CENTRE INTERNATIONAL DE FORMATION EUROPÉENNE
INSTITUT EUROPÉEN · EUROPEAN INSTITUTE

Centre international de formation européenne

Master in Global Energy Transition and Governance

Academic year
2021 - 2022

HOW CANADA CAN UNLOCK DEMAND-SIDE POTENTIAL THROUGH RESIDENTIAL DEMAND RESPONSE

Natasha Kettle Reid

June 2022

Research Director and Supervisor:
Dr. Rachel Guyet and David Desfosses

ABSTRACT

The Canadian electricity sector is the cornerstone of the nation's net zero strategy. As the electricity system grows and expands with the energy transition, so will the need for a flexible load. This thesis examines how Canada can unlock demand-side potential through residential demand response (RDR). The research methodology applies a three-prong approach, including stakeholder interviews, literature review, and a public survey that received over 700 responses.

Canada is an energy-rich nation that has been traditionally focused on securing supply, rather than controlling demand. The Canadian RDR market currently lags other countries because it has not yet reached a critical junction to force the industry to adapt. However, there will be increasing pressure on the electricity system as the country transitions to net zero. The electrification of transport and an increasing share of variable renewables will be the key drivers of RDR deployment in Canada.

The main barriers of RDR adoption are political, social and financial in nature. There is a fundamental lack of trust between governments, utilities, technology and citizens. There is also a lack of centralised authority to align provincial energy sectors to meet national targets. The industry is structured and regulated in a manner that does not foster innovation or collaboration.

Canada must acknowledge that long-standing patterns of governance will not be sufficient to match the speed and innovation required to meet net zero targets. In the short term, provincial and territorial governments should legislate public utilities, regulators and system operators to pursue climate goals. However, there is a great need for the industry to shift towards centralised regulation to foster collaboration and innovation, including RDR deployment.

ACKNOWLEDGEMENT

This thesis was written in nine months, but in many ways, I have unknowingly been building it throughout my entire career. It ties together my life as a utility design engineer, a software product manager, and now a social and political science student. I would like to thank everyone who has mentored me along this path, many of whom have actively participated in interviews and data collection for this research. I would specifically like to thank Dr. Rachel Guyet and David Desfosses for their support, encouragement, and guidance.

My motivation for writing this thesis is to make a meaningful and valuable contribution to the energy transition and the fight against climate change. I look forward to also dedicating my career to this cause.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

List of Abbreviations

ADR	Automated Demand Response
AMI	Advanced Metering Infrastructure
BC	British Columbia
BDR	Behavioural Demand Response
BG&E	Baltimore Gas & Electric
C&I	Commercial & Industrial
CAISO	California Independent System Operator
CAMPUT	Canada's Energy and Utility Regulators
COR	Cost or Revenue
COS	Cost of Service
DER	Distributed Energy Resources
DLC	Direct Load Control
DR	Demand Response
DSM	Demand-Side Management
DSO	Distribution System Operator
EV	Electric Vehicle
FERC	Federal Energy Regulatory Commission
G7	Group of Seven
GHG	Greenhouse Gas
Hz	Hertz
IESO	Independent Electricity System Operator
IoT	Internet of Things
kW	Kilowatt
kWh	Kilowatt-hour
MW	Megawatt
NERC	North American Electric Reliability Council
NIST	National Institute of Standards and Technology
NB	New Brunswick
NL	Newfoundland and Labrador
NRCan	Natural Resources Canada
OECD	Organisation for Economic Co-operation and Development
OpenADR	Open Automated Demand Response
PV	Photovoltaics
RC	Randomised Control

RDR	Residential Demand Response
RTBF	Right To Be Forgotten
ToU	Time of Use
TSO	Transmission System Operator
UK	United Kingdom
US	United States
VRE	Variable Renewable Energy
WEC	World Energy Council

1 INTRODUCTION

1.1 Context

All roads to net zero pass through electrification. A critical step in the fight against climate change is the transition from a fossil fuel-based economy to clean electricity. Canada has committed to achieving a net zero electricity grid by 2035 and a net zero economy by 2050. In the most recent report released by the Canadian Climate Change Institute, the transformation of the electricity system will revolve around three critical pillars: the Canadian electricity sector must become **bigger, cleaner** and **smarter** (Canadian Climate Institute, 2022).

Canada is an energy-rich nation and has built its economy around vast reserves of oil, natural gas, uranium, and freshwater. Canada's electricity mix is currently 83% non-emitting, with the majority generated from 61% hydroelectricity (IEA, 2022). Due to its abundant and diverse energy resources, the sector has been historically focused on increasing supply rather than controlling demand.

Despite its large share of low-carbon energy, Canada's energy intensity is relatively high compared to other G7 countries[1]. This energy intensity is due to several factors, including its location in a northern climate, abundance of energy, low population density, and extreme amounts of transportation. Canada adopted the enhanced Paris Agreement targets to reduce emissions by 40-45% from 2005 levels by 2030 (Government of Canada, 2022). However, **Canada is the only G7 country that has seen emissions rise since signing the Paris Agreement** (WEC, 2022).

[1] G7 is an inter-governmental political forum 'Group of Seven' including Canada, France, Germany, Italy, Japan, the United Kingdom and the United States (Government of Canada, 2022)

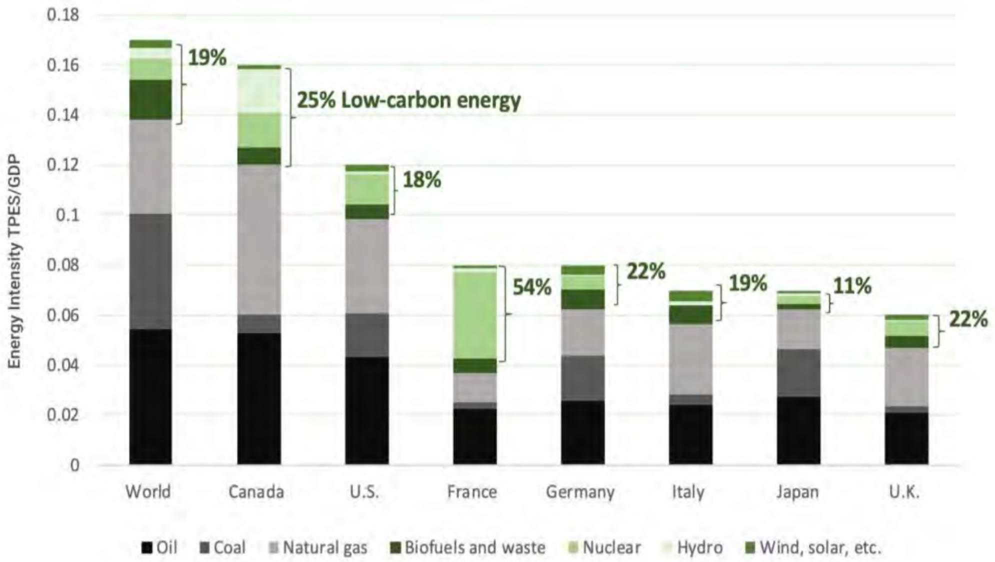


Figure 1-1: Energy Intensity of G7 Countries in 2018 (Canadian Climate Institute, 2022)

The energy transition will put increasing pressure on both supply and demand, as end-use sectors become electrified. This shift will pose many new challenges for traditional electricity grids. The energy transition is linked with an increasing share of variable renewable energy (VRE) such as wind and solar (IRENA, 2019). These generation sources are intermittent, meaning that they are not dispatchable and cannot be varied to match the demand. Therefore, a new solution is needed to deal with variable supply: **a flexible load**.

Demand Response (DR), also called load shifting, is a means of managing power consumption in response to grid conditions. The practice of DR enables the load to adapt to changes in the grid, such as an influx of energy from variable renewables. Unlocking demand-side flexibility will also lower peak load, which will delay infrastructure upgrades and reduce electricity generated in fossil fuel burning peaker plants.

Residential demand response (RDR) is still a relatively new and underdeveloped market in Canada. The **residential sector accounts for 40% of Canada's electricity consumption** and is a vastly **untapped resource** (Mordor Intelligence, 2021). Navigant Research estimates that RDR will more than triple by 2028. The graph below indicates that the majority of this capacity growth will be in North America (Walton, 2019).

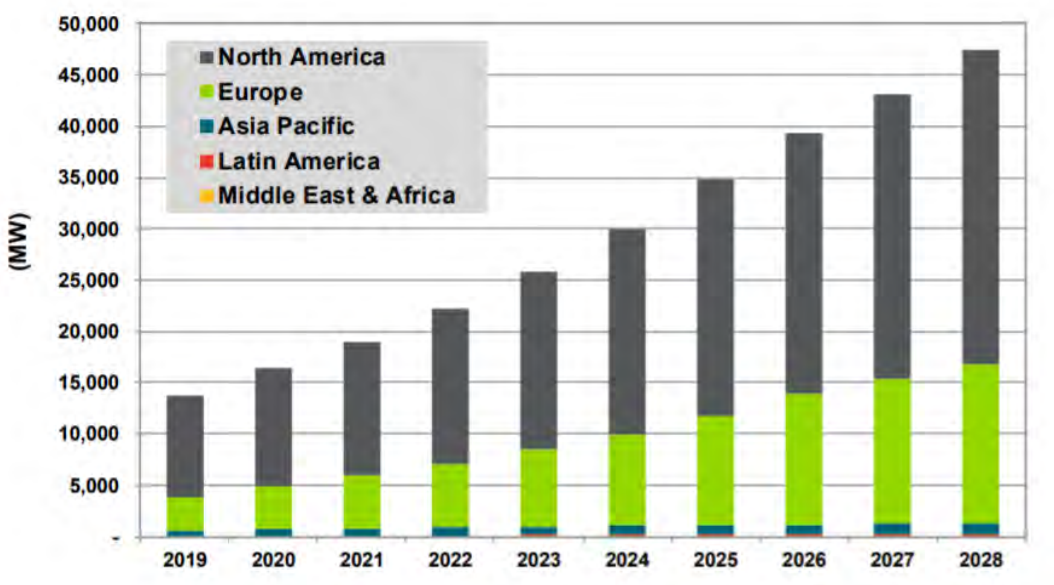


Figure 1-2: RDR Capacity Forecast by Region (Walton, 2019)

This thesis will tackle the question: **can Canada unlock demand side potential through residential demand response**?

1.2 Thesis Structure and Methodology

The balance of this chapter is dedicated to **why** widespread RDR should be deployed in Canada. It will set the scene with Canada's current electricity mix and market to understand the starting point on the road to net zero. It will discuss the existing RDR deployment and its potential. It will also unpack the benefits that RDR can provide to support the energy transition.

The second chapter will address **who** and **what** will drive RDR adoption in Canada. It will analyse the drivers with respect to the energy trilemma: energy security, environmental sustainability and energy equity. It will also discuss the key actors supporting or resisting RDR adoption in Canada based on their respective roles and motivation.

The third chapter examines the **key barriers** that must be addressed to foster widespread RDR deployment in Canada. It examines the social, technical and political challenges facing various actors across the country.

The fourth chapter will address **how** RDR can be adopted in Canada by introducing recommendations to address the key barriers. It will draw on lessons learned from case studies in other markets and countries.

The thesis research and analysis methodology is represented in Figure 1-3. It will apply a three-prong approach, combining interviews, a public survey and metadata research. The industry interviews and public survey bring a unique Canadian perspective to the study. This analysis will answer if and how Canada can unlock demand side potential through RDR.

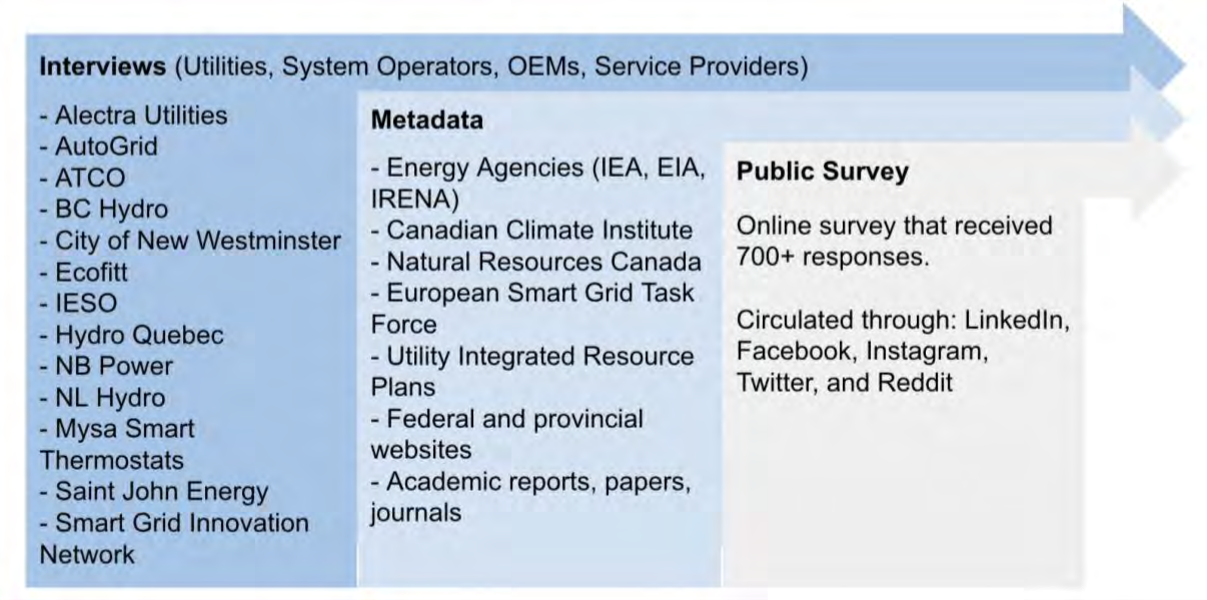


Figure 1-3: Thesis Research Methodology

1.3 Demand-Side Management

Demand-Side Management (DSM) refers to a broad series of tools designed to manage and optimise energy consumption from the consumer side. This can include energy efficiency measures and demand response (Kling, 2013).

Energy efficiency measures, such as insinuating buildings, reduce both the energy demand and peak load by lowering energy usage overall (Figure 1-4). Demand response (DR) focuses on shifting peak load to off-peak hours (Kling, 2013). Both approaches have a role to play in DSM and the energy transition.

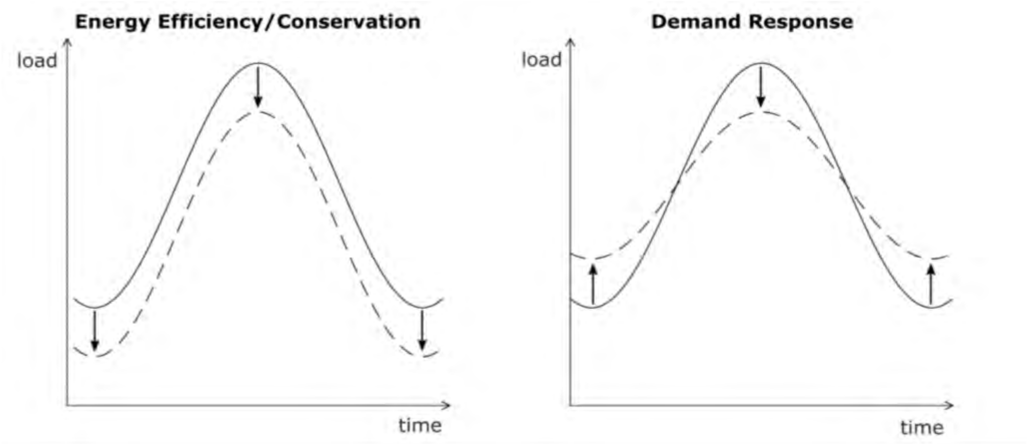


Figure 1-4: Energy Efficiency versus DR (Kling, 2013)

1.3.1 Demand Response

The main premise of DR is to influence the timing and magnitude of consumption to match energy supply to optimise generation cost. The concept of DR is not a new phenomenon and has been used in various forms for decades.

The most rudimentary form of DR is load shedding as a last resort to avoid a system blackout. The concept has evolved over time, and in the 1980s and 1990s, utility operators would call or page industrial customers, who would manually reduce their load when the grid was strained (Blanc et al., 2014).

DR can be further divided into Commercial and Industrial (C&I) DR and Residential DR (RDR). C&I DR involves curtailing larger loads, including factories, mills and warehouses. Traditionally utilities have worked with C&I to influence grid load because these customers consume large amounts of energy and can therefore have a greater impact on the grid by scaling back their consumption. C&I customers also generally have a greater understanding of their energy consumption and sometimes have their own backup generation on-site that can be called upon in emergency situations. The DR process has been traditionally triggered manually by calling, emailing, or texting C&I customers to curtail large amounts of power during peak times. This is the primary form of DR used in Canada today (SGIN, 2020).

Residential Demand Response (RDR) is focused on smaller loads that are at a household level. The challenge of RDR is that individual households do not have a large impact on the network. Therefore, in order to influence the grid, **tens of thousands of these residential loads across the network must be aggregated together.** This thesis will focus on the challenges facing RDR rollout.

1.3.2 Residential Demand Response

RDR can be further categorised into behavioural DR (BDR) and automated demand response (ADR). BDR can also be considered Price-Based DR in Figure 1-5 and includes mechanisms such as Time-of-use (ToU)[2], Critical Peak Pricing (CPP) and Real-Time Pricing (RTP). In these models, consumers manually adjust their energy consumption based on the price signals (Laitsos et al., 2021).

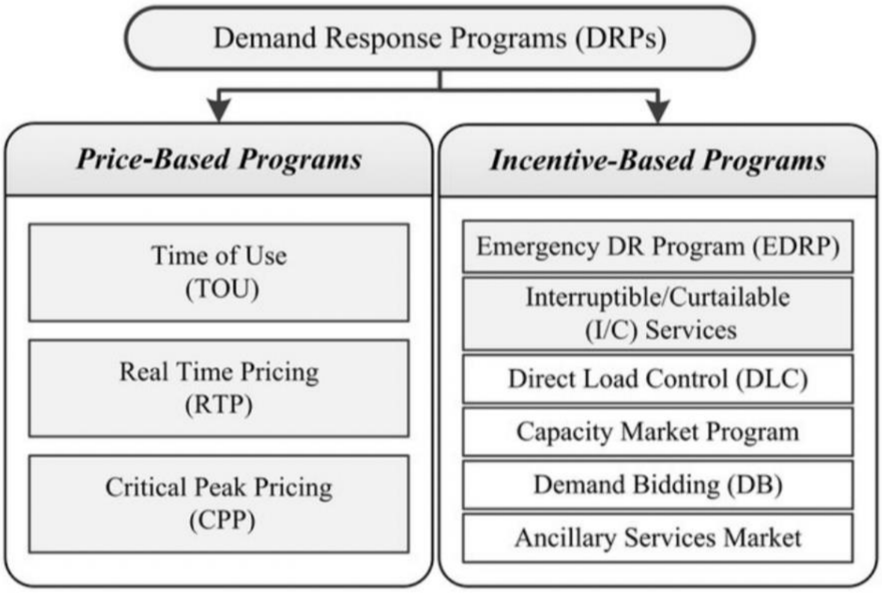


Figure 1-5: Categorization of DR programs (Laitsos et al., 2021)

ADR is an incentive-based 'hands-off' solution where consumers enrol smart home devices in a RDR program in exchange for an incentive. This incentive can include bill credit, gift cards, a draw or charity donation. In these ADR events, the loads can be automatically reduced using Direct Load Control (DLC) and then restored following the event window (Laitsos et al., 2021).

1.3.3 Benefits of RDR

Over the past two decades, interest in DR has grown exponentially. DR is **driven by both cost-efficiency and sustainability**. It can be a competitive alternative to battery storage and will be a key part of the energy transition puzzle. In their most recent report, the IEA identifies DR as a critical player in their energy scenarios and predicts that electricity system flexibility needs to rise by **two-thirds globally** over the next decade (IEA, 2021). Today, the electricity sector is undergoing a rapid technological transformation and entering a new era: the **age of the smart grid**.

[2] Further descriptions of all the types of DR programs can be found in Appendix 1.

In order to understand why Canada should harness demand side potential, the benefits of this technology must first be explored. RDR is another tool in the tool kit to help system operators to balance the grid by influencing demand. It makes the system more resilient and efficient by offering the following advantages discussed in this section.

1.3.3.1 *Peak Load Reduction*

Naturally, the load on an electricity network fluctuates based on the consumption pattern of the customers. The load profile varies regionally in response to climate, house construction, efficiency and habits. Generally, utilities are either summer or winter-peaking. Because Canada is a northern country with a high heating load, most utilities are winter-peaking, such as Hydro Québec (Figure 1-6). However, the province of Ontario is summer-peaking because the majority of the population is concentrated near the US border, where they experience hot summers and high air conditioning load (Figure 1-7).

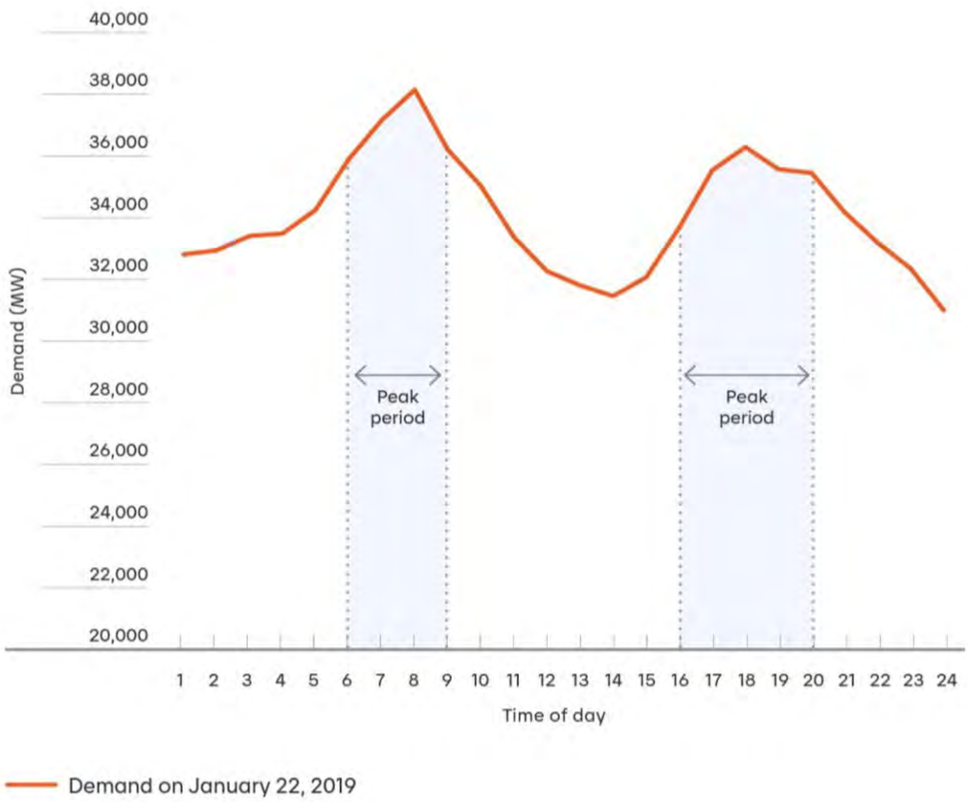


Figure 1-6: Hydro-Québec Peak load (Hydro-Québec, 2019)

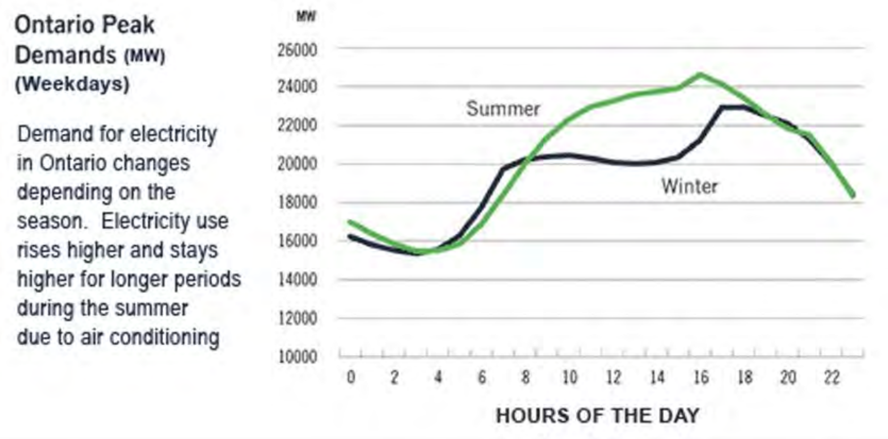


Figure 1-7:Ontario Peak Load (Faruqui et al., 2016)

Power systems must be designed with adequate capacity to supply peak load. However, peak demand periods only account for 5% of the yearly load. Therefore **20% of the installed generation capacity is only used for 18 days a year** (Lotfi et al., 2018). It is in a utility's interest to minimise the peak load in order to avoid expensive infrastructure investments and upgrades that are rarely utilised.

In a traditional system, the grid operators ramp up and down the generation to match the load. The supply and the load must always be in sync. In many systems, including some jurisdictions in Canada, the 'peak load' is met by burning fossil fuel in 'peaker plants[3]'. Minimising the energy usage during these hours reduces both the carbon intensity and price of this electricity. If peak load can be reduced through RDR, this results in **less electricity generated at peak times and less fuel burned in peaker plants**. This yields both **cost and emission savings** for utilities.

Lowering peak demand also lowers demand charges for distribution-only utilities that purchase electricity from suppliers. The demand charge rates and structures vary, but utilities such as Saint John Energy pay $15 a kilowatt(kW) for the highest peak energy usage each month (NB Power, 2022). Therefore, harnessing **RDR to lower this peak could result in significant demand charge savings.**

Reduction in peak load can also **increase capacity**. Capacity does not refer to actual electricity generation, but rather the ability to produce electricity when called upon by the

[3] Peaker plants are the last plants to be dispatched to meet electricity demand. They must be flexible to ramp up and down to balance load and are typically fossil fuel based (Wijesuriya, 2022).

system operator. Electricity markets must always be prepared to supply peak electricity demand. Therefore, they must have adequate generation capacity on reserve. RDR can increase capacity and thus reduce or differ infrastructure upgrades needed to meet peak load. It also gives utilities and operators more capacity and flexibility to buy and trade with neighbouring electricity markets.

The end result of decreasing peak load through RDR is a **more efficient, less overbuilt** and **less polluting** electricity network.

1.3.3.2 Frequency Regulation

The North American grid is a large machine, made of four regional "interconnections" (Figure 1-8). Within each interconnection, every generator in the system rotates in near steady-state synchronism. The speed of this rotation in North America is 60 Hertz(Hz), or 60 cycles-per-second. System operators and balancing authorities must ensure a real-time balance of supply and demand across the regional power network to keep the operating frequency stable at 60Hz (NERC, 2011).

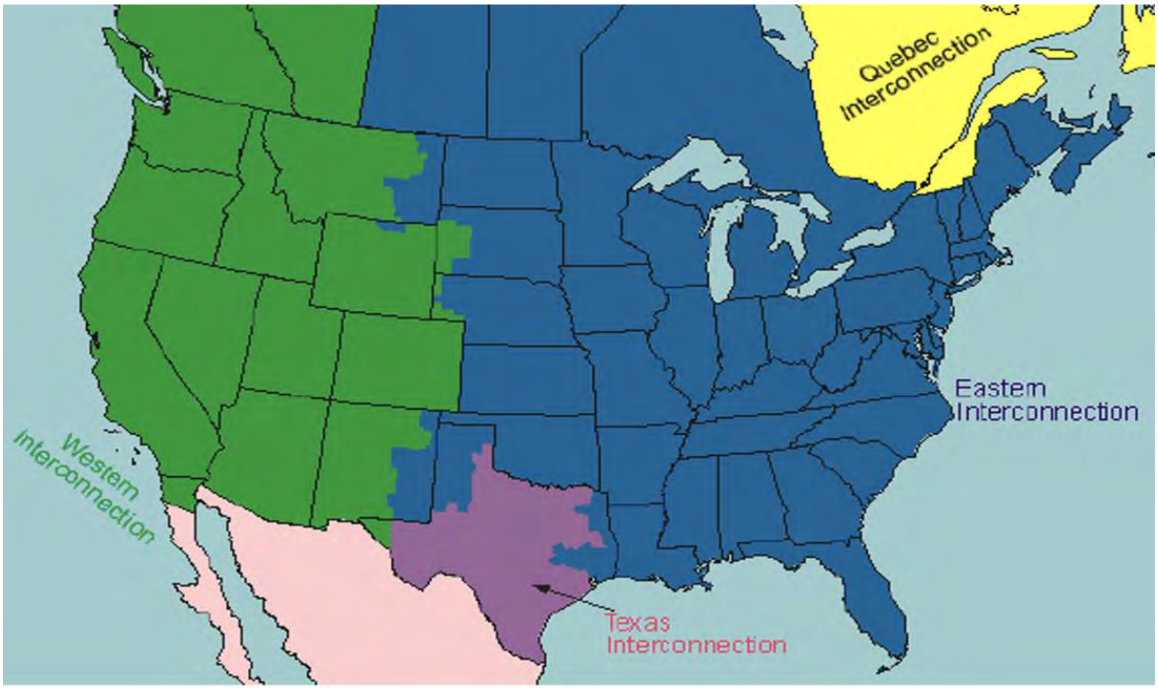


Figure 1-8: North American Interconnections (NERC, 2011)

Under normal operating conditions, the frequency only varies with a narrow window of approximately ± 0.05Hz[4]. If demand exceeds generation, the system frequency declines until it reaches equilibrium. Conversely, if generation is greater than demand, the frequency rises (Centrica, 2022).

Maintaining the system frequency will become an increasing challenge due to the rising share of VRE and the electrification of large loads, such as electric vehicles (EVs). **RDR can is a mechanism that can modify the load to match the supply to maintain frequency at 60Hz.**

Frequency regulation is typically the most lucrative overall DR program. However, this can be challenging for RDR because frequency regulation requires extensive market interaction and communication with the grid operator every 2-6 seconds (Centrica, 2022). Therefore, BDR programs are not capable of this level of communication and system response.

1.3.3.3 Voltage Regulation

Similar to frequency regulation, electricity system operators must ensure that the power is delivered within a defined voltage bandwidth[5]. If the system voltage goes over or under the operating limits, it can cause equipment damage.

One factor that influences voltage is generation, so if there is an excess of solar PV production in the middle of the day, it will cause the system voltage to rise. Another factor is load, so if many EVs are charging simultaneously, it will draw down the voltage. This push and pull effect is happening on the grids constantly as generation and loads switch on and off. RDR can be used to ease loads when the grid is high. This can be achieved through ADR or through an increased price per kilowatt-hour(kWh) during this time. When generation is high due to an influx of solar or wind, RDR can be used to automatically turn on appliances and store electricity in EV batteries or water tanks. The price can also be decreased to incentivise participants to use energy at high supply times with BDR.

---

[4] The operating frequency range depends on the interconnection. For example, the operating frequency in the Eastern Interconnection is between 59.95-60.05 Hz, Western Interconnection is 59.856-60.144 Hz.

[5] See Appendix 2 for the permissible voltage range set by the Canadian standards association.

1.3.3.4 Emergency Situations

During a system emergency, when reserve margins are low, it can be necessary for utilities to ration loads to avoid regional blackouts. RDR can be an important tool to help **reduce stress on electricity grids during times of unplanned outages or severe weather.** This could include extremely hot or cold snaps, transmission line outages or plant failure.

DR can help improve reliability by easing the inrush current when feeders come online after an outage. There was a six-day period of rolling blackouts in Newfoundland during January 2014, referred to as "DarkNL." During "DarkNL," when distribution lines would come back in service, all the neighbourhood loads such as heaters and hot water tanks would be brought back online simultaneously. This drew large inrush currents, which blew feeder fuses and tripped the distribution lines again (Kind, 2017). RDR can play an important role in staggering load to minimise inrush current during such emergency circumstances.

One example of successful DR implementation was during the same winter of 2014 in the Northeastern United States (US). Regions experienced a prolonged cold snap during the same period that 20% of power plants were offline. Customers reduced their electricity usage by 1,900 Megawatts(MW), which enabled the region to avoid a complete blackout (Panfil, 2014).

In summary, Canada should use RDR to harness the power of DSM in order to **reduce emissions, increase reliability and cost-efficiency.**

1.4 Canadian Energy Situation

In order to determine why Canada should unlock demand side potential using RDR, it is essential to first understand Canada's energy landscape and legacy. Each country faces unique decarbonization challenges based on its natural resources, existing infrastructure, market structure and government. This section aims to provide context to Canada's starting point on the road to net zero.

1.4.1 Canadian Energy Mix

Canada is an energy-rich nation, and it has built its economy around abundant reserves of oil, natural gas, uranium and freshwater. Canada is a net energy exporter and was the fourth-largest petroleum producer in 2018 (EIA, 2019).

Canada's energy intensity is relatively high compared to other industrialised economies. As can be seen in Figure 1-9, its economy is powered by petroleum, natural gas and hydroelectricity (EIA, 2019).

