In contrast, 58 GW of new natural-gas fired generation has come online since 2009 and an additional 97 GW is expected by 2025 [26].

This significant transformation of the North American generation fleet has implications on system planning and operation. In the 2015 Long-Term Reliability Assessment report, NERC notes that despite substantial progress made to date in addressing the interdependencies between the natural gas and electricity markets, a growing reliance on natural gas continues to raise reliability concerns and enhanced planning approaches to fuel deliverability, availability and responses to pipeline contingencies are needed [26].

Ontario is ahead of the curve when it comes to replacing coal with cleaner burning natural gas fired generation. Ontario retired its entire 6,400 MW coal fleet and installed approximately 5,000 MW of natural gas-fired generation (among other resources). In April 2015, the IESO launched a stakeholder engagement initiative, seeking input on proposed enhancements to the communication and coordination efforts with natural gas generators in Ontario and natural gas pipeline companies. In January 2016, having considered stakeholder feedback and concerns, the IESO concluded that, at this point in time, the current Market Rules place sufficient obligations on Market Participants to communicate any fuel supply limitations and enable the IESO to conduct reliable planning and operations.

3.2 Nuclear's Mixed Success despite Being Zero-Emission

In August 2015, following approval from the Nuclear Regulation Authority, Kyushu Electric Power Co restarted the 890 MW Sendai-1 reactor on Kyushu, the third largest island of Japan [27]. In an effort to reduce greenhouse gas emissions and reliance on imported liquid natural gas (LNG) and coal, Japan has started bringing its nuclear units back online. Two additional units have been restarted since.



In the aftermath of the Fukushima Daiichi accident, Japan idled its 54 nuclear units and began safety reviews of the fleet. Germany, also in reaction to the accident, committed to phasing out nuclear energy by 2022. Even the French government, which is majority-owner of the world's largest nuclear company, Areva, is scaling back domestic nuclear generation [28]. In 2010, prior to the Fukushima accident, there were 431 nuclear reactors operating worldwide. Today there are 394 [29]. Contrary to the trend in the OECD, the International Energy Agency calculates that nuclear capacity needs to double by 2050 to limit global warming to 2° C in accordance with the goal of the COP21 agreement [30]. And there is some progress towards this, as China and other emerging economies are aggressively building new units.

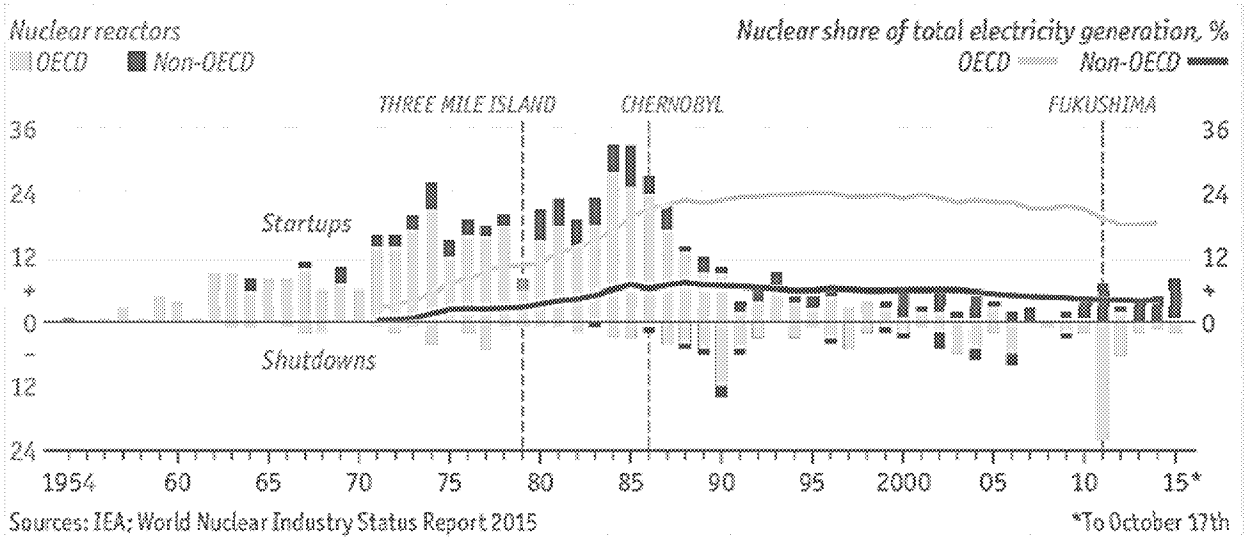


Figure 4: Nuclear reactor commissioning and retirement split by OECD and non-OECD countries [28]

In the US, the nuclear situation depends on whether an individual state has a regulated or unregulated electricity market. In October 2015, the Watts Bar 2 plant in Tennessee, which is expected to achieve commercial operation in spring 2016, became the first new nuclear reactor to be licensed in America in 20 years. Four additional units are under construction in South Carolina and Georgia [28].

> "Emissions increases due to nuclear retirements would sabotage the carbon reductions targeted by the Clean Power Plan"
>
> Third Way, a moderate think tank, noted in a much publicized report in September 2016 [30]

On the other hand, UBS Global research has identified 12 nuclear units, representing over 10 GW, in northeastern power markets as at risk of early closure due to low wholesale electricity prices driven down by low natural gas prices. In December 2014, Entergy shut down its 620 MW Vermont Yankee plant and in Q2 2015 the company announced plans to retire the 838 MW Fitzpatrick plant in New York and the 680 MW Pilgrim plant in Massachusetts by 2019. The company cited "reduced plant revenues", "poor market design" and "high operational costs" as key factors [31].

Interestingly, in Ohio, which is part of a deregulated market, FirstEnergy has proposed an out-of-market Power Purchase Agreement (PPA) for its 889 MW Davis-Besse nuclear plant to the state regulator. The PPA would provide additional revenues, allowing the company to keep the plant operational [32]. However, the proposed deal has been highly criticized and other independent power producers have asked FERC to intervene in the matter [33].

In Ontario, there have been recent major developments on the nuclear front. In December 2015, the IESO amended its existing PPA with Bruce Power to support the refurbishment of six units at Bruce Nuclear Generating Station (6,300 MW). In January 2016, the government announced that they plan to move ahead with the refurbishment of the 4 units at OPG's Darlington Generating Station (3,500 MW). The costs for the Darlington refurbishment will be subject to review and approval by the OEB. The Province also announced plans to continue operations at Pickering Generating Station until 2024.

3.3 Microgrids Progress from Pilots to Deployment

"After Sandy, thousands of New Yorkers ventured northward from Manhattan looking for places to charge computers and cell phones. Some walked more than 50 blocks to locate a working outlet or a coffee shop with functioning internet service. Throughout New York and New Jersey, mobile charging stations – some powered by solar – were set up to help get basic power services to 'digital refugees.' Expectations of constant connectivity have changed the public's perception of utilities. At a time when businesses can track virtually any product in real time, customers became increasingly frustrated after Sandy when power companies couldn't give them an accurate timeline for restoration. Many people reported seeing crews unfolding paper maps and scribbling notes manually. 'The situation seemed pretty ridiculous in modern America,' according to Scott Olsen, the deputy mayor of Byram Township, New Jersey."

Excerpt from "Resiliency: After Superstorm Sandy, Changed America's Grid" [33]

In July 2015, the New York Energy State R&D Authority (NYSERDA) announced 83 winners in the first stage of its $40M NY Prize competition, which is designed to "animate a microgrid market". Due to the overwhelming interest, NYSERDA gave over three times as many $100,000 awards to study the feasibility of community microgrids as originally anticipated. The winners of the next phase will receive up to $1M for engineering design. In the final stage, projects will receive up to $5M toward constructions of their projects. As an example, Southampton has proposed microgrids at the town hall, three fire stations and the police station [34].

The NY Prize and other state resiliency programs are in large part motivated by the events of October 2012, when Super Storm Sandy left eight million people without power. The storm hit New Jersey and New York particularly hard and some areas were left in the dark for two weeks. However, in the heart of New York City, powered by 13.4MW of natural gas-fired combined heat and power (CHP), NYU's Washington Square campus was lit [35]. Following Super Storm Sandy, resiliency emerged as a key issue in the sector. Yet, despite the buzz around resiliency

and grid hardening, adoption of microgrids has been slow.

One of the major barriers to deployment of microgrids is a lack of regulatory frameworks that quantify the value of resiliency and that establish how it should be prioritized. Regardless, some utilities are proposing to own and operate "public purpose" microgrids. For instance, in Illinois, Commonwealth Edison (ComEd) has proposed legislation that would permit it to develop and operate six microgrids, including a 17MW system at Chicago Rockford International Airport [36]. Other states are supporting the development of non-utility microgrids through other mechanisms, such as the NY Prize.

Another barrier is the lack of standardization of microgrid systems. Currently projects are custom-engineered, resulting in long lead times and high costs. There are many initiatives on the way to address this issue. For instance, Duke Energy along with two dozen partners has developed a system that integrates off-the-shelf components and can be deployed in less than a month [37]. In addition, major grid OEMs such as Siemens, General Electric and Schneider Electric have launched product offerings, providing integrated systems.

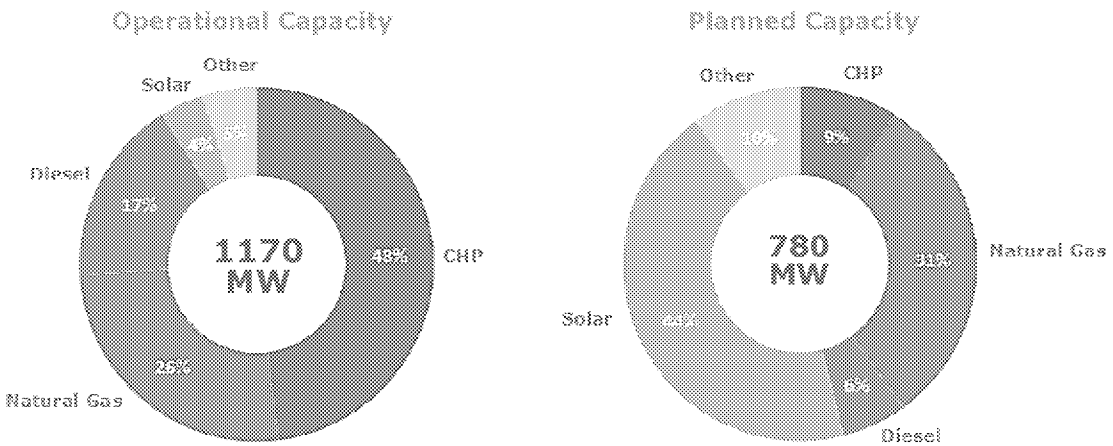


Figure 5: Total operational and planned US microgrid generation capacity by generation type [38]

Moreover, it is expected that microgrid deployments in coming years will be smaller in scale and increasingly make use of solar energy and batteries. This is unlike the installations today, which are typically large systems at university campuses or military compounds that make use of natural gas-fired CHP. With support from state resiliency programs and as microgrid sub-component integration issues are addressed, microgrid capacity is poised to double in North America and the microgrid market is expected to reach $3.5B by 2020 [39].

In Ontario, the IESO concluded the Combined Heat and Power Standard Offer Program (CHPSOP) 2.0 in June 2015, awarding 91MW of CHP to district energy projects and greenhouse operations. While the contract requires facilities to connect directly to the grid, islanding is permitted (i.e. contract holders have the option of using the CHPSOP contract as part of a microgrid). Additionally, the IESO continues to support behind-the-meter CHP through the saveONenergy and the Industrial Accelerator Program.

