From Nuclear to Renewables: The role utility-led voluntary contribution, community renewable, and grid modernization initiatives can play in allowing for a transition to nuclear-free electricity production in Ontario

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Table of Contents

Foreword

My Master's program research was initially guided by an interest in the way businesses are currently adapting to changing economic conditions resulting from climate change. Thus, the learning objectives for my plan of study centered around providing me with a better understanding of the way business operations can impact the environment and vice-versa.

My original proposal was to look specifically at selling green electricity as a business model that produced mutual benefits for the business and the environment. I thought this would provide me with a better understanding of how business models could be designed that had both economic and environmental benefits. However, after engaging with that topic in depth for a few months I decided it was no longer what I wanted to write my paper on. After a discussion with my supervisor I determined that I had become more interested in several other initiatives being undertaken by utilities in Ontario, that seemingly had greater potential for environmental benefit. I decided to instead produce a major paper that was an analysis of the potential of three notable initiatives that utilities are engaging in to improve the contribution of renewable energy to Ontario's electricity supply.

While the new topic did not fit perfectly within the learning objectives of my original plan of study, through my research I was still able to gain clear insights into how business initiatives can produce desirable environmental outcomes while simultaneously benefiting the business. I was also able to learn a significant amount about energy systems in Ontario and the role environmental policy can play in business decisions.

Abstract

Ontario's present electricity supply is one that relies heavily on nuclear generation to provide energy. Though it does not release greenhouse gases during operation, nuclear houses several other ecological risks. This paper looks at voluntary contribution initiatives, community renewable energy generation, and grid modernization, as three areas where initiatives and are being undertaken by utilities that will contribute to a greater portion of Ontario's electricity demand being met by renewables as opposed to nuclear. Ultimately this paper seeks to determine if initiatives in any of these areas could ultimately lead to an electricity system transition in Ontario away from nuclear towards renewables. Grid modernization appears to have the highest potential to significantly increase the contribution of renewably-sourced electricity to Ontario's supply. However, utilizing voluntary contribution strategies, and supporting the development of community renewable projects, while unlikely to eventually prompt a large electricity-system change, can meaningfully contribute to goal of increasing the supply of renewably-sourced electricity in Ontario.

Introduction

The ecological sustainability of nuclear energy in Ontario has been a topic of considerable debate for several years. The government of Ontario argues that since it does not noticeably contribute climate to change via greenhouse gas emissions, nuclear can be considered a sustainable way of meeting future energy demand (Government of Ontario, 2017). However, authors such as MacFarlene, (2010) and Winfield et al. (2006) suggest instead, due to other inherent ecological risks associated with its use, that nuclear cannot truly be considered a sustainable method of energy production. Investment in the development of non-nuclear renewable technologies is significant because they may provide an alternative to nuclear energy as a long-term method of energy production in Ontario. Utilizing renewable energies for electricity generation in Ontario holds the potential to mitigate future ecological disasters, while simultaneously allowing the economy to continue to grow. However, in Ontario, meaningful increases in the contribution of renewably-sourced electricity to the total electricity supply will be difficult to achieve without significant social, economic, and political incentives acting as drivers.

Currently wind, solar, hydroelectricity and biofuel collectively account for approximately 13660 MWs, or 37 percent, of total installed capacity in Ontario (Independent Electricity System Operator, 2018). The remainder (63 percent) is primarily comprised of nuclear (13,009 MW), and gas and oil (10,277 MW), (Independent Electricity System Operator, 2018). This paper analyzes voluntary contribution, community renewable generation, and grid modernization as three areas where Ontario's utilities have, and are currently, introducing initiatives to improve the contribution of renewable electricity resources to Ontario's electricity supply. The primary question this paper aims to answer is: "In what capacity can utility-led voluntary-contribution, community renewables, and grid modernization initiatives contribute to a system-wide shift from nuclear to renewable electricity in Ontario?". Grid modernization initiatives will likely be the most impactful in allowing renewables to effectively substitutable for nuclear supply in Ontario. Conversely, focusing on community-renewables and voluntary contribution programs is not redundant, as they can play an auxiliary role in encouraging an electricity system change.

The Hazards of Nuclear Energy

Canada's ratification of the Kyoto Protocol in 2002, marked the start of an interesting era in electricity generation within the country. As part of the new agreement, Canada committed to a six percent reduction in greenhouse gas emissions from 1990 levels by 2012 (Environment Canada, 2013). Less than one year later, in 2003, Ontario committed to begin phasing out coal powered electricity generation within the province (Government of Ontario, 2017). While done to address ongoing concerns of the health implications of burning coal (Government of Ontario, 2017), the transition also had the added benefit of significantly reducing Ontario's contribution to Canada's greenhouse gas (GHG) emissions.