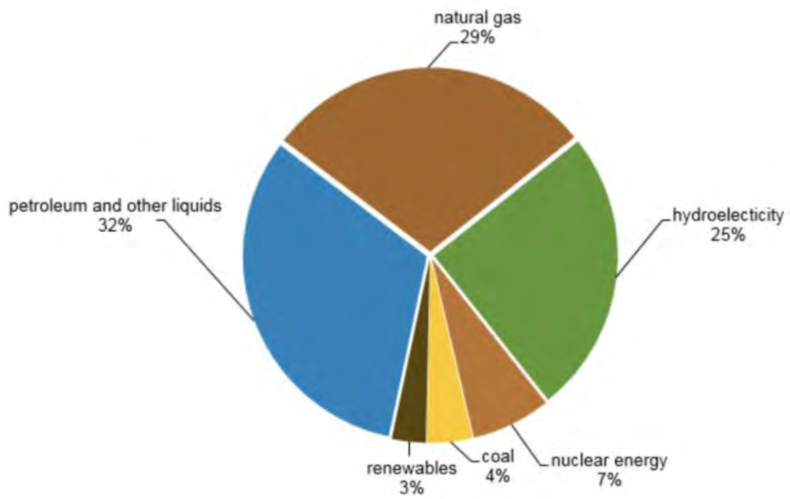


Figure 1-9: Canada primary energy consumption 2019 (EIA, 2019)

1.4.2 Canadian Electricity Mix

Canada has an abundance of rivers and mountainous regions that have led to the development of large hydroelectric plants. This generation type is both flexible and dispatchable, and it has one key advantage that variable renewables lack: **the capacity to store energy**. It achieves this by storing water as potential energy in the dams. This energy storage is extremely valuable in a net zero world (Canadian Climate Institute, 2022).

Hydroelectricity has helped make Canada's electricity system among the cleanest in the world. In 2020, 83% of Canada's electricity was generated by non-emitting sources, with 61% coming from hydroelectric generation (IEA, 2022). Canada has a significant presence of hydropower and nuclear generation in its electricity mix, which is an extremely valuable source of firm, predictable, non-emitting electricity (Figure 1-10).

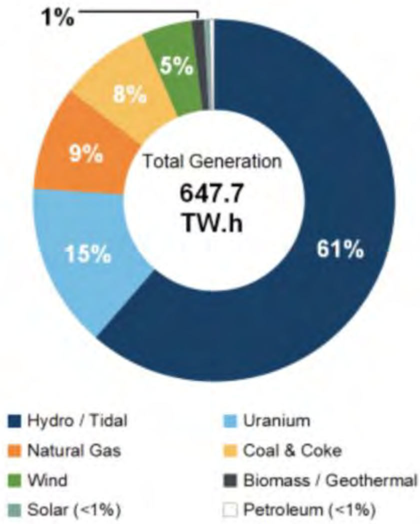


Figure 1-10: Electricity Generation Mix 2018 (Canada Energy Regulator, 2022)

Due to the high share of non-emitting generation, Canada's electricity sector accounts for only 10% of national greenhouse (GHG) emissions, compared to an average of 26% in other advanced economies (IEA, 2022). Overall, Canada's electricity system is at a strong starting point on the road to net zero. However, the generation mix varies greatly by province and territory (Figure 1-11). Provinces that are not hydropower-rich will face more challenges in decarbonizing their grids.

1.4.3 Canadian Electricity Regulation and Market Structure

The electricity regulation is relatively decentralised in Canada, with no central governing authority. The federal government sets national carbon reduction targets such as phasing out coal generation by 2030 and net zero electricity grid by 2035. It also holds authority over nuclear generation, inter-provincial transmission and electricity exports. However, under Canada's Constitution, each province is responsible for regulating electricity generation, transmission, and distribution within its borders (Christian et al., 2020). Therefore, the electricity mix, tariffs, and market structure vary based on province and territory.

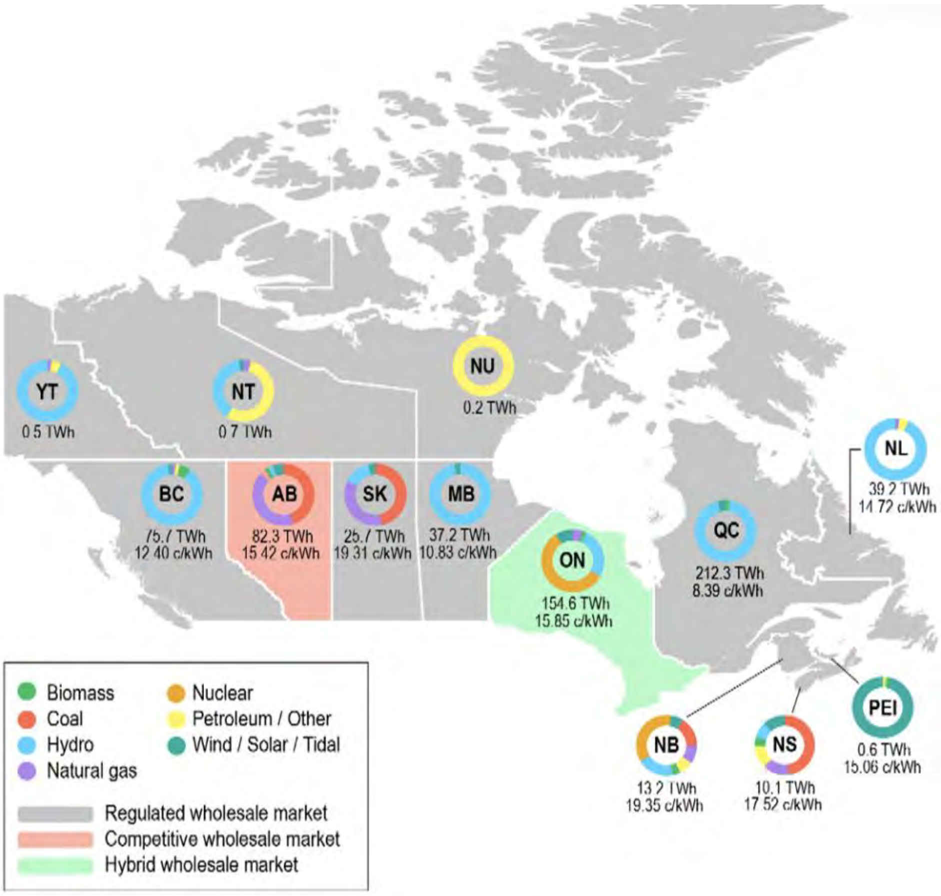


Figure 1-11: Market structure and electricity mix by province / territory (IEA, 2022)

A significant characteristic of the provincial energy markets in Canada is the degree to which the main utility service providers are owned by their respective provincial governments. As can be observed in Figure 1-11, the majority of the electricity system in Canada operates in a regulated wholesale market.

Historically, the electricity systems in most provinces were run by vertically integrated crown corporations owned by their respective provincial governments. This history has shaped the current electricity landscape in Canada. It can be seen in Table 1 that crown corporations still play a dominant role in most Canadian jurisdictions. The primary benefit of government ownership is greater control over the sector and associated policies. This means that specifically in provinces with crown corporations, **politics and the electricity sector are intrinsically linked.**

Table 1: Canadian electricity market structure and ownership by province / territory (Canadian Climate Institute, 2022)

Type of Electricity Market	Ownership (Generation, Transmission, Distribution, system operation, distribution, and retail)	Province / Territory
Vertically integrated market Little wholesale and retail competition	Mainly **crown corporations** Some independent power producers (IPPs), municipal and private distribution companies	British Columbia, Saskatchewan, Manitoba, Quebec, New Brunswick, Nunavut
	Both crown corporations and private companies	Newfoundland and Labrador, the Northwest Territories, Yukon
	Mainly **private companies**	Nova Scotia, Prince Edward Island
Competitive wholesale market Transmission and distribution systems remain fully regulated	Private companies and municipalities Alberta Electric System Operator (AESO) (Transmission system operator)	Alberta
Hybrid wholesale market Nuclear and hydroelectric generation are rate-regulated	Crown corporations, private companies and municipalities. Ontario's Independent Electricity System Operator (IESO) (Transmission system operator)	Ontario

Since the majority of the Canadian electricity market is vertically integrated, RDR deployment will hinge on the direct adoption of the technology by utility companies. This is contrary to what is seen in open markets, where RDR providers and aggregators can bid directly into the capacity market and bypass utilities.

Only two Canadian provinces, Ontario and Alberta, have gone through some level of unbundling within their electricity sectors. There is currently little political will to undertake further market restructuring in other provinces. This lack of political will is due to low-priced electricity, coupled with the problems encountered when restructuring the markets in Alberta and Ontario (Trebilcock & Hrab, 2006, 419).

In Ontario, the Independent Electricity System Operator (IESO) oversees electricity transmission and holds a capacity auction twice a year. Any energy providers, including DR aggregators, can bid for a place in the merit order (IESO, 2022).

In Alberta, transmission and distribution functions are regulated, while there is a competitive market for electricity generation (IEA, 2022). In 2016, the Alberta Electric System Operator (AESO) announced that they planned to implement a capacity market that would come online in 2021. However, they revoked this decision in 2019, and the Alberta market remains an energy-only market (Howard, 2019). Therefore, DR providers are excluded from participating in the Albertan wholesale market.

1.4.4 Price of Electricity

Hydroelectricity is cheap to produce due to low marginal costs because the fuel(water) is free. It holds a 61% share of the electricity mix in Canada, which drives the average cost of electricity rates down (IEA, 2022). Figure 1-12 compares electricity prices across Organisation for Economic Co-operation and Development (OECD) countries, and it can be seen that Canada's electricity rates are extremely competitive.

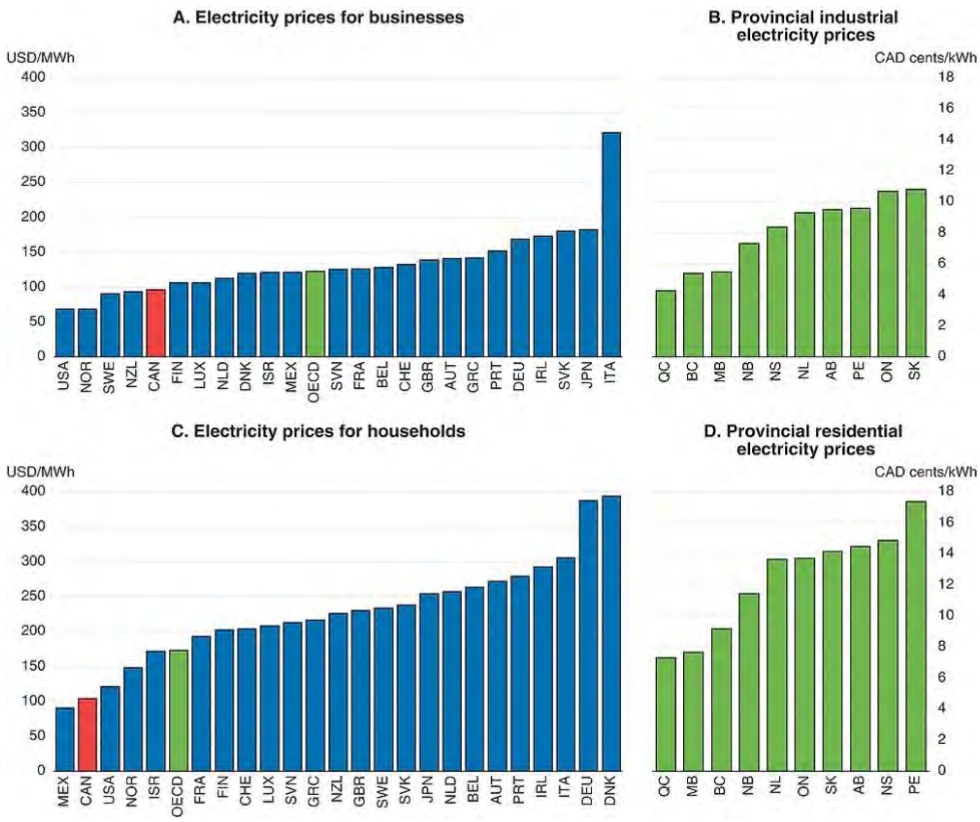


Figure 1-12: OECD household electricity prices in 2013 (OECD, 2016)

The Canadian electricity rates vary across the country because they are regulated on a provincial and territorial level. Québec has the cheapest electricity rates in North America at 7.3 cents a kWh due to the abundance of hydroelectricity (Urban, 2020).

This section shows that Canada is starting at a strong position when facing the decarbonisation of its electricity sector. However, the electricity sector in Canada varies largely between provinces and territories. Each region has a unique generation mix, market structure and tariffs. Therefore, each province will face its own unique challenges on the path to net zero, and some regions will have a higher potential for RDR adoption.

1.5 RDR in Canada

RDR is still a relatively new and underdeveloped market in Canada. The residential sector accounts for 40% of Canada's electricity consumption and is a largely untapped resource (Mordor Intelligence, 2021). This section will discuss the current status of RDR development and its potential across Canada.

1.5.1 Current RDR in Canada Overview

Canada has made steps towards modernising its grid with a series of smart grid applications, as seen in Figure 1-13. 82% of the electricity metres in Canada are classified as "smart metres" (NRCan, 2018). Smart metres are important enabling infrastructure for RDR in order monitor the timing and consumption of energy to gauge a DR events success. There have been some DR developments, but mainly in the C&I sector. Figure 1-14 illustrates Ontario peak load reduction using C&I DR.

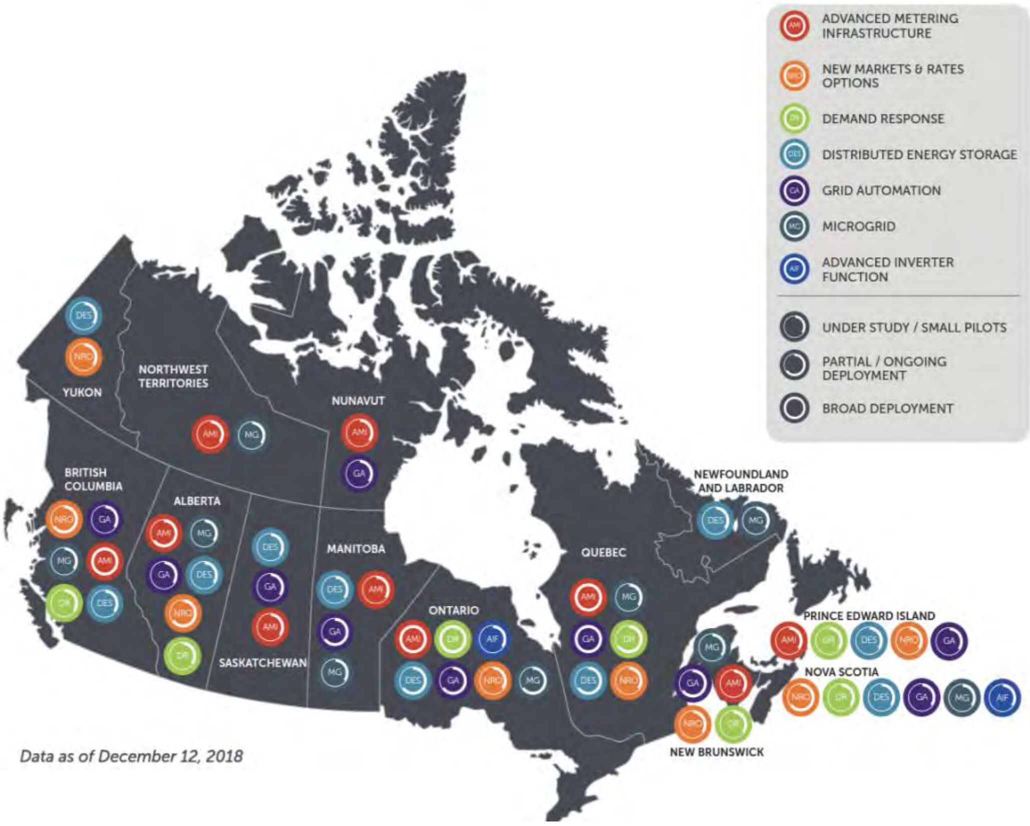


Figure 1-13: Smart grid deployment across Canada (NRCan, 2018)

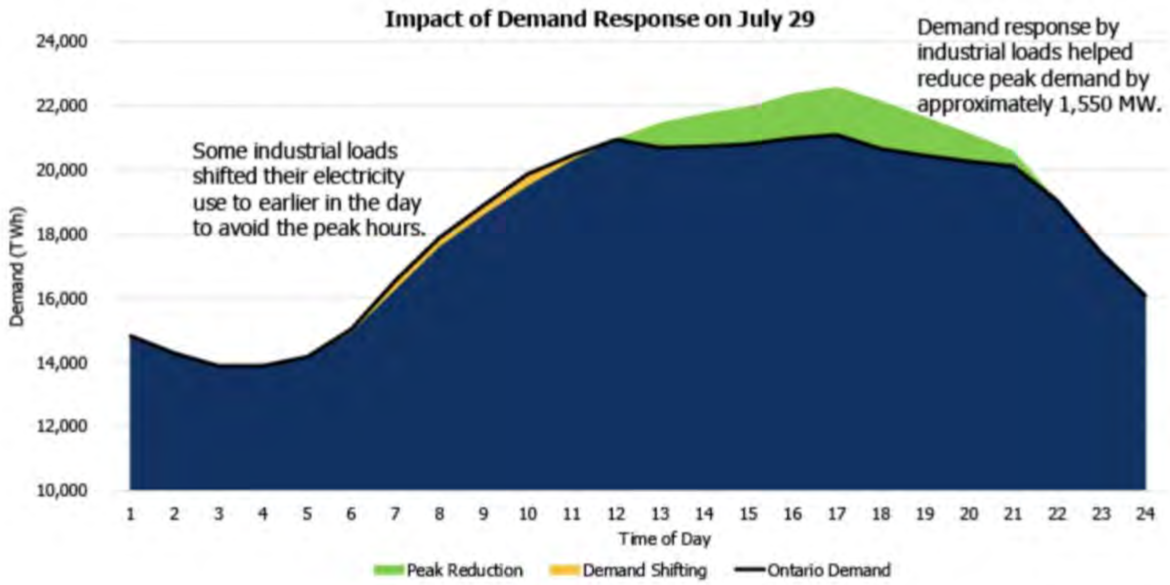


Figure 1-14: Ontario C&I DR Event (IESO, 2019)

In Canada, behavioural RDR has been deployed in two provinces, Ontario and Québec. Ontario currently offers a ToU rate structure, and Hydro-Québec implemented an optional dynamic pricing scheme[6]. The Hydro-Québec Dynamic Pricing Program has been operating

[6] For more information on Ontario and Hydro Québec rates and participation, please refer to Appendix 3.

for three heating seasons. Over the past 2021-2022 winter heating season, 157,000 customers enrolled and reduced consumption by 157MW per peak demand event (Hydro-Québec, 2022). However, ADR still primarily in the experimental and pilot phase across Canada[7].

1.5.2 Projected Load Growth

In the evolving policies scenario, Canadian electricity demand is predicted to grow 44% from 2021 to 2050 (CER, 2022). This load increase is largely attributed to the generation of hydrogen and the electrification of transportation (Figure 1-15).

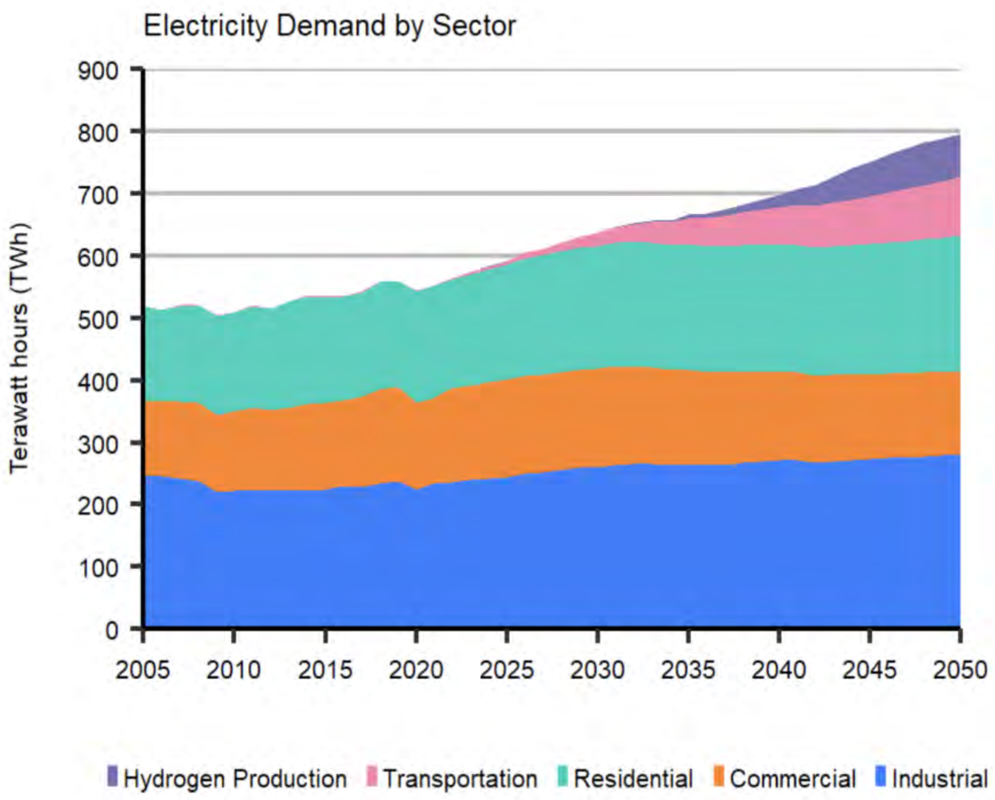


Figure 1-15: Canadian electricity demand forecast using the Evolving Policies Scenario (CER, 2022)

Utilities are examining alternate solutions to plan for the phaseout of coal-fired power plants and increasing electricity demand, including DSM. When reviewing the provincial integrated resource plans, BC Hydro plans to use DR programs to reach "220MW of capacity savings at the system level by fiscal 2030" (BC Hydro, 2021).

[7] For further information on smart grid deployment in Canada, please see Appendix 4.

1.5.3 RDR Potential

Natural Resources Canada (NRCan) classifies residential electric loads into five main end-use categories: space heating, space cooling, water heating, lighting, and appliances. The appliance and lighting categories were found to be poor candidates for RDR due to ensuring user comfort (Wong, 2015).

In 2015, NRCan evaluated the potential for RDR across its provinces. The results can be seen in Table 3. The research shows that the highest RDR potential is located in the largest provinces of Ontario and Québec (Wong, 2015).

Table 2: Electric end-use load attributes by province (Wong, 2015)

		BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	Total
Space Heating	Peak Load (GW)	3.6	0.58	0.25	1.2	6.1	13	1.1	0.68	0.02	0.93	27
	Thermal Storage Capacity (GWh)	7.2	1.2	4.9	2.4	12	25	2.2	1.4	0.05	1.9	58
Space Cooling	No. Homes with Central AC (k)	198	221	194	271	3110	524	52	18.0	0.5	4.8	4593
Water Heating	Peak Load (GW)	0.73	0.12	0.08	0.27	1.3	3.6	3.3	2.3	0.01	0.23	12
	Thermal Storage Capacity (GWh)	2.8	0.46	0.30	1.0	5.2	14	1.3	0.91	0.05	0.88	27

RDR has the potential to play a key role in the energy transition and the future of the Canadian grid. Each province will face unique challenges and opportunities based on its respective geography, load, existing infrastructure and energy mix.

Currently the residential sector accounts for 40% of Canada's electricity consumption, and residential loads will increase as end-use sectors become electrified (Mordor Intelligence, 2021). Electricity accounts for 23% of household energy consumption today, and this is predicted to grow to 96% by 2050 (Canadian Climate Institute, 2022). Therefore, **residential customers are going to have a larger impact on the net zero electricity grid,** which will prove to be a driver for RDR adoption. This driver along with others, will be discussed in Chapter 2.

2 DRIVERS OF RESIDENTIAL DEMAND RESPONSE ADOPTION

The purpose of this chapter is to understand **what** and **who** will drive and push widespread RDR adoption in Canada. Examining the drivers will also give insight as to why the current RDR market in Canada is underdeveloped compared to other countries. This chapter will also analyse the complex relationship between each driver and actors within each driver to determine if Canada can unlock DSM through RDR.

The need for DR has been driven by sustainability (environmental and socioeconomic), energy security and cost-efficiency. Therefore, the drivers will be analysed in the context of the energy trilemma index. The energy trilemma index is a means to evaluate a country's energy performance based on balancing three pillars: energy security, environmental sustainability and energy equity. **Energy security** refers to the nation's capacity to meet current and future energy demand. **Environmental sustainability** examines the country's ability to mitigate and avoid environmental and climate change impacts. **Energy equity** refers to the nation's capacity to provide universal access to reliable, affordable energy for domestic and commercial use (WEC, 2022).

Canada has consistently maintained a strong position in the top 10 countries categorised by the World Energy Council (WEC) energy trilemma index ranking. As can be seen in Figure 2-1, Canada scores an overall grade of A in the energy equity and energy security categories. Its weakest ranking is in environmental sustainability (WEC, 2022). The drivers to push RDR adoption in Canada will fall under these three broad categories.

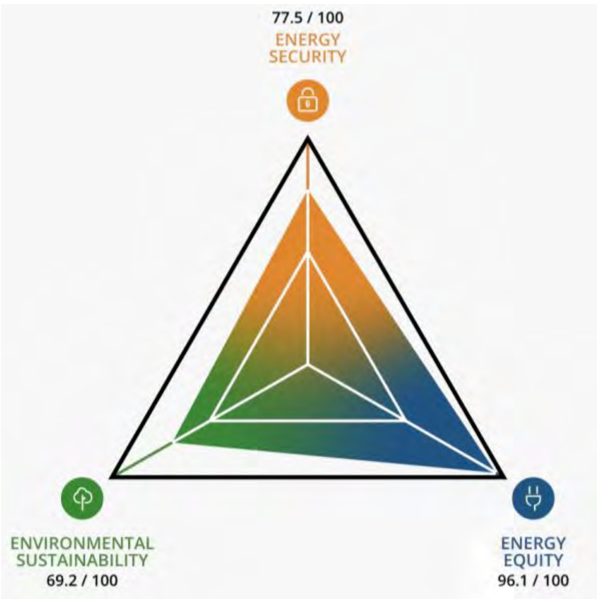


Figure 2-1: Canada's 2021 Energy Trilemma rating (WEC, 2022)

2.1 Residential Demand Response Actors

Before discussing the drivers of RDR adoption, it is important to understand the actors in the Canadian electricity sector and how they interact. The electricity network is the largest interconnected machine in North America. RDR will require the communication, coordination, cooperation and support of various actors to integrate this technology into homes and grids across Canada (Figure 2-2).

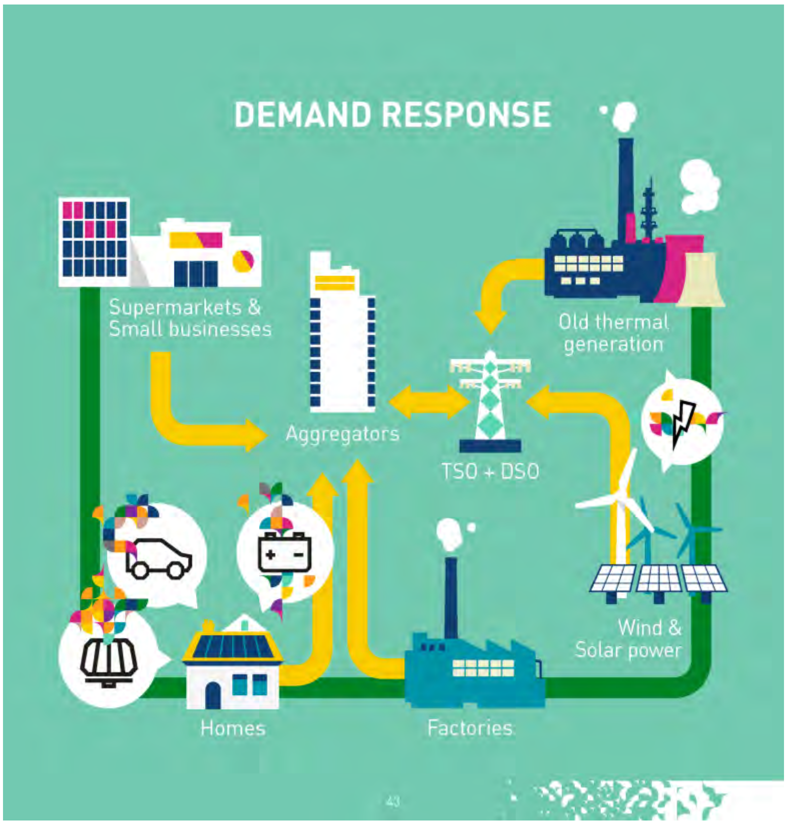


Figure 2-2: Demand Response Players (Decarb Europe, n.d.)

Some actors support RDR adoption, while others tend to resist based on their motivation. Technology providers and aggregators are pushing for RDR adoption, while regulators and utilities are resistant to non-wires alternatives. They hold traditional mindsets and have been conditioned to be conservative and risk averse. In the wake of the climate crisis, governments know that they need to meet climate targets, but their policies are lacking. This complicated relationship is summarised in Table 3.

Table 3: RDR in Canada Stakeholder Mapping

Stakeholder	**Role** *Actions that stakeholder will take to enable RDR adoption in Canada*	**Motivation** *Why the stakeholder will take the actions. What they want to accomplish.*	**Influence** *The degree to which stakeholder can influence RDR adoption in Canada*	**Resistance or Support** *Does stakeholder currently support or resist RDR*
Residential consumers	Purchase and install DR capable devices or appliances. Enrol in DR programs.	Save money through program incentives. Sense of environmental duty and reducing carbon footprint	High - customer participation and acceptance is essential to RDR programs.	Both - Early adopters support DR programs, but the general public lacks understanding
Aggregators	Aggregate different types of loads and work with utilities to offer DR programs. Bid directly into an open electricity market with aggregated load.	Increase total load under control. Make money from connection fees from utilities or through winning load in the capacity market.	Moderate - must gain the trust of the utility companies and facilitate RDR.	Support
Technology providers	Create smart technology that is DR compatible. Integrate with aggregators, or work directly with utilities.	Sell more units. Create recurring revenue through RDR device connection fee	Moderate	Support
Utilities	Create and roll out RDR programs in regulated monopolies. Administer rebates and incentives. Work with aggregators to provide smart metre data in some liberalised markets.	Deliver reliable, low cost energy. Reduce carbon emissions. Integrate variable renewables. Reduce demand charges (Distribution-only utilities) Maintain public image.	Extremely High- especially in regulated monopolies	Resist - Canadian utilities are implementing RDR pilots but are wary of large scale deployment.

System Operators	Create framework and regulations for RDR providers to bid into the market.	Provide the lowest cost reliable power. Ensure that demand is met with supply. Manage transmission and / or distribution system networks.	High - in liberalised markets.	Both - IESO has an open capacity market that allows aggregators to participate
Federal Government	Set overall nation-wide carbon reduction targets. Provide funding for rebates and incentives. Authority over nuclear generation, inter-provincial transmission and electricity exports. Provide funding for research and projects	Reach net-zero by 2050. Phase out coal generation by 2030. Net zero electricity sector by 2035 Maintain public image and get reelected.	Moderate - must gain the trust of the utilities and the customer to facilitate RDR.	Both
Provincial Government	Create policies to reduce emissions to meet national targets. Provide funding for rebates and incentives. Regulate the electricity sector. Oversee crown corporations.	Reduce emissions in line with national targets. Get reelected.	Extremely High - especially where the utilities are crown corporations	Both
Banks / Private investors	Invest, fund and scale RDR deployment	Make profit on investment	Moderate	Both - Depending on the business case.
Canada's Energy and Utility Regulators (CAMPUT)	Regulate electric monopolies. Responsible for approving and approving electricity and fuel rates.	Ensure that utilities have planned adequately to supply future load growth. Ensure that the consumers are paying fair energy prices	Extremely High - must be convinced to approve RDR programs	Resist - Risk averse, slow to act.

North American Electric Reliability Corporation (NERC) Demand Response Availability Data System Working Group (DADSWG) (2008)	Develop and enforce reliability standards in the North American Grid Annually assess seasonal and long-term reliability. **Information Sharing** Collect demand response enrollment and event information. Measure performance, release reports and recommendations for demand response. (NERC, 2022)	Ensure the reliability and security of the North American Grid.	High - Can influence utilities by knowledge sharing. Enforces reliability standards that can include RDR as a source of reliability.	Support

There are three common themes amongst the motivations and objectives of various actors: environmental sustainability, energy security and energy equity. These three parameters of the energy trilemma provide a framework to analyse the drivers for RDR adoption in Canada. Understanding the drivers forms a basis to determine if Canada can unlock DSM through RDR.

2.2 Environmental Sustainability

Environmental sustainability is the weakest grade in Canada's WEC energy trilemma ranking, receiving a 69.2. The Canadian sustainability ranking has been declining since 2009 and fell another 2 points in 2021 (WEC, 2022).

Along with many other countries, Canada has committed to achieving a net zero economy by 2050. Canada has also adopted the enhanced Paris Agreement targets to reduce emissions by 40-45% from 2005 levels by 2030 (Government of Canada, 2022). However, **Canada is the only G7 country that has seen emissions rise since signing the Paris Agreement** (WEC, 2022). This evidence highlights Canada's need for **more aggressive and effective decarbonization policies** to meet its climate targets. This section will examine how moving towards net zero will drive RDR adoption in Canada.