3.4 New Demand Response Aggregator Models

The Europeans are just starting to create structures to facilitate the participation of demand-side resources in markets. Capacity mechanisms are being implemented in France and being considered in Germany, where there is concern over security of supply given the plan to phase-out nuclear by 2022. The United Kingdom held its first capacity auction in December 2015 for delivery in 2019/2020 [40]. Commitment periods provided as part of the UK auction were (a) one year for existing facilities and demand response, (b) three years for existing facilities that require refurbishment and (c) 15 years for new build facilities. However, only 1% of the capacity cleared in the auction was demand response [41]. Given the differing commitment periods, the auction has been criticized for not allowing demand response to compete fairly.

In 2011, FERC issued Order 745, requiring wholesale electricity markets to compensate demand response resources on par with generation resources. However, the D.C. Circuit Court of Appeals invalidated the order, arguing that FERC had overstepped its authority beyond the wholesale market by requiring compensation for retail customers that participate as an aggregated resource. The issue was elevated to the Supreme Court, which ruled in favour of FERC, highlighting the convergence of retail and wholesale markets.

In American markets, demand response has achieved significant penetration and is expected to grow further. In PJM, where demand response has been incorporated in capacity, energy and ancillary services markets, 6% of the system's peak load can be met using demand response resources [42]. Additionally, after over a year of uncertainty about the participation of demand response resources in US wholesale electricity markets, in January 2016, the Supreme Court decided to uphold FERC Order 745, putting the demand response market back on a path of strong growth in 2016.

Not having a capacity market, California has been meeting its resource adequacy needs through bilateral contracts. In December 2014, the state initiated the Demand Response

Auction Mechanism (DRAM) – a first-of-its-kind pilot to secure a small portion of its capacity requirements through Distributed Energy Resources (DER). The process was structured as an annual pay-as-bid auction open to a diverse set of resources. Participants are required to have at least 100 kW of aggregated demand reduction available for up to four hours per day and are required to bid into the California ISO's (CAISO) energy market [43]. In January, the Californian utilities announced over 40 MW of winning bids for the 2015 auction. The list of winners is an array of cloud software-based aggregators of DER, including 0.9 MW of behind-the-meter batteries, 11 MW of home energy management systems (HEMS) and 1.2 MW electric vehicle charging systems. However, the bulk of the 40MW of capacity procured came from the more traditional aggregation of industrial, commercial and institutional (IC&I) demand response [44].

In Ontario, the IESO's first annual Demand Response Auction was held in December 2015. The auction cleared about 400MW of capacity, which will start bidding into the IESO energy market in May 2016. In addition, in August 2015, the IESO concluded the Demand Response Pilot Request for Proposal (RFP) and selected 80MW of demand response resources. The pilot is aimed at better understanding the capability of demand response to provide five-minute load following, hourly load following and day-ahead or four hour-ahead load reduction.

Winners of the California Independent System Operators (CAISO) 40 MW Demand Response Auction Mechanism (DRAM)

Startup that provides inexpensive electric plug-in vehicle charging stations, which it provided for free to retail customers who signed up to be aggregated for the DRAM.

One of the startups that provide apps for disaggregation and analysis of in-home loads. Chai Energy is aggregating behavioural demand response.

Aggregator of Commercial and Industrial load, primarily reducing load through variable frequency drive (VFD) motors and pumps.

Publicly-traded and leader in the demand response market, EnerNOC aggregates IC&I load, which reduce consumption or turn on back-up generation.

One of the leaders in deployment of distributed IC&I batteries. Revenue from CAISO will contribute to existing revenue streams, such as customer load shifting.

Another one of the leaders in deployment of IC&I distributed batteries. Along with several other major industry players, Exelon via its venture capital arm has a stake in Stem.

A startup acquired by Alarm.com in 2013, Energy Hub aggregates residential smart thermometers, using a "bring your own" smart meter model.

A startup acquired by Johnson Controls in 2011, EnergyConnect aggregates residential behavioural demand response, smart thermometers and smart home appliances.

A startup providing whole-home energy management, including integration with Nissan Leaf/Chevy Volt chargers, ecobee/Nest thermostat, and Honeywell and Belkin Wemo smart home devices.

4. Electricity Policy, Regulations and Markets

4.1 Solar + Storage: Utility in a Box?

The 2015 edition of Reading of the World briefly discussed the Tesla Motors/Panasonic "gigafactory" being built in the Nevada desert. The gigafactory and several less publicized projects are significantly ramping up lithium-ion battery production capacity around the world, approximately tripling existing capacity by 2020. The expected economies of scale are predicted to drive down the cost of lithium-ion batteries. Today the cost is about $250/kWh. Tesla Motor's goal is $100/kWh by the end of the decade [45]. The US Department of Energy's target is $125/kWh by 2022 [46].

Table 2: Large battery capacity build-out projects planned [47]

Company	Capacity (GWh)	Location	Year
Panasonic/Tesla	35	Nevada, US	2017
LG Chem	7.5	China/Michigan, US	2019
Foxconn	15	China	2019
BYD	20	China	2020
Boston Power	10	China	2020
Samsung	1.5	South Korea/China	-
Total	90		

While the US energy storage market saw an impressive 240% growth in 2015, the market remains small [48]. Since 2013, less than 400MW of storage have been deployed, 80% of which made use of lithium-ion batteries [49]. The market is also concentrated in jurisdictions where the value that storage offers can be monetized. To date, the primary market has been PJM, supported by revenues from their fast-response frequency regulation market. California currently holds a smaller share of the market, but the state has a 4GW pipeline of storage projects [48].

In November 2015, Southern California Edison (SCE) announced the winners of its Local Capacity Requirement (LCR) Request for Offers (RFO). SCE was seeking to secure 2,200 MW of capacity in West Los Angeles Basin and Moorpark areas to make up for the closure of San Onofre nuclear power plant. While most of the capacity was awarded to natural gas power plants, SCE also contracted for 260 MW of storage, including 100 MW of ahead-of-the-meter batteries, 135MW of behind-the-meter batteries, and 25 MW of thermal storage [50].

Two "use cases" are driving the battery storage potential in California. First, as part of utility procurements, storage is being used for its capacity value, which can be used to defer transmissions/distribution investment. Second, storage is being installed behind-the-meter by IC&I customers for demand charge management. In addition to this, battery storage has several secondary value streams, including backup power, time of use arbitrage, solar self-consumption and aggregation for grid services. However, the economics for behind-the-meter storage for residential customers remains poor, given typical retail rate structures and today's cost for battery systems. The small amount of adoption by residential customers is primarily as a result of the value customers see in back-up power and resiliency [49].

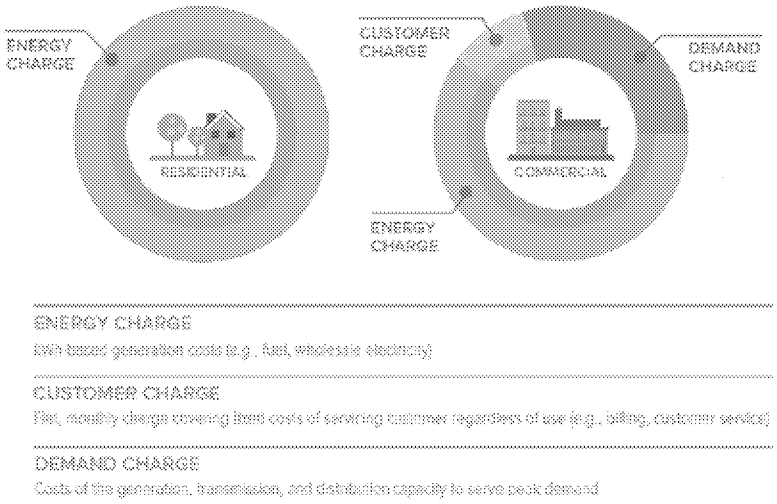


Figure 6: Different retail rate charge components [50]

In 2015, several solar-plus-battery systems started being offered by the market, driven by partnerships such as Tesla and SolarCity, Green Charge Networks and SunEdison, and Stem and SunPower. Solar-plus-battery has been positioned by some as "utility in a box" and has recently fueled heightened debate around the "utility death spiral", given the downward price trend of both solar and battery technology. In an effort to bring more rigorous analysis to the debate, think tank Rocky Mountain Institute published the report The Economics of Load Defection in April 2015 [50]. The report is the highly anticipated update to the widely discussed 2014 report The Economics of Grid Defection [51].

> "...we think that customers in parts of the U.S. and Europe may seek to avoid utility grid fees by going 'off-grid' through a combination of solar power and energy storage. We believe there is not sufficient appreciation of the magnitude of energy storage cost reduction already achieved, nor of the further cost reduction magnitude."
>
> Morgan Stanley
> July 2014 report [52]

"Pricing *needs to* **evolve** in 3 *critical* ways:
1. Locational, allowing some electric-grid equivalent of congestion pricing or incentives
2. Temporal, allowing for continued evolution of *time-of-use* pricing and *real time* pricing
3. Attribute-based, breaking apart *energy, capacity, ancillary services*, and other service components"

Rocky Mountain Institute
Economics of Load Defection
April 2015 [17]

The reports' analyses conclude that while currently nascent, solar-plus-battery systems are expected to achieve retail grid parity in select markets such as California and Hawaii by 2020 and in the majority of American markets by 2030 - a timeframe that is well within the economic life of new investments in conventional generation made today. However, the reports argue that even with economic parity, the number of customers that would actually go off-grid would likely be small and most customers would instead install *grid-connected* solar-plus-storage systems. Grid-connected systems would benefit from integration with other grid resources and can be sized optimally, making them smaller and cheaper and allowing for sooner adoption. It is also noted that the system installed would evolve over time, from "grid only in the near term, to grid-plus-solar, to grid-plus-solar-plus-storage in the longer term". In short, grid-defection is not expected, but significantly reduced net load on the grid - or load defection – is. The reports further predict that eliminating net energy metering policies would not prevent this outcome, only delay it temporarily. Introducing fixed charges are anticipated to result in customers holding off until the economics reach a tipping point, upon which they will go off-grid.