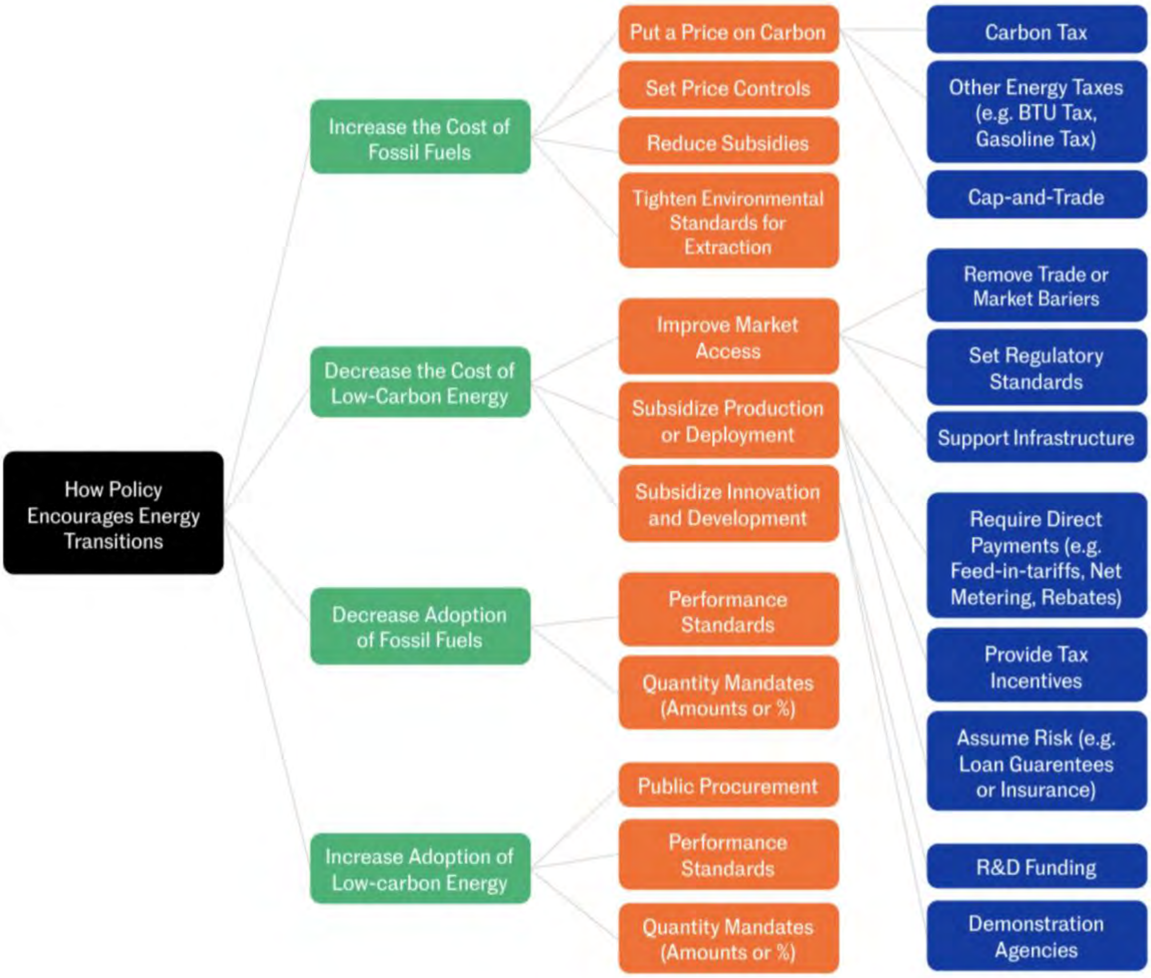
2.2.1 Decarbonization Policies

The first step to decarbonizing the economy is decarbonizing the electricity sector. Canada's federal government has set national mandates to phase out coal fired power plants by 2030 and remaining fossil fuel generation by 2035 to meet its net zero 2035 electricity sector target (Canadian Climate Institute, 2022).

These national mandates and commitments are passed down to provincial governments to implement and design policies. Jurisdiction over the electricity sector is mostly held by the provinces and territories. However, the federal government does hold some authority over certain aspects of the electricity sector, such as nuclear generation, electricity exports and inter-provincial transmission. The federal government also has significant influence over environmental performance, and uses tools such as taxation, emissions performance standards and carbon pricing (IEA, 2022).

This multi-level governance has brought challenges such as a lack of coordination and policy gaps between short and long-term goals. The most recent report by the Canadian Climate Institute highlighted that **provincial and territorial policies are not sufficient to meet the federal net zero target** (Canadian Climate Institute, 2022).

It is up to provinces (and territories) to design policies to achieve a net zero electricity sector by 2035. These policies can include carbon taxes, feed-in-tariffs, rebates, incentives, building codes and standards. The tools, policies and mechanisms that governments use to foster the energy translation are represented in Figure 2-3.



Source: *School of sustainability, Arizona State University*[8]

Figure 2-3: How policy encourages energy transition (NRCan, 2020)

2.2.2 Increased Share of Variable Renewables

There are three main reasons governments and utilities are integrating VRE into their grids. The first is to decarbonize the economy (environmental sustainability), the second is to reduce reliance on energy imports (energy security), and the third is to take advantage of low generation costs (energy equity) (IRENA, 2021). Therefore, variable renewable generation affects all three pillars of the energy trilemma.

Canada's potential for meeting domestic electricity needs with solar and wind power is among the highest in the world. This is mainly attributed to the fact that it is the second-largest country by landmass (Canadian Climate Institute, 2022). The breakdown of the VRE potential in Canada can be viewed in Figure 2-4.

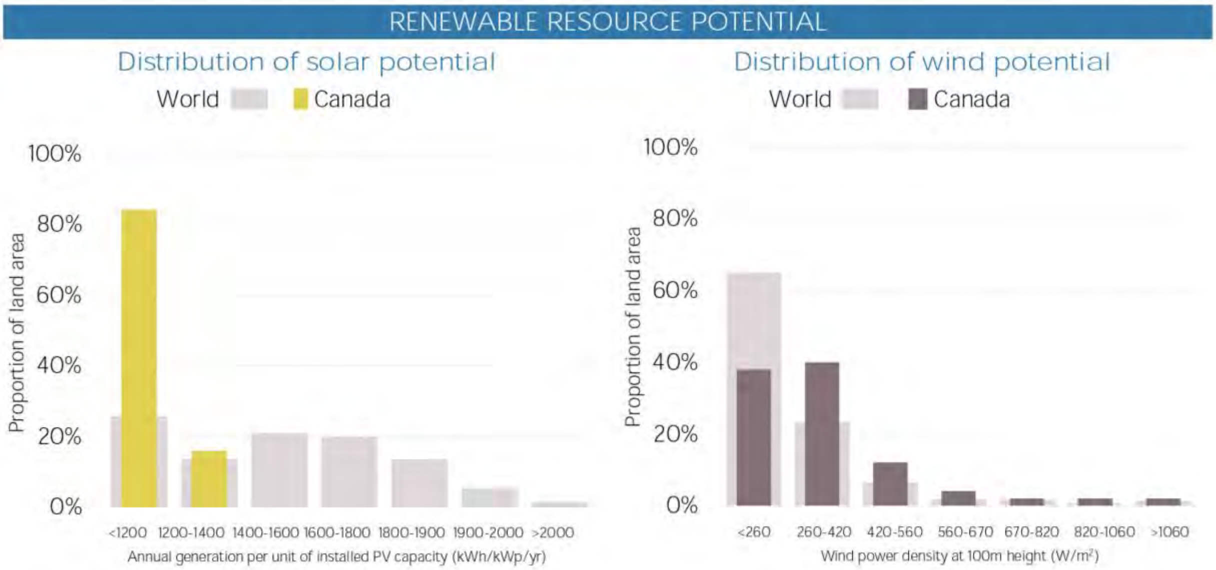


Figure 2-4: Canada's Renewable Resource Potential (IRENA, 2021)

Today, VRE only accounts for only 6% of Canada's electricity mix. However, by 2050, wind and solar could generate **31-75% of Canada's electricity** (Canadian Climate Institute, 2022). The range of possible future energy mixes based on multiple scenarios is shown in Figure 2-5.

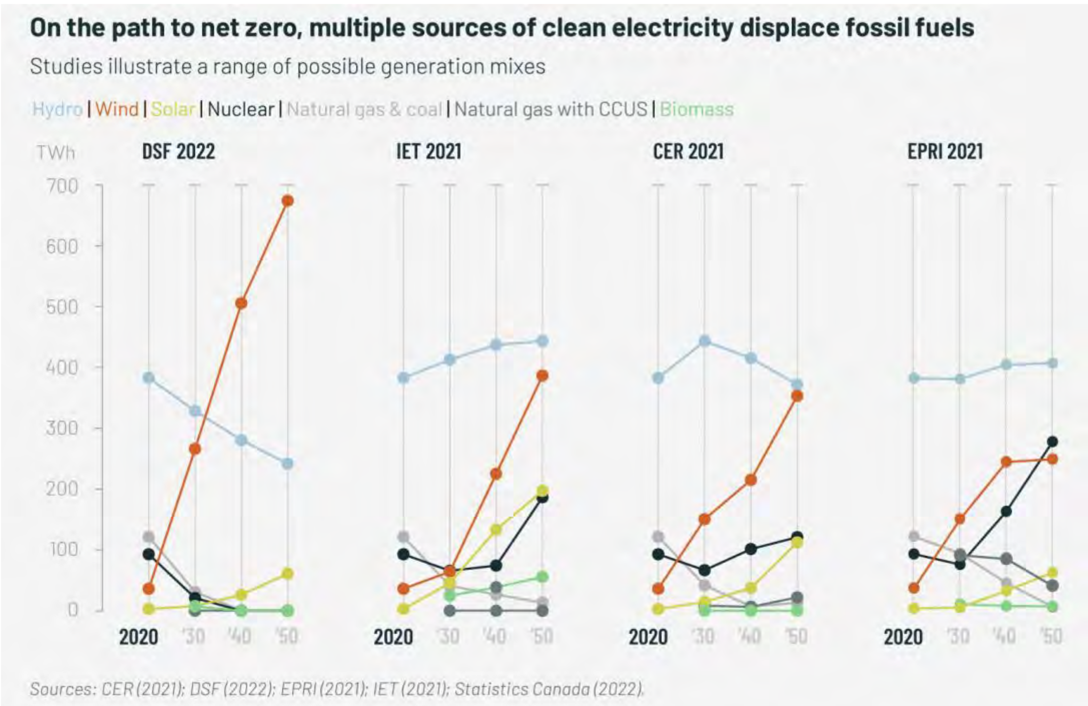


Figure 2-5: Possible generation mixes in Canada[8] (Canadian Climate Institute, 2022)

[8] Modelling Studies: DSF (David Suzuki Foundation), IET (Institut d l'Énergie Trottier), CER (Canada Energy Regulator), EPRI (Electric Power Research Institute)

One of the key challenges of integrating VRE is that it is not dispatchable. This poses many challenges to the traditional electricity network that has been designed around flexible generation. Variable renewables introduce energy storage challenges, in addition to voltage and frequency regulation. RDR offers a flexible load to help balance the grid; thus, **an increasing share of variable renewables drives RDR adoption in Canada**.

2.2.3 Electrification of End-Use Sectors

The path to decarbonization is through electrification. Therefore, the share of natural gas and gasoline in the energy mix will steadily decrease between now and 2050 (Figure 2-6). The Canadian Climate Change Institute estimates **that by 2050 Canada's electricity grid will have to expand 2.2 to 3.4 times larger** than it is today to support this mass electrification (Canadian Climate Institute, 2022).

As the demand for electricity increases, this will put increasing pressure on the grids to be larger and more flexible. There are multiple end-uses that will be electrified, but this section focuses on two of the biggest residential consumers of energy in Canada: **heating and transport.**

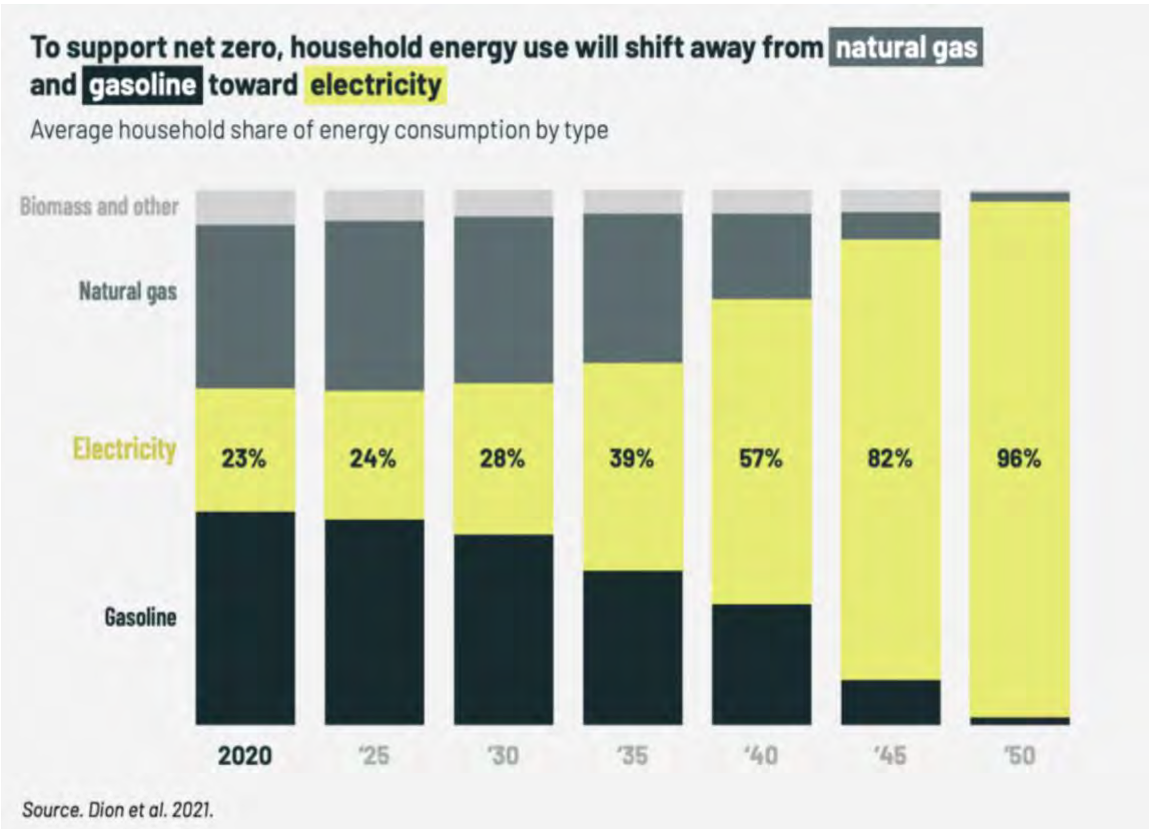


Figure 2-6: Household energy consumption (Canadian Climate Institute, 2022)

2.2.3.1 Electrification of Transport

Transportation accounts for roughly 25% of GHG emissions in Canada, and almost half of these emissions come from passenger vehicles. This is why the federal government set a mandatory target for all new passenger vehicle sales to be electric by 2035 (Government of Canada, 2022).

It can be argued that the electrification of transport will be the single largest driver for RDR in Canada because it encompasses many of the drivers mentioned in this section. The electrification of the transport will increase the demand for electricity and therefore threaten **energy security.** To compensate for this drastic increase in demand there will be an **increased share of VRE**. The electrification of transport will primarily be driven by national and provincial **decarbonisation policies**, including mandates and subsidies. It will also be driven by **increasing fuel prices** and carbon tax. Electrification of transport is also a huge driver because only a small fraction (0.68%) of passenger vehicles on the road in Canada are currently electric (PwC, 2020). Therefore, **the electrification of transport will essentially be a complete transition.**

The significance of EV adoption has been recognized by utilities around the world as the biggest challenge to the traditional grid. It will need to be facilitated through supporting infrastructure, such as charging stations and upgraded distribution equipment. The demand for electricity will increase exponentially, and this load will not be stationary. It will move from one location to another, drawing large amounts of power. This moving load presents a challenge but also a significant opportunity to store excess electricity in car batteries, then feed it back to the grid when needed. This technology is referred to as “vehicle-to-grid” and has been implemented in countries such as Denmark, Japan, France, the UK and the US (Rhythm Team, 2021). A recent study found that coordinating EV charging in Alberta could avoid 1050 MW of capacity in 2031 (Canadian Climate Institute, 2022).

Renee Smith, NL Hydro Resource and Production Planning Manager, recognizes that the **electrification of transport will be the largest driving factor of RDR adoption** in Newfoundland and Labrador’s grid. A Hydro-Québec representative echoed a similar statement during interviews.

2.2.3.2 *Electrification of Heating*

In Canada, 61% of total residential energy is consumed by heating (Figure 2-7). Of this, 61%, 68% of water heating and 47% of space heating is created by burning natural gas (NRC, 2019). In order to achieve decarbonization, the residential customers must join the energy transition and replace their heating sources with electrified appliances. This transition can be aided by programs and policies offered by utilities, federal and provincial governments.

Increased electricity demand due to the electrification of heating will have similar effects to the electrification of transport. This increased demand will threaten energy security, which will drive the installation of more VRE, which in turn will require a greater load flexibility to balance the grid. Similar to EVs, the control of heating not only offers the opportunity to shed load but also to store energy through DR. This is done in the form of thermal storage rather than electric storage. In the US, hundreds of thousands of radio-controlled load switches on hot water tanks have been used as a grid resource for over thirty years (Accenture, 2017). However, until recently, they have only been used to shed load. There are several pilots testing load shifting and thermal storage using hot water tanks when there is a surplus of electricity on the grid. For example, Pacific Gas & Electric has been working with WatterSaver to install this technology and aims to reach 2.5 MW of grid load-shifting capacity by 2025 (Canary Media, 2022).

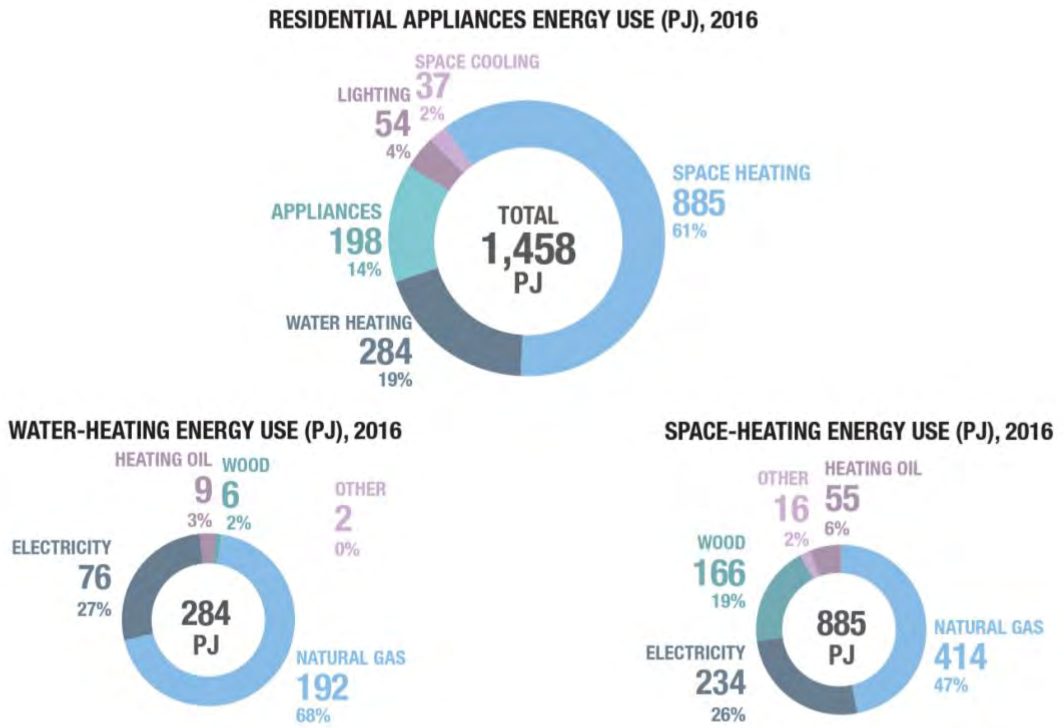


Figure 2-7: Heating Energy consumption in Canada (NRC, 2019)

Electrification of heating is not a main driver in Québec or NL because heating in these provinces is already largely electrified. This is why the electrification of transport was flagged as the key driver of DR adoption in both jurisdictions. However, the electrification of heating in provinces such as Alberta, Ontario and Saskatchewan will make a significant impact on the grid (Figure 2-8).

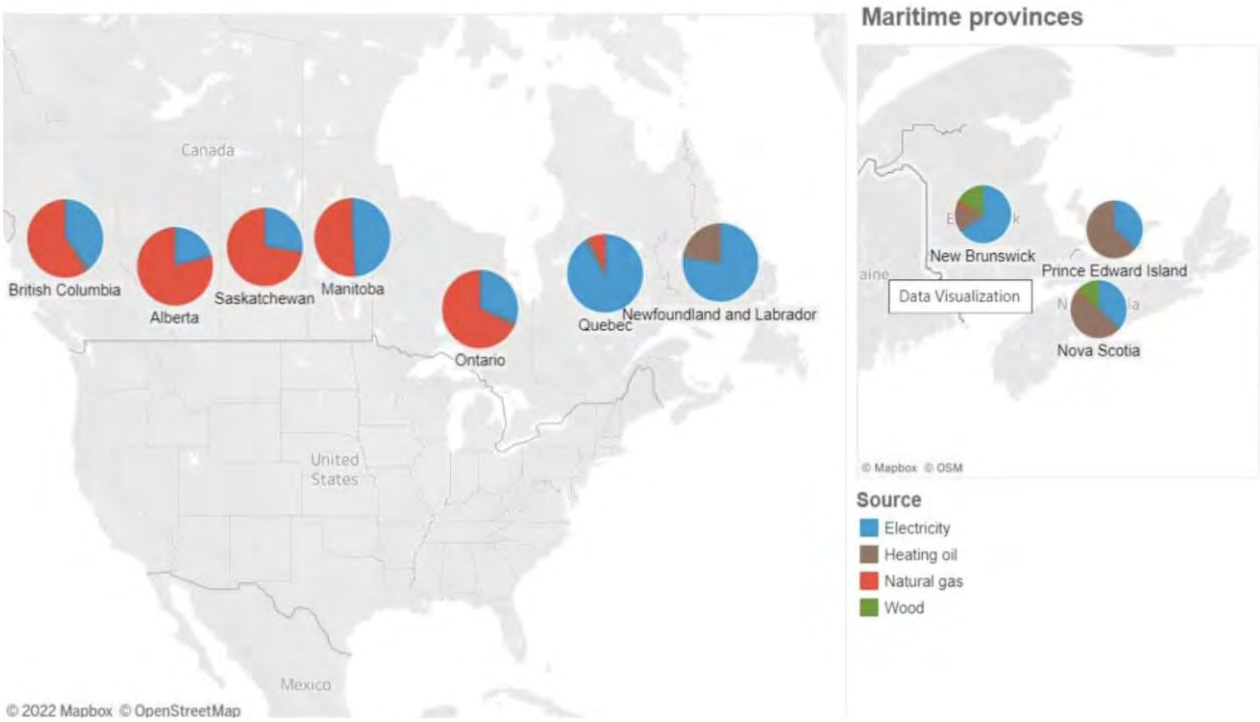
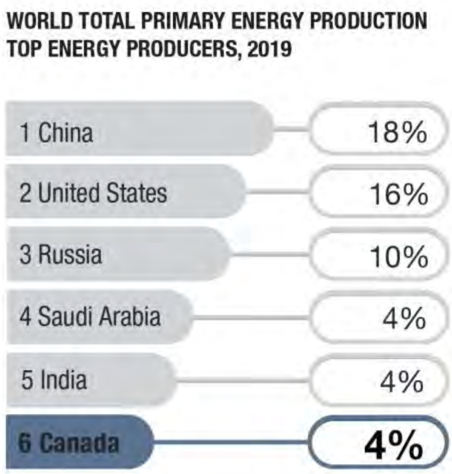


Figure 2-8: Heating energy sources by provinces in 2015 (Chung, 2022))

2.3 Energy Security

Energy Security refers to a nation's ability to reliably meet current and future energy demand. It takes into account both energy imports, diversity, reliability and resilience of energy infrastructure (WEC, 2022). Canada has benefited from years of energy security due to its rich endowment of natural resources, which is reflected in its ranking of 77.5 or A in this category. Canada is a global leader in energy production and exports, which is reflected in Figure 2-9. It is also a net exporter of electricity and exports 10% of its generation to the US (IEA, 2022).



GLOBAL ENERGY RANKINGS FOR CANADA

	Proved reserve/ capacity	Production	Exports
Crude oil	4	4	3
Uranium	3	4	6
Hydroelectricity	3	3	-
Electricity	8	6	3
Coal	16	14	6
Natural gas	17	5	6

Figure 2-9: Canada Global Energy Rankings (NRCan, 2021)

The primary motivation of utility companies, TSOs, regulators and governments is to ensure that there is enough energy supply to meet the demand. Energy is the diver for economies, and a lack of energy can endanger the lives and livelihoods of citizens. Therefore, energy security is a key driver for these actors to adopt RDR, although their motivations differ based on self-interest.

Canada is an energy-rich nation that has been traditionally focused on securing supply, rather than controlling demand. Canada as a whole has not yet reached a critical junction that forces the energy sector to adapt. However, there will be increasing pressure on the electricity system to adapt as the country transitions to net zero.

A **lack** of energy security has proven to be a **key driver** for DR innovation and adoption, as can be seen when examining California. The prices on California's wholesale electricity market increased by 500% between 1999 and 2000. The situation became more dire when customers were required to curtail their power consumption, and California's largest energy company collapsed. This caused widespread rolling blackouts and the economic fall-out in 2002 (Pham, 2019). The California energy crisis in 2002 served as the **critical junction** that ultimately resulted in the creation of the Open Automated Demand Response (OpenADR) standard. In 2014, California updated its building code Title 24 such that any new or retrofit thermostat, networked lighting controller, heating, ventilation, and air conditioning system are enabled for communication via the OpenADR 2.0b protocol (St, 2014). Today, California is a DR market leader in the US, and the world (Figure 2-10).

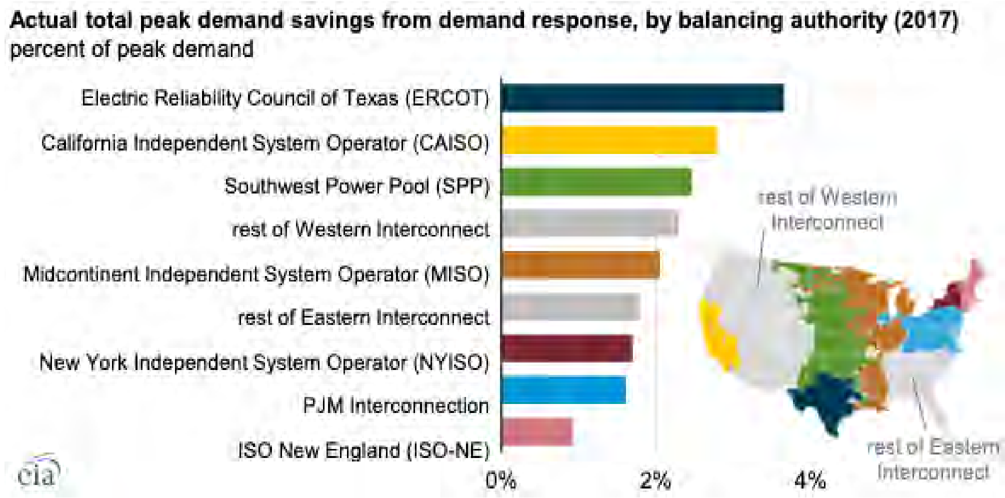


Figure 2-10: US Peak Demand Savings from DR (EIA, 2019)

Energy security has become increasingly important due to recent global events, and western sanctions against Russian oil and gas. It highlights the danger of relying too heavily on energy imports, and specifically relying too heavily on a single supplier. Therefore, governments are motivated to secure energy within their borders in the form of VRE and DSM.

RDR helps **increase energy security through the integration of variable renewables**. It also helps improve the reliability of the grid by providing the operators with an extra tool to respond to disturbances in the network. This can include **minimising the risk and impact of blackouts and brownouts** across the system.

Energy security is not currently a key driver for RDR adoption in Canada, but it could be in the future.

2.4 Energy Equity

Canada's highest score in the energy trilemma is energy equity at 96.1. This is primarily due to its 100% electrification rates and low electricity prices (WEC, 2022). However, creating a larger and more resilient electricity system to align with net zero could potentially put upward pressure on electricity rates. This section will discuss how increasing electricity and fuel costs are drivers for RDR adoption in Canada.

2.4.1 High Electricity Rates

The electricity network across Canada is made of ageing infrastructure and is facing significant maintenance and infrastructure upgrades, independent of the energy transition. Transitioning the electricity systems will require additional capital investments in storage as well as generation, transmission and distribution infrastructure. One study estimates that overall electricity rates could increase by 19.1% overall in Canada by 2050. However, the electricity rates will vary from province to province (Figure 2-11). This rate pressure has already started to emerge within some provinces in Canada. Nova Scotia Power is currently filing a submission to increase rates due to investments required to reduce emissions in electricity production (Canadian Climate Institute, 2022).

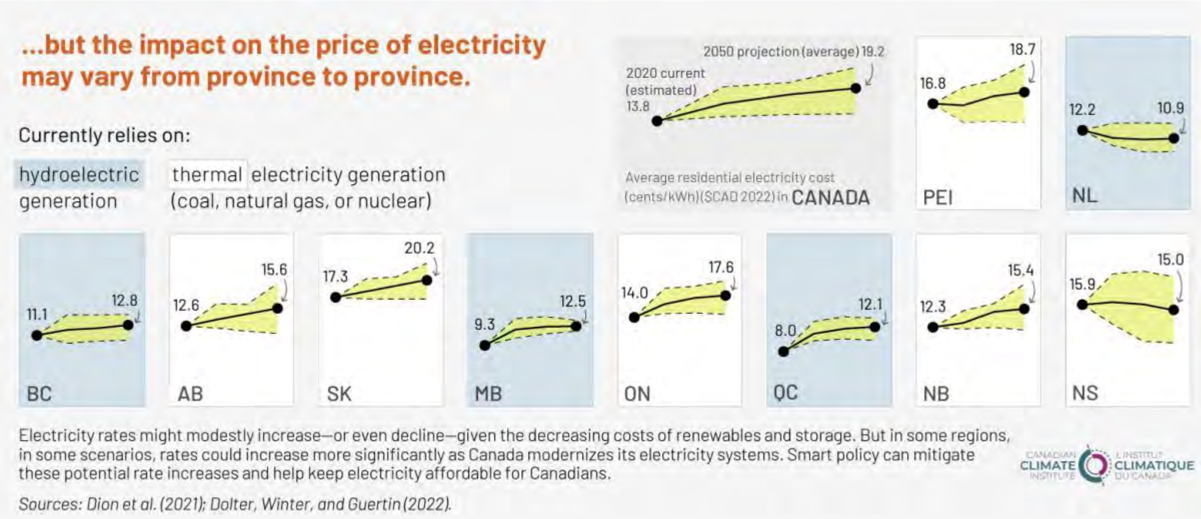


Figure 2-11: Canadian electricity rate prediction by province (Canadian Climate Institute, 2022)

Despite this upward rate pressure, in some jurisdictions, investments to decarbonize electricity systems will lead to overall lower costs of electricity due to the near-zero operating cost of VRE.

The capital investment costs of solar and wind resources have plummeted over the past decade. Utility-scale solar photovoltaics (PV) dropped 85% between 2010 and 2020. Onshore wind fell 56% during the same time period (IRENA, 2021). The levelized cost of electricity (LCOE) for fossil fuel generation is represented in Figure 2-12 with the grey band. The cost of VRE has now reached cost parity with fossil fuel generation and is undercutting these traditional generation sources. Therefore, the decision to incorporate an increasing share of VRE can be largely **financially motivated.**

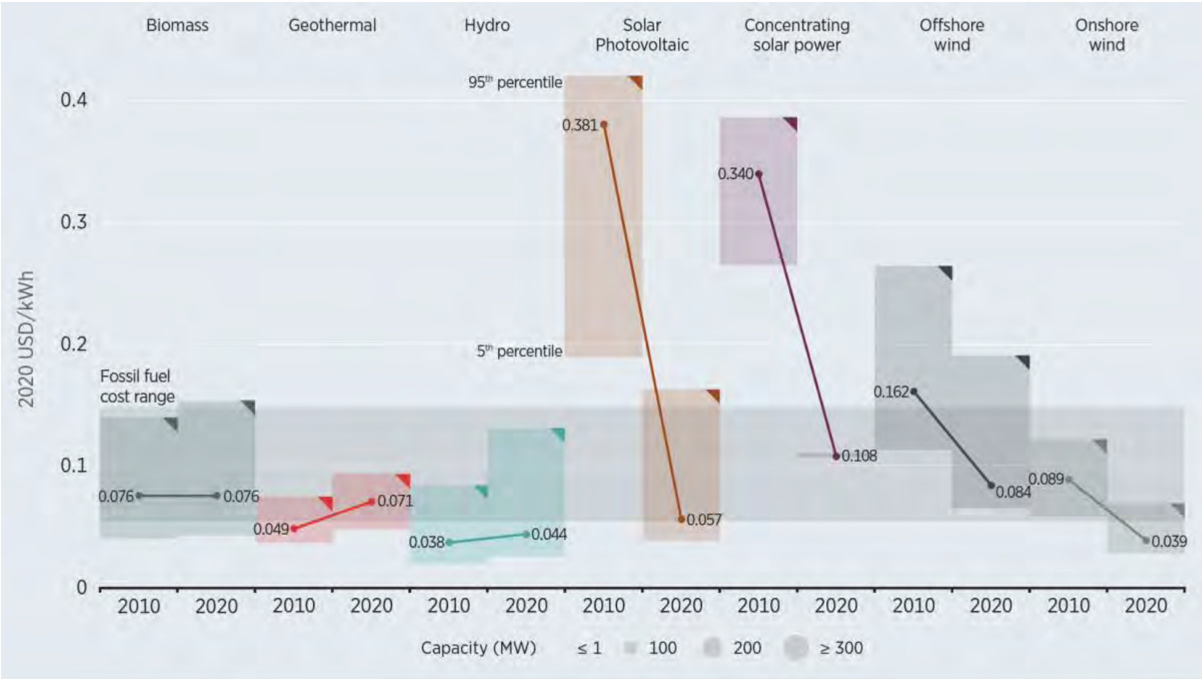


Figure 2-12: Global LCOEs utility-scale renewable power generation, 2010-2020 (IRENA, 2021)

The falling cost of VRE and increasing cost of electricity also encourage customers to invest in their own generation. The energy transition is not just a move toward non-emitting energy, but also a shift from centralised to decentralised generation. Depending on the cost of electricity, it can be cheaper for customers to invest in rooftop solar than to purchase electricity from their supplier. This can also be encouraged through feed-in-tariffs or subsidies included in decarbonization policies and programs. Therefore, a **higher cost of electricity will drive a higher share of renewables, which will create a need for RDR.**

A higher value of electricity per kilowatt-hour also makes RDR programs more economical for aggregators, TSOs, DSOs and utilities. Thus, a **higher electricity rate corresponds to a better business case for RDR programs.** The more valuable a kWh is, the greater financial incentive can be offered for reducing load through RDR programs. Higher electricity prices also make customers more mindful of their consumption and **encourage them to respond to price signals or "behavioural DR."**

However, high electricity costs could also undermine the business case for end-use electrification, so it is important for Canada to plan a cost-effective transition.

2.4.2 Increasing Fuel Prices

Energy rates are soaring worldwide, as can be seen in Figure 2-13. In September 2021, the energy rates in Canada increased 20.1% compared to 2020 (OECD, 2021).

Figure 2-13: OECD Energy Inflation (OECD, 2021)

The Russian invasion of Ukraine and resulting western sanctions have caused the cost of fuel to skyrocket. Fuel prices in Canada and the US hit record highs in May 2022, reaching $2.06 CAD a litre (Baldwin, 2022). The soaring energy and commodity prices caused Canada's national inflation rate to climb to 6.8% in April 2022. This is the highest national inflation rate in over 30 years (Trading Economics, 2022).

Figure 2-14: Canada annual inflation rate (Trading Economics, 2022)

Aside from inflation, fossil fuel prices are also steadily increasing due to carbon tax policies. The federal government sets a minimum national carbon pollution pricing benchmark that all provincial systems must meet. This benchmark was introduced at $20 per tonne in 2019 and increased by $10 per tonne annually until it reached $50 in 2022. From 2023 to 2030, the federal benchmark will increase by $15 annually (Government of Canada, 2022). Provincial governments are free to implement the national policy or design their own carbon pricing system tailored to local needs.

This steady increase in fuel costs will inevitably lead to the electrification of end-use sectors, as it becomes increasingly unaffordable to burn fossil fuel. This electrification of end-use sectors is a major driver of RDR, as discussed previously.

Both electricity and fuel prices are regulated by Canada's Energy and Utility Regulators[9] (CAMPUT). Commodity prices such as electricity and fuel rates differ on a province-by-province basis. Therefore, the electrification of end use sectors will vary based on region. In Alberta, natural gas is produced locally and the province benefits from low fuel rates. Jeanie Chin, Supervising Engineer, says that there is currently no move to electrify heating in Alberta due to a combination of cheap and abundant local natural gas and the existing legacy infrastructure. Even if Alberta electrified heating, their grid currently runs on 90% fossil fuel-fired generation (CER, 2022). However, increasing fuel rates will result in increased

[9] A list of these regulators can be found in Appendix 5.

electricity rates in fossil fuel dominated grids. This will create a push to invest in VRE, which will, in turn, drive RDR adoption through a need for a flexible load.

2.4.3 Electricity Market Liberalisation

Electricity market liberalisation was based on the premise that effective markets are fuelled by competition. It was designed in the 1990s to promote innovation, minimise costs and allow end-users to benefit from **lower rates** and a better quality of service. (Fisher & Nilsson, 2002). This pressure to deliver cost-competitive electricity also drives innovation, such as RDR.

Canada's electricity markets are regulated on a province-by-province basis. Only two provinces, Ontario and Alberta, have gone through some level of unbundling and market reform. Liberalisation enables competition and therefore has been proven to drive technological development. One example of such developments is the Advanced Metering Infrastructure (AMI) Initiative introduced in Ontario in 2004. This AMI program was a part of a larger plan introduced by the government of Ontario to reduce energy consumption by creating a culture of conversion. This was the **first** and largest smart metre deployment in Canada (Auditor General of Ontario, 2014). Therefore, this liberalised market paved the way for the rest of the nation's AMI deployment.

Based on lessons drawn from US history, market liberalisation has been followed by subsequent research and technological advancement regarding DSM. The United States pioneered electricity market liberalisation in the 1990s. The US also led Smart Grid research and was the first to mention DSM in 2005. The UK and EU followed this trend closely, as did their smart grid research and innovation. The growth of the DR industry in the US can be traced back to wholesale market access (Shen et al., 2012). This relationship between liberalisation and research and development can be observed in Figure 2-15.

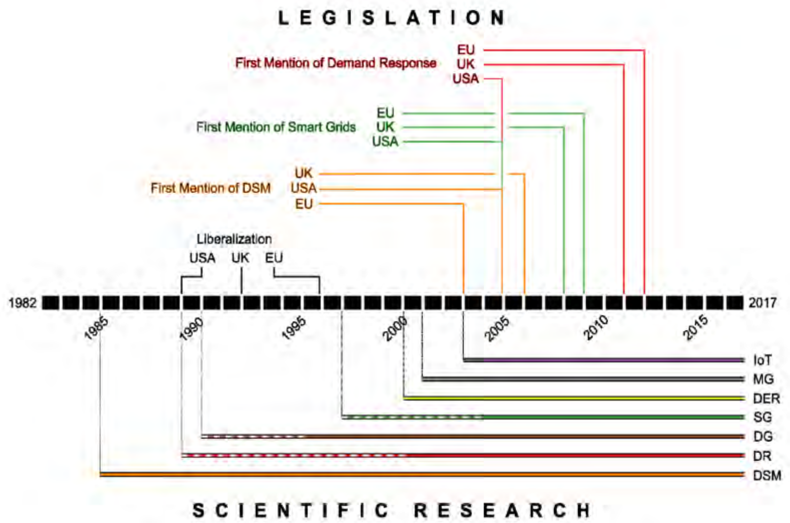


Figure 2-15: Electricity market legalisation and DSM research (Lotfi et al., 2018)

Today, the US remains a global leader in demand-side flexibility due to mature capacity markets in several states, including the liberalised markets of California and Texas (IEA, 2021). Therefore, it can be argued that market liberalisation is a driver of innovation, including RDR. However, both Texas and California also have energy security challenges along with a higher share of variable renewables (US DOE, 2021). Therefore, it is difficult to decouple DR capacity due to the liberalised market structure with the other influencing drivers of energy security and VRE.

2.5 RDR Drivers Key Points

The RDR drivers are all interlinked and revolve around the three pillars of the energy trilemma, as represented in Figure 2-16. **Historically, many of these drivers have not been present in Canada, so the industry has not been forced to adapt.** Therefore, the Canadian RDR market lags other countries where these drivers are dominant. The drivers for each province vary due to a unique profile of commodity pricing, generation mix and load profiles. However, RDR deployment in Canada will primarily be tied to an increasing **share of VRE** and the increased demand for electricity due to the **electrification of end-use sectors**.

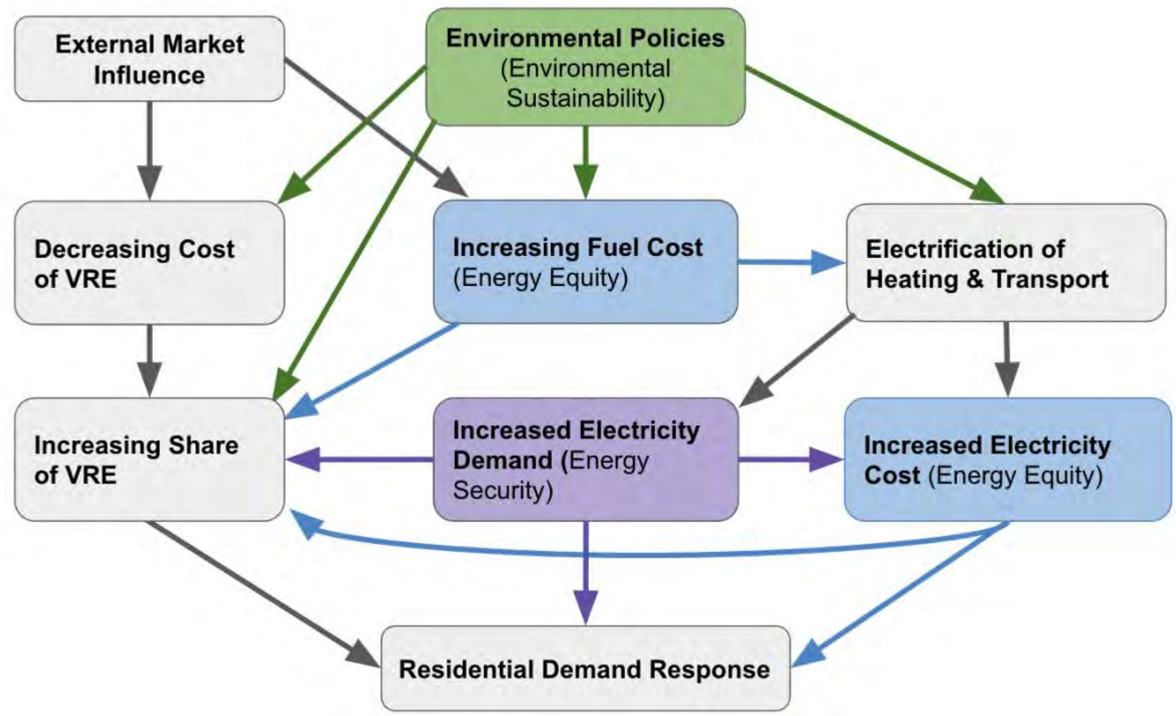


Figure 2-16: Graphic Illustration of RDR Drivers in Canada

The next chapter will discuss the barriers these actors must overcome to enable large-scale RDR in the Canadian market. The challenges each province and territory will face will vary due to their unique generation mix, market structure and load profiles.

3 CURRENT CHALLENGES FOR RDR ADOPTION

The residential sector accounts for 40% of Canada's electricity consumption. Despite this, RDR programs remain trapped in the pilot stage for most Canadian utilities. The purpose of this chapter is to discuss and examine barriers that must be overcome for RDR deployment across Canada. The main challenges can be grouped into four categories: public participation, service provider adoption, industry standardisation and market access.

Understanding the barriers will help determine if Canada can unlock demand-side potential using RDR. It will also provide the basis for recommendations to address these challenges in Chapter 4.

3.1 Public Participation

In recent years, emerging technologies have shifted the role of the customer. Residential customers do not often have access to wholesale markets like large industrial customers (NACAA, 2015). RDR is an opportunity to empower customers to have a direct impact on shaping the electricity system and the energy transition (CEA, 2014). The success of RDR hinges on public adoption, engagement and participation.

To gauge the public perception of DR in Canada, a survey was circulated online through LinkedIn, Facebook, Instagram, Twitter and Reddit. It received over 700 responses from across the country[10]. The survey results show that the public is relatively open to participating in DR programs, with only 18.8% indicating that they would not (Figure 3-1). The recurring themes that will hinder public participation are cost, lack of trust and lack of understanding.

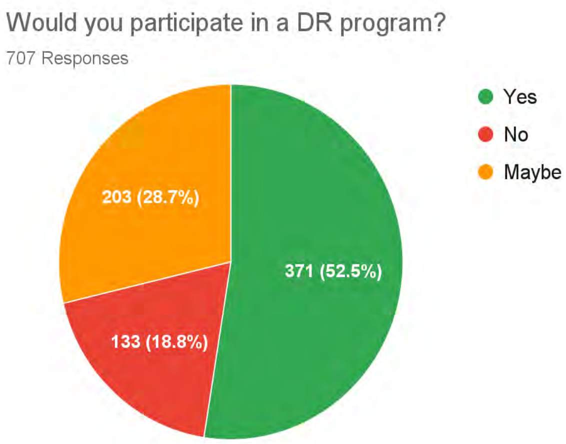


Figure 3-1: Survey Results: DR Participation

[10] Survey results can be found in Appendix 6.

3.1.1 Adoption of Smart Devices

ADR program success hinges on the adoption of DR capable devices into consumer homes. Connected devices are mandatory for ADR because these programs directly control loads remotely during an event. In behavioural DR (BDR), smart devices are not required, but they are an asset. In BDR, customers can manually adjust load based on price signals sent by the electricity supplier. However, there is a greater potential to reduce load if the devices can be controlled remotely when users are not at home. Smart devices also be programmed around ToU rates. Therefore, a high presence of connected devices creates a greater potential pool of participants for RDR programs.

Smart device adoption in Canada has gone up steadily in the past years, but the proportion of smart home devices in households managing energy is still relatively low, at around 10% (Figure 3-2). John Hobson, director of customer success at AutoGrid, mentions that this is one of the reasons why the Canadian RDR market is lagging the US. There is not as great a proliferation of smart devices in homes, and therefore less potential load to control. The number of homes with smart home energy management devices in the US was around 16% in 2019, compared to 6.6% in Canada in 2019 (Statista, 2019). The adoption of smart home devices to the broader general population may also slow down once the earlier adopter market has been saturated.

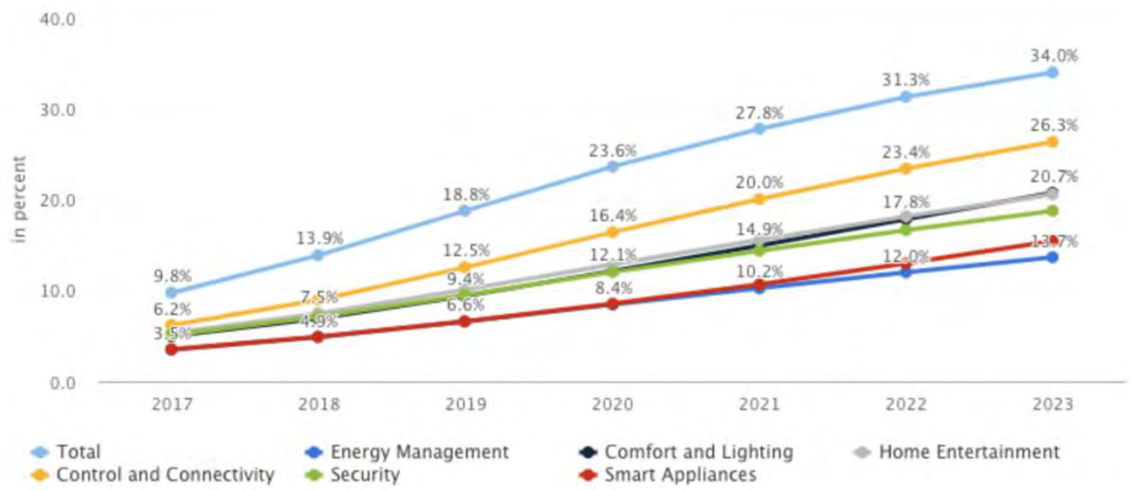


Figure 3-2: Smart home penetration and forecast in Canada (Statista, 2019)

When asked why participants would be reluctant to participate in an RDR program, they selected the following responses in Figure 3-3. The leading barriers to public participation are the cost of the device and a lack of trust in the technology or data privacy concerns.

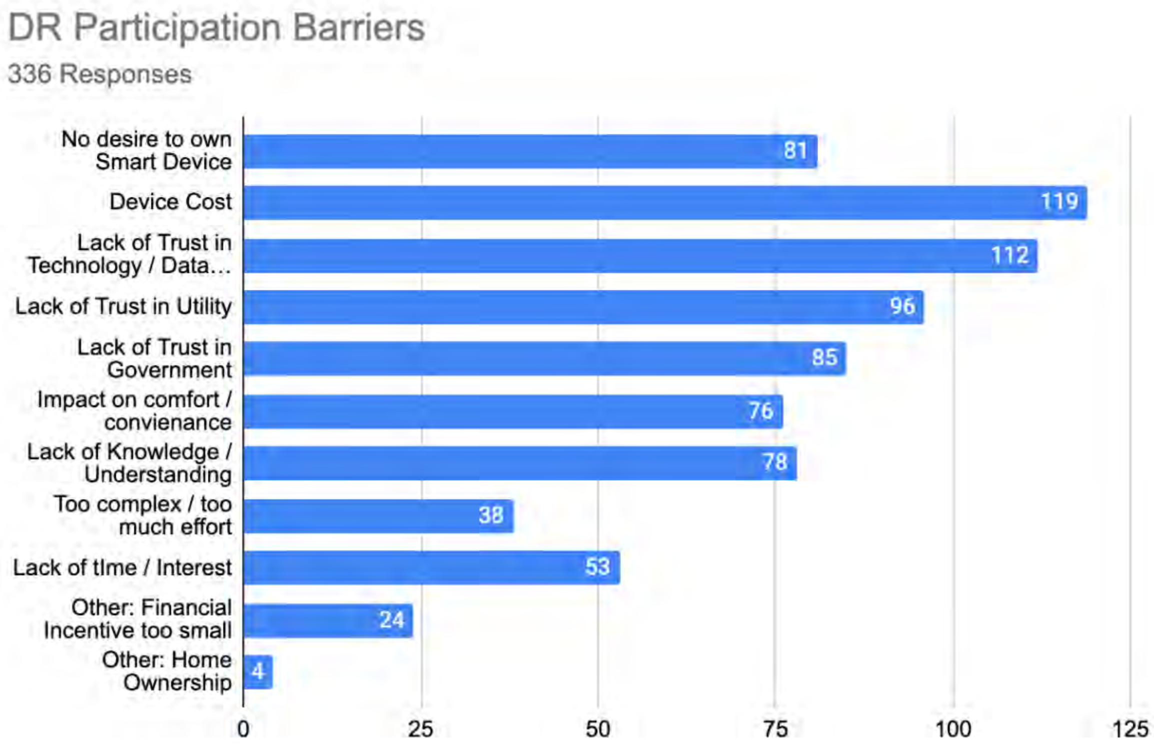


Figure 3-3: Survey Results: Barriers to DR participation

3.1.1.1 Lack of Trust in Technology

Traditionally there tends to be a sense of fear associated with the adaptation of new technologies. In the digital age, this lack of trust can also be manifested in data privacy concerns. Many smart and connected devices record personal data such as addresses, schedules, vacancy and occupancy patterns. If this information was hacked, it could make homes vulnerable to break-ins (World Economic Forum, 2020).

Data breaches and cybersecurity attacks are not uncommon in Canada. Statistics Canada reported that 42% of Canadians experienced a cybersecurity incident in 2020 (O'Driscoll, 2022). Therefore, it is understandable that data privacy is a leading concern for potential participants.

A general lack of trust in technology is a valid concern for customers in the Internet of Things (IoT) age. The World Economic Forum survey found that safety, security, privacy and trust pose the greatest levels of risk in the consumer IoT domain (Figure 3-4). Consumers have little to no transparency as to what happens to the data that is collected by IoT devices. There is also no global framework to address users' privacy concerns (World Economic Forum, 2020).

Figure 3-4: Risk levels of IoT (World Economic Forum, 2020)

3.1.1.2 Lack of Understanding

The lack of trust in technology is often linked with a lack of understanding. Customers often do not understand their energy usage and what can be done to reduce it. "Electricity is intangible, people don't think about it. People are not aware of where their electricity comes from, or how much they are using" reflects Aidan Girard, Account Manager. If the public does not understand their energy usage, they will not appreciate the value and potential cost savings offered by smart devices.

Studies show that only around one-third of programmable thermostats are set on a schedule (EIA, 2017). If the device is installed but never connected or programmed, it generates no energy savings or RDR potential. Therefore, consumers must be educated on how to take advantage of smart features in an effective way.

3.1.1.3 High Investment Cost

According to survey results, 36% of participants responded that they would not participate in a DR program due to investment cost. Smart devices have a wide price range, but they are significantly more expensive than their manual alternatives. Figure 3-5 illustrates the cost difference between manual, digital and smart thermostats on the market. Customers are hesitant to make the initial investment and purchase a smart device that comes with a hefty price tag. Another survey conducted by the American Council for an Energy-Efficient

Economy found that "five out of nine program administrators said they believe that technology **cost is the biggest barrier to adoption**" (Smith, 2019).

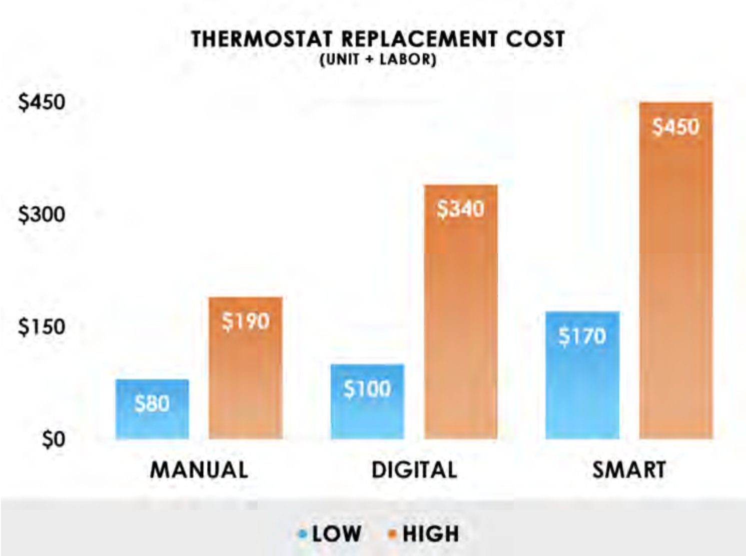


Figure 3-5: Thermostat Replacement Cost(HomeGuide, 2022)

The cost barrier is also linked to lack of understanding. Before making this investment, customers must first understand the value and how to use the device to obtain energy savings. However, even if they do understand the value, the upfront cost and initial investment can still be prohibitive to some customers.

There is also an issue of who would make this investment and upgrade in rental properties. Neither the landlords nor the tenants have sufficient incentive to invest the time and money to make energy improvements, including installing DR compatible devices. Currently, 37% of Canadian families rent their homes and would fall into this category (Uppal, 2019).

3.1.2 Enrolment in RDR Programs

3.1.2.1 Lack of Trust in Utility

In many parts of Canada, the public perception of utilities is quite negative, especially in cases where customers do not have a choice of their utility provider. In jurisdictions with utility monopolies, customers lack the influence to demand change or alternatives (NRCan, 2020). This pattern is evident in the survey results found in Figure 3-3, where 30% of customers indicated that they would be reluctant to participate in an RDR program due to a lack of trust in their utility.

These results were confirmed by a study published on Energy Literacy in Canada[11] where Eisler found that participants "hold negative views of energy company executives, **mistrust information from industry associations,** and lack trust in their provincial and federal governments" (Eisler, 2016).

One reason that Canadians have lost trust in their utilities is due to **miscommunication**. For example, in Ontario, some customers were under the impression that installing smart metres would result in price reductions on their electricity bill. However, these AMI installations were also coupled with a rate increase. Therefore, when bills did not decrease, the customers felt betrayed (NRCan, 2020).

Customers have also lost faith in utilities as the result of mega-projects that have a history of going over budget and overschedule. The recent Muskrat Falls project has been a point of public discontent and political conversely in the province of Newfoundland and Labrador (NL). The 824-megawatt hydro project was initially estimated to cost $6.2 billion CAD, but CBC reports that "after a decade of **delays and deception**, the final price tag is now set to come in at more than $13 billion" (Cochrane, 2021). It has been argued that Muskrat Falls illustrates the **problem with the public ownership of large-scale projects**. It is well known that cost overruns and delays are near inevitable in large-scale public infrastructure projects. Oxford University scholar Bent Flyvbjerg examined major government projects in 20 countries and found that 90% of infrastructure projects incurred cost overruns (Yunis & Aliakbari, 2021). Mega-projects done in the public sector are not well suited to minimise cost, and this erodes the trust of the customers

3.1.2.2 Lack of Trust in Government

Survey results showed that 25.3% of participants would not participate in RDR due to a lack of trust in their government. The 2021 CanTrust Index shows that public trust in government and media has steadily declined over the past five years (Figure 3-6). There are a number of contributing factors to this decline in recent years, including the Covid-19 pandemic, economic turbulence, inflation and the discovery of mass graves at residential schools across Canada in 2021 (Goodhue, 2021).

[11] Please see Appendix 7 Energy Literacy in Canada Survey Results

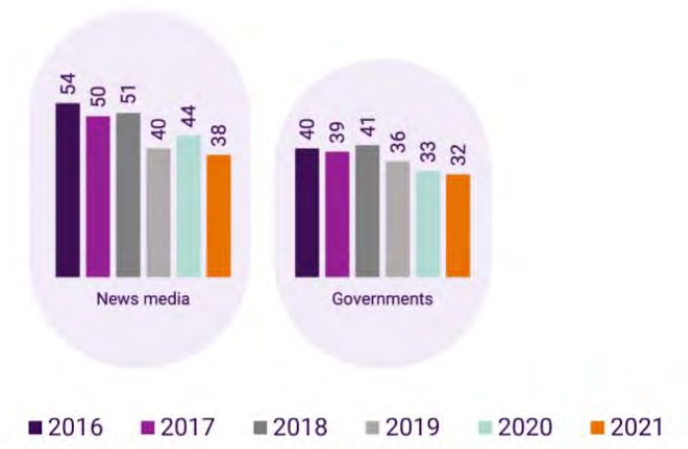


Figure 3-6: CanTrust Index Score Government (Proof Strategies, 2021)

This lack of trust must be overcome to enable widespread RDR adoption and the energy transition as a whole. "**Trust is the foundation for the legitimacy of public institutions and a functioning democratic system**. It is crucial for maintaining political participation and social cohesion" (OECD, 2022).

3.1.2.3 Lack of Understanding

The general public does not understand what DR is and why it is important. Survey results showed that 78.4% of respondents do not understand the concept of DR (Figure 3-7). Therefore, they are reluctant to purchase DR compatible devices and enrol them in RDR programs. Studies have shown that the **more customers understand the problem, the more they would be willing to participate in the solution** (Szablya, 2012).

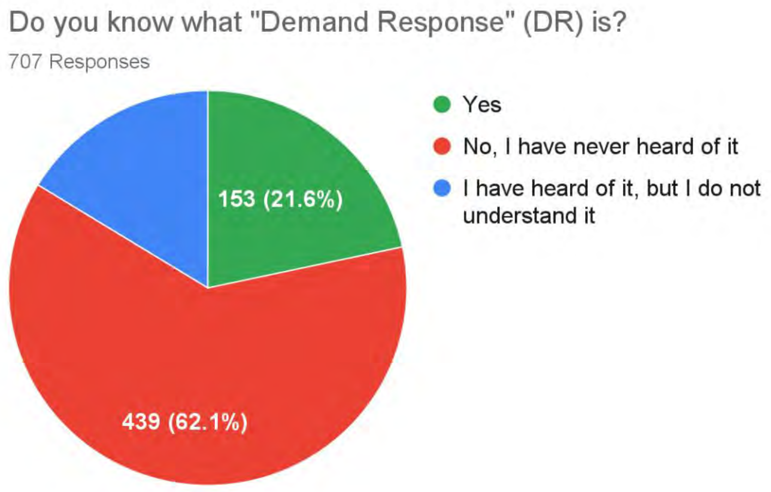


Figure 3-7: Survey Results: DR Knowledge

3.1.2.4 Lack of Financial Incentive

Based on survey results, the two key motivators for customers to participate in RDR programs are the financial incentive and the desire to reduce environmental impact[12]. Therefore, there must be a high enough financial incentive to entice customers to sign up and participate in the program. Hamza Mortage from Alectra Utilities indicated that the current lack of financial value could be a barrier mass public adoption of the technology. Several other utility representatives expressed similar concerns during interviews. Some RDR programs in Ontario do not pay customers individually but instead enter them in a raffle or draw for participation. When examining the survey results in Figure 3-3, 24 respondents provided additional feedback to indicate that a $10 monthly bill credit was not high enough to merit participation. This metric most likely would have been higher had it been included in the original selection options.

In order to offer a greater financial incentive to customers, utilities must create a viable business case and receive budget approval. These barriers to service provider adoption, among others, are discussed in the next section.

3.2 Service Provider Adoption

Utilities can be slow to embrace change, especially when adopting experimental or unproven concepts and technologies. This is partially due to the regulated nature of operations in many provinces. As utilities face the energy transition, they must make a shift in their traditional business model from a commodity provider to a service provider. This is done through empowering customers to reduce their energy consumption (Walton, 2015).

The electricity system in Canada has been built around three pillars that have shaped the industry over the past hundred years: affordability, reliability and sustainability (CEA, 2014). In order to introduce any new technology into the grid, these three pillars must be balanced. This section will analyse barriers that utilities face for RDR adoption.

3.2.1 Lack of Trust

When analysing electricity suppliers, whether it be utilities, Transmission System Operators (TSOs) or Distribution System Operators (DSOs), the main barrier to RDR adoption is a lack of trust due to lack of experience and data. Utilities have been conditioned to be extremely

[12] See survey results in Appendix 6

risk-averse and cautious. Above all else, they want to ensure reliable, affordable energy access to their customers. NL Hydro's mission is to "provide safe, cost-effective, reliable electricity" to their customers (NL Hydro, 2022). The key challenge for service provider adoption is, therefore, to prove that RDR is a reliable solution for load shed on strained electric grids.

3.2.1.1 Lack of data / Lack of scale

DR behaviour varies regionally, as load patterns are characterised by local weather, building construction, electric appliances and usage behaviours. This poses a problem when it comes to accurately predicting DR load reduction capacity in each service area. Therefore, utilities and service providers tend to invest in small pilot projects in order to gradually build knowledge, experience and eventually, trust.

One challenge is that in Canada, these pilot projects are so small, it is hard to see an impact at the grid level. There is still a lack of "reliable and predictable data" says Renee Smith, Resource and Production Planning Manager. Renee wants to ensure that the island of Newfoundland will have enough electricity to meet system demand throughout the harshest temperatures and the worst storms, when electricity consumption tends to peak.

There is currently federal government funding for RDR pilot projects, which can help promote utility research and development. However, this funding generally excludes considerations of scaling. This is a common issue with innovative pilots, Brattle Group Principal Ryan Hledik says "They are being done **without planning for full-scale deployment**, and without that planning, there is a strong possibility there will be no further deployment." Hledik goes on to say that this is indicative of "the bigger problems" of **mistrust of technologies** (Trabish, 2021).

3.2.1.2 Lack of trust in the technology

Many RDR technology providers are new and young companies who, by nature, tend to be more fragile and vulnerable to economic fluctuation. Yukon Energy awarded a DR pilot project to CaSA Energy[13] in 2019. This technology provider then declared bankruptcy in 2020. Renee Smith, NL Hydro Resource and Production Planning Manager, said that from a

[13] CaSA Energy was a Canadian technology company that built DR software and hardware solutions for residential loads

utility's perspective, CaSA's collapse is very unsettling. The utility could potentially invest in a 60MW DR virtual power plant and lose access to it overnight.

This lack of trust in the technology also extends to the software that is running these programs in the background. Increasingly, cloud-based software such as Amazon Web Services (AWS) is the backbone of many smart technologies and apps on the market today. In December of 2021, there were three AWS outages that affected millions of customers and took down popular sites, including social networks, online stores and smart technologies. During this time, smart thermostats such as Ecobee and Nest were also offline (Targett, 2021). This further shakes the utility's trust in connected DR technology as a reliable source of load shed.

3.2.2 Reluctance to Change

The Canadian Electricity Association says that "the industry is designed to be conservative and controlled so it can ensure reliability" (CEA, 2014). The Canadian electricity sector has been built on a history of electric monopolies, many of which still exist in many jurisdictions. This legacy has fostered a culture where ingenuity takes a back seat to reliability, safety and stability. These values have been reinforced by political and regulatory mandates. Therefore, utilities within Canada have been conditioned to be **risk-averse and reluctant to change** (NRCan, 2020).

It has been found that there is a difference in culture between crown corporations and investor-owned and private utilities. In profit-driven utilities, shareholders demand growth and have a higher risk tolerance (NRCan, 2020). This can drive innovation by forcing more experimentation and investments.

DSM poses challenges to the traditional business model that utility companies have been operating within for decades. In order to enable the widespread deployment of RDR, utilities must shift their mindset from a 'poles and wires' solution to a 'non-wires' solution. "The biggest barrier of the energy transition is the utility itself," revealed an anonymous utility executive during interviews. Therefore, there must be a shift in culture in order to foster the adoption of RDR and other smart grid technologies. "The industry has been operating at a near steady state for decades, and it's about to explode" reflects Greg Robart, Smart Grid Innovation Network CEO. Not only must utilities change their risk tolerance, but also the way that they think of electricity, the grid and their business.