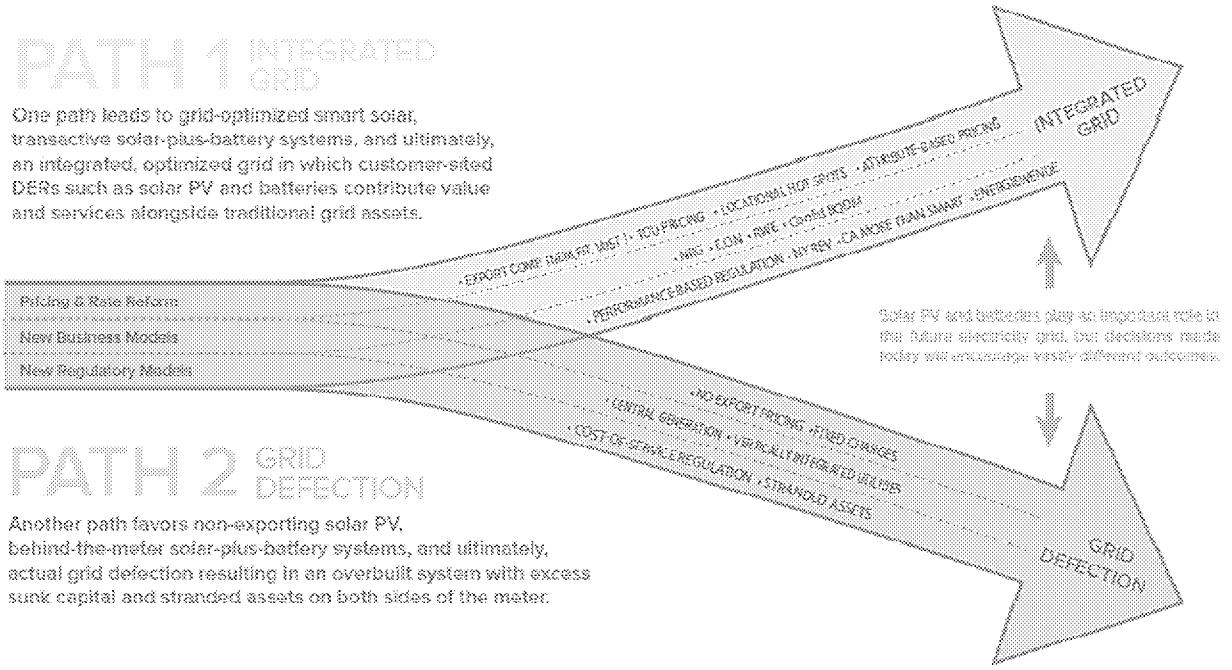


Figure 7: Possible trajectories for electricity grid evolution [50]

The reports' predictions are not all "gloom and doom". It is noted that for customers, having choice and the availability of cost effective DER is good news. Additionally, new DER will provide value to the distribution grid, such as upgrade deferrals. The value of the distribution grid itself would be higher too, as an integrator or "platform" as it is increasingly being called. However, for central generation and transmission, "there is a real risk of stranded assets" according to Rocky Mountain Institute. The reports advise that we are at a metaphorical fork in the road. Down one path electricity pricing, utility business models and regulations are structured to oppose solar-plus-storage systems, favouring grid defection. Down the other path the sector is structured to appropriately value DER, favouring an integrated grid.

In December 2014, Consolidated Edison of New York received approval for the Brooklyn/Queens Demand Management program (BQDM), which is seeking 52 MW of load management by 2018 in the BQDM Target Area to defer a US$1 billion substation investment. Instead, $200 million is being spent on traditional utility upgrades and $200 million is being spent on "customer-sided" energy efficiency and demand response and "utility-sided" batteries [90].

In Ontario, in November, the IESO concluded the second phase of the Energy Storage RFP, which resulted in 10-year contracts being awarded to 9 projects, totaling 16.75MW. All the projects were battery storage, except for a 1.75MW compressed air project developed by NRStor. NRStor is the Toronto based (technology agnostic) energy storage developer, who along with the software solutions company Opus One Solutions, will be distributing Tesla's Powerwall battery storage pack in Canada starting in 2016.

While the IESO is engaged in the debate around grid defection, there is not urgent concern. Unlike Hawaii and California, rooftop solar is not at retail grid price parity in Ontario - for now.

4.2 US Battle over Net Metering Heats Up

More than half of the US states are reviewing or considering potential changes to their net-metering policies [52]. To date, outcomes have generally been in favour of net-metering, such as the January 2016 decision in California. However, there are some exceptions: in December 2015, the Nevada Public Utility Commission decided to eliminate net-metering, shocking their burgeoning solar market.

Following the introduction of net-metering and a generous grant to SolarCity to locate operations in the state, Nevada became the fastest growing solar market in the US [53]. However, in December, arguing that solar customers do not pay their fair share of the cost of the grid, the Public Utility Commission decided to, gradually over the next four years, reduce compensation for solar generation exported to the grid from the retail rate to the wholesale rate for electricity. In addition, the fixed portion of bills will be increased from the previous US$12.75 per month to US$38.51 [54]. The most surprising part of the decision was to not grandfather existing residential solar installations, which Lauren Randall, CEO of Sunrun, called "the most egregious anti-business, anti-solar decision that we've seen" [55]. However, following intense opposition to the changes, the Nevada Public Utility Commission reversed its decision on grandfathering and even amended the plan to phase in the new rates over four years to over a 12 year period [56]. Regardless, SolarCity, Sunrun and Vivint Solar have laid off staff and shut down operations in Nevada [57].

The Nevada net metering controversy has been framed as an "epic battle" between billionaires [91]. Warren Buffet owns the utility, NV Energy, through his holding firm, Berkshire Hathaway. Elon Musk is one of the co-founders of SolarCity, owns 15% of the company and is its chairman.

California, which is the biggest solar market in North America, took a different approach in enacting its successor net metering tariff, dubbed Net Metering (NEM) 2.0. While the Californian utilities also made use of the "cost shift" argument, the regulator rejected them and largely kept the existing net metering regime in place. One of the tweaks made was to institute a minimum monthly bill (instead of fixed charges). Additionally, time-of-use rates will be mandatory for net metering customers. And notably, the new net metering policy comes with a 20 year "grandfathering guarantee". In short, the new net metering regime continues to be favourable toward residential rooftop solar [58].

Nevada and California net metering rates illustrate two extremes: remuneration for export of behind-the-meter generation at the wholesale rate and at the retail rate. In actuality, the "value of solar" is somewhere in between. In fact, for this reason, the California regulator intends to again review net metering in 2019 and has made it clear that NEM 2.0 is only a stopgap to NEM 3.0. California, along with many other jurisdictions, has begun developing holistic frameworks for better valuing and better integrating distributed energy

Hawaii has seen record-breaking penetration of rooftop solar as a result of its net metering program. In Oahu about 1 in 6 residential customers have rooftop solar. However, in October 2015, the Hawaii Public Utilities Commission ended the program, reducing grid export rates for rooftop solar to between US$0.15 to US$0.24 per kWh depending on the island. This is as opposed to the average retail rate of US$0.39 per kWh that was received previously for grid exports. Additionally, going forward, rooftop solar that is combined with battery storage will receive expedited approval from the utilities. It should be noted though that this situation differs from the Nevada net metering decision. Even at the reduced rates, rooftop solar is expected to be viable in Hawaii [92].

resources. In particular, New York has taken significant steps toward this.

In Ontario, rooftop solar is deployed through the microFIT and FIT standard offer programs. In early December 2015, the microFIT program achieved its target for the year of 50 MW, almost exclusively consisting of residential rooftop solar projects (about 9000 projects). The FIT 4.0 program has received almost 1000 applications for IC&I rooftop solar, totaling about 200 MW. Contract awards are expected in Q2 2016.

As discussed in the Reading of the World 2015, the OEB made a decision in April 2015 to de-couple distribution delivery costs from volumetric retail electricity rates. This will be phased in over a four year period, starting in 2016. As such, going forward, net-metered rooftop solar would not be able to avoid fixed distribution system costs. It should be noted that fixed transmission costs have not been decoupled.

While not common knowledge, we have net metering for renewables in Ontario. In place since 2009, the OEB allows renewable resources that are smaller than 500kW to be net metered. However, as mentioned previously, given that rooftop solar has not achieved retail grid parity here, rooftop solar projects in Ontario are enabled by the IESO's procurement programs. Nevertheless, the IESO and the Ministry of Energy are exploring potential ways of evolving microFIT and FIT to net-metering based compensation with additional support through some other mechanism.

4.3 New York's Reforming the Energy Vision

As discussed in last year's edition of The Reading of the World, in April 2014, the New York Public Service Commissions commenced the Reforming the Energy Vision (REV) proceedings. REV's policy objectives are several-fold: (1) customer engagement, (2) system reliability and resilience, (3) market animation using customer contributions, (4) system efficiency, (5) resource diversity, and (6) reduction of carbon emissions [59]. The REV aims to achieve this by overhauling the regulations that govern utilities, defining a new utility business model and creating new markets at the distribution level for DER.

"Significant technological innovation in software and hardware systems that improve the intelligence and flexibility of the delivery system, and similar advances that have significantly reduced the cost and increased the value of distributed energy resources, present the opportunity to fundamentally improve how utilities meet their service obligations."

NY Public Service Commission
July 2015 Staff White Paper

"Let's stop thinking of the distributed, unpredictable world of the grid edge as a wild frontier to be subdued via utility command and control. Instead, let's start thinking of it as an internet-enabled free market, where customer devices and grid systems can barter over the proper way to solve their mutual problems, and settle on the proper price for their services, in close to real time."

Excerpt from GTM News article
A How-To Guide for Transactive Energy

The REV envisions a "plug-and-play" grid, where the utility operates the distribution system as a "Distribution System Platform" (DSP) that integrates customer and third-party DER by actively managing them and compensating them for system benefits they provide. While many other jurisdictions have initiatives underway to establish better ways of integrating DER, New York's REV has the clearest vision of the desired end-state. Given that the REV is such a comprehensive effort, it is expected to take several years before the vision fully materializes. However, the proceeding is progressing, with Track 1 and Track 2 underway.

Track 1 focuses on identifying investments, strategies and action plans required to develop a market (and underlying infrastructure) for DER. In October 2015, regulator staff published guidance on what to include in Distribution System Implementation Plans (DSIP), which utilities must submit by September 2016 [60]. Among other things, the plans will address:

- System Planning - new planning methodology and hosting capacity methodology
- Grid Operations - budget and deployment plan for communications and IT infrastructure
- Pricing - what the frequency and locational granularity of pricing data will be

- NYISO Interface – how coordination with NYISO and dispatch will be done
- Data Access - system/customer data to be shared and protocols for protecting privacy

Track 2 focuses on redefining the utility business model and ratemaking. While rates in the state of New York are decoupled (making utilities less sensitive to changes in volumetric sales), regulators note that financial incentives for utilities are still misaligned. For instance, in the traditional regulatory model, utilities are incentivized to employ wires solutions in order to make capital investments and earn a rate of return for shareholders, even when there may be an opportunity to use DER to defer such investments. Along similar lines, integration and optimization of DER may not involve significant capital expenditure but may involve higher operating costs, which utilities traditionally do not earn a return on.

In July 2015, New York Public Service Commission staff published a white paper, proposing three new mechanisms that would allow utilities to develop and operate as DSP:

- Modified Clawback Mechanism: with the current rate-setting model, if a utility receives approval to make certain capital expenditures but ends up spending less, the unspent capital cost and the associated returns are clawed back by the regulator. The new proposed model would allow the utility to retain the returns if it pursued an alternative, non-wires solution.
- Earning Impact Mechanism: would allow utilities to earn a higher percentage return depending on performance on a set of metrics (i.e. "performance-based" regulation), including affordability, interconnection, peak load reduction, energy efficiency deployment, and customer engagement and information access.
- Market-Based Earnings: would allow utilities to charge fees for services offered to customers and third-party users of the Distribution System Platform, such as providing dispatch and balancing services for DER. In this manner, utilities can generate revenues from channels outside the traditional rate base [61].

In 2014, the OEB evolved the rate-setting mechanism for local distribution companies (LDC) in Ontario to a performance based model from the previous, traditional cost-of-service model. The Renewed Regulatory Framework sets distributors' rates based on a scorecard that measures performance metrics such as customer service, operational effectiveness, public policy responsiveness and financial performance. The mechanism allows LDCs to retain some of the benefits of cost efficiencies (which would not have been allowed under cost-of-service ratemaking). While is a step in right direction, it does not resolve LDC's bias towards wires solutions over alternative solutions (performance based regulation impacts what percentage rate of return can be earned on *traditional* distribution system assets).