3.2.3 Lack of Collaboration

One well-known and documented problem facing the Canadian electricity sector is the lack of knowledge and information sharing between jurisdictions. This is evident in the siloed system planning approach as well as research and development. Even physically, many provinces are not interconnected with transmission lines (Canadian Climate Institute, 2022).

A result of this lack of collaboration is that the same or similar pilot projects are often repeated in different areas due to limited or no information sharing. “Canada is full of pilots” says Supervising Engineer Jeanie Chin. This phenomenon can lead to pilot fatigue for customers, utilities and solution providers who have the impression of “**perpetual pilot projects**” (Katofsky, 2020).

Lack of knowledge sharing can also result in the industry term “**Death by 1,000 Pilots Syndrome**”. This phenomenon can be fatal to vendors who are struggling through long sales cycles and small projects to innovate new technology. It is also a challenge for utilities to make responsible investments without assurance of how the technology will perform on the grid at a large scale (PLMA, 2018).

3.2.4 Viable Business Case

The first pillar in the electricity sector is affordability. Canada has some of the lowest electricity rates in the world so it can be difficult to justify a business case for RDR. DER technologies face more challenging economics compared to larger projects that benefit from economies of scale. It is also difficult to capture and evaluate indirect cost savings such as deferred infrastructure investments (NRCan, 2020).

Utilities and solution providers across Canada struggle to monetize smart grid projects and scale their investments. This is due in part because it is difficult to recover the costs of flexible assets because the value of the asset is **not accurately assessed by the regulator** (NRCan, 2020).

3.2.5 Outdated Regulations

Every province and territory has a form of electricity regulator, which is usually a utility commission or energy board[14]. Regulators provide oversight and approval of system planning, reliability, investments, and rates. However, the current regulatory environment does not

[14]A list of regulators can be found in Appendix 5.

encourage innovation and is perpetuating conservative and risk-averse approaches (NRCan, 2020).

A study by NRCan found that “across Canada, regulators often lag behind current markets with **outdated regulations** and **traditional mindsets**.” Interviewees noted that the regulations and approval structures are outdated and no longer match market needs. Today’s smart technologies did not exist when the regulations were written. This regulatory lag “further perpetuates a **conservative and risk-averse mentality to adopting innovation**” (NRCan, 2020).

Regulars are concerned about destabilising risks introduced to the grid by new and smart technologies. They have not determined how to model technology such as energy storage from a power flow or financial perspective. Therefore, regulation in these markets **favours older and familiar grid technologies** due to perceived risks and barriers to the adoption of non-traditional technologies (NRCan, 2020).

The slow pace of regulatory change has a major impact on the adoption of new technologies such as RDR in the electricity sector. Although the market is normally ahead of regulation, it responds well to regulatory clarity. AMI installation rolled out quickly across several provinces due to regulatory support (NRCan, 2020).

3.3 Lack of Industry Standardisation

Smart grids are rapidly evolving in different countries and markets simultaneously. The current RDR market is highly fragmented, with many players (Figure 3-8). One key barrier to RDR rollout is a lack of standardised technical specifications and agreements (JRC, 2020).

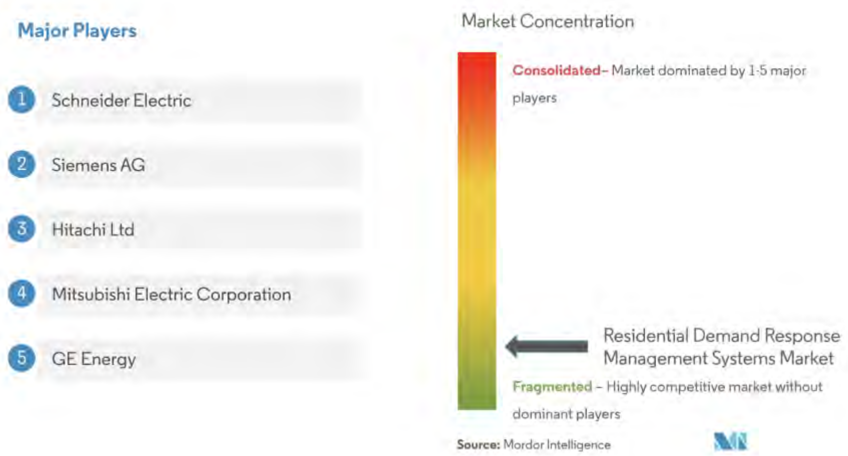


Figure 3-8: DR Market Fragmentation (Mordor Intelligence, 2021)

The lack of industry standardisation is a barrier for both aggregators and DR technology providers. Many integrations require a customised software solution to communicate, which is both costly and time-consuming. Industry standardisation is also a barrier for utilities. Canadian utilities are not looking to be innovative but would rather use 'industry best practices.' This lack of standardisation extends to terms, definitions, communication protocols and load drop calculations.

3.3.1 ADR Communication Protocol Standardisation

There is currently no widespread standard for ADR communication protocols. In the US today, there are 63 recognized open standards for performing DR (NIST, 2021). This leads to confusion between utilities, aggregators and technology manufacturers alike. Each project is a new and custom integration, making progress slow, inefficient and cumbersome.

3.3.2 Load-drop estimate standardisation

One challenge of RDR is quantifying how much load was reduced due to a DR event. Since flexibility cannot be measured, a baseline is needed as a benchmark to quantify the value delivered.

Residential load fluctuates on a momentary basis in response to temperature, wind, calendar day, month, occupancy and activity. There is no way of knowing with 100% certainty what the load will be on a given day, but there are numerous methods to estimate this value. Many methods involve calculating a "baseline" for the load. This can involve the standard "3-in-10" baseline in which the hourly average of the three highest energy usages over the previous past ten similar days. There are numerous variations of this baseline method including averages and adjustment factors (NAESB, 2008).

The IESO in Ontario requires RDR to implement randomised controlled (RC) baseline methodology. In this approach, there are two groups: the "control group" and the "treatment group". The RC then evaluates the difference between the consumption of these two groups and the same-day adjustment[15] (IESO, 2022).

This issue of a fragmented baseline calculation approach has been raised in both the US and EU markets. In 2009, the Federal Energy Regulatory Commission (FERC) noted that the "development of standardised practices for quantifying demand reductions would greatly improve the ability of system operators to rely on demand response programs" and "central to the issue of measurement is a determination of the customer baseline" (EnerNOC Inc., 2011).

3.4 Market Access

In the Canadian electricity market, only two provinces have wholesale markets, and only one capacity market is open to DR solution providers. Market rules that are designed for traditional generation can create challenges for emerging technologies such as RDR. The Canadian Climate Institute reported that "utility and market structures, which were **developed to serve centralised, baseload supply,** often **fail to incentivize** the uptake of **cost-effective distributed energy resources"** (Canadian Climate Institute, 2022).

The policy environment in Canada is confusing to navigate and does not foster the foresight required to make investments in future innovation. The **full value and role of RDR in flexibility is not recognised** by current market structures. DERs can operate as both a load centre and an energy provider, and there is currently no market standard to model these devices. When the resources are not adequately compensated for their value, it is difficult to build a successful business case for deployment (NRCan, 2020).

3.4.1 Smart Metre Data Access

In the open capacity market in Ontario, DR aggregators can bid directly into the market. However, in order to participate in these markets, they must obtain measurement and verification data from smart metres. The incremental consumption data is used to verify load

[15] IESO baseline calculation can be found in Appendix 8

shed during DR events. In order to access this data, aggregators must purchase it from local utilities at a hefty price. IESO Manager of Partnerships, says that this can significantly cut into their profits and use 40% of their budget. In these cases, it is no longer economically feasible for the aggregator to participate in the capacity market.

3.5 RDR Barriers Key Points

The main barriers to RDR adoption in Canada are not technical in nature but rather **social, cultural** and **financial**. There are recurring themes such as a lack of trust, low risk tolerance and lack of knowledge that are inhibiting the uptake from various actors. There will need to be a cultural shift within utilities, regulators and the public to adopt this new technology.

The regulations and market structure were designed for traditional generation sources and are not welcoming to new technology and innovation. There is also a lack of consistency and knowledge sharing across provinces and territories. Recommendations of how to overcome these barriers will be discussed in Chapter 4 to determine how Canada can unlock demand-side potential through RDR.

4 Recommendations for RDR Deployment

In order to unlock demand-side potential through RDR, Canada must empower the customer, encourage service provider adoption, enable market access, increase centralised regulation and move towards industry standardisation. This can be achieved this through building trust, shifting culture, enabling policies and increasing collaboration.

4.1 Empower the Customer

The public is the end-users of RDR, and the success of these programs hinges on their acceptance. This is a challenge but also a great opportunity to empower the customers to be a part of shaping the future energy system while reducing their energy bill.

4.1.1 Build Trust in Technology by Protecting Customer Privacy

The establishment of trust for public adoption of smart devices currently lies with the manufacturer. The technology is customer-facing; therefore, it is ultimately up to companies to engender trust among users. They must **create a customer-centred business** and take steps to ensure **customer privacy through design** (World Economic Forum, 2020).

Jerry Power, Intelligent IoT Integrator, says, “as people spend more time online, companies will begin to **compete on trustworthiness in order to win customers**” (World Economic Forum, 2020).

One way to create a customer-centred business is to provide **reliable and excellent customer service**. Another way to gain customer trust is to **put the control back into the hands of the users.** One example of this shift in control is Amazon's Alexa smart speaker. Public concern was that the recorded data was being listened to without consent. To combat these concerns, Amazon gave user access to view and delete collected data. Another privacy by design feature is having customers "opted out" of data sharing by default and giving them the option to "opt in" if they so desire (World Economic Forum, 2020). Customers should have the right to know what data is being collected, access it, and delete it.

Addressing customers’ privacy concerns has been largely the responsibility of IoT manufacturers and service providers. However, it is difficult to navigate the conflicting and fragmented world of international privacy regulations. Industry is shifting towards adopting customer’s “right to be forgotten” (RTBF). RTBF was introduced in the EU in 2014 and gives citizens a right to the “erasure of personal data.” While this is not currently mandatory in Canada, it is being discussed in the federal court (Promislow, 2021). **Technology providers should take the initiative to adopt the RTBF framework and establish a way to erase all customer data if requested.**

Consumers generally lack the awareness and knowledge necessary to manage their own exposure to IoT security risks. Therefore, **governments also have a role to play in protecting their citizens' data and privacy through regulation**. Industry standards and government recommendations are emerging as an important tool in risk management. Some government bodies are working on initiatives to develop privacy “trustmarks” and “nutrition labels” to help guide customers when purchasing IoT devices (World Economic Forum, 2020). **The Canadian government should consider developing privacy trustmarks and mandating RTBF on a national level to protect citizen privacy.**

As with most new technologies, the rapid pace of IoT innovation and deployment has left the effort to govern and regulate it far behind. “It is like technology is running naked,” says Lei Zheng (World Economic Forum, 2020). This gap between the technology risks and governance is displayed in Figure 4-1.

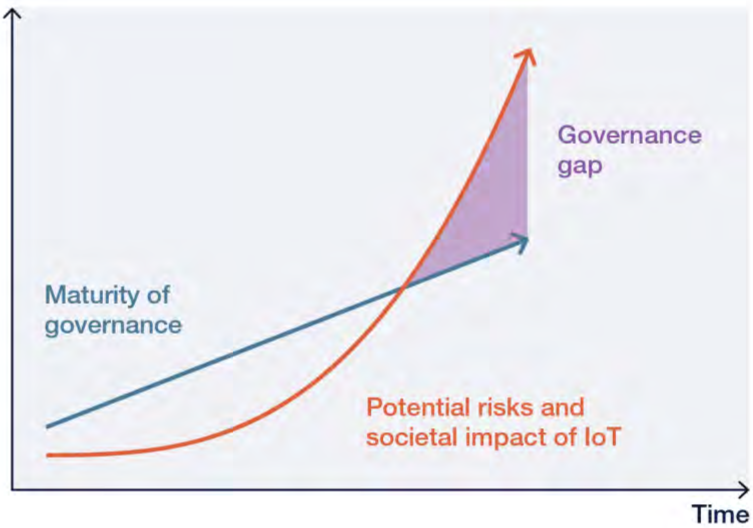


Figure 4-1: IoT Governance Gap (World Economic Forum, 2020)

Canada has implemented a CyberSecure Canada program in which small or medium companies can obtain certification. Some utilities, such as BC Hydro, **require all their technology partners to obtain this cybersecurity certification**. BC Hydro also contributes towards the costs of certification for their partners. This is a good practice that other Canadian utilities should adopt to protect their customers and increase their trust in both the technology and the utility.

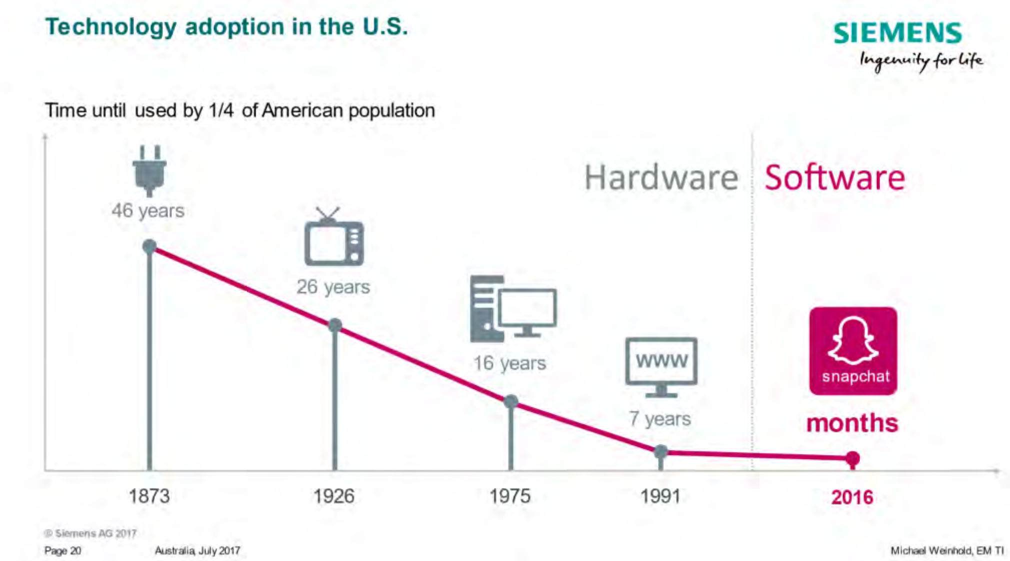


Figure 4-2: Technology adoption in the US (Weinhold, 2017)

One encouraging trend is that the rate of public acceptance and the adoption of new technology is accelerating naturally (Figure 4-2). Therefore, it is not a large leap to see a future where the majority of the population has smart technology performing RDR in their homes and adapting to fluctuations in the grid.

4.1.2 Build Customer Trust in Utilities and Governments

Survey participants listed both a lack of trust in the utility and a lack of trust in their government as barriers to RDR participation. Because many of the utilities are owned by their respective provincial governments, often **a lack of trust in the utility reflects a lack of trust in the government and vice versa**. The biggest gap in the Canadian electricity sector is a lack of openness and transparency, which, in turn, creates a perceived lack of integrity (Eisler, 2016).

One way that utilities can have greater transparency with their customers is to open the electricity bill "black box". Rather than just giving customers their total monthly usage, utilities can offer customer access to energy consumption information via online portals or mobile applications. The utility can also provide insights into how customers can save money by shifting to a lower ToU tariff or pricing plan. This promotes openness and trust while also educating the consumer.

Utilities can gradually rebuild trust through excellent customer service and anticipating future needs (Stenner et al., 2017). The public **must have a voice** in the energy sector and energy transition. Even in regulated monopolies, the public must have a platform to speak and influence the system. There should be community meetings and public consultations prior to the development of large projects or the introduction of new rate structures. The utility must engage customers in order to design products, services and rate structures that are **customer-centred and meet their needs**.

One promising approach to create a sense of trust among underserved customers is to partner with community-based organizations. Organisations such as food banks and health care centers are more attuned to customers' needs and are more likely to have a positive relationship with residents. Therefore, these organisations are well-positioned to promote energy efficiency programs and educate customers about benefits. They can also provide valuable insight in order to design programs that are beneficial to the community (Holowka, 2020).

Trust does not need to be established from scratch in utilities across Canada. In fact, survey respondents gave an average trustworthy rating of 3.4 to their local utilities compared to 2.8 in their government. Some smaller utilities, such as Saint John Energy, noted that they maintain a good relationship with their customers and feel like their customers trust them. There seems to be a pattern that larger crown corporations tend to be more distrusted due to a history of scandal, overspending and bad press. These utilities will have to build public trust by improving communication and customer service. Then they must maintain it through reliable service and responsible spending (Stenner et al., 2017).

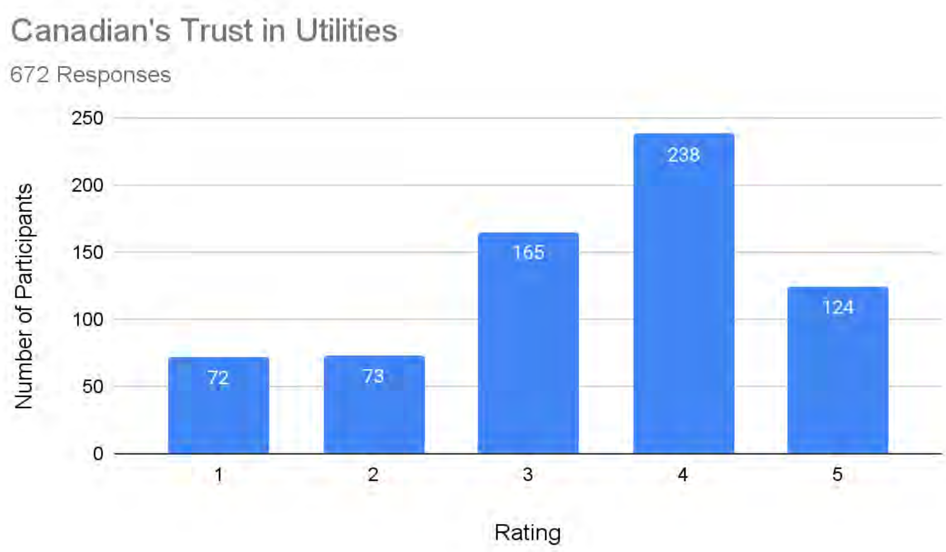


Figure 4-3: Survey Results: Trust in Utility

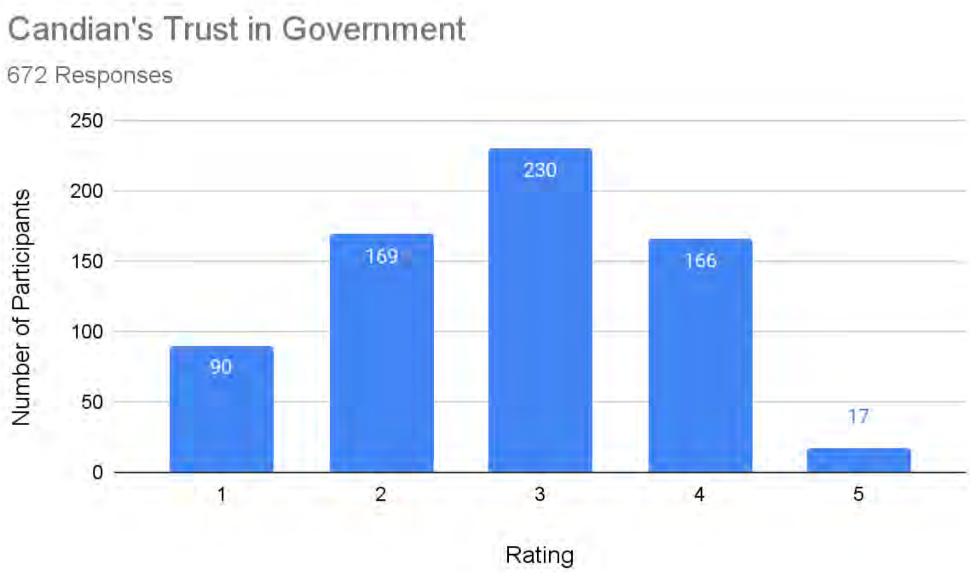


Figure 4-4: Survey Results: Trust in Government

It will be a greater challenge to build public trust in government, as the population holds a negative and deteriorating view of this institution. Trust is hard to gain and easy to lose. However, it is not fixed. The foundation for building trust in governments, utilities and technology is the same: improving the public experience. Figure 4-5 represents how the perceptions of the government can be driven through various policy dimensions.

Figure 4-5: Drivers of Public Trust in Government (OECD, 2022)

4.1.3 Raise Consumer Awareness

RDR programs are still very new in Canada, so there is a lack of public awareness and understanding. There is a role for both the manufacturer and the utility to educate and empower the customer through sharing knowledge and raising awareness. Information alone is powerful. Schneider Electric found that just raising awareness amongst customers of the details of their energy consumption resulted in a reduction of 8% on energy bills (Mikelann, 2021).

The success of RDR programs hinges on customer participation on a large scale, which makes it important to understand the motivations for customer participation and communicate them effectively.

Parks Associates found that most customers are motivated to conserve energy by keeping their bills low (Parks Associates, 2021). A German study concluded that both financial and environmental benefits underlie participation (Sloot et al., 2022). Similar findings were reflected in the public survey results in Figure 4-6. Similar sentiments were echoed by a Hydro-Québec Executive, who said the public is primarily financially motivated. However, some customers would be willing to participate with the knowledge that they would be helping the environment.

Society is becoming progressively aware of environmental impacts and the climate crisis. Consumers are also becoming increasingly conscious of the soaring costs of energy. This poses an opportunity to educate the customer on how DR can reduce both GHG emissions and their electricity bill (Ponds et al., 2018).

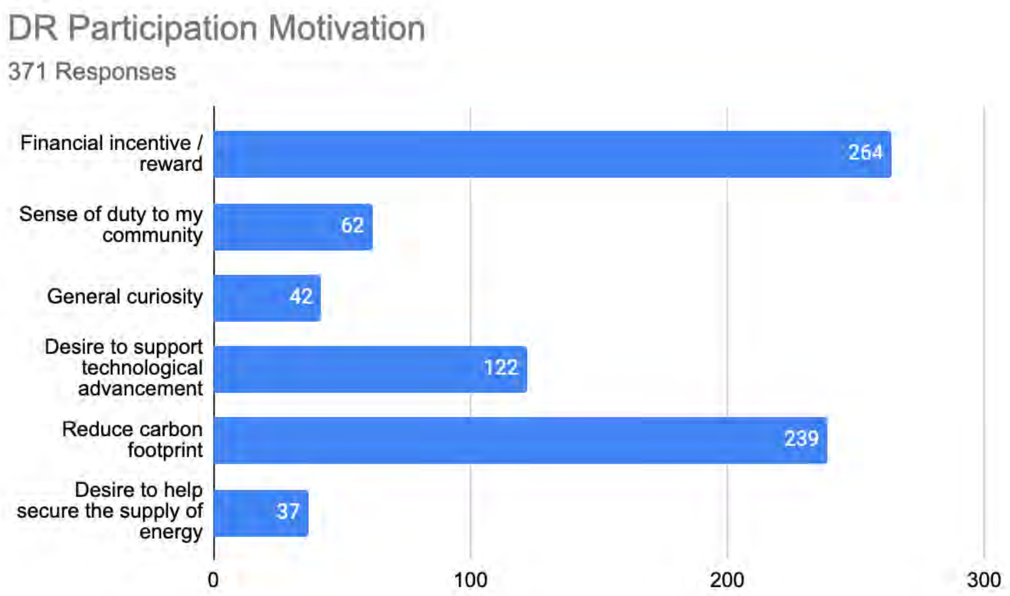


Figure 4-6: Survey Results: Motivation for DR participation

It must be noted that there is a **fundamental link between trust and knowledge sharing**. The public must first trust the source of this information before they will be willing to receive it. This principle applies to governments, utilities and technology providers alike. Customers have also been conditioned to be skeptical of advertisements, and weary of online scams. Therefore, it can be beneficial to partner with a more trusted source of information to digest this information to the public. OhmConnect Director of Partnerships noted a 4 to10 fold increase in DR program recruitment when co-marketing with the California Community Choice Aggregators. Some Canadian utilities have taken the approach of creating a subsidiary or adjacent organization such as TakeCharge NL or Efficiency Nova Scotia, which distances the core business from DSM initiatives (TakeCharge, 2022).

Social media poses a new opportunity for information sharing. Baltimore Gas & Electric found that social media was a key factor that enabled an 80% customer participation rate in their DR program. Participants received notifications the day after a peak demand event, saying, “Thanks for participating, you saved $11”. Then, in turn, many participants shared this information on social media, and it became a competition. Some customers even shared photos of how they conserved electricity during these peak times (St.John, 2017). This leads to another way to engage customers: through competition. OhmConnect leverages gamification through their app to engage customers to earn points with energy savings and cash in on rewards (OhmConnect, 2017).

Utilities in Canada should take away key learnings from this program: **engage with customers often**, **communicate clearly how much money they have saved** during peak events, **leverage partnerships** and the power of social media to engage with customers.

4.1.4 Empower the Customer to Customize their Experience

The industry is shifting control away from the utility and into the hands of the customer. Aidan Girard, Account Manager, shares that “Manufacturers such as Sinope, Ecobee and Nest are giving the customer a lot more power to choose how the [DR] experience unfolds”. Hilo Energy, a subsidiary of Hydro-Québec, has created an app where customers can select their desired participation mode: moderate, intrepid or extreme. Each mode results in varying levels of energy reduction, and corresponding rewards. Hilo also prompts users for feedback following each ‘challenge’ (Hilo, 2022). These steps help empower users by handing over control and providing space for feedback. Therefore, **manufacturers and utilities should offer customization options in DR events** to encourage customer participation.

In August of 2022 a US utility, Xcel Energy, locked approximately 22,000 customers out of their smart thermostats during a heatwave. This resulted in huge public backlash, where people reported internal home temperatures reaching as high as 88 degrees Fahrenheit. All the customers affected were enrolled in a DR program, but most did not read the fine print that allowed Xcel Energy to lock them from controlling their devices during an energy emergency (Schemmel, 2022). These incidents are extremely damaging for the public perception of utilities, smart technology and DR programs. Canadian utilities and technology providers should heed this warning as they design their DR programs. **Customers should always have control of their devices, and their comfort.**

4.1.5 Subsidise Investment Cost through Rebates & Rentals

According to survey results, the initial purchase price was flagged as the leading public barrier of RDR adoption. Utility rebates have been proven to break the cost barrier and make smart technologies more accessible to customers while boosting satisfaction and public perception.

Parks Associates reported that 23% of US households that recently purchased a smart thermostat were triggered by an incentive or rebate offered by their energy provider (Parks Associates, 2021). Therefore, **Canadian utilities should subsidise DR enabled smart devices to promote smart device adoption**. This will break down cost barriers, build a customer-centred business and improve public image. There are already existing programs in BC, Nova Scotia, NL, Ontario and Québec that offer rebates for smart thermostat products. However, these incentives are quite low compared to rebates offered by US utilities that cover up to 100% of the device cost (Energy Star, 2022).

Some Canadian utilities, such as NB Power and Saint John Energy, tackle the challenge of home ownership and cost barriers by offering rental programs for appliances such as heat pumps and hot water tanks. This provides the utilities with great knowledge, control and standardisation of residential loads. According to Nick Fraser, Saint John Energy Smart Grid Analyst, this has also been a very lucrative business model for the utility and affordable option for the customer. NB Power hot water tank rentals rates are only $7 a month (NB Power, 2021). This allows the customers to benefit from new and modern technologies without the upfront investment cost. These rental programs also remove the barrier of home ownership. **More Canadian utilities should explore the model of renting hot water tanks and heat pumps to their customers**.

4.2 Encourage Service Provider Adoption

Sierra Club's report refers to electric utilities as "the cornerstone of economy-wide decarbonization" (Sierra Club, 2021). They are essential players in enabling RDR adoption. The lack of trust held by utilities must be overcome with **predictable and reliable data on a large scale**. This can be achieved through collaboration, cultural shift, a change of business model, increased funding and updated regulations.

4.2.1 Increase Knowledge Sharing and Collaboration

The federal government has recognized the lack of collaboration in the electricity sector and proposed to create a Pan-Canadian Grid Council. The liberal government has allocated $2.4 million in the 2022-23 budget for Natural Resources Canada to create this council with a mission “to **establish national standards, best practices,** and incentives to promote infrastructure investments, smart grids, grid integration, and **electricity sector innovation**” (Trudeau, 2022). This is an important initiative because many smaller utilities with limited resources look to larger utilities such as Hydro-Québec to lead research and development efforts in the sector. Therefore, **utilities should participate in this council, in addition to other conferences and information-sharing bodies** such as the Smart Grid Innovation Network. The increased knowledge sharing, and collaboration will help utilities to avoid perpetual pilot projects by building on knowledge and best practices. This will lead large and faster RDR demonstrations at scale.

Utilities often have robust data on their customer base, consumption patterns, and lessons learned from RDR pilot projects. However, this data is not broadly shared for the public good, even though it could potentially accelerate cross-country implementation of RDR and smart grid technology (Gass et al., 2017). Therefore, Canada should create an **independent, credible, centralised institution** such as the Energy Information Administration in the US (Eisler, 2016). This source of non-politicized energy information would increase knowledge sharing and help remedy the credibility gap in the public perception of energy companies.

4.2.2 Leverage Policy to Shift Culture

Changing an organisation's culture is one of the most difficult tasks to undertake because culture embodies an interlocking set of roles, processes, values, attitudes and assumptions (Rick, 2015). Because Canadian utilities are closely tied to politics, “**utilities see the route to change through regulatory and policy-led direction**” (NRCan, 2020). Therefore, Canada will have to use a top-down approach to shift culture through regulation.

Public utilities are a common characteristic of Canada’s electricity landscape. This represents **both a challenge and an opportunity**. The challenge is the reluctance to change that is deeply ingrained in these companies. The opportunity is that because these utilities are government-owned, provincial and territorial governments have greater control and influence over mandates and objectives. Therefore, provincial and territorial governments should **issue directives and legislation mandating that public utilities, regulators, and system operators pursue climate goals** (Canadian Climate Institute, 2022).

The provinces of British Columbia (BC) and Québec have already tasked their respective public utilities, BC Hydro and Hydro-Québec, to deliver significant parts of their climate change strategies (Canadian Climate Institute, 2022). **Public utilities should set targets to incentivize the adoption and deployment of new technologies such as RDR.** An overview of how Canada can leverage policy to drive the energy transition is captured in Figure 4-7.

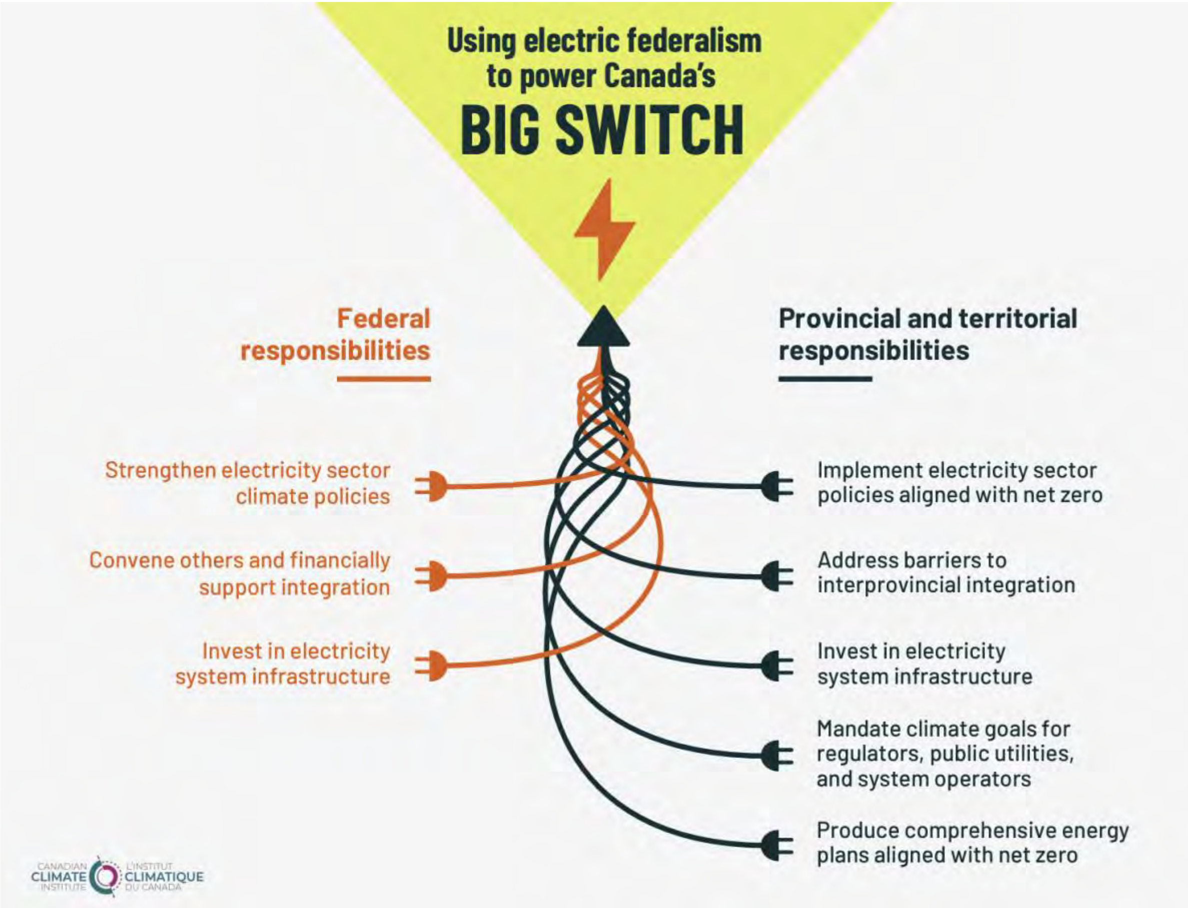


Figure 4-7: Federal, provincial and territorial responsibilities (Canadian Climate Institute, 2022)

4.2.3 Restructure Business Models

As utility businesses evolve with the energy transition, so must their business models. The traditional "cost of service" (COS) model allows utilities to collect earnings from long-term capital investment. It was designed to encourage utilities to upgrade and expand physical infrastructure and is widely used within the vertically integrated utilities that are prominent in Canada (NRCan, 2020). Policy mechanisms should incentivise the adoption of smart grid technologies such as RDR through the adoption of **value-driven business models**. "Cost of revenue" (COR) models would allow utilities to earn revenue and reinvest into new innovative projects (NRCan, 2020).

The provinces of Alberta and Ontario are exploring performance-based models. These models put more of the utility's earnings on goals and metrics. These metrics can include many things such as enhanced reliability, integration of DERs, GHG emissions or customer satisfaction rates. The traditional COS models have a higher bias toward capital infrastructure investments (NIST, 2020). **COR models should be adopted to provide utilities and solution providers more flexibility to deliver services.**

DR Program benefits and costs are multidimensional and can be very complicated to weigh and assess. The US Department of Energy (DOE) published an analytical framework[16] and computational tool to evaluate and weigh the costs and benefits of DR programs (Figure 4-8). It is recommended that **Canadian utilities use this framework to develop a business case for DR by estimating the cost-effectiveness**.

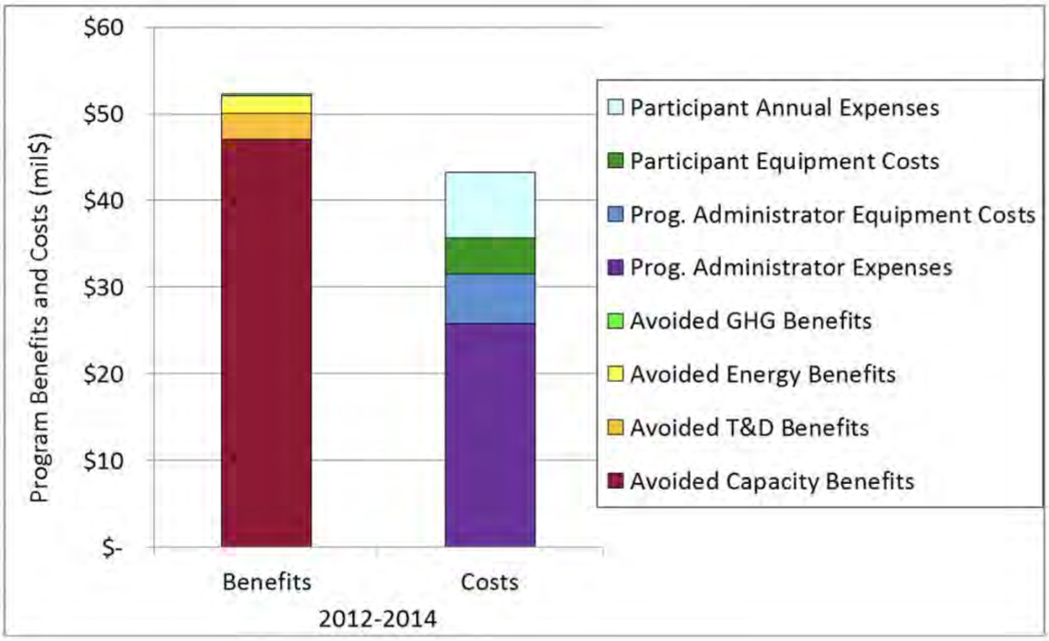


Figure 4-8: Example DR Cost-Effectiveness Results (US DOE, 2013)

4.2.4 Fund Scaling of Viable RDR Solutions

There must be significant capital investment raised in the coming years to decarbonize Canada's energy platform. This funding can be raised from a variety of sources, including government grants, private investors, utilities, banks and other partners.

[16] To access the US DOE DR Cost-effectiveness framework, please see https://www.ferc.gov/sites/default/files/2020-04/napdr-cost-effectiveness.pdf

One issue with government funding is that generally it is short-term in nature, around five years. Short-term grants motivate short-term projects and pilots, and generally do not consider scaling viable solutions. Therefore, even when pilots are technically successful, they may not be scaled. There should be more metrics within government funding around **developing a viable business model to scale RDR solutions** (NRCan, 2020). The funding could be structured such that a project can unlock "phase 2" of funding if the results were successful in phase 1. Phase 2 could be dedicated to scaling the solution and collecting mass data. The federal government should also increase grants for research, development, and demonstration projects.

Utilities should explore partnerships with non-traditional **partners such as cities and municipalities**. This can build investment in RDR technologies and programs, reducing reliance on short-term funding. To make meaningful change, the return on investment needs to extend to longer-term investments of 10 or more years (NRCan, 2020).
Canada also needs to harness the power of banks and private investors to finance the energy transition. The development of the Canadian green taxonomy[17] started in 2018 and is long overdue. Progress has stalled due to "fundamental differences of opinion" when developing the framework and classification of activities (Verney, 2022). **The green taxonomy must be pushed forward** to drive private investment in green solutions, such as RDR.

An emerging financial institution to accelerate private investment in green infrastructure is green banks. They act as a focal point to address market barriers and channel private capital into low-carbon projects (Whitney et al., 2020). It can be seen in Figure 4-9 that green banks are gaining momentum around the world but have not yet emerged in Canada.

[17] Green taxonomy is a classification system of environmental activities. It is designed to direct investment towards sustainable projects (EU, 2022)

Figure 4-9: Existing and Emerging Green Banks (Whitney, 2020)

These public-private partnerships remove the investment barrier by leveraging private financing. Therefore, **Canada should implement the Green Bank model drive private clean energy investment in order to scale mature and commercially viable technologies**, including RDR[18].

4.2.5 Update Regulations to Foster Innovation

It is clear that outdated regulations hamper the deployment of RDR in Canada. However, this problem is a symptom of a greater issue in the structure and regulation of the Canadian energy industry.

"If Canada wants to achieve the goal of zero carbon emissions by 2050, then **energy companies need the freedom to invest in solutions** that will help make that happen. We have seen this first-hand with many electricity companies in Canada, who need to do more, faster, to increase the capacity of the electricity grid and reduce GHG emissions – only for it to be **hampered by outdated legislation,"** says Francis Bradley, Electricity Canada CEO (Cleland & Gattinger, 2022)

[18] For further information on how Green Banks can accelerate green technology deployment in Canada, please see https://www.evergreen.ca/downloads/pdfs/2017/Green_Bank_Financing_2017.pdf

When comparing Canada and the US, it can be seen that the policies and regulations in Canada have a lower risk tolerance and slow the speed of adoption. This is due to the fact that traditional regulations have not been forced to adapt. In the states of New York, Texas and California, regulations are more risk tolerant, which drives innovation and adoption (NRCan, 2020).

In provinces with open markets, such as Alberta and Ontario, utilities are exploring new performance-based models. Performance based regulation (PBR) is more flexible and creates opportunities for solution providers and utilities, allowing both to be more competitive in the delivery of their services.

In all provinces, regulators must shift away from their traditional role of weighing only goals such as reliability and affordability. They must broaden their position to balance larger priorities such as emission reduction requirements and climate resilience in infrastructure. These investments may cost more initially but lead to lower costs over time.

CAMPUT is a pan-Canadian forum that brings together energy regulators. They should put pressure on regulators across Canada to redefine their priorities, increase risk tolerance and drive innovation. This will also include approving new business models, variable rates and **market structures**.

4.3 Enable Market Access

Non-wire alternatives, such as RDR, have a limited opportunity to compete with conventional offerings on the market. The current system is designed to categorise each resource as either generation, load, transmission or distribution infrastructure. DERs, including DR, do not fit into these traditional categories, and can play a role of both generation and storage. This limits the full potential and value of these resources, making them less competitive. To address this challenge, **a new resource type with different rules must be defined** (Hastings-Simon, 2021).

The Joint Research Centre published recommendations to enable DR participation in Europe. Such market design elements include **frequent auctions**[19]**, minimal bid sizes, and short time durations** of 15 to 30 minutes (Bertoldi et al., 2016).

A case study of FERC's storage mandate offers useful insight into how redefining market rules can enable market access[20]. FERC Order 841 required operators to create new rules to allow energy storage to participate in wholesale markets. DR would fall into this energy storage category. The new rules were able to **capture the full value of the energy storage technology by compensating them for all the services they provide** (Hastings-Simon, 2021). Changing these market rules to better reflect the value of DER was found to **lift barriers, increase deployment and unlock investment.**

California has also fostered DR growth by implementing mandatory AMI data sharing requirements. The California Independent System Operator (CAISO) requires that utilities provide aggregator access to AMI data upon customer consent (CAISO, 2016). This AMI data is used to create baselines and verify load drop during DR events.

It is important to note a key difference between the Canadian and American markets: in Canada, there is no federal body with equivalent authority to FERC. Therefore, the federal government can offer guidance, but the initiative to redefine market rules and structure must be **pushed forward by provincial and territorial governments and regulators.**

Short-Term: Encourage Access within current Market Structure

Ontario should leverage their liberalized market and focus on **redefining roles to foster RDR adoption**. They should create rules for energy storage based on FERC orders to capture the full value of the resource. In Ontario, AMI infrastructure is in place, but this data is costly and expensive to access. The Ontario ISO should implement a similar legislation to the CAISO where AMI data is required to be accessible to aggregators.

[19] For further reading on JRD recommendations, please visit: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC101191/ldna27998enn.pdf

[20] For further reading on the FERC case study, please visit: https://climateinstitute.ca/wp-content/uploads/2021/09/CICC-Barriers-to-innovation-in-the-Canadian-electricity-sector-and-available-policy-responses-by-Sara-Hastings-Simon-FINAL-1.pdf

Alberta's energy market should shift away from energy-only and implement regulatory framework to **harness the power of C&I DR**. "Residential DR will be the last crack" says Jeanie Chin, Canadian Utility Supervising Engineer.

In provinces with closed markets, Canada should focus on implementing RDR within the existing utility structures. They should also push AMI infrastructure rollout to the balance of the system.

Long-Term: Restructure Electricity Market

Access to the generation, transmission, and distribution markets is extremely limited across Canada. There has been a slight shift from vertically-integrated electric utilities to a limited level of liberalisation. The movement for market unbundling that occurred in many countries in the 1990's was primarily driven by economics. However, Canada should **move towards unbundling in order to drive the speed and innovation** necessary to reach net zero. This will also allow the industry to harness private investment to fund the transition and encourage competition. However, unbundling should be approached carefully and strategically by engaging stakeholders and learning from the successes and failures in other markets.

4.4 Move Towards Industry Standardisation

Interoperability is the key to unlocking the economics of the future smart grid. It is a critical enabler of customer empowerment and market value creation. Interoperability can minimise cost and technical barriers for new projects and market participation (NIST, 2020).

There is currently no widespread standard for ADR protocols, although several countries and states are making strides towards industry standardisation. Australia is in the process of rolling out the nation-wide DR standard AS 4755 that outlines DR capabilities and modes of a variety of residential loads (AEMO, 2020). However, this standard has been criticized claiming that it is basic and outdated because it only requires one-way communication (Kuiper & Gill, 2021). This highlights a critical point: **standardisation can be both an enabler and a blocker for ADR**.

Lessons learned from the Australian approach to standardisation is that it is better to adopt a widely used standard that has evolved with the market. The danger of creating a new standard is that it can lag the market and thus hinder rather than foster development.

The OpenADR standard is emerging as a leading industry standard in the US and is currently mandated by the California building code Title 24 for all new buildings. BC Hydro is encouraging their DR partners to adopt the OpenADR standard, however Sophia Tham, Project Manager, admits that this standard is far from perfect and needs modifications. She does, however, see the value in making solutions compatible and harmonised.

The challenge with standardisation in Canada is a matter of who has the authority to select and enforce a standard at a national level. The electricity sector in Canada is decentralised and the National Energy Board holds little influence. Therefore, currently it would be up to provincial governments, regulators and individual utilities to enforce a standard. However, this would lead to a fragmented approach, and standardisation should be tackled on either a national, or North American level. Canada should **shift more of the responsibility of standardisation to a national level.**

Short-Term: Encourage adoption of leading industry and FERC standards
Canada and the US are physically linked and trade electricity across borders, under the regulation of NERC. The US wholesale market is regulated by FERC (FERC, 2022). In the absence of an equivalent body as FERC, **Canada should aim to maintain coherence with FERC standards and protocols.**

In the absence of national standards, it is recommended that utilities look to adopt leading industry RDR standards. It is recommended that **utilities, system operators, governments, educational institutions, regulators and technology providers participate in the Pan-Canadian Grid council, collaborate, share knowledge, and implement best practices.** It is recommended that the Council creates a website and database where these **regulations, standards and information can be readily accessed**.

Long-Term: Select and Enforce Standards through Regulation
An industry standard should be selected and **enforced through regulation**. The problem is that currently there are no mechanisms to standardise codes and practices on a national level (Hastings-Simon, 2021).

When looking at the issue of standardisation, it highlights the disadvantage of having such a decentralised governing of the electricity sector in Canada. There is little or limited involvement of the federal energy regulator. In the current structure, each provincial regulator will have to champion the initiative to redefine its regulations. Therefore, Canada needs to **move towards more centralised regulation.**

4.5 Increase Centralised Industry Regulation

It is difficult to change regulations with top-down pressure if there is little federal authority in the sector. It is also a challenge to move towards national industry standardisation if there is no authority to enforce these standards. This also affects the ability to enable market access. Therefore, there is a fundamental problem with the way that the electricity sector is organised that inhibits the large-scale deployment of RDR. However, the issue is bigger than RDR, it affects the energy transition as a whole. It is clear that in order to align the Canadian energy system with net zero, there needs to be a regulatory reform.

The potential for highly centralised control and regulation of the energy industry is limited in Canada. Provincial regulators dominate the system and there is a **lack of inter-jurisdictional cooperation**. In order to overcome these constitutional and cultural barriers, Canada must acknowledge that **long-standing patterns of governance will not be sufficient to reach net zero by 2050**. The industry has been operating at a steady state for decades, and is not equipped to match the scale, complexity and speed needed to meet this timeline (Cleland & Gattinger, 2022).

Short-Term: Create National Taskforce

At its core, Canada needs to bring together federal, provincial and territorial regulators and policy makers. **NRCan in partnership with CAMPUT should create a two-to-three-year national taskforce** to bring together leaders engaged in energy delivery to **develop concrete, actionable recommendations for legislative change.** These recommendations should also include clear roles and responsibilities for provincial, territorial and federal policymakers and regulators (Cleland & Gattinger, 2022). It is important to consider that there are highly diverse provincial and territorial energy profiles, market systems, resources and challenges. Therefore, regulation will not have a "one-size-fits-all" approach across Canada.

Long-Term: Implement Legislative Change

The actions from the established task force should be implemented. This could include creating a Canadian body similar to FERC. FERC regulates all aspects of the US wholesale electricity market, while state authorities regulate retail markets. Establishing a more centralised regulation would help foster **collaboration**, **industry standardisation**, and pave the way to **enabling market access** for RDR.

4.6 Strategically Scale RDR

Short-Term: Use Behavioural RDR to build knowledge, scale and trust

Market and regulatory reform is a massive undertaking that will take time. However, there can still be progress in scaling RDR under the current electricity structure and regulation.

Canada should focus on paving the way for RDR through enabling behavioural DR (BDR). BDR does not offer a fast enough response time to support frequency or voltage regulation, however it can reduce system peaks. ToU rates are currently underutilised by Canadian utilities and regulators. Therefore, the electricity rates do not reflect the true real-time cost of service. The price signals in the market are muted through inefficient flat-rate design. ToU rates can incentivize users to shift their energy consumption, and also create opportunities in the market for products and services that shift demand. It is estimated that time-of-use pricing has reduced summer peaks in Ontario by a range of 1.1 to 3.6 per cent per year since 2014 (Canadian Climate Institute, 2022). This is a preferable first step to unlock demand side potential because it is **less technical, less investment,** and **requires less trust from both customers and utilities**.

Several interviewees expressed that the broader Canadian public is not yet ready to hand over control of their appliances to a utility. However, there has been a significant uptake in voluntary BDR programs such as Hydro-Québec's dynamic pricing program. Last year 157,000 customers enrolled in this program and shed 157 MW of peak load (Hydro- Québec, 2022).

Similar market trends have been observed in the US. Baltimore Gas and Electric's (BG&E) initial Peak Rewards DLC program has been operational for nine years and reached a saturation point at 320,000 customers. This is a fairly typical pattern of DLC programs in the US, the participation rate usually plateaus around 5%. However, BG&E then implemented a new BDR program and that yielded a 70-80% participation rate (St.John, 2017).

Opower CEO Alex Laskey said that they changed their approach to "go after the mass market by not asking them to sign on the dotted line but giving them signals and information to drive and change their behaviour." (St.John, 2017). RDR is a numbers game, because each individual household load is small. Therefore, in order to target the mass market, utilities should **implement a program that requires less access, less control, and therefore LESS trust.** There still needs to be some level of credibility, so that the customer trusts that they are being fairly compensated for the load that was reduced during peak times. However, they do not have to hand over control of their appliances to utility companies.

A study published by Opower (since acquired by Oracle Inc.) found that **customer relationship metrics increased** after utilities introduced BDR programs (Figure 4-10). Their solution includes highly customised results and leads to increased customer engagement (Opower, 2013).

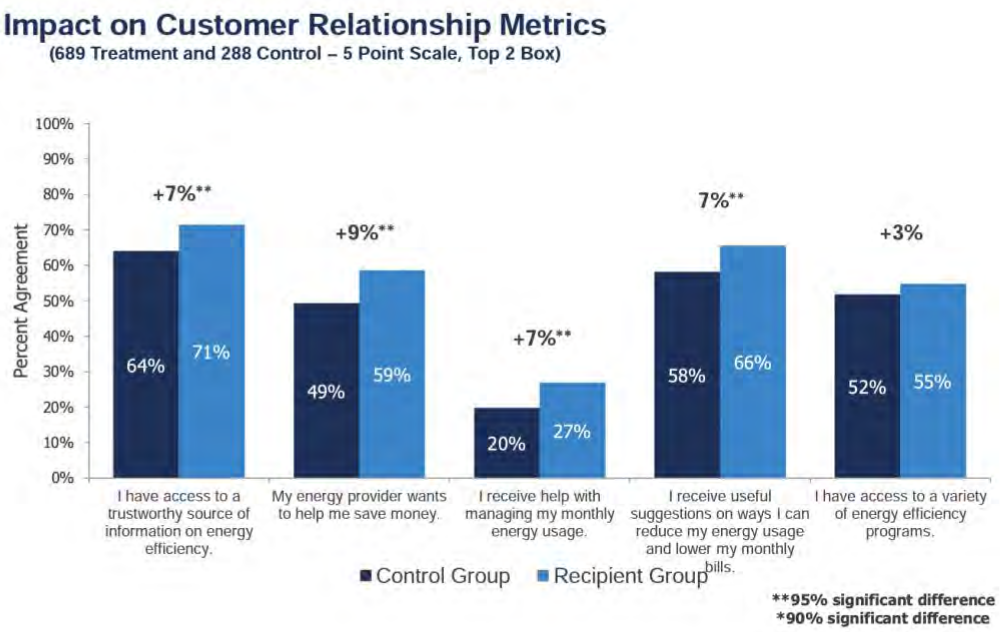


Figure 4-10: Impact of BDR on Customer Metrics (Opower, 2013)

There are three key supports necessary in order to roll out ToU rates: **technical, social and regulator**y. The technical gateway is AMI and supporting backend infrastructure to read and transmit the interval consumption data. Smart meters enable utilities to track the timing and consumption of electricity in order to bill customers with ToU tariffs. Currently there are only three provinces with complete AMI installation, however with the rollout is underway in many remaining jurisdictions. Canada should push provinces to complete AMI and backend infrastructure installation.

Provincial regulators must adjust regulations to implement ToU rates. This shift has already been made in the provinces of Ontario and Québec. BC Hydro is currently submitting an application to the BC Utilities Commission to introduce a ToU rate option (BC Hydro, 2022).

Lessons learned from BDR implementation in Ontario and Québec can provide best practices to other provinces. Specifically, to ensure **social support** of the new rate design. In the BC rate design, BC Hydro completed a phase of public engagement and consultation in 2021 (BC Hydro, 2022). The programs should be customer-centred, and **opt-in only**. **Public consultations should be held on rate design, prior to implementation.**

Paving the way with BDR can help build the trust of both the utilities and the customers. Utilities will have less investment in new infrastructure, and thus lower risk. BDR will also drive a larger participation rate, and therefore also achieve a larger demonstration of scale. It will raise awareness and educate the population on why electricity is more expensive during peak times. ToU rates will lay the groundwork for a good business case for both utilities and customers to control the timing of more loads through DLC.

DLC pilots should continue to be conducted through collaboration across the country to accelerate the learning curve of DLC technology. "There is a real danger of letting **the perfect be the enemy of the good** [..] we have to develop new programs, learn from them, and move forward." says Minnesota Public Utilities Commissioner, Matt Schuerger (Trabish, 2021).

Long-Term: Unlock Full DSM with DLC

With the foundation of scale, collaboration and trust, Canada can move towards full deployment of ADR. It will be enabled through all recommendations discussed above including standardisation, market access, funding and regulation. This will allow Canada to unlock the full potential of automatic frequency and voltage support through ADR.

4.7 Recommendation Key Points

Canada must acknowledge that climate change poses an unprecedented challenge and re-evaluate the way that the electricity industry is structured. There must be more direction, leadership and regulation at a central level to align the country with climate goals. In the current structure, utilities and provinces need to take initiative to foster innovation within their jurisdictions. It will require significant political will, trust and national collaboration to unlock demand-side management through RDR.

5 CONCLUSION

Canada is an energy-rich country with an abundance of natural resources, hydroelectricity and low electricity rates. The legacy of vertically integrated crown corporations shaped the national energy landscape, and many are still operating in monopoly markets today. Therefore, both the energy sector and the energy transition are highly political. Due to its prosperous past, the market in Canada was not largely liberalised as it was in many other western countries. The culture of the industry in Canada is conservative, risk-averse and traditional. The industry is structured and regulated in a manner that **does not foster innovation or collaboration**. Canada's energy sector has been operating at a near steady-state for decades and has not been forced to adapt. However, as the electricity system grows and expands with the energy transition, so will the need for a flexible load.

Overall, there is an absence of **drivers to push for large-scale RDR deployment in Canada**. Canada already has a very clean electricity mix, with a low share of VRE. There is little market competition and low electricity rates. However, each province has a unique portfolio of resources, market and policy landscapes that introduce various challenges and opportunities for RDR adoption. Overall, the **main drivers of RDR adoption in Canada will be the electrification of the transport sector and the increased share of VRE**. Until there is a larger uptake and adoption of EVs, there will be little pressure to push past the barriers facing RDR deployment in Canada.

There are many political, regulatory, social, and financial barriers that stand between Canada and large-scale RDR adoption. There is a fundamental lack of trust between citizens, government, utilities and technology. Trust is the foundation of legitimacy; hence, trust must be established to achieve the energy transition. This will take time and require consistent communication, transparency and integrity between all actors. Therefore, it is recommended to first lay a foundation with BDR to build trust in the customer, utility and technology. Then with increased knowledge, experience and trust, Canada can unlock full RDR potential through ADR deployment.

Planning and regulation occur in silos in Canada, with very little central authority or governance. Energy policy, regulations and markets fall almost entirely under the domain of provincial governments. However, existing **provincial policies do not align with federal net zero targets.** Provincial and territorial governments should **issue legislation mandating that**

public utilities, regulators, and system operators pursue climate goals. There must be a fundamental shift in the culture, regulations, market structure and business models to incentivise and foster the energy transition. It is encouraging that Canada is creating a Pan-Canada Grid Council to increase nationwide collaboration. However, Canada must acknowledge that **long-standing patterns of governance will not be sufficient to match the speed and innovation necessary to meet net zero targets** and shift towards centralised regulation.

This thesis provided a high-level overview of barriers and recommendations for RDR deployment in Canada. These recommendations are starting points, and further research should be conducted to explore how Canada should approach market and regulation restructuring. Market unbundling has been met with various levels of challenges and success around the world. It should be approached carefully and strategically by engaging stakeholders and learning from the successes and failures in other markets. Technical challenges around ADR deployment have not been discussed, including connectivity issues, integration and response times. However, these technical challenges can be overcome through collaboration and standardisation. The greatest challenges for RDR deployment, and the energy transition as a whole, are not technical in nature but rather **political, financial and social**.

Electricity infrastructure and smart grid investments can have a lock-in impact and influence the evolution of the industry. **Acting now** with clear and forward-thinking policies will **significantly reduce overall costs to achieve net zero through driving innovation**. It will also **accelerate the learning curves** of important technologies such as RDR through deployment.

Collaboration is the **key** to the energy transition, and the citizen is the **heart** of the energy transition. Canada can unlock demand-side potential through RDR, but it will require unprecedented collaboration, political will and commitment to unite governments, regulators, utilities, service providers, and citizens.

References

Accenture. (2017, April 6). *The future of demand response in electricity distribution*. Accenture. Retrieved May 17, 2022, from https://www.accenture.com/t20170406t202722z__w__/us-en/_acnmedia/pdf-48/accenture_future-demand-response-pov.pdf

AEMO. (2018, February 6). *AEMO | Managing frequency in the power system*. Australian Energy Market Operator. Retrieved January 23, 2022, from https://aemo.com.au/learn/energy-explained/energy-101/managing-frequency-in-the-power-system

AEMO. (2020). *AEMO | AS 4755 - Demand Response Standard*. Australian Energy Market Operator. https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/standards-and-connections/as-4755-demand-response-standard

Alves, B. (2021, March 11). *• Canada: electricity prices by province 2021*. Statista. Retrieved May 24, 2022, from https://www.statista.com/statistics/516279/electricity-costs-for-end-users-canada-by-province/

Auditor General of Ontario. (2014). *3.11: Smart Metering Initiative*. Office of the Auditor General of Ontario. Retrieved June 11, 2022, from https://www.auditor.on.ca/en/content/annualreports/arreports/en14/311en14.pdf

Baldwin, D. (2022, May 17). *Gasoline prices hit record highs in Canada ($2.06 a litre) and U.S. ($4.43 a gallon)*. National Post. Retrieved May 25, 2022, from https://nationalpost.com/news/canada/gasoline-prices-hit-record-highs-in-canada-2-06-a-litre-and-u-s-4-43-a-gallon

BC Hydro. (2021). *DRAFT 2021 Integrated Resource Plan*. BC Hydro. Retrieved March 15, 2022, from https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/integrated-resource-plans/current-plan/draft-integrated-resource-plan.pdf

BC Hydro. (2022). *Residential rate design*. BC Hydro. Retrieved June 5, 2022, from https://www.bchydro.com/about/strategies-plans-regulatory/rate-design/current-activities/residential-rate-design.html?utm_source=direct&utm_medium=redirect&utm_content=yourrates

Beck, M., & Robertson, B. (2019, July 23). *Canada's energy data problem*. Policy Options. Retrieved April 20, 2022, from https://policyoptions.irpp.org/magazines/july-2019/canadas-energy-data-problem/

Bertoldi, P., Zancanella, P., & Boza-Kiss, B. (2016). *Demand Response status in EU Member States*. JRC Publications Repository. Retrieved June 2, 2022, from https://publications.jrc.ec.europa.eu/repository/bitstream/JRC101191/ldna27998enn.pdf

Blanc, J., Duretz, B., & de la Selle, A. (2014). *The Benefits of Demand Response for Utilities*. Schneider Electric. Retrieved April 24, 2022, from https://www.energy-pool.eu/wp-content/uploads/2016/07/The-benefits-of-Demand-Response-for-Utilities.pdf

Brown, S. P., & Jefferson, M. (n.d.). *How Energy Deregulation works in the United States and Canada*. Direct Energy Business. Retrieved January 19, 2022, from https://business.directenergy.com/what-is-deregulation

CAISO. (2016, August 26). *Distributed Energy Resource Provider Participation Guide with Checklist Version 1.0 August 26, 2016*. California ISO. Retrieved June 17, 2022, from http://www.caiso.com/Documents/DistributedEnergyResourceProviderParticipationGuideandChecklist.pdf

Canada Energy Regulator. (2022). *Provincial and Territorial Energy Profiles – Canada*. Canada Energy Regulator. Retrieved March 14, 2022, from https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-canada.html

Canadian Climate Institute. (2022, May 4). *The Big Switch*. Canadian Climate Institute. Retrieved May 16, 2022, from https://climateinstitute.ca/reports/big-switch/

Canadian Climate Institute. (2022, May 4). *The Big Switch: Powering Canada's net zero future*. Canadian Climate Institute. https://climateinstitute.ca/wp-content/uploads/2022/05/The-Big-Switch-May-4-2022.pdf

Canadian Climate Institute. (2022, May 4). *Electric Federalism: Policy for aligning Canadian electricity systems with net zero*. Canadian Climate Institute. https://climateinstitute.ca/wp-content/uploads/2022/05/Electric-Federalism-May-4-2022.pdf

Canary Media. (2022, April 11). *Home water heaters: A new ally in making grids cleaner*. Canary Media. Retrieved May 16, 2022, from https://www.canarymedia.com/articles/grid-edge/home-water-heaters-a-new-ally-in-making-grids-cleaner

CEA. (2014). *THE FUTURE OF CANADA'S ELECTRICITY SYSTEM*. Canadian Electricity Association. Retrieved March 15, 2022, from https://electricity.ca/wp-content/uploads/2014/04/Vision2050.pdf

Centrica. (2022). *How Frequency Regulation can maximize your Demand Response revenue*. Centrica Business Solutions. Retrieved May 20, 2022, from https://www.centricabusinesssolutions.com/us/blogpost/how-frequency-regulation-can-maximize-your-demand-response-revenue

CER. (2022, January 27). Régie de l'énergie du Canada. Retrieved March 14, 2022, from https://www.cer-rec.gc.ca/en/about/publications-reports/annual-report/2018/energy-in-canada.html

CER. (2022, February 14). *Canada's Energy Future 2021 - Key Findings*. Régie de l'énergie du Canada. Retrieved March 16, 2022, from https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/key-findings.html

CER. (2022, July 28). *CER – Provincial and Territorial Energy Profiles – Alberta*. Canada Energy Regulator. Retrieved Sept 17, 2022, from https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-alberta.html

Christian, J., Shipley, L., & Lundell, L. (2020). *Electricity regulation in Canada: overview*. Thomson Reuters Practical Law. https://ca.practicallaw.thomsonreuters.com/5-632-4326?transitionType=Default&contextData=(sc.Default)&firstPage=true

Chung, E. (2022, January 30). *Why oil and gas heating bans for new homes are a growing trend*. CBC. Retrieved May 14, 2022, from https://www.cbc.ca/news/science/bans-fossil-fuel-heating-homes-1.6327113

City-zen. (n.d.). *Demand Response on tertiary site / Tertiary Flexibility*. City-zen. Retrieved January 23, 2022, from http://www.cityzen-smartcity.eu/ressources/smart-grids/demand-response-on-tertiary-site-tertiary-flexibility/

Cleland, M., & Gattinger, M. (2022, April 4). *Net Zero: An International Review of Delivery System Policy and Regulation Energy for Canadian Energy Decision Makers*. Electricity Canada. Retrieved June 2, 2022, from https://www.electricity.ca/news/energy-sector-calls-for-national-regulatory-task-force/

Cochrane, D. (2021, July 28). *Ottawa to give NL billions of dollars to offset Muskrat Falls costs*. CBC. Retrieved May 28, 2022, from https://www.cbc.ca/news/politics/muskrat-falls-hydro-newfoundland-labrador-1.6119276

Decarb Europe. (n.d.). *Demand Response – DecarbEurope*. Decarb Europe. Retrieved January 23, 2022, from https://decarbeurope.org/solutions/demand-response/

EIA. (2017, July 19). *US Energy Information Administration*. EIA. Retrieved June 14, 2022, from https://www.eia.gov/todayinenergy/detail.php?id=32112

EIA. (2019, March 29). *Demand-side management programs save energy and reduce peak demand - Today in Energy - US Energy Information Administration*. EIA. Retrieved January 19, 2022, from https://www.eia.gov/todayinenergy/detail.php?id=38872

EIA. (2019, October 7). *Canaeda*. EIA. Retrieved May 24, 2022, from https://www.eia.gov/international/analysis/country/CAN

Eisler, D. (2016, Jan). *Volume 9 • Issue 1 • January 2016 - ENERGY LITERACY IN CANADA: A SUMMARY*. The School of Public Policy. Retrieved April 20, 2022, from https://www.policyschool.ca/wp-content/uploads/2016/03/energy-literacy-canada-eisler.pdf

Enefirst. (2019, November). *USING TIME-OF-USE TARIFFS TO ENGAGE CUSTOMERS AND BENEFIT THE POWER SYSTEM*. Enefirst. Retrieved June 2, 2022, from https://enefirst.eu/wp-content/uploads/1_Using-ToU-Time-of-Use-tariffs-to-engage-consumers-and-benefit-the-power-system.pdf