Ontario does not currently have a comprehensive regulatory process looking at the integration of DER like California, New York and some other jurisdictions.

4.4 Evolution of the Transmission-Distribution Interface

To help better inform the debate underway on the future of electric utility regulation and business models, the US Department of Energy has commissioned a series of reports to be produced by Lawrence Berkeley National Laboratory. The second installment of the series, "Distribution Systems in a High Distributed Energy Resource Future", was published in October 2015 and offers a framework to address the impact of growth of DER over time in a logical sequence [62].

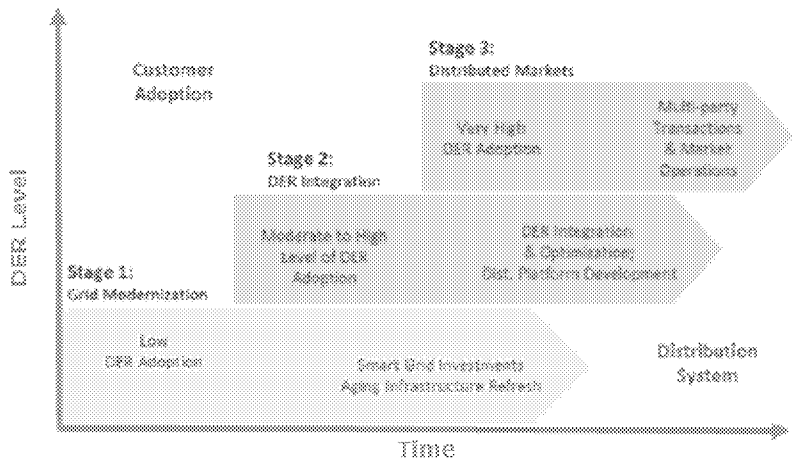


Figure 8: Distribution system evolution [62]

The figure above depicts the three stages of the evolution of the distribution system contemplated in the report. Each stage represents a set of DER adoption levels, public policies and distribution system capabilities. Each stage builds on capabilities developed in the previous stage and becomes increasingly sophisticated in order to reliably operate the distribution system and integrate and unlock the value of DER:

- Grid modernization: Material changes to distribution system infrastructure and operation are not required as DER adoption is low. At this stage, expecting an increase in DER, the distributor should streamline connection procedures and regularly asses DER hosting capacity.
- DER Integration: starting at DER adoption of about 5% of system peak, there is potential for operational problems, such as bi-directional flows on high DER circuits, requiring more advanced equipment and operations. On the other hand, DER can also provide value to the system. Utilities can procure services from the DER, deferring or avoiding infrastructure investment. DER can also provide value by participating in wholesale markets, but this may need coordination between the utility and system operator to ensure reliability. California and Hawaii are at this stage.
- Distributed Markets: this is the grid architecture that the New York REV is working towards, where DER go beyond providing services to the utility and engage in

transactions in a distribution level market. Transactions may occur outside of the local area and involve using the transmission system, emphasizing the need for coordination between the utility and the system operator.

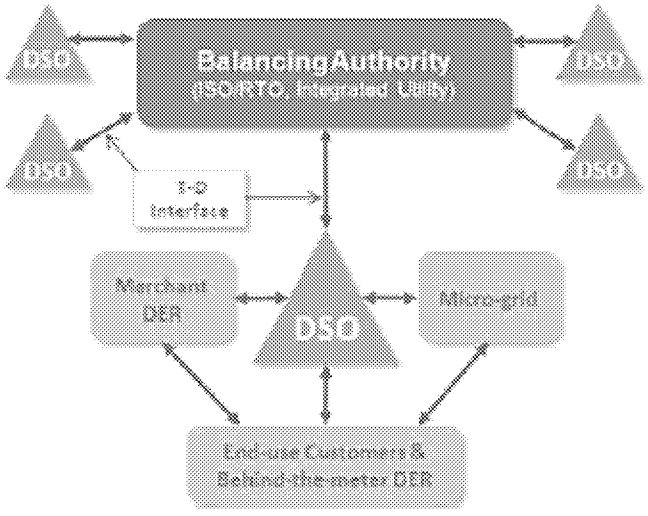


Figure 9: Integrated system operations (high DER, multidirectional energy flows and optimization of resources at multiple levels [63]

The Lawrence Berkeley National Laboratory also outlines potential ways that the utilities and system operators would interact across the transmission-distribution (T-D) interface in a high DER future. Three models for how roles and responsibilities (and associated functional capabilities) could be divided are provided:

- Total Transmission System Operator: the transmission system operator dispatches an integrated system, which extends down to the distribution system and the location of individual distributed energy resources. Given the complexity involved with this, it is considered an unlikely scenario.
- Minimal Distribution System Operator (DSO): the transmission system operator dispatches DER, but assumes that resources are located at the T-D interface, as it does not have visibility down to distribution circuits. The distribution utility is responsible for physical coordination of the DER. This would require communication and real-time coordination between the distribution and transmission system operators.
- Distribution System Market: the DSO would dispatch DER, balancing supply and demand, including imports or exports across the T-D interface. This model is a simplification for the transmission grid operator, which would only see a single dispatchable resource at the T-D interface.

5. Grid Modernization

5.1 Smart T&D Investment on the Rise

Global spending on electricity delivery and management has been one of the fastest growing segments of the electricity sector in the past five years, growing an estimated 19% in 2015 and 266% since 2011. The growth is driven in large part by stimulus funding following the global recession. Major markets such as China, Europe and the US have been investing in renewable generation, which in turn have given rise to the need for new or upgraded transmission, distribution and smart grid infrastructure [64].

> "The fundamental technology for injecting intelligence into the grid has been in existence for years. However, the past 18 to 24 months have seen accelerating technological advancements and shifting priorities among utility industry stakeholders. Indeed, as one executive said, when it comes to smart grid technology, 'not much is new, yet everything has changed.'"
>
> Navigant Research, Q3 2014 Smart Grid Technologies Report [101]

Table 3: Global electricity delivery and management revenue (millions) by segment [64]

	2011A	2012A	2013A	2014A	2015E
Transmission	$9,800	$17,900	$6,100	$29,300	$42,600
Distribution	$6,900	$7,500	$3,400	$8,500	$9,200
Advanced Metering Infrastructure (AMI)	$6,300	$6,500	$5,800	$5,800	$6,700
Microgrids	$3,700	$4,400	$5,500	$4,400	$4,300
Charging Infrastructure	$130	$360	$420	$460	$510
Energy Storage	$120	$790	$650	$460	$2,100
Enabling Information and Communication	$8,400	$28,100	$29,300	$30,600	$32,900
Total	$35,400	$65,400	$51,200	$79,500	$98,400

The transmission system is already "smart". Most transmission systems are monitored with real-time SCADA systems, collecting data at 4 to 5 second intervals and have significant power system automation and controls already in place. However, there are some new technologies being deployed to further improve the reliability and the flexibility of the transmission grid to accommodate new resources. For instance, through funding from the American Recovery and Reinvestment Act of 2009, the number of synchrophasors on the North American grid has grown five-fold, from fewer than 200 in 2009 to 1700 in 2014 [65]. Synchrophasors allow transmission operators to collect data on power quality at a rate of 60 times per second. Coupled with advanced analytics, this enables the detection of system disturbances that are only visible using high-frequency interval data and provides operators with improved situational awareness of grid conditions. Additionally, power electronics on the transmission system, known as Flexible Alternating Current Transmission Systems (FACTS), are receiving increased interest in the context of coal and nuclear plant retirements and the expansion in large-scale wind and solar generation. FACTS are used to control a range of power quality issues, improving reliability and creating a more flexible grid.

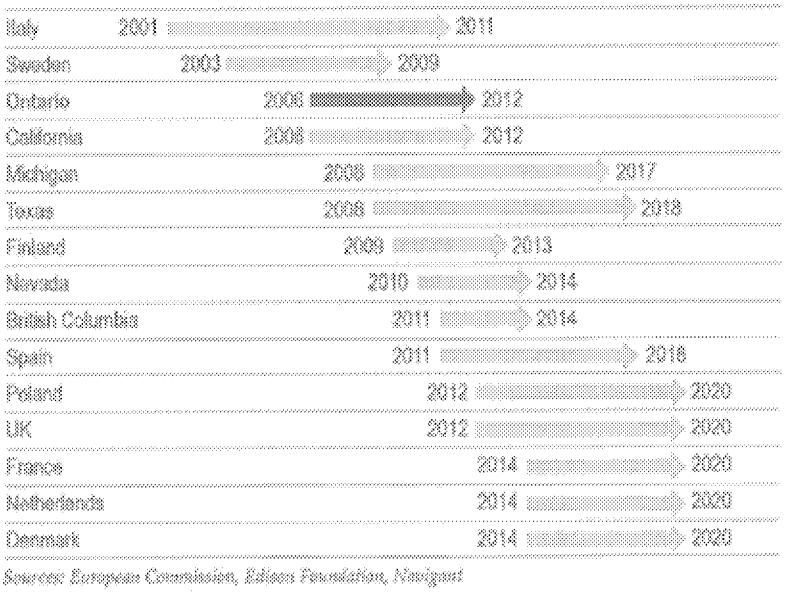


Figure 10: Smart meter timelines across multiple jurisdictions [66]

The proliferation of DER has prompted industry to develop similar (but miniaturized) technologies for visibility and control of the distribution system. This development is being enabled by foundational investment in Advanced Metering Infrastructure (AMI), extending communication networks which in the past terminated at substations, all the way down to individual customers. The AMI market is maturing and shifting from early adopter jurisdictions to major deployments across the globe. In North America, smart meter penetration today is about 50% and is expected to reach 70% by 2020 [67].

Smart inverters have seen significant deployment at the distribution level in some jurisdictions. A component of solar or battery installations, inverters are devices that convert between alternating current (AC) and direct current (DC) power. Unlike standard inverters (which are marginally less expensive), smart inverters are electronic devices that have real-time data connectivity and provide visibility to generation output levels, visibility to circuit conditions, real-time central control, autonomous decision making and (perhaps most importantly) grid services, such as improving grid stability and supporting power quality. Beyond smart inverters, there are a variety of power electronics that are being developed, are dropping in price and are being pilot-tested. These devices promise precise, digitally-enabled control of the distribution system.

In 2013, a consortium of west-coast utilities sent a letter to governors, commissioners and legislators, calling for new rules that would require the use of smart inverters on future solar projects. The letter notes that smart inverters only cost an incremental $150 (i.e. ≤1.5% of total system cost). As a cautionary tale, the utilities point to Germany, where they are looking at hundreds of millions of dollars in cost to retrofit inverters with smartness [120].

Figure 11: Overview of revised Rule 21 implementation phases

In December 2014, the California Public Utilities Commission made revisions to its interconnection tariff known as Rule 21, establishing new standards for smart inverters to enable their functionalities to be used in the state. Starting January 2016, California is the first jurisdiction to require the use of smart inverters. Implementation of Rule 21, which requirements do not apply to existing inverters, will be phased in:

PHASE 1	PHASE 2	PHASE 3
• Anti-Islanding • Voltage Ride-through • Frequency Ride-through • Volt-Var Control • Ramp Rate Control • Fixed Power Factor	• Modular Capability for Communications • TCP/IP Addressability • IEC 61850 Compliant • Cybersecurity	• Emergency Alarms • Status of Energy Ancillary Services • Limit PCC Export on Utility Command • Disconnect + Reconnect on Command

One of the leaders globally in smart meter deployment, Ontario has installed 4.8 million smart meters and transitioned the vast majority of residential and commercial customers over to time-of-use rates.

In 2011, the Ministry of Energy launched the $50M Smart Grid Fund, which currently supports 28 projects that are testing, developing and commercializing emerging smart grid solutions. The third round of applications closed on November 2015. Selected projects have not been announced yet.

GRIDCO SYSTEMS

Gridco is CEO Naimesh Patel's second start-up. The company provides power electronics devices for controlling voltage and power quality on individual feeder lines. Greater Sudbury Hydro has successfully piloted their technology. Gridco joins other start-ups such as Varentec and grid giants such as ABB in developing a new class of power electronics devices that digitally manipulate the electricity on distribution circuits.

"We needed to ensure the reliable delivery of power within CSA limits, especially to customers with voltage-sensitive equipment, and the Gridco Systems IPR-50 helped us achieve this goal. We are also using the IPF to maintain near unity power factor and cancel voltage and current harmonics, which have been getting worse over time due to the large amounts of customer-connected non-linear loads and electronics-based power supplies."

Brian McMillan
VP Distribution Systems
Greater Sudbury Hydro
January 2015 [94]

5.2 Challenge and Opportunity of Data Sharing

The world generated over 8 zettabytes (or 8,000,000,000,000 gigabytes) of data in 2015, which is equivalent to 3 megabytes per minute per person. Astonishingly, the annual amount of data we generate doubles every two years [68]. In the power sector, billions of granular data points are collected on a daily basis from more than 500 million smart meters globally [67]. As new networked grid sensors and grid-edge devices proliferate, as quantities of data collected grow, and as the electricity system evolves, the focus on cyber security, open access to data, and consumer privacy protections is sharpening.

As data volumes grow, scalability and flexibility of meter data management (MDM) systems is increasingly valued. Despite concerns around privacy and security, there is a trend in the industry towards acceptance of cloud-based and software as a service (SaaS) solutions [69].

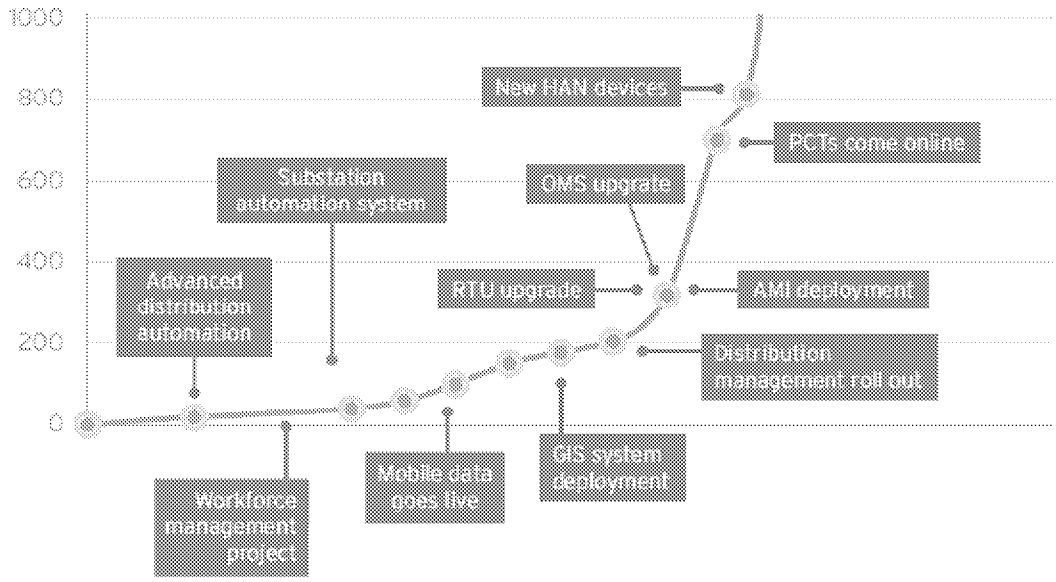


Figure 12: Typical smart grid data volume growth (terabytes) [69]

Green Button, the energy data standardization initiative, has been adopted broadly across North America. Through the "Download My Data" Green Button implementation, residential and commercial customers can download their smart meter data in a standard format and upload it to a third party to assess energy services that can offered. The standardized format allows customer acquisition to be faster, easier and cheaper for energy service companies and DER providers – a benefit that is shared with the customer. Additionally, hundreds of apps that make use of the standardized energy data to help customers explore

and manage their energy use have been developed. Beyond "Download My Data", the Green Button has a "Connect My Data" implementation that is a more advanced, automated version of the tool, allowing customers to give consent to a third party to receive the data directly from the utility. However, its adoption has been slow, with California being the only jurisdiction to fully roll it out [70].

California and New York are at the forefront of the data sharing debate. As part of regulatory processes to overhaul the utility planning process, the states are in the midst of figuring out how much data utilities and DER companies need to share with each other as the electricity system evolves. It is argued that neither side has the complete data set needed. In a sense, a data swap is being suggested where the DER providers share behind-the-meter rooftop solar performance data and utilities share grid information. Regulators are asking utilities to disclose detailed operational data at the feeder-level in as close to real-time as possible. This would allow for transparent determination of hosting capacity of feeders and allow DER developers to better determine the value of their projects, guiding investment in alignment with system needs. It is envisioned that the utilities would have a map on their websites where you could for instance click on a substation and download detailed historical performance data. As would be expected, Californian utilities have security and privacy concerns about disclosing this type of information. Additionally, utilities note that systems to enable this type of functionality would take years to develop and would be costly [71].

Working with HECO, the local utility, inverter manufacturer Enphase Energy has helped clear the 90% backlog of solar rooftop customers waiting for approval to connect to the grid on Oahu, Hawaii – a commitment that HECO made in October 2014. Using the five-minute voltage and frequency data collected in the cloud from the 25,000 Enphase inverters installed on the island, grid conditions were analyzed at circuit level granularity. Based on the results, in April 2015, HECO released approvals for 4,000 rooftop solar systems, totalling about 20MW [95]. This was HECO and Enphase's second achievement in 2015. In February 2015, Enphase remotely updated the software on 800,000 inverters in Hawaii, reprogramming voltage and frequency ride-through settings, in one day [96].

The "Download My Data" Green Button standard was launched in Ontario in 2013 by the Ministry of Energy and MaRS Discovery District. Today about 60% of Ontario home and business customers have access to their consumption data (24 hours after usage) through the Green Button initiative [121]. MaRS is currently testing the "Connect My Data" standard as part of pilots with London Hydro and Hydro One.

Designated as the Smart Metering Entity, the IESO manages the Meter Data Management Repository (MDM/R). The MDM/R is Ontario's smart meter data management system, which stores all the data reads from smart meters in the province, processes the data and makes it available for download by LDCs for billing purposes (among other things). In November 2015, the IESO published the final report for the Foundations Project, which outlines recommendations for expanding the MDM/R data set and refining the framework for third party access to the data. Additionally, the IESO is currently piloting the MDM/R Data Mart, which provides improved data extraction capabilities.

5.3 Advanced Distribution Management Systems

For many years the industry has been calling for "insights, not data". While big data is collected and there is an understanding that it is valuable, extracting the value has been an ongoing challenging. While challenges persist, some data analytics use cases are now well-defined and a growing number of utilities are undertaking major big data analytics projects that include alerts/reports, dashboards and visualization. Additionally, there is a recognition that as the convergence of operational technology (OT) and information technology (IT) continues to advance, new tools will become available that can address the utilities' biggest challenges, such as integration of DER and customer engagement.

BC Hydro

Illegal marijuana growers account for the majority of the estimated $100 million of revenues that BC Hydro loses to electricity theft. However, following the installation of smart meters, BC Hydro was able to analyze the big data collected to compare voltage levels at different points across the distribution system and detect theft, saving millions of dollars [92].

Most of the data analytics use cases today – time-of-use (TOU) billing, fraud detection, asset management and demand-side management – are descriptive and make use of historical data that is downloaded, cleaned and processed in batches. However, to fully extract the value of the stream of data being received from smart meters, grid sensors and grid-edge devices, technology companies are developing software that is able to process data in real-time and makes use of predictive analysis, giving operators situational awareness into grid operations.

The impact of Superstorm Sandy has accelerated Outage Management System (OMS) deployments and upgrades, which today are in fairly high penetration in North America. Combining multiple systems such as customer information, SCADA, smart meters and geographic information system (GIS), to generate a topographical model that provides granular outage identification, generates work orders for the distribution grid operator, dispatches work crews, communicates outage information to customers, and verifies restoration. These systems have led to significant improvements in outage performance metrics [72].

"Mobile connectivity and device integration are becoming 'must haves'. Utilities today want their field and office workers to have access to systems data wherever they are – utilities want their systems to be accessible and easy to interact with via smart phones and tablets."

Navigant Research
Smart Grid IT Systems
research report, Q2 2015 [46]

C3 IoT is a well-funded, well-connected big data analytics company. Started in 2009 by Silicon Valley serial entrepreneur and billionaire, Tom Siebel, the company has been focussed on R&D for years. C3 IoT believes its full suite of software as a service (SaaS) solutions can save $300 per meter per year [99]. Its product offerings are receiving increasing attention, with clients including Enel Italy, PG&E, ComEd and Hydro Quebec.

Bit Stew is a quiet Canadian startup and one of the leaders in big data analytics. The company has been working with BC Hydro since 2011 to manage the utility's smart meters. Bit Stew's system draws in data in as close to real-time as the underlying hardware permits and uses machine learning to constantly make and test predictive assertions, improving its predictive ability as it collects and processes more data [100].

Distributed Energy Resource Management Systems (DERMS) have emerged in the past few years as a software-based solution that could address some of the economic and technical challenges associated with the proliferation of customer-sited distributed energy resources, such as solar, battery storage and electric vehicle charging stations. DERMS provide utilities with real-time, granular visibility into the output of DER on the system, improving the accuracy of short-term load forecasting. Enabled by bi-directional information exchange, the DERMS can also provide market price signals and directly control distributed resources. While still in early stages of development and facing challenges with the massive data volume and poor data quality involved, DERMS providers, such as Spirae and Enbala, are making inroads in areas that have high penetration in DER, particularly Europe.

Distribution Management Systems (DMS), which monitor power flows and maintain power quality on the distribution network, have been available for some time. However, in recent years technology firms have begun offering the next generation of these systems, receiving strong interest from large utilities. Advanced Distribution Management Systems (ADMS) combine the capabilities of the DMS, OMS, SCADA, potentially DERMS and other enterprise systems into a single integrated system. The system is an as-built, as-operated real-time GIS-based model that unifies operational, engineering and customer management databases and analytics, typically in the cloud. Despite its potential benefits being recognized by utilities, ADMS technology is still emerging and has not yet been deployed widely. Additionally, installing the system is expensive and requires a large enterprise-wide integration effort that involves a high degree of customization [73].

5.4 Culture Shift: Ratepayers, Customers or Prosumers?

Historically, the power sector has thought of end-consumers as "ratepayers", i.e. price-taking and predictable load. However, the utility-customer relationship is quickly becoming more complex as an increasing number of products and services, some of which compete directly with utility services, are becoming available to customers. Moreover, customer expectations are changing. Today, many large commercial customers want 100% renewable energy to meet corporate sustainability goals. Municipalities are seeking to create microgrids and invest in smart city infrastructure, such as networked LED street lighting. And residential customers want to understand and manage their energy use using smartphones, smart thermometers and other connected devices.