Energy Star. (2022). *Special Offers and Rebates from ENERGY STAR Partners*. Energy Star. Retrieved May 19, 2022, from https://www.energystar.gov/rebate-finder?scrollTo=444&sort_by=utility&sort_direction=asc&page_number=0&lastpage=0&zip_code_filter=&find_rebates=Find+Rebates&search_text=smart+thermostat&product_clean_isopen=&product_types=Select+a+Product+Category

EnerNOC Inc. (2011). *The Demand Response Baseline*. Energy Efficiency Program Library. Retrieved March 16, 2022, from https://library.cee1.org/sites/default/files/library/10774/CEE_EvalDRBaseline_2011.pdf

EU. (2022). *EU taxonomy for sustainable activities | European Commission*. European Commission. Retrieved June 10, 2022, from https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

European Smart Grids Task Force. (2019, April 1). *Final Report: Demand Side Flexibility*. European Commission. Retrieved December 8, 2021, from https://ec.europa.eu/energy/sites/ener/files/documents/eg3_final_report_demand_side_flexiblity_2019.04.15.pdf

Faria, P., Spínola, J., & Vale, Z. (2017, March 31). *Identified Short and Real-Time Demand Response Opportunities and the Corresponding Requirements and Concise Systematization of t*. European Commission. Retrieved December 8, 2021, from https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b167253a&appId=PPGMS

Faruqui, A., Lessem, N., Sergici, S., Mountain, D., Denton, F., Spencer, B., & King, C. (2016, Febuary 3). *Analysis of Ontario's Full Scale Roll-out of TOU Rates – Final Study*. The Brattle Group. Retrieved June 10, 2022, from https://images.app.goo.gl/ZUwVKEYaeiLUjEiF8

Fisher, J., & Nilsson, M. (2002, December 20). *Lessons from Liberalised Electricity Markets*. International Energy Agency. Retrieved May 24, 2022, from https://iea.blob.core.windows.net/assets/d0c52ee9-6f54-4735-81b2-6e0dd3ddbe13/LessonsNet.pdf

FERC. (2022). What FERC Does. Federal Energy Regulatory Commission. Retrieved October 25, 2022, from https://www.ferc.gov/what-ferc-does

Gass, P., Echeverría, D., & Asadollahi, A. (2017, September). *Cities and Smart Grids in Canada*. International Institute for Sustainable Development. Retrieved May 31, 2022, from https://www.iisd.org/system/files/publications/cities-smart-grids-canada.pdf

Goodhue, A. (2021, August 5). *The pandemic has tested Canadian's trust in government*. The Gateway. Retrieved June 12, 2022, from https://thegatewayonline.ca/2021/08/the-pandemic-has-tested-canadians-trust-in-government/

Government of Canada. (2022, January 31). *Net-Zero Emissions by 2050*. Canada.ca. Retrieved March 16, 2022, from https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

Government of Canada. (2022, March 22). *Carbon pollution pricing systems across Canada*. Canada.ca. Retrieved May 13, 2022, from https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work.html

Government of Canada. (2022, May 14). *Canada and the G7 - Toronto*. Global Affairs Canada. Retrieved May 26, 2022, from https://www.international.gc.ca/world-monde/international_relations-relations_internationales/g7/index.aspx?lang=eng

Hastings-Simon, S. (2021). *Barriers to innovation in the Canadian electricity sector and available policy responses*. Canadian Climate Institute. Retrieved June 4, 2022, from https://climateinstitute.ca/wp-content/uploads/2021/09/CICC-Barriers-to-innovation-in-the-Canadian-electricity-sector-and-available-policy-responses-by-Sara-Hastings-Simon-FINAL-1.pdf

Hilo. (2022). Rise to the challenge and earn rewards. Hilo Energie. Retrieved May 25, 2022, from https://www.hiloenergie.com/en-ca/our-service/hilo-challenges/#soutien-defi

Holowka, T. (2020, December 21). *Building Customer Trust: Utility Partnerships with Community-based Organizations*. Alliance to Save Energy. Retrieved May 18, 2022, from https://www.ase.org/blog/building-customer-trust-utility-partnerships-community-based-organizations

HomeGuide. (2022). *2022 Thermostat Costs | Installation & Replacement Prices (In Home)*. HomeGuide. Retrieved May 27, 2022, from https://homeguide.com/costs/thermostat-installation-cost

Howard, K. (2019, July 24). *Farewell Capacity Market: Alberta to remain an Energy-Only Market*. McCarthy Tétrault LLP. Retrieved May 21, 2022, from https://www.mccarthy.ca/en/insights/blogs/canadian-energy-perspectives/farewell-capacity-market-alberta-remain-energy-only-market

Hydro Ottawa. (2016, March 9). *Distribution System Voltage and Power Quality*. Hydro Ottawa. Retrieved April 06, 2022, from https://static.hydroottawa.com/documents/specifications/ECG0008.pdf

Hydro-Québec. (2019, November). *Overview of Hydro-Québec's Energy Resources*. Hydro-Québec. Retrieved March 15, 2022, from https://www.hydroquebec.com/data/achats-electricite-quebec/pdf/electricity-supply-plan-2020-2029.pdf

Hydro-Québec. (2019, December 1). *Dynamic pricing results*. Hydro-Québec. Retrieved May 27, 2022, from https://www.hydroquebec.com/residential/customer-space/rates/dynamic-pricing-results.html

Hydro-Québec. (2022, April 1). *Dynamic pricing results*. Hydro-Québec. Retrieved May 13, 2022, from https://www.hydroquebec.com/residential/customer-space/rates/dynamic-pricing-results.html

Iacobucci, E., & Trebilcock, M. (2012, March). *THE ROLE OF CROWN CORPORATIONS IN THE CANADIAN ECONOMY*. The School of Public Policy. Retrieved April 20, 2022, from https://www.policyschool.ca/wp-content/uploads/2016/03/privatization-crown-corp.pdf

IEA. (2021, May 17). *Net Zero by 2050 – Analysis*. International Energy Agency. Retrieved December 5, 2021, from https://www.iea.org/reports/net-zero-by-2050

IEA. (2021, November). *Demand Response – Analysis - IEA*. International Energy Agency. Retrieved March 16, 2022, from https://www.iea.org/reports/demand-response

IEA. (2022). *Canada 2022 Energy Policy Review | en*. INTERNATIONAL ENERGY AGENCY. Retrieved May 24, 2022, from https://www.oecd.org/publications/canada-2022-energy-policy-review-a440d879-en.htm

IESO. (2019). *2019 Year End Data*. Independent Electricity System Operator. Retrieved June 10, 2022, from https://www.ieso.ca/en/Corporate-IESO/Media/Year-End-Data/2019

IESO. (2021). *CONTRACT FOR ENERGY AND RESERVE SERVICES (DIRECT PARTICIPANT)*. IESO York Region Non-Wires Alternatives Demonstration Project. https://yrdemo.com/file/NWA%20Demonstration%20-%20Contract%20for%20Energy%20Services%20(DIRECT%20PARTICIPANT).pdf

IESO. (2022). *Capacity Auction*. Independent Electricity System Operator. Retrieved June 10, 2022, from https://www.ieso.ca/en/Sector-Participants/Market-Operations/Markets-and-Related-Programs/Capacity-Auction

IESO. (2022). *IESO York Region Non Wires Alternatives Demonstration Project*. Independent Electricity System Operator. Retrieved March 16, 2022, from https://www.ieso.ca/en/Sector-Participants/Engagement-Initiatives/Engagements/IESO-York-Region-Non-Wires-Alternatives-Demonstration-Project

IESO. (2022). *Rates For Residents and Small Businesses*. Independent Electricity System Operator. Retrieved May 12, 2022, from https://www.ieso.ca/en/Learn/Electricity-Pricing/For-Residents-and-Small-Businesses

IRENA. (2019). *Demand-side flexibility for power sector transformation*. International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Dec/IRENA_Demand-side_flexibility_2019.pdf

IRENA. (2021, June). *Renewable Power Generation Costs in 2020*. IRENA. Retrieved May 17, 2022, from https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020

IRENA. (2021, September 29). *Canada*. IRENA. Retrieved May 30, 2022, from https://www.irena.org/IRENADocuments/Statistical_Profiles/North%20America/Canada_North%20America_RE_SP.pdf

IRGC. (2015). *DEMAND-SIDE FLEXIBILITY FOR ENERGY TRANSITIONS*. International Risk Governance Council. Retrieved March 15, 2022, from https://irgc.org/wp-content/uploads/2018/09/IRGC-Demand-Response-Report-2016-WEB.pdf

JRC. (2020, November 19). *Current status of Demand Response in the EUOverview of DR services, markets, and regulatory issues*. Delta Webinar. https://onlinelibrary.wiley.com/doi/full/10.1002/er.3683

Katofsky, R. (2020, September 30). *Utility Pilot Best Practices and Future Pilot Areas*. MPSC Electronic Docket Filings. Retrieved May 31, 2022, from https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t000000Ei9QfAAJ

Kind, S. (2017, April 06). Newfoundland & Labrador: Rolling Blackouts, The Liberty Reports, & The Role of Reliability in Energy Provision. *Dalhousie Journal of Interdisciplinary Management*, *13*. 10.5931/djim.v13i1.6932

Kling, W. (2013, July 21). *History of demand side management and classification of demand response control schemes*. Semantic Scholar. Retrieved June 10, 2022, from https://www.semanticscholar.org/paper/History-of-demand-side-management-and-of-demand-Lampropoulos-Kling/3c9be775df807129df9bebee050b2dc2e77c1de9

Kuiper, G., & Gill, M. (2021, August 6). *Five issues with demand response standard AS4755 - Institute for Energy Economics & Financial Analysis*. IEEFA's. Retrieved March 15, 2022, from https://ieefa.org/ieefa-australia-five-issues-with-demand-response-standard-as4755/

Laitsos, V., Bargiotas, D., Daskalopulu, A., Arvanitidis, A. I., & Tsoukalas, L. (2021, November 30). *An Incentive-Based Implementation of Demand Side Management in Power Systems*. MDPI. Retrieved May 30, 2022, from https://www.mdpi.com/1996-1073/14/23/7994

Lotfi, M., Shafie-khah, M., & Monteiro, C. (2018). *Evolution of Demand Response: A Historical Analysis of Legislation and Research Trends*.

Mikelann, M. (2021, March 29). *Can Your Smart Device Save You Energy and Money? Here's What to Look For.* Alliance to Save Energy. Retrieved June 4, 2022, from https://www.ase.org/blog/can-your-smart-device-save-you-energy-and-money-heres-what-look

Mordor Intelligence. (2021). *Canada Power Market | 2022 - 27 | Industry Share, Size, Growth*. Mordor Intelligence. Retrieved June 13, 2022, from https://www.mordorintelligence.com/industry-reports/canada-power-market

Mordor Intelligence. (2021). *Global Residential Demand Response Management Systems Market | 2021 - 26 | Industry Share, Size, Growth*. Mordor Intelligence. Retrieved January 19, 2022, from https://www.mordorintelligence.com/industry-reports/global-residential-demand-response-management-systems-market-industry

NACAA. (2015, May 21). *Implementing EPA's Clean Power Plan: A Menu of Options*. National Association of Clean Air Agencies. Retrieved January 19, 2022, from https://www.4cleanair.org/sites/default/files/Documents/Chapter_23.pdf

NAESB. (2008, September 29). *The Demand Response Baseline*. North American Energy Standards Board. Retrieved June 13, 2022, from https://www.naesb.org/pdf4/dsmee_group3_100809w3.pdf

NB Power. (2021). *Tank Sizes and Rental Rates*. Énergie NB. Retrieved June 9, 2022, from https://www.nbpower.com/en/products-services/water-heaters/your-options

NB Power. (2022, April 1). *Rates*. Énergie NB. Retrieved May 17, 2022, from https://www.nbpower.com/en/products-services/business/rates

NERC. (2011, January 26). *NERC Balancing and Frequency Control 040520111.pdf*. NERC. Retrieved May 22, 2022, from https://www.nerc.com/docs/oc/rs/NERC%20Balancing%20and%20Frequency%20Control%20040520111.pdf

NERC. (2022). *Demand Response Availability Data System (DADS)*. NERC. Retrieved May 16, 2022, from https://www.nerc.com/pa/RAPA/dads/Pages/default.aspx

NIST. (2020, July). *Smart Grid Framework*. NIST. Retrieved June 5, 2022, from https://www.nist.gov/el/smart-grid/smart-grid-framework

NIST. (2021, February 18). *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 4.0*. NIST. https://www.nist.gov/publications/nist-framework-and-roadmap-smart-grid-interoperability-standards-release-40

NL Hydro. (n.d.). *About Hydro*. Newfoundland & Labrador Hydro. Retrieved March 15, 2022, from https://nlhydro.com/about-hydro/

NRC. (2019, July). *Energy Fact Book 2019-2020*. Natural Resources Canada. Retrieved May 17, 2022, from https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/Energy%20Fact%20Book_2019_2020_web-resolution.pdf

NRCan. (2018). *SMART GRID IN CANADA*. Natural Resources Canada. Retrieved March 15, 2022, from https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/pdf/Smart%20Grid%20in%20Canada%20Report%20Web%20FINAL%20EN.pdf

NRCan. (2020, September). *Industry Perspective*. MaRS Discovery District. Retrieved May 27, 2022, from https://www.marsdd.com/wp-content/uploads/2020/10/MaRS-NRCan-Smart-Grid-Report-2020.pdf

NRCan. (2021). *Energy Fact Book 2021-2022*. Natural Resources Canada. Retrieved June 11, 2022, from https://www.nrcan.gc.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf

O'Driscoll, A. (2022, May 17). *Canada Cyber Crime Statistics: Cyber Security in 2020-22*. Comparitech. Retrieved May 26, 2022, from https://www.comparitech.com/blog/information-security/canada-cyber-crime-statistics/

OECD. (2016, June 13). *OECD Economic Surveys: Canada 2016*. OECD. https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-canada-2016_eco_surveys-can-2016-en

OECD. (2021, November 4). *Consumer Prices, OECD - Updated: 4 November 2021*. OECD. Retrieved May 30, 2022, from https://www.oecd.org/sdd/prices-ppp/consumer-prices-oecd-updated-4-november-2021.htm

OECD. (2022). *Trust in Government*. OECD. Retrieved April 20, 2022, from https://www.oecd.org/gov/trust-in-government.htm

OhmConnect. (2017). Gamification for good: How to "level up" your bank account, your relationships and your impact. OhmConnect. Retrieved October 25, 2022, from https://www.ohmconnect.com/impact/gamification-for-good-how-to-level-up-your-bank-account-your-relationships-and-your-impact

OpenADR Alliance. (n.d.). *The OpenADR Primer*. OpenADR Alliance. https://www.openadr.org/assets/docs/openadr_primer.pdf

Opinion Dynamics. (2019, October 11). *Smart Thermostat Customer Preference Study*. AWS. Retrieved June 3, 2022, from https://ilsag.s3.amazonaws.com/AIC_Thermostat_Customer_Preference_Study_Results_FINAL_2019-10-11.pdf

Opower. (2013). *Behavioral Demand Response*. A National Summit on Smart Grid & Climate Change. Retrieved June 12, 2022, from https://www.smartgridclimatechange.org/wp-content/uploads/2013/10/Orfei-Alex-2-A.pdf

Panfil, M. (2014, June 30). *Resiliency+: Demand Response Can Help Prevent Blackouts in the Northeast*. EDF. Retrieved May 16, 2022, from https://blogs.edf.org/energyexchange/2014/06/30/resiliency-demand-response-can-help-prevent-blackouts-in-the-northeast/

Parks Associates. (2021, March 24). *Incentives, discounts, and interest in energy conservation are triggering smart thermostat purchases*. Parks Associates. Retrieved June 3, 2022, from https://www.parksassociates.com/blog/article/pr-03242021

Pham, T. (2019). Market Power Issues in Liberalized Wholesale Electricity Markets: A Review of the Literature with a Look into the Future. *Revue d'économie politique*, *129*, 325-354. https://doi.org/10.3917/redp.293.0325

PLMA. (2018). *38th Conference Agenda, Austin, TX*. Peak Load Management Alliance. https://www.peakload.org/38th-plma-conference

Ponds, K. T., Arefi, A., Sayigh, A., & Ledwich, G. (2018). *Aggregator of Demand Response for Renewable Integration and Customer Engagement: Strengths, Weaknesses, Opportunities, and Threats*. MDPI. Retrieved June 3, 2022, from https://www.mdpi.com/1996-1073/11/9/2391

Promislow, R. (2021, July 21). *A Key Step Towards the Right to Be Forgotten? Federal Privacy Laws and Internet Search Engines*. Bennett Jones. Retrieved June 5, 2022, from https://www.bennettjones.com/Blogs-Section/A-Key-Step-Towards-the-Right-To-Be-Forgotten

Proof Strategies. (2021). *CanTrust Index 2021*. Proof Strategies. Retrieved June 12, 2022, from https://getproof.com/what-we-do/cantrust/

PwC. (2020). *Accelerating Canada's electric vehicle transition*. PwC. Retrieved June 12, 2022, from https://www.pwc.com/ca/en/industries/automotive/publications/accelerating-canadas-electric-vehicle-transition.html

The Rhythm Team. (2021, December 5). *What is Vehicle-to-Grid Technology?* Rhythm. Retrieved May 16, 2022, from https://www.gotrhythm.com/blog/electric-vehicles/what-is-vehicle-to-grid-technology

Rick, T. (2015, May 25). *Why is organizational culture change difficult*. Torben Rick. Retrieved June 5, 2022, from https://www.torbenrick.eu/blog/culture/why-is-organizational-culture-change-difficult/

Schemmel, A. (2022, September 2). Company locks customers from changing smart thermostats due to 'energy emergency'. WCIV. https://abcnews4.com/news/nation-world/company-locks-customers-from-changing-smart-thermostats-due-to-energy-emergency

SGIN. (2020). *Smart Grid in Canada 2020*. Smart Grid Innovation Network. https://www.clarion-events-group.com/EnlitEurope2020_Canada_report_SGIN

Shen, B., Ghatikar, G., Ni, C., & Dudley, J. (2012, June). *Addressing Energy Demand through Demand Response: International Experiences and Practices*. OSTI.GOV. Retrieved January 21, 2022, from https://www.osti.gov/servlets/purl/1212423

Sierra Club. (2021, January). *The Dirty Truth About Utility Climate Pledges | Beyond Coal*. Beyond Coal. Retrieved March 12, 2022, from https://coal.sierraclub.org/the-problem/dirty-truth-greenwashing-utilities

Sloot, D., Lehmann, N., & Ardone, A. (2022, February). Explaining and promoting participation in demand response programs: The role of rational and moral motivations among German energy consumers. Energy Research & Social Scienc, 84(2022). https://www.sciencedirect.com/science/article/pii/S2214629621005181

Smith, S. (2019, June 3). *Barriers to Smart Home Technology Adoption*. Product Catalog. Retrieved May 26, 2022, from https://info.amconservationgroup.com/blog/barriers-to-smart-home-technology-adoption

St, J. (2014, April 3). *California's New Building Code: A Grid-Smart Thermostat in Every Facility*. Greentech Media. Retrieved May 12, 2022, from https://www.greentechmedia.com/articles/read/californias-title-24-a-grid-smart-thermostat-in-every-building

Statista. (2019, July 22). *Smart home market penetration in Canada and the US*. Statista. Retrieved May 16, 2022, from https://brandondonnelly.com/2019/07/22/6274/

Statistics Canada. (2022, April 4). *Statistics Canada*. Automotive statistics. Retrieved May 17, 2022, from https://www.statcan.gc.ca/en/topics-start/automotive

Stenner, K., Frederiks, E. R., Hobman, E. V., & Cook, S. (2017). Willingness to participate in direct load control: The role of consumer distrust. *Applied Energy*, *321*, 76-88. https://www.sciencedirect.com/science/article/pii/S0306261916315458

St. John, J. (2017, January 11). *The Inside Story on Baltimore Gas & Electric's Behavioral-Based Demand Response | GTM Squared*. Greentech Media. Retrieved May 31, 2022, from https://www.greentechmedia.com/squared/dispatches-from-the-grid-edge/the-inside-story-on-baltimores-behavioral-based-demand-response

Szablya, L. (2012, October 1). *Breaking Down Barriers to Residential Demand Response*. https://www.power-grid.com/news/breaking-down-barriers-residential-demand/#gref

Targett, E. (2021, December 7). *AWS down: US-EAST-1 fails again*. The Stack. Retrieved May 30, 2022, from https://thestack.technology/aws-down-december-2021/

Trabish, H. K. (2019, January 28). *An emerging push for time-of-use rates sparks new debates about customer and grid impacts*. Utility Dive. Retrieved June 4, 2022, from https://www.utilitydive.com/news/an-emerging-push-for-time-of-use-rates-sparks-new-debates-about-customer-an/545009/

Trabish, H. K. (2021, January 6). *Two barriers to utility and customer savings with flexible loads and how regulators can help*. Utility Dive. Retrieved June 4, 2022, from https://www.utilitydive.com/news/two-barriers-to-utility-and-customer-savings-with-flexible-loads-and-how-re/592084/

Trading Economics. (2022). *Canada Inflation Rate - April 2022 Data - 1915-2021 Historical - May Forecast*. Trading Economics. Retrieved May 30, 2022, from https://tradingeconomics.com/canada/inflation-cpi

Tran, C. (2016, April 28). *Worldwide electricity prices: How does Australia compare?* Australian Energy Council. Retrieved March 14, 2022, from https://www.energycouncil.com.au/analysis/worldwide-electricity-prices-how-does-australia-compare/

Trebilcock, M. J., & Hrab, R. (2006). Chapter 12: Electricity Restructuring in Canada. In *Electricity Market Reform: An International Perspective* (p. 419). https://www.researchgate.net/publication/228235739_Electricity_Restructuring_in_Canada

Trudeau, J. (2022). *Clean Electricity: A Net-Zero Grid By 2035*. Liberal Party of Canada. Retrieved June 2, 2022, from https://liberal.ca/climate/clean-electricity-a-net-zero-grid-by-2035/

Uppal, S. (2019, August 8). *Homeownership, mortgage debt and types of mortgage among Canadian families*. Statistique Canada. Retrieved May 27, 2022, from https://www150.statcan.gc.ca/n1/pub/75-006-x/2019001/article/00012-eng.htm

Urban, R. (2020, February 14). *Electricity Prices in Canada 2021*. energyhub.org. Retrieved March 14, 2022, from https://www.energyhub.org/electricity-prices/

US Department of Energy. (2006). *BENEFITS OF DEMAND RESPONSE IN ELECTRICITY MARKETS AND RECOMMENDATIONS FOR ACHIEVING THEM*. Department of Energy. Retrieved June 2, 2022, from https://www.energy.gov/sites/default/files/oeprod/DocumentsandMedia/DOE_Benefits_of_Demand_Response_in_Electricity_Markets_and_Recommendations_for_Achieving_Them_Report_to_Congress.pdf

US DOE. (2013, February 1). *A Framework for Evaluating the Cost-Effectiveness of Demand Response*. Federal Energy Regulatory Commission. Retrieved June 7, 2022, from https://www.ferc.gov/sites/default/files/2020-04/napdr-cost-effectiveness.pdf

US DOE. (2016, September). *Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program*. US Department of Energy. Retrieved June 1, 2022, from https://www.energy.gov/sites/prod/files/2016/12/f34/AMI%20Summary%20Report_09-26-16.pdf

US DOE. (2021, March). State and Regional Energy Risk Profiles. Department of Energy. Retrieved October 25, 2022, from https://www.energy.gov/ceser/state-and-regional-energy-risk-profiles

Verney, P. (2022, April 25). *Canada's transition taxonomy paused due to 'fundamental differences of opinion'*. Responsible Investor. Retrieved June 8, 2022, from https://www.responsible-investor.com/canadas-transition-taxonomy-paused-due-to-fundamental-differences-of-opinion/

Walton, R. (2015, November 18). *The future of behavioral demand response: Utilities warm to a bullish new market*. Utility Dive. Retrieved May 20, 2022, from https://www.utilitydive.com/news/the-future-of-behavioral-demand-response-utilities-warm-to-a-bullish-new-m/409400/

Walton, R. (2019, April 17). *Navigant: Residential DR will triple by 2028, global capacity to top 47 GW*. Utility Dive. Retrieved January 19, 2022, from https://www.utilitydive.com/news/navigant-residential-dr-will-triple-by-2028-global-capacity-to-top-47-gw/552859/

Wang, B., Cai, Q., & Sun, Z. (2020, September 29). *Determinants of Willingness to Participate in Urban Incentive-Based Energy Demand-Side Response: An Empirical Micro-Data Analysis*. MDPI. https://www.mdpi.com/2071-1050/12/19/8052

WEC. (2022). *Canada*. WEC Energy Trilemma Index Tool. Retrieved May 23, 2022, from https://trilemma.worldenergy.org/#!/country-profile?country=Canada&year=2021

Weck, M., van Hooff, J., & van Sark, W. (2016, November 21). Review of barriers to the introduction of residential demand response: a case study in the Netherlands. *Wiley Online Library*. https://onlinelibrary.wiley.com/doi/10.1002/er.3683

Weinhold, M. (2017, October). *The future Energy System and resulting opportunities for Electricity Grids*. Siemens Energy Management. Retrieved June 13, 2022, from https://labelec.edp.com/sites/edplabelec/files/2019-05/20171031_weinhold_edp_labora_v12.pdf

Whitney, A., George, T. G., Meisel, J., & Bodnar, P. (2020). *State of Green Banks 2020*. RMI. Retrieved June 8, 2022, from https://rmi.org/insight/state-of-green-banks-2020/

Wijesuriya, S. (2022). *The "Peakers" : The role of peaking power plants and their relevance today*. SciencePolicy circle. Retrieved May 20, 2022, from https://www.sciencepolicycircle.org/38-the-peakers-the-role-of-peaking-power-plants-and-their-relevance-today

Wong, S. (2015, April 1). *Summary Report on Canadian Residential Demand Response and Ancillary Service Market Opportunities*. Natural Resources Canada. Retrieved April 24, 2022, from https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/CdnResDRandASMktOps-FINALE_EN.pdf

World Economic Forum. (2020, December 11). *World Economic Forum*. State of the Connected World 2020 Edition. Retrieved May 31, 2022, from https://www.weforum.org/reports/state-of-the-connected-world-2020-edition

World Nuclear Association. (2021). *Renewable Energy and Electricity | Sustainable Energy | Renewable Energy*. World Nuclear Association. Retrieved January 19, 2022, from https://world-nuclear.org/information-library/energy-and-the-environment/renewable-energy-and-electricity.aspx

Yunis, J., & Aliakbari, E. (2021, August 20). *Muskrat Falls project illustrates problem with public ownership of large-scale projects : op-ed*. Fraser Institute. Retrieved May 28, 2022, from https://www.fraserinstitute.org/article/muskrat-falls-project-illustrates-problem-with-public-ownership-of-large-scale-projects

Zenith Energy. (n.d.). *Energy Deregulation*. Zenith Energy Network. Retrieved January 19, 2022, from https://www.zenith.energy/deregulation

APPENDIX 1: DR PROGRAM DEFINITIONS

Demand Response Program Definitions (US Department of Energy, 2006)

Demand Response Options	
Price-Based Options	**Incentive-Based Programs**
• *Time-of-use (TOU):* a rate with different unit prices for usage during different blocks of time, usually defined for a 24 hour day. TOU rates reflect the average cost of generating and delivering power during those time periods. • *Real-time pricing (RTP):* a rate in which the price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity. Customers are typically notified of RTP prices on a day-ahead or hour-ahead basis. • *Critical Peak Pricing (CPP):* CPP rates are a hybrid of the TOU and RTP design. The basic rate structure is TOU. However, provision is made for replacing the normal peak price with a much higher CPP event price under specified trigger conditions (e.g., when system reliability is compromised or supply prices are very high).	• *Direct load control:* a program by which the program operator remotely shuts down or cycles a customer's electrical equipment (e.g. air conditioner, water heater) on short notice. Direct load control programs are primarily offered to residential or small commercial customers. • *Interruptible/curtailable (I/C) service:* curtailment options integrated into retail tariffs that provide a rate discount or bill credit for agreeing to reduce load during system contingencies. Penalties maybe assessed for failure to curtail. Interruptible programs have traditionally been offered only to the largest industrial (or commercial) customers. • *Demand Bidding/Buyback Programs:* customers offer bids to curtail based on wholesale electricity market prices or an equivalent. Mainly offered to large customers (e.g., one megawatt [MW] and over). • *Emergency Demand Response Programs:* programs that provide incentive payments to customers for load reductions during periods when reserve shortfalls arise. • *Capacity Market Programs:* customers offer load curtailments as system capacity to replace conventional generation or delivery resources. Customers typically receive day-of notice of events. Incentives usually consist of up-front reservation payments, and face penalties for failure to curtail when called upon to do so. • *Ancillary Services Market Programs:* customers bid load curtailments in ISO/RTO markets as operating reserves. If their bids are accepted, they are paid the market price for committing to be on standby. If their load curtailments are needed, they are called by the ISO/RTO, and may be paid the spot market energy price.

APPENDIX 2: OPERATING VOLTAGE BANDWIDTH

Steady State Operating Voltage Ranges (Hydro Ottawa, 2016)

Nominal Voltage (RMS V)	Allowable Deviation from Nominal (%)	Normal Minimum Voltage (RMS V)	Normal Maximum Voltage (RMS V)	Reference
120V / 240V	+4.17% ; -8.33%	110V / 220V	125V / 250V	At Service Entrance per CSA CAN3-C235-83 Table 3.0
120V / 208Y	+4.17% ; -6.67%	112V / 194Y	125V / 216Y	At Service Entrance per CSA CAN3-C235-83 Table 3.0
347V / 600Y	+3.75% ; -8.33%	318V / 550Y	360V / 625Y	At Service Entrance per CSA CAN3-C235-83 Table 3.0
2400V / 4160Y	+6.00% ; -6.00%	2256V / 3910Y	2544V / 4410Y	At Point of Sale per CSA CAN3-C235-83 Clause 6.1
4800V / 8320Y*	+6.00% ; -6.00%	4512V / 7821Y	5088V / 8819Y	At Point of Sale per CSA CAN3-C235-83 Clause 6.1
7200V / 12470Y	+6.00% ; -6.00%	6768V / 11722Y	7632V / 13218Y	At Point of Sale per CSA CAN3-C235-83 Clause 6.1
7600V / 13200Y*	+6.00% ; -6.00%	7144V / 12408Y	8056V / 13992Y	At Point of Sale per CSA CAN3-C235-83 Clause 6.1
15930V / 27600Y*	+6.00% ; -6.00%	14974V / 25944Y	16886V / 29256Y	At Point of Sale per CSA CAN3-C235-83 Clause 6.1
44000V*	+6.00% ; -6.00%	41360V	46640V	At Point of Sale per CSA CAN3-C235-83 Clause 6.1
46000V	+6.00% ; -6.00%	43240V	48760V	At Point of Sale per CSA CAN3-C235-83 Clause 6.1

Table 1: Steady State Operating Voltage Ranges Under Normal Conditions, adapted from CSA document CAN3-C235-83.
*** Note:** Voltage not recognized in CSA CAN3-C235-83.

APPENDIX 3: BEHAVIOURAL RDR PROGRAMS IN CANADA

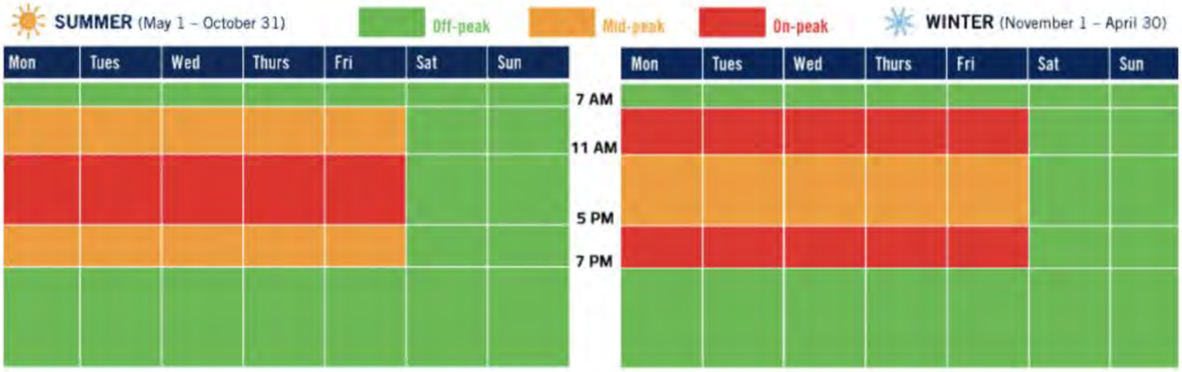
Ontario Time-of-Use Rates (IESO, 2022)

Current Time-of-Use Rates and Schedule

Residential and small business consumers will pay the following TOU prices set by the Ontario Energy Board (OEB) for the **summer period** (May 1 - October 31).

- 8.2¢/kWh off-peak
- 11.3¢/kWh mid-peak
- 17.0¢/kWh on-peak

Visit the OEB website for more information about time-of-use rates.