> "A new generation — those born after 1980 and sometimes called "digital natives" — are comfortable with the digital world. By 2020, they will comprise more than half the North American population. Digital natives will be demanding and leading the change to which both utilities and policy makers must respond."
>
> Excerpt from Key Trends Driving Change in the Electric Power Industry, December 2014 [101]

OPOWER

Opower has matured since its early days as one of the pioneers of behavioural demand side management, where it used smart meter data to provide neighbor comparisons and rankings on customer's bills, resulting in energy savings. Opower had its IPO in April 2014 and currently trades at about $450 million market valuation. In the past year, the company has expanded to provide a full suite of customer care software solutions, including tools to help customers understand their bills and save energy, a call-centre analytics program and enterprise web services involving a complete overhaul of a utility's website [102].

The power sector lags in customer engagement compared to other consumer-facing industries, such as retail, transportation and banking [74]. Playing catch-up, utilities are now accelerating the digitization of their customer service, developing full multi-channel communication strategies that encompass postal mail, emails, call centres, text message alerts, smartphone applications, social media and online tools. When implementing this, there is a strong trend in the sector to partner with vendors that provide white label software for enterprise-wide customer care that the utility then brands [75]. In particular, utilities are just now starting to use mobile device apps to deepen engagement and allow customers to more easily pay their bills, monitor their energy use and contact customer service.

Customers can also be notified of opportunities to participate in demand response and energy efficiency programs.

Used to describe the emerging proactive, producing electricity consumer, "prosumer" is a buzzword that has entered the utility lexicon recently. There is now a wide range of home energy technologies and smart home appliances available and the competition to become the provider of the home internet-of-things ecosystem is fierce. Pivoting from their respective entry points, the home energy market is attracting entrants from a wide variety of industries, including solar, security, telecom, utility, home appliance and high tech. Of particular interest is the rise of Home Energy Management Systems (HEMS) – the hub or brains of the smart home – which monitors, analyzes and controls energy use in the home. While still in early stages of market growth, the pieces of the puzzle that will enable the intelligent, connected, potentially net zero home are starting to fall into place. As home energy technologies mature, HEMSs are envisioned to intelligently and automatically optimize sophisticated behind-the-meter energy systems that encompass rooftop solar, battery storage, electric vehicle charging and smart appliances in response to consumer needs and distribution level market signals as envisioned in the New York REV. While there is general public awareness of the trends towards increased sensing, control and automation of energy use, generation and storage in the home, these trends are even stronger among commercial and industrial customers, who are adopting Building Energy Management Systems and Industrial Energy Management Systems.

ENPHASE

In September 2015, Enphase Energy released its next-generation energy management system, which monitors whole-house load and integrates a solar PV and battery system. The system optimizing operation based on predicted customer load, weather forecast and utility billing structure. This is just one example of residential solar players entering the connected home market [103].

bidgely

Bidgely has developed an app that uses smart meter data to disaggregate electric appliance loads in the home, which the start-up provides to utilities as software as a service (SaaS). The company is venture capital-backed and includes utilities RWE, Exelon and E.ON as investors. The company's software analyzes smart meter data to identify appliance's unique energy signatures. Pilots have shown that the data can be used to achieve behavioural demand side management.

Having searched for apps from major LDCs in both Android and Apple app stores, it does not appear that LDCs in Ontario currently provide mobile device applications to their customers. As part of London Hydro and Hydro One's "Connect My Data" pilots, a handful of third party apps are being offered, including several of the winners from the 2014 Energy Apps for Ontario Challenge, as part of which the Ministry of Energy provided $50,000 in awards to app developers to create tools that make use of Green Button data.

6. Power & Utilities Markets and Transactions

6.1 Reforms Create Investment Opportunities Globally

International momentum for electricity sector reform has picked up in recent years. Ernst and Young notes that "more than 30 countries are now considering, commencing or continuing the process of breaking up long-standing integrated utilities" [40]. These reforms, many of which are in established markets, are motivated by both the need for injecting capital into utilities and the desire to free up government funds in order to invest in other public infrastructure projects. From investors' perspective, this affords the opportunity to acquire regulated assets, prized for their stable, long-term returns.

> "Between 1995 and 2002 a wave of major regulatory reform aimed at introducing competition in various utility functions – known broadly as 'electricity restructuring' – transformed the industry. At the time, it was widely expected that this transformation would eventually lead the entire industry to a less-regulated and more market-based structure. Yet following the 2000-2001 electricity crisis in California's restructured market – the movement for electricity deregulation encountered a significant backlash. public policy after 2002 is more accurately described as a cessation of any further restructuring."
>
> Excerpt from The U.S. Electricity Industry after 20 Years of Restructuring (August 2015) [134]

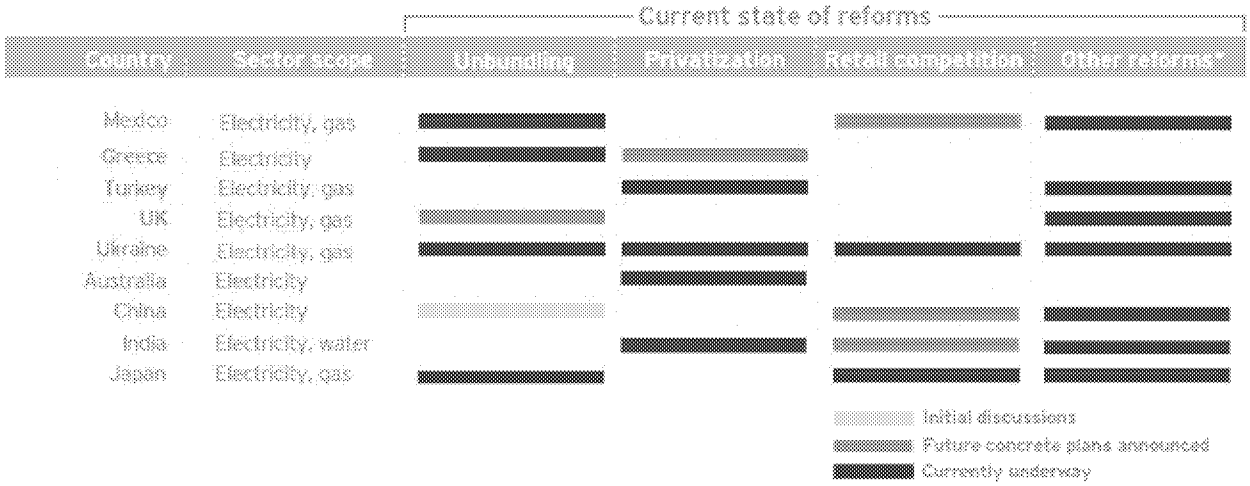


Figure 13: Select countries that are undergoing energy sector reform [76]

[76]

In Australia, the state of New South Wales is privatizing T&D assets. In November 2015, a 99-year lease for Transgrid, the state's transmission company, was sold for $8.2 billion USD to a consortium of local and international investors, including Quebecois institutional investor Caisse de Depot et Placement du Quebec (CDPQ) [77]. The Indian government, as part of its privatization strategy, intends to sell partial stakes in several of its state-owned electricity companies. The Japanese are in the midst of makeover to their electricity sector and have a comprehensive restructuring process underway. Following sweeping reforms, Mexico announced winners of its first bid process for power purchase agreements in March 2015 [76].

European countries have generally undergone the restructuring process and are generally set up as energy-only markets. However, in light of high penetration of renewables depressing energy prices and the resulting stranding of conventional generation plants, the Europeans are tweaking their market design. Many jurisdictions are turning to capacity mechanisms to reinforce their market structure. As discussed previously, the UK held its first capacity auction in December 2015. France and Italy are implementing capacity mechanisms as well. Germany and Poland are considering it [40].

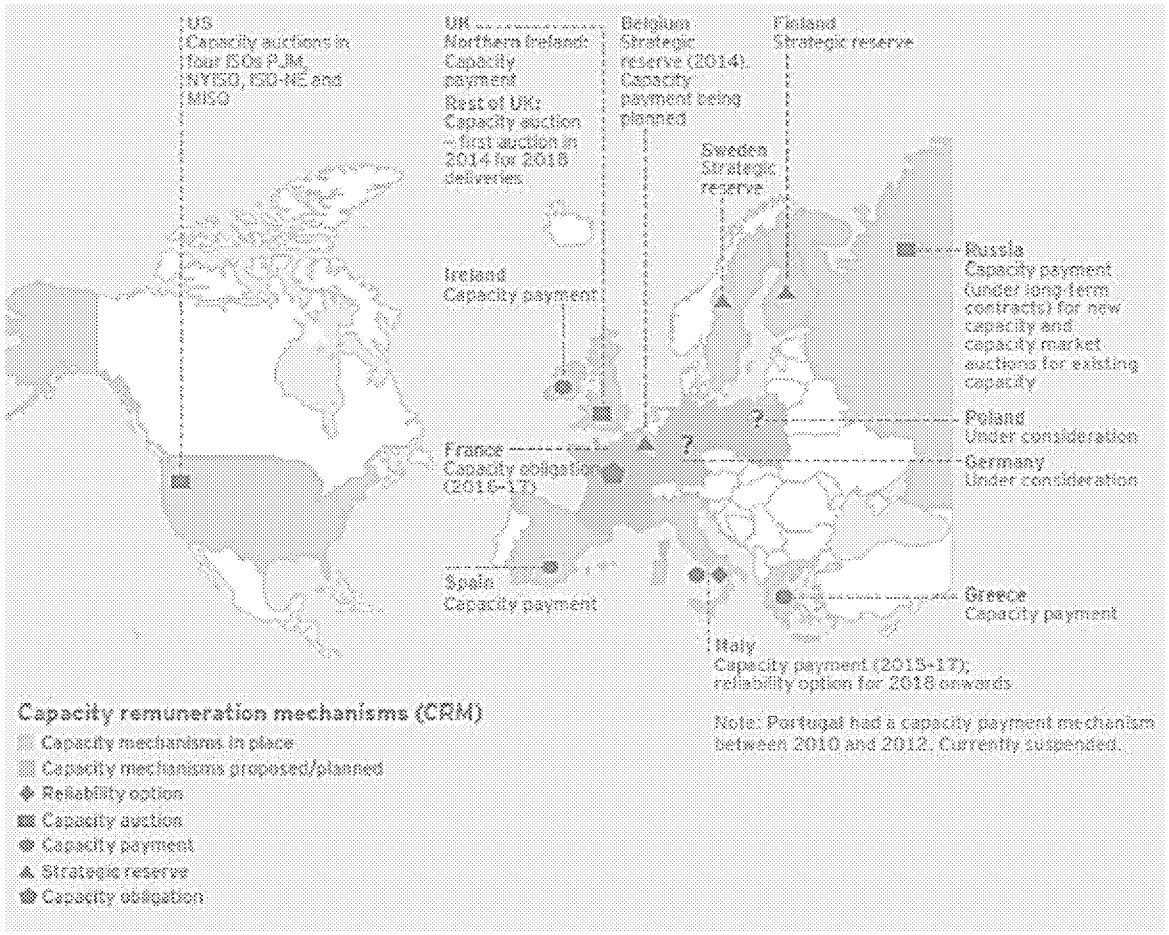


Figure 14: Global snapshot of capacity markets [40]

The composition of the Ontario power generators has quietly shifted recently. With the retirement of coal plants and planned retirement of the Pickering nuclear plant, the only remaining regulated generating stations in the province will be the Darlington nuclear station and legacy hydro-electric plants. Basically, all other market participants have an IESO contract, with the exception of a few merchant Non-Utility Generators (NUGs) with expired OEFC contracts.

Since the introduction of the electricity market in Ontario, new capacity resources have been secured using competitive procurements that award long-term contracts. However, in March 2016, the IESO initiated the Market Renewal Stakeholder Engagement to develop a work plan to introduce a day-ahead market, a incremental capacity auction and locational marginal pricing.

6.2 Competition Ends the Transmission Monopoly

Global investment in transmission infrastructure is rising, driven by the historical underinvestment in aging power infrastructure, the retirement of coal and nuclear power plants, and the connection of renewable resources in accordance with environmental policies, such as the CPP in the US. While competitive procurement processes have been used for generation for decades, competitively procuring transmission infrastructure is a more recent trend.

Table 4: Jurisdictions with competitive transmission processes [78]

Brazil	Since 1999 all transmission projects have been auctions
UK	Tenders for transmission connecting offshore wind projects
US	ERCOT's competitive renewable energy zones (CREZ) Jurisdictions at different stages of implementing FERC order 1000
Ontario	One competitive solicitation for transmission to date
Alberta	Developed a competitive process; currently running first RFP

Notably, in 2011 FERC issued Order 1000, which laid out a framework to allow non-incumbents to participate in bidding processes for major transmission investments. The process for filing compliance plans and receiving approval from FERC has been a long and complicated process, and ISOs and RTOs have only recently started implementing competitive processes.

FERC Order 1000 removes incumbent utilities (i.e. the entity that has the monopoly franchise rights) Right of First Refusal (ROFR) to construct, own and operate large transmission projects within their service territories – a potentially dramatic development, changing the dynamics in the transmission segment of the US market.

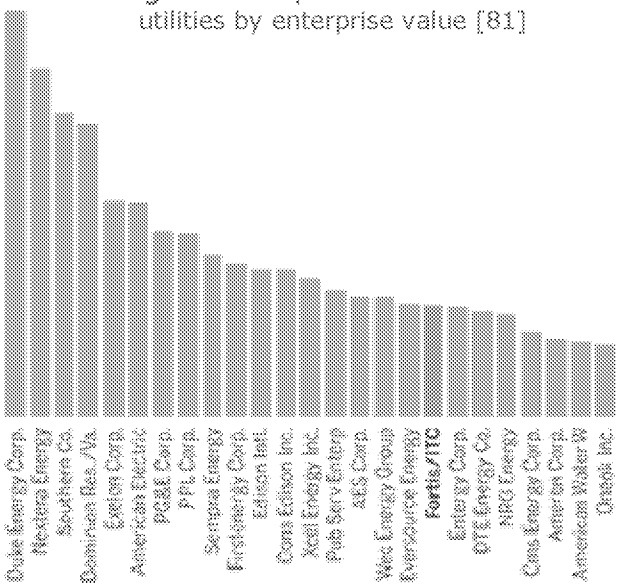
As a trial run for procurements under FERC Order 1000 was issued in 2013 by PJM Interconnections seeking a solution to address stability issues in an area of New Jersey known as Artificial Island. The solicitation received proposals with a range of solutions from eight transmission developers, including non-incumbent utilities. However, the process has been highly controversial, illustrating the complexities of procuring transmission. The evaluation of the proposals involved PJM staff applying their professional judgment to assess subjective criteria, such as "constructability", and even modifying proposals

submitted. In June 2014 PJM staff recommended the selection of a modified proposal from PSE&G, the incumbent utility, to PJM Interconnection's board. However, following an outcry from losing bidders and stakeholders, questioning the impartiality of the process, the board re-opened the process. Ultimately, a proposal from LS Power to build a new 230-kV transmission line from New Jersey's Artificial Island to Delaware was selected in July 2015 [79].

Over Q2 2015, ITC filed for permits with Canada's National Energy Board and the US Department of Energy. Given that the Lake Erie Connector project crosses the border. Over summer 2015, ITC undertook a non-binding, open solicitation for expression of interest for transmission rights. The company is now in negotiations with interested parties'. The result of the process is seen as key to whether the project moves forward. ITC expects receiving permits and approvals need to start construction in 2017 and commercial operation in 2019.

Competition for transmission has allowed the entry of new transmission players, such as ITC Holdings Corporation. ITC is the first and biggest independent electricity transmission company (similar in concept to an Independent Power Producer) in the US. The company operates 25,000 km of transmission lines in six Midwest states, including Michigan [80]. In addition to developing, acquiring and operating regulated assets, ITC is also a developer of merchant transmission projects, including a proposed 1000 MW, bi-directional, High-Voltage Direct Current (HVDC) transmission line that would connect the IESO's grid to PJM. In February 2016, St. John-based Fortis Inc., one of Canada's biggest utility owners, announced that it will be acquiring ITC for US$11.3B. Over the past decade, Fortis has been expanding its footprint across Canada, US and Central America. However, the ITC deal, which is the biggest Canadian takeover of a US utility, will be transformative for Fortis, making it one of the top 15 utilities in North America [81].

Figure 15: Top 25 North American utilities by enterprise value [81]



Hydro One's initial public offering (IPO) was completed on November 5, 2015. The province sold a 15% stake in the company, raising $1.83 billion, which along with a deferred tax asset benefit and special dividend and payments-in-lieu of taxes, netted about $5 billion for the government [107]. Over time, the Province intends to reduce its ownership further to 40%.

The IPO saw strong demand from both retail and institutional investors. While the initial range for the IPO was $19-$21 per share, the stock's final IPO price was on the higher end of the range at $20.50 per share, given the strong interest [108]. The share price closed at $24.31 on March 31, 2016 - up 18.6% since the IPO. Investors see potential for Hydro One to pursue growth through further investment in its existing system, consolidating assets in Ontario, and acquiring assets in other provinces and the US. In fact Hydro One has made several acquisitions in the recent past, including the January 2016 $222 million deal with Brookfield Infrastructure to purchase Great Lakes Transmission, one of the four other transmission operators in Ontario that make up the 4% of the province's transmission assets that Hydro One does not own [109].

In 2013, the Ontario Energy Board ran Ontario's first competitive bid process for a transmission project. The East-West Tie Line was awarded to NextBridge, a consortium made up of NextEra, Enbridge and Borealis Infrastructure. Hydro One also submitted a bid as part of a consortium, but was not selected. Future major transmission projects are also expected to be open to competition. In October 2015, the government tabled Bill 135, which if enacted, would allow the government to direct the IESO to undertake procurement processes for transmission infrastructure.

6.3 Regulated T&D Assets Attract Premium Valuations

While consolidation has been a consistent feature of the North American power and utilities sector, the past two years has seen a sizable uptick in activity. In particular, utilities are moving more aggressively to acquire regulated power and gas T&D assets – and in some cases even divesting merchant exposure. Institutional investors are attracted to regulated assets given the low-risk, stable revenues. For strategic buyers, there are a number of drivers: replacing lost capacity from retired coal plants, finding growth in a low demand-growth environment, hedging against commodity risk and merchant risk, and finding scale economies. As a stark example, in Q4 2015, NextEra divested about 3GW of merchant natural-gas fired generation and instead pursued the acquisition of Oncor Electric Delivery, the largest T&D utility in Texas [82]. Given investor's bullish sentiment, regulated T&D assets are trading at historic highs and attracting premium valuations in transactions.

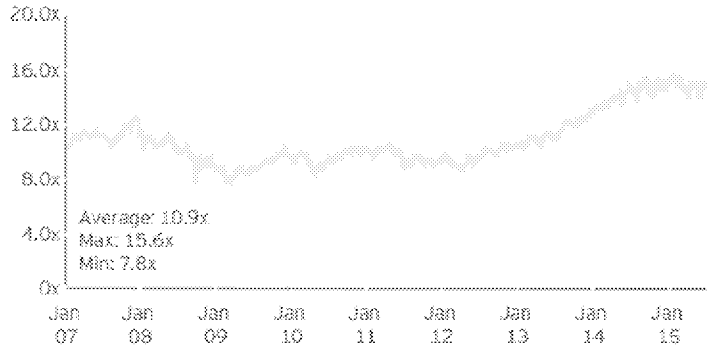


Figure 16: Average price/earnings (P/E) trading multiples for select T&D utilities [83]

Across Canada, utility ownership varies depending on the province. Many of the provinces have vertically integrated utilities (Hydro Quebec, NB Power, SaskPower, Manitoba Hydro, BC Hydro). Other provinces have privatized their utilities, notably Emera (Nova Scotia Power) and Fortis (Newfoundland Power). Interestingly, both Emera and Fortis have been involved in "megadeals" with US utilities in the past year. As previously discussed, Fortis is acquiring Michigan-based ITC. Emera is acquiring TECO Energy, which owns regulated electric and gas utilities in Florida and New Mexico, for US$10.4 billion. In deregulated Alberta, separate entities own transmission, generation and distribution. Alberta has two of the largest municipal utilities, EPCOR and ENMAX, which serve Edmonton and Calgary respectively, along with a long list of other municipalities. In fact, outside of Ontario's 70+ LDCs, there are only a handful of municipal utilities in Canada. In short, Ontario's distribution utilities are highly fragmented, presumably resulting in inefficiencies given the lack of scale economies.

Table 5: Electricity utility ownership by province (Nov 2015) [84]

Province	Ownership	Utility	Transmission Lines (km)	Distribution Lines (km)	Distribution Customers
British Columbia	Crown	BC Hydro	18,300	65,000	1,900,000
	Private	FortisBC Electric	1,450	5,750	160,400
	Municipal	Nelson, New Westminster, Grand Forks, Kelowna, Penticton, Summerland			
Alberta	Private	ATCO Electric	11,000	88,000	720,000
	Private	FortisAlberta	0	119,000	530,000
	Private	AltaLink	12,500	0	0
	Municipal	EPCOR	200	5,100	360,000
	Municipal	ENMAX	200	7,500	385,000
Saskatchewan	Crown	SaskPower	13,400	147,400	510,000
	Municipal	Saskatoon Light and Power	12,000	76,000	58,000
Manitoba	Crown	Manitoba Power	20,000	113,000	595,000
Ontario	Crown	Hydro One	0	3,500	1,200,000
	Municipal	70+ LDCs	34,200	116,000	2,610,000
	Private	FortisOntario	6,400	20,000	64,100
Quebec	Crown	Hydro Quebec	0	750	4,100,000
New Brunswick	Crown	NB Power	9,800	20,000	310,000
	Municipal	Saint John Energy	0	750	36,500
PEI	Private	Fortis (Maritime Electric)	500	4,400	
	Municipal	Summerside Electric	0	110	8,900
Nova Scotia	Private	Emera (NSPI)	0	6,200	500,000
Newfoundland	Crown	Nalcor(Newfoundland & Labrador Hydro	4,000	4,300	35,000
	Private	Fortis(Newfoundland Power)	0	11,000	270,000