Hydro-Québec Dynamic Pricing Model (Hydro-Québec, 2019)

	Rate D (base rate)	Rate D with Winter Credit Option	Rate Flex D
Summer period	Base rate price	Base rate price	Base rate price
Winter period, **outside** of peak demand events	Base rate price	Base rate price	Price lower than base rate
Winter period **during** peak demand events (Max. 100 hours/winter)	Base rate price	Base rate price minus credit of 51.967¢ per kWh curtailed	Price higher than base rate: 51.967¢ per kWh consumed
Days when peak demand events may occur		7 days a week	Monday to Friday
Impact on bill in relation to base rate		**Potential for savings** Risk-free: your bill can only get smaller	**Potential for substantial savings** Your bill can increase if consumption is not reduced during peak demand events

Hydro-Québec Dynamic Pricing Results (Hydro-Québec, 2022)

Winter 2021-2022

Global data	
Number of participating customers	About 157,000
Total curtailed power	157 MW per peak demand event
Number of customers corresponding to the curtailed power	30,000 residential customers per peak demand event

Winter Credit Option	
Number of participating customers	About 141,000
Number of peak demand events	29
Overall credit issued to customers	About 6,773 546[*]
Average credit per customer	About $46[*]

Winter 2020-2021

Global data	
Number of participating customers	About 61,000
Total curtailed power	65 MW per peak demand event
Number of customers corresponding to the curtailed power	12,000 residential customers per peak demand event

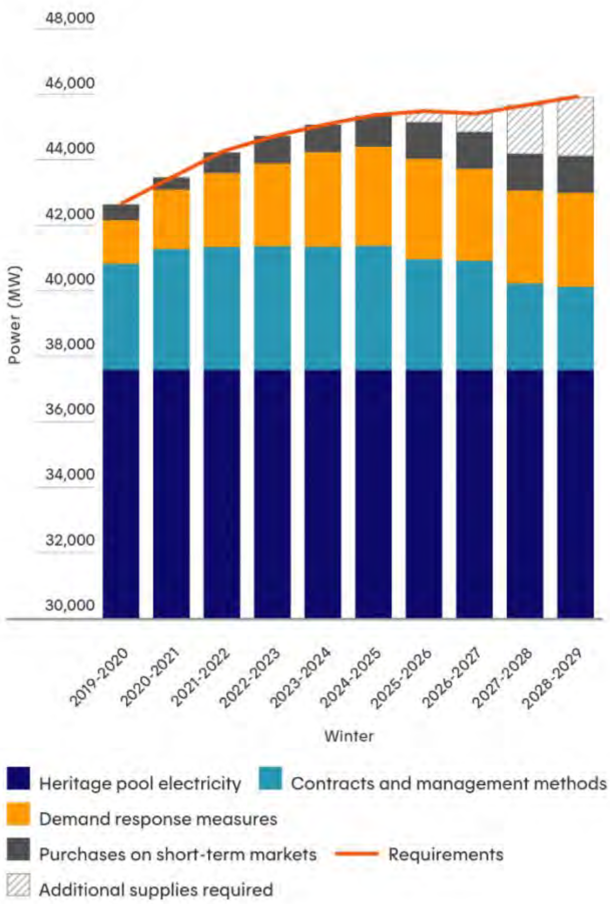
Winter Credit Option	
Number of participating customers	About 53,000
Number of peak demand events	22
Overall credit issued to customers	About $2,105,302
Average credit per customer	$40

Winter 2019-2020

Global data	
Number of participating customers	About 20,000
Total curtailed power	16 MW per peak demand event
Number of customers corresponding to the curtailed power	3,000 residential customers per peak demand event

Winter Credit Option	
Number of participating customers	About 17,400
Number of peak demand events	21
Overall credit issued to customers	About $500,000
Average credit per customer	$28

Hydro-Québec capacity balance forecast (Hydro-Québec, 2019)



APPENDIX 4: SMART GRID DEPLOYMENT IN CANADA

Smart Grid Status in Canada by Province / Territory (SGIN, 2020)

Province	Smart Meter	"Automated data sharing (Green Button)"	Demand Response	Solar net-metering	Microgrid (DG Planned Islanding Standard)
AB	C&I		Industrial	Net Billing	
BC	Completed		Testing R	Yes	Yes
MB			Industrial	Yes	
NB	Planned		Testing R, C&I	Yes	Pilot
NL			C&I	Yes	
NS	Planned		R	Yes	Pilot
NT			No	Yes	
NU			No	Yes	
ON	Completed	Proposal	R, C&I	Yes	Pilot
PEI			No	Yes	
QC	Completed		R, C&I	Yes	Pilot
SK	C&I		C&I	Yes	
YK			R	Yes	

Table prepared by SGIN
***C&I**: Commercial and Industrial, **R**: Residential

APPENDIX 5: CANADA RDR ACTORS

1.1 Residential consumers
The public are the end users of residential demand response programs and products. The capacity value of demand response depends on the ability and willingness of customers to curtail load (IRGC, 2015). Ratepayers and consumers are the ones that will register and voluntarily participate in these programs. They will also purchase products that are demand response compatible. European Union: "the customer in the heart of the Energy Transition" (European Smart Grids Task Force, 2019).

1.2 Aggregators
Aggregators are relatively new players in the electricity market. They have a portfolio of consumers and act as brokers between the end-customers and the utility operator (IRGC, 2015). In the case of RDR, aggregators are extremely important because individual household loads are small, however, when controlled with a network of other homes, this pool of loads makes an impact on the electric grid. Aggregators can work directly with utility companies, or bid directly into liberalised electricity markets as an energy provider. Aggregators currently operating in Canada include EnergyHub and AutoGrid.

1.3 Utilities
Sierra Club's report refers to electric utilities "the cornerstone of economy-wide decarbonization" (Sierra Club, 2021). Their importance can not be overstated in the path to energy transformation. In Canada, the utility's role in RDR is even more critical than in other countries because 85% of the provincial and territorial markets are serviced by electric monopolies. Therefore in non-liberalised markets, aggregators do not have the opportunity to bid directly into the electricity market. In these non-liberalised markets, RDR adoption will hinge on utility adoption and partnership with aggregators and DR technology providers.

1.4 Transmission System Operator (TSO)
TSOs are in charge of coordinating the transmission of power from generation plants to regional or local electricity distribution companies. In liberalised markets, the TSO or the DSO will sign contractors with aggregators to integrate demand response capacity into their grids. In Canada, the main TSOs are the Ontario Independent Electricity System Operator (IESO) and the Alberta Electric System Operator (AESO) who are responsible for the two liberalised Canadian markets. .

1.5 Technology Suppliers and Manufacturers
The second actors are manufacturers and technology providers. In order to perform residential demand response, there must be products on the market that are DR compatible. These suppliers range from thermostats to hot water tanks, to electric vehicles to batteries.

1.6 Federal Government
Under Canada's Constitution, the federal government holds authority over certain aspects of the electricity sector, including nuclear generation, inter-provincial transmission and electricity exports, mainly to the United States (Christian et al., 2020). The federal government also sets emissions targets and commitments on a National Level. The Government of Canada is committed to reach net-zero by 2050. Canada has also adopted the enhanced Paris Agreement targets to reduce emissions by 40-45% from 2005 levels by 2030 (Government of Canada, 2022). These national commitments are then the catalyst to set policies and targets to achieve these reduction goals. Such targets include Canada's policy to

completely phase out coal-fired power plants by 2030 and bring the electricity sector to net zero by 2035 (Government of Canada, 2022).

1.7 Provincial Governments

Under Canada's Constitution, each province is responsible to control and regulate the electricity generation, transmission, distribution within its borders (Christian et al., 2020). A significant characteristic of the provincial energy markets in Canada is the degree to which the main utility service providers are owned by their respective provincial governments. In British Columbia, Manitoba, New Brunswick, Newfoundland, Saskatchewan and Québec, the dominant electricity companies are crown corporations where the province is the main owner. This means that specifically in these provinces politics and energy are intrinsically linked. In these provinces, politicians running for office have energy policies in their election platforms. It also means that when there is public discontent with the government or budget, changes are made in the crown corporations.

1.8 Canada's Energy and Utility Regulators (CAMPUT)

CAMPUT boards and commissions are tasked with the regulation of electric, water, gas and pipeline utilities within Canada. There is a board assigned to each province, and they are responsible for approving projects and energy rates. Therefore, it is critical to receive the regulator's approval in order for a crown utility to roll out a RDR project.

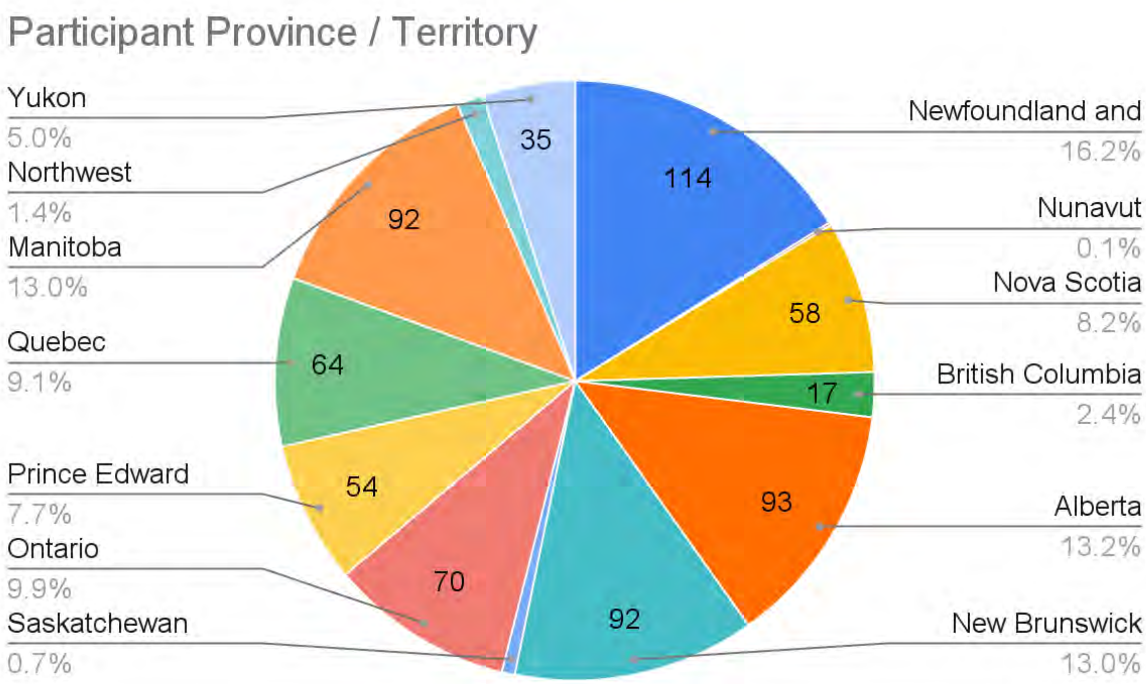
1. Alberta Utilities Commission
2. Alberta Market Surveillance Administrator
3. British Columbia Utilities Commission
4. Manitoba Public Utilities Board
5. National Energy Board
6. New Brunswick Energy and Utilities Board
7. Newfoundland & Labrador Board of Commissioners of Public Utilities
8. Northwest Territories Public Utilities Board
9. Nova Scotia Utility and Review Board
10. Nunavut Utility Rates Review Council
11. Ontario Energy Board
12. Prince Edward Island – Island Regulatory and Appeals Commission
13. Régie de l'énergie du Québec
14. Saskatchewan Rate Review Panel
15. Yukon Utilities Board

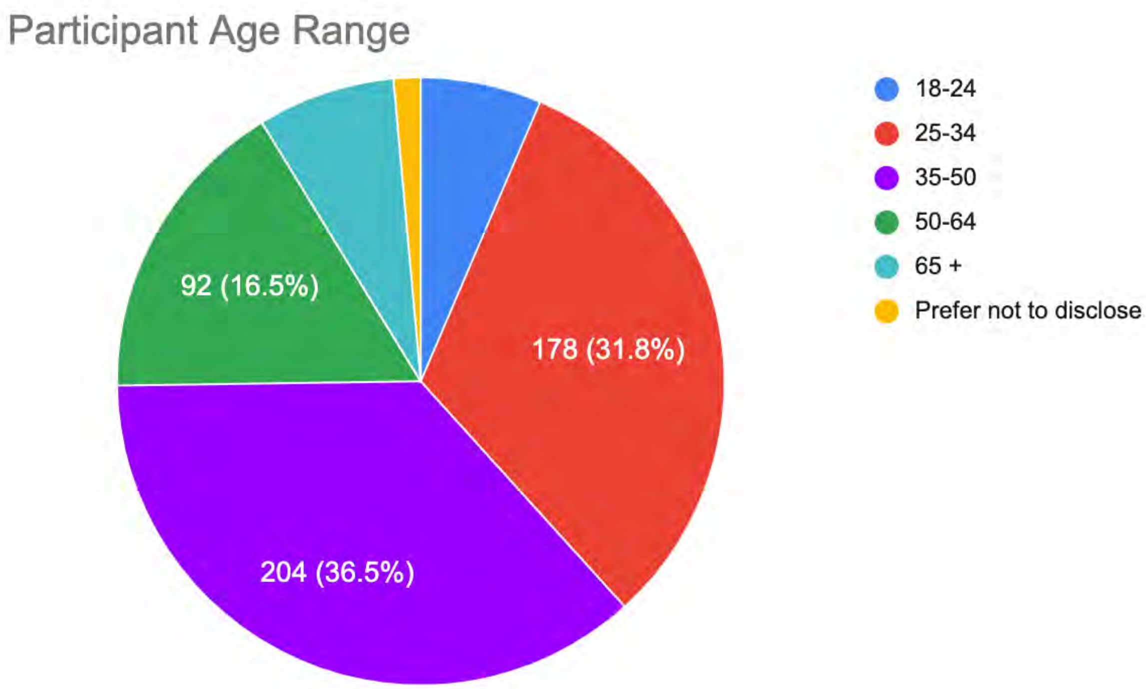
1.9 North American Electric Reliability Corporation (NERC)

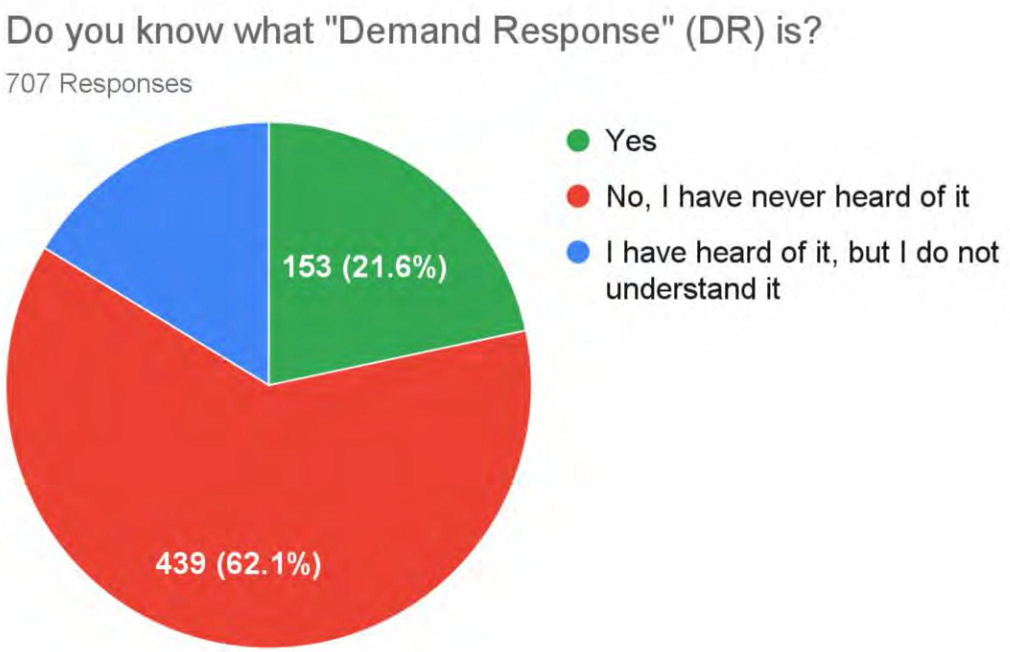
The North American Electric Reliability Corporation (NERC) is a not-for-profit organisation that exists to improve reliability and security of the power system in Canada, the United States and a portion of Mexico. It does this by enforcing mandatory reliability standards, load forecasting, and assessing system weaknesses. The organisation also conducts audits and provides education services (NERC, 2022). NERC created a Demand Response Availability Data System Working Group (DADSWG) in 2008 and has

There are North America-wide reliability standards to govern the bulk electricity transmission system. These standards provide a level of uniformity in energy trade across different jurisdictions, entities and the private/public sector. These standards are mandatory and enforced by the North American Electric Reliability Corporation (NERC). NERC's mission is to assure reliability across the North American electricity system.

APPENDIX 6: RDR IN CANADA SURVEY RESULTS

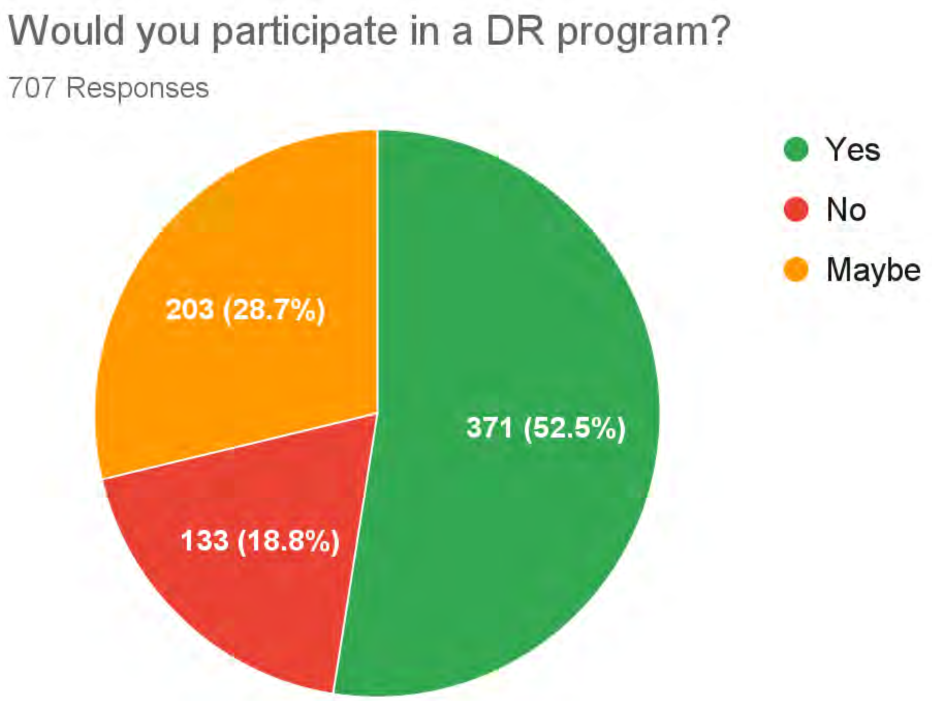




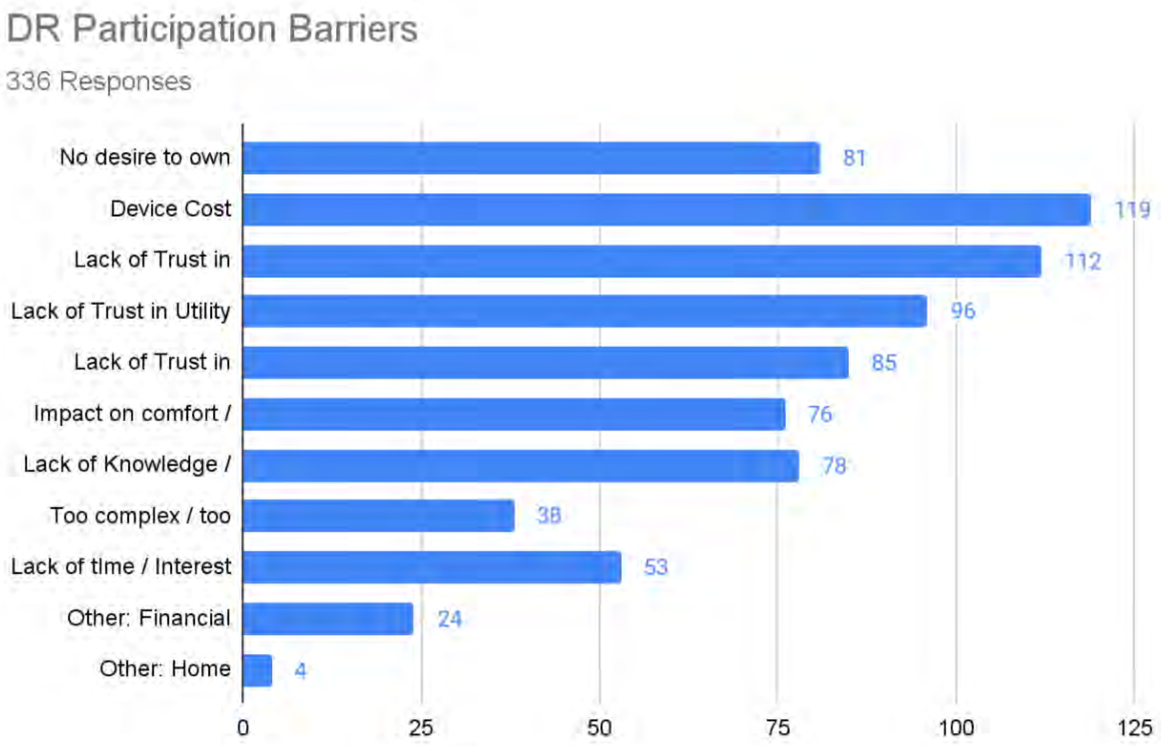


In this theoretical scenario, you will receive a $10 monthly bill credit for enrolling a smart device to participate in 5 DR events per month, lasting 2 hours each. During the event time frame, the energy controlled by that device will be reduced. You will always have control of your device and can override the event at any time.

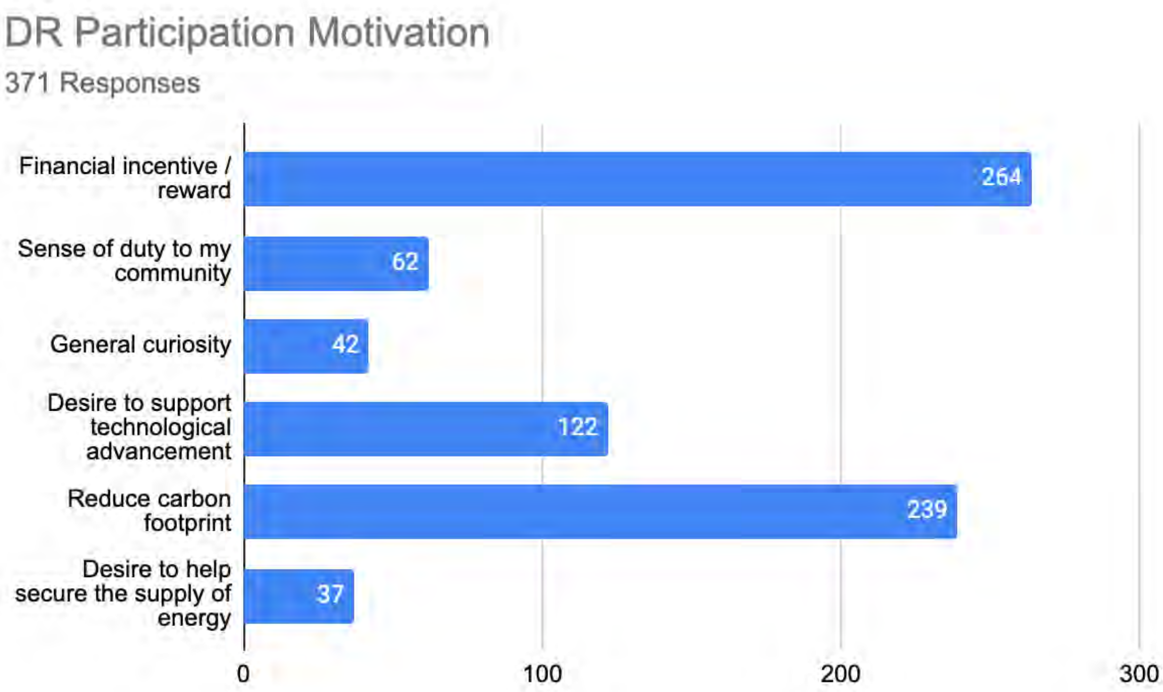
(Examples of smart devices for DR include smart thermostats, EV chargers, smart appliances, hot water heaters)



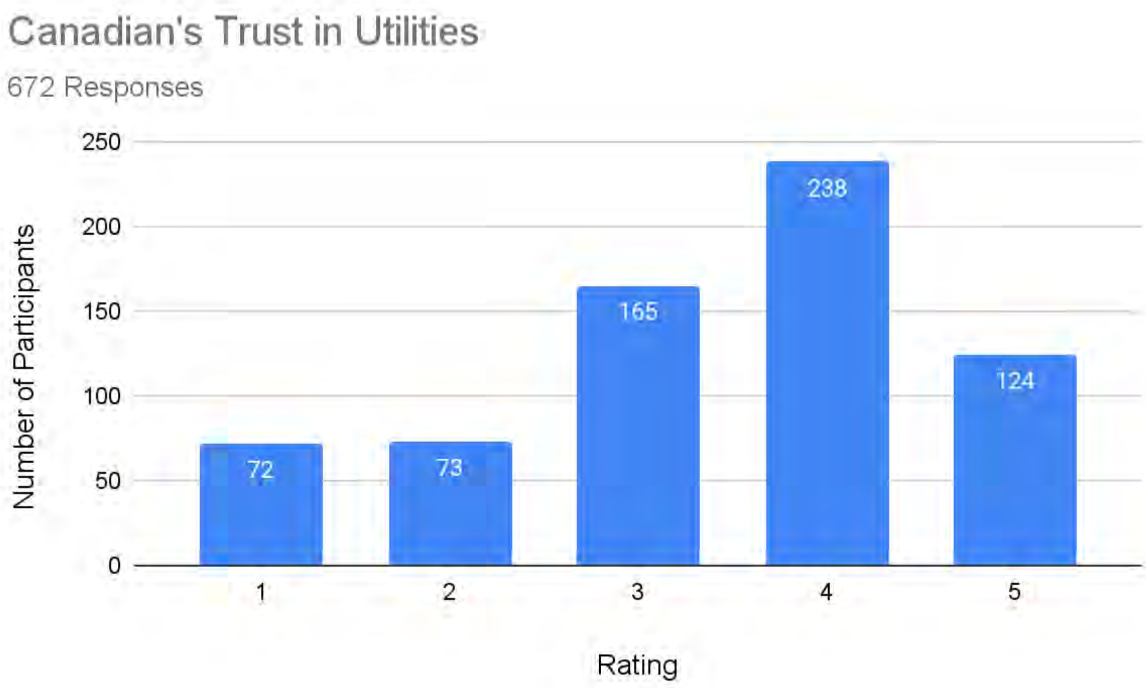
Why would you not participate in this DR program? (Select all that apply)
Note: Participants had an option to write their own text under "other"



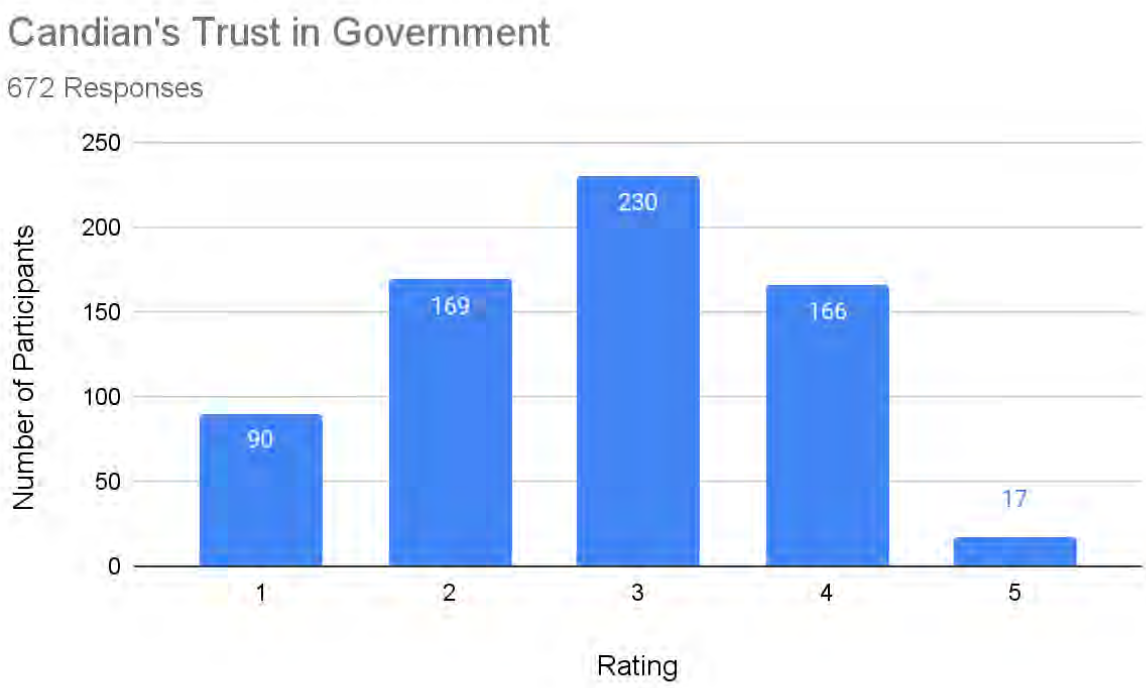
What is your main motivation for participating? (Select all that apply)



Please rank your trust in your local energy provider



Please rank your trust in your local government



APPENDIX 7: ENERGY LITERACY IN CANADA SURVEY

Select Results from Energy Literacy in Canada Survey(Eisler, 2016)

TABLE 2 MOST IMPORTANT ISSUE FACING CANADA TODAY GENERAL POPULATION

Economy	22%
Health Care	15%
Employment	11%
Government Spending/Debt/Deficit	8%
Environment/Climate Change	5%
Poverty/Homelessness	4%
Pensions/Retirement	3%
Taxes	3%
Oil and Gas/Energy Prices and Production	2%

Source: André Turcotte, Michal C. Moore and Jennifer Winter, "Energy Literacy in Canada," University of Calgary School of Public Policy Research Paper 5, 32 (University of Calgary, October 2012), Appendix A, Question A1.

TABLE 7 "WHO DO YOU TRUST?" PERCENTAGE OF TOTAL RESPONDENTS RANKING TRUSTWORTHINESS

Category	No Trust (0)			Some Trust to Neutral (1-5)			Neutral to Full Trust (6-10)		
	Aboriginal Survey* (N=300)	General Population Survey** (N=1,508)	Business and Policy Leaders Survey*** (N=589)	Aboriginal Survey* (N=300)	General Population Survey** (N=1,508)	Business and Policy Leaders Survey*** (N=589)	Aboriginal Survey* (N=300)	General Population Survey** (N=1,508)	Business and Policy Leaders Survey*** (N=589).
Oil and Gas Companies	34%	26%	14%	51%	41%	54%	14%	19%	29%
Energy Executives	32%	22%	15%	52%	52%	56%	17%	21%	27%
CAPP	27%	19%	12%	48%	50%	49%	15%	24%	32%
Local Band Council	10%	n/a	n/a	45%	n/a	n/a	35%	n/a	n/a
Provincial Government	15%	13%	5%	53%	49%	41%	27%	34%	51%
Federal Government	24%	15%	9%	49%	47%	44%	23%	34%	44%
City Council	8%	8%	7%	58%	55%	49%	26%	31%	39%
Environmental Groups and Activists	6%	7%	7%	44%	40%	47%	46%	46%	42%
Community Groups and Activists	5%	5%	6%	41%	44%	49%	48%	47%	40%
Economists	8%	4%	3%	42%	39%	34%	43%	51%	59%
Academics	4%	3%	3%	30%	31%	29%	59%	58%	65%
Local Chamber of Commerce	10%	6%	4%	47%	47%	49%	32%	39%	40%

* Source: Michal C. Moore, André Turcotte and Jennifer Winter, "Aboriginal-Canadians and Energy Literacy: A Survey of Opinions and Thoughts on Energy," University of Calgary School of Public Policy Research Paper 7, 6 (University of Calgary, February 2014), Appendix C, Questions F2.0–F2.11.

** Source: André Turcotte, Michal C. Moore and Jennifer Winter, "Energy Literacy in Canada," University of Calgary School of Public Policy Research Paper 5, 32 (University of Calgary, October 2012), Appendix A, Questions E3.0–E.11.

APPENDIX 8: IESO BASELINE CALCULATION METHODOLOGY

IESO Residential Baseline Calculation Methodology(IESO, 2020)

Baseline Calculation: For each Activation Hour for the Contracted DER , the residential baseline (the "**DR Residential Baseline**") shall be calculated as follows:

Adjusted Control Group Load$_h$

= (Total Consumption$_h$ / Number of Control Group DERs $_m$) x Same-Day Adjustment

Where:

- "h" is an Activation Hour.
- "m" is the month in which the activation event takes place.
- "Total Consumption" is the measurement data for the Control Group for the Activation Hour.
- "Same-Day Adjustment" is calculated as described below.

Same-Day Adjustment:

Same Day Adjustment = $C \div D$

Where:

- "C" is the average actual consumption of the Contracted DER during the adjustment window hours on the Activation Day for the Treatment Group divided by the number of Control Group DERs.
- "D" is the average actual consumption during the adjustment window hours on the Activation Day for the Treatment Group divided by the number of Control Group DERs.

IESO Control Group Size

Local Capacity Obligation (kW) of the Contracted DER	Minimum Control Group size (number of Control Group DERs)
100 – 240	150
250 – 490	200
500 – 740	250
750 – 990	300
≥ 1000	350