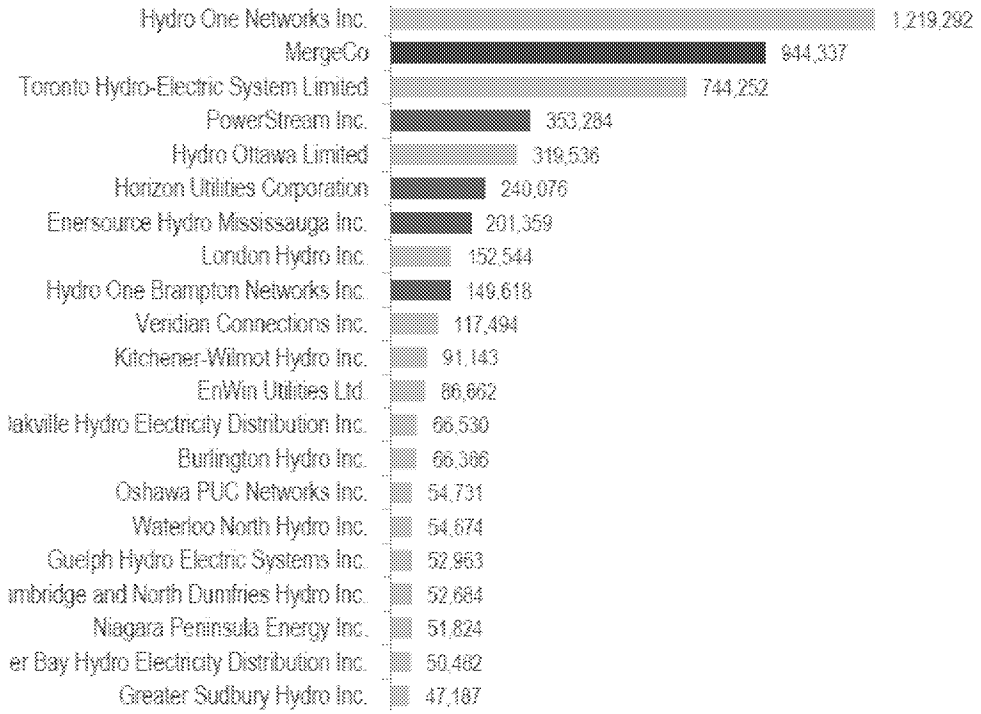


Figure 17: Top 20 electric distribution utilities ranked by number of customers [84]

It is in this context that the Hydro One IPO took place. Regulated T&D assets are seeing premium valuations. Privatized Canadian utilities are making multi-billion dollar acquisitions south of the border. And, the distribution segment of the Ontario sector is fragmented. Hydro One, which is already the province's biggest LDC (mostly rural assets), is expected to be well positioned to be a consolidator, given its size, access to the public equity market, and existing presence and relationships throughout the province. Since 2014, Hydro One has closed acquisitions for Haldimand Hydro, Norfolk Power and Woodstock Hydro.

It is also in this context that the government spun off Hydro One Brampton in August (prior to the IPO) with the intent of merging it with Enersource, Powerstream and Horizon Utilities. The merger of the four utilities will create the second largest LDC in the province and is expected to become an urban consolidator. In March 2016 the three utilities agreed to purchase Hydro One Brampton from the government for $607 million [105]. The six municipalities involved, i.e. Mississauga, Markham, Barrie, Vaughn, St. Catherines and Hamilton, have all approved the merger. The deal is expected to close later in 2016, subject to approval from the Competition Bureau and Ontario Energy Board (OEB).

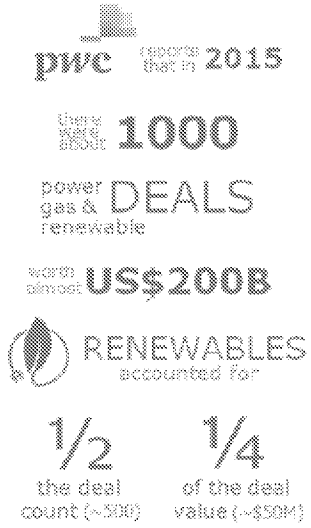
In line with the Clark Report's recommendations, as part of the Ontario 2015/2016 budget the government introduced limited time tax relief (i.e. over next two years) to encourage consolidation of LDCs. The changes to the applicable tax rules include: (1) A reduction in the transfer tax rate from 33% to 22%, (2) an exemption from transfer tax for distributors with fewer than 30,000 customers, and (3) an exemption from the capital gains portion of the departure tax [106]. This is expected to reduce the cost of acquisitions and give LDCs increased access to the private capital investment needed to acquire other distributors. In this regard, Hydro One currently holds an advantage, given that it is the only LDC that is publicly traded and has access to the public equity market. In January 2016 rumors emerged that Toronto Hydro, the third biggest LDC and one of the three expected key consolidators, is developing a plan to privatize.

Under the federal income tax system, an LDC is tax exempt if a municipality owns at least 90% of its shares. Under Ontario's Electricity Act, municipally-owned LDCs instead make "payments in lieu of taxes" (PILs) to the Ontario government.

A "departure tax" applies if a municipally-owned LDC stops being tax-exempt – i.e. if private investors take an ownership stake of more than 10%. This is viewed as a barrier to private investment, "locking" LDCs into municipal ownership.

A "transfer tax" applies when an LDC is sold regardless of whether the LDC is municipally-owned or investor-owned and whether it is in or out of the PILs regime. This is viewed as a barrier to consolidation.

6.4 Investors Turn to Low-Risk Renewable Assets



[85]

Global renewable asset deal value was up 29% in 2015 over 2014 [85]. Despite the debate around "yieldcos", the market expects continued growth supported by climate change and energy policy around the world, such as the COP21 Paris Agreement and India's renewable energy targets for example. Similar to regulated T&D assets, renewables are in demand by both financial and strategic buyers. Institutional investors (e.g. pension funds, insurance companies, etc.) value the low-risk, long-term, stable revenues of renewable assets supported by Power Purchase Agreements. Strategic buyers (i.e. other power and utilities companies) are adding renewable assets to their portfolios to reduce merchant exposure and to conform to regulatory requirements.

The increase in interest for renewable assets comes as investor sentiment towards merchant coal power plants, and in some jurisdictions even gas and nuclear power plants, declines. Some power companies with high exposure in thermal generation are seeing a significant drop in their market valuations [82]. The market instead rewards restructuring and divestments. As reported in the Reading of the World 2015, Germany-based E.ON., which is one of the biggest utility owners in the world, is undergoing a major restructuring. On January 1, 2016, the company separated its conventional power generation and energy trading operations into a new company, Uniper. In December 2015, RWE, Germany's second biggest utility, announced a similar move. RWE intends to undertake an IPO in late 2016 for a new entity which will hold its renewables, network and energy services assets [85].

In December 2015, NRG Energy CEO David Crane stepped down. At the time the company had lost over 60% of its market value since the beginning of the year. The company's YieldCo, NRG Yield, was doing just as poorly. Under Crane's leadership, NRG adopted a strategy focused on DER and home energy services, shifting away from centralized fossil fuel power plants. However, the company's strategy confused the market and investors became concerned that new investments were not producing results. Motivated by very different reasons than E.ON. and RWE, in September 2015, NRG announced that it will be restructuring and separating the clean energy side of the business from the conventional generation side [110].

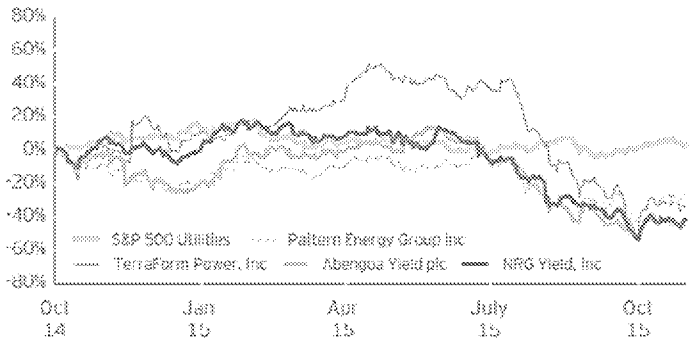


Figure 18: S&P 500 utilities vs yieldcos (Oct 2014 to Oct 2015) [83]

"Developing an innovative and profitable prosumer business model is a challenge we also need to address successfully, as we see a billion-euro market emerging alongside our traditional value chain. We will position ourselves as a project enabler and operator, and system integrator of renewables"

2015 Pixie Strategy Paper [111]

"Under the most common model, yieldcos are publicly traded holding companies that buy power plants, from their parent and from other developers. Those sales give developers capital to build new projects, and the yieldcos get long-term revenue streams from selling electricity. The risk is that the parent, sometimes known as the sponsor, will influence yieldco management to approve purchases of power plants that don't make economic or strategic sense."

Bloomberg Technology's Best 2015 [111]

In the US, the recent surge in renewables deal activity is primarily fueled by the yieldcos. However, the second half of 2015 saw a significant sell-off by investors, who are questioning the viability of the ownership model. Many yieldcos' dividend targets assume very aggressive growth in their asset base, requiring a steady stream of acquisitions. Investors are concerned about the unsustainable growth assumptions, impact of the interest rate increase in the US, and lack of acquisition discipline [83]. The decline of yieldco market valuations, which affect their ability to raise funds through secondary public offerings, is expected to contract renewable deal activity in the US. In particular, Terraform, SunEdison's yieldco, has been under considerable scrutiny, impacting both companies' market valuations. Upon market-close on March 31, 2016, SunEdison's share price was US$0.54, down from its 2015 high of US$33.45, and Terraform's share price was US$8.65, down from its 2015 high of US$42.66. Given SunEdison's decline in market value and its current debt load, there are serious concerns that, what was the world's biggest renewable company a year ago, is about to go bankrupt [86].

In March 2016, the IESO offered 16 Large Renewable Procurement (LRP) contracts, comprised of about 300MW of wind, 140MW of solar and 15.5MW of hydroelectric projects.

Several yieldcos are active in the Ontario electricity market, including Brookfield Renewable Energy Partners, TransAlta Renewables and Terraform's parent company, SunEdison.

Similar to the utility restructuring in Europe, TransAlta Renewables was created in 2013 as a spin off from parent TransAlta Corporation, which had "the worst-performing power generation stock in North America" in 2012 [113].

SunEdison participates in a variety of IESO procurements and is a major IESO contract counterparty. The company has a local office here in Toronto, which has laid off more than half of its staff in the past year.

7. Conclusion

The past year saw many elements of the distributed, cleaner and smarter future come into focus. Climate change policy at every level – from global to local – took major steps forward. New generation investment is primarily in renewable or natural gas power plants, pushing out conventional generation. DER technologies continue to mature and to drop in price, including solar PV, batteries, microgrids and aggregated demand response. Customers increasingly have options for managing their energy consumption and are expecting more of their utilities. Forward-thinking jurisdictions, such as New York and California, have started working on how to overhaul their regulatory framework to better integrate DER and extract their value, proposing new markets, new business models and new relationships amongst industry players. Meanwhile, smart grid hardware and software, which promise to enable a more dynamic distribution system, continue to slowly advance. Investors, who are shifting away from conventional generation assets, are injecting capital into T&D and renewable assets, allowing faster deployment of new smart grid infrastructure and clean energy resources.

"No one has managed multi-million node networks from a business operations perspective. The utilities are the first in the world to face this problem at scale, all these connected devices. That brings with it a whole host of network challenges, and costs."

Kevin Collins
CEO & Co-founder
Itron Silver Systems

"We always **OVERESTIMATE** change that will occur in **the next 2 years** and **UNDERESTIMATE** change that will occur in **the next 10**."

Bill Gates

We have been promised a more distributed, cleaner and smarter grid for over a decade, but it has been slow to materialize – frustrating those who have bought into the notion while giving those who have not ammunition to dismiss it in favour of the status quo. However, it should be recognized that the electricity system is already "the biggest and most complex machine ever built". The evolution that is being contemplated will make the system orders of magnitude more complex and will take years to fully take form. The past year does however seem to suggest momentum is increasing.

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