To fill the gap in electricity generation, nuclear electricity entered center-stage as a 'clean' replacement for coal (Government of Ontario, 2017). However, while true that nuclear generation emits significantly less GHG emissions than coal, numerous concerns regarding waste management and the toxicity of nuclear material makes it a potentially dangerous long-term energy option. Winfield et al. (2006) note "no other energy source combines the generation of a range of conventional pollutants and waste streams … with the generation of extremely large volumes of radioactive wastes that will require care and management over hundreds of thousands of years.". Despite this, in 2017 the government of Ontario highlighted nuclear electricity as an integral part of their future strategy to meet energy demand, stating that "the most cost-effective option for producing the baseload generation to meet the province needs while releasing no GHG emissions is to refurbish Ontario's nuclear generating stations." (Government of Ontario, 2017).

Nuclear energy comprises approximately 35 percent of Ontario's installed energy capacity and provides approximately 58 percent of the province's electricity supply (Alectra Utilites, 2016). The electricity generation process is relatively safe and produces large amounts of energy with limited material input. Coupled with the relative abundance of uranium and radium ore (the fuel for nuclear reactors), nuclear generation is considered by many to be a hugely sustainable way of meeting long term energy demands within Ontario. However, despite its social and economic benefits, the radioactive properties of nuclear waste make it potentially lethal to most biological organisms (Christie, 1981). Therefore, even relatively small mismanagements in any of the processes involved in nuclear generation can yield catastrophic results on the natural environment.

It is not necessary to refer to nuclear disasters like Chernobyl (1986), and Fukushima (2011), to observe the threatening implications of using nuclear energy. In fact, soil and groundwater contamination due to the processing of uranium and radium ore has already presented problems in the community of Port Hope, Ontario (Eyles et al. 2012). Several studies have reported elevated risk and occurrence of various types of cancer among Port Hope residents linked the procurement of nuclear ore (Lees et al. 1987, McLaughlin et al. 1993, Eyles et al. 2012). This is consistent with research by MacFarlane (2010) which suggests that the risks associated with nuclear generation extend far beyond the generating plants. MacFarlane (2010) notes,

> "The largest and most problematic wastes associated with mining [the raw materials for nuclear generation] are uranium mill tailings, which are the rock residue from the extraction of uranium from the ore. The problem is that all the uranium daughter products … take from millions to billions of years of decay [and] remain with the residual rock. These pose risks from windblown dust exposure, radon emissions, and leaching into groundwater…The mill tailings are generally kept in large sludge ponds on site. Like coal mine impoundments, these structures can fail, with catastrophic results to surrounding communities and the environment."

Several concerns have also been raised about the ability for nuclear waste to be properly disposed of. Currently nuclear waste is disposed of by burying it deep underground in a 'secure' container (Nuclear Waste Management Organization, 2018). The belief is that by burying nuclear waste deeply enough risks of groundwater contamination associated with the failure of the storage container are mitigated (Nuclear Waste Management Organization, 2018). Interestingly, previous nuclear management waste strategies which also resolved to store nuclear waste underground were also suggested to be safe but have since been connected to soil contamination (Government of Canada, 2018). Therefore, despite being current best practice it is difficult to predict the implications of present nuclear waste management strategies on future generations due to the exceptionally long period that the nuclear waste takes to decay (MacFarlane, 2010). It is probable that many of the impacts associated with current disposal of nuclear waste may only be felt several generations from now.

First Nation communities have also expressed concerns about the use of nuclear energy, and disposal of the resulting waste. Some First Nation groups feel they are being disrespected by decisions to bury nuclear waste on their land (Chiefs of Ontario, 2009). Additionally, several of these communities have also expressed concerns about the lack of assurance and insurance that storing nuclear waste underground will not alter their environment in any way (Chiefs of Ontario, 2009).

There are also economic risks inherent to nuclear generation which should not be understated. As nuclear facilities grow older issues surrounding their safety and cost become more central (Robertson, 2017). Reactors and facilities that reach their end of life cycle, must be decommissioned or retrofitted for further use (Robertson, 2017). Refurbishments typically extends the life of nuclear plants 25-30 years of use before initiatives must be undertaken again. A report by the Financial Accountability Office of Ontario estimated that the cost of a retrofit to the Darlington Nuclear Facility to be CAD $12.8 billion (Financial Accountability Office, 2017). This means that maintaining current facilities could cost the province billions of dollars over the next several years.

Due to inherent ecological risks, declining utility as renewables become cheaper and high refurbishment costs it may be better for the province to decommission nuclear facilities rather than refurbish them as they reach the end of their life-cycle (Torrie et al., 2003). The decision to maintain such a heavy focus on nuclear generation may ultimately be hindering the development and implementation of renewable electricity programs. It is also likely that Ontario's decision to pursue nuclear energy in as a significant part of its energy supply will have environmental effects beyond what can presently be speculated. Given the known risks associated with nuclear waste, it is not possible to suggest that the present use of nuclear energy will in no way inhibit the ability of future generations to sustain themselves.

Future Electricity Demand in Ontario

Between 2006 and 2016 demand for electricity in Ontario has remained relatively stable despite a population increase of almost 1.5 million (Statistics Canada, 2017). However, it is possible that Ontario may soon see a growth in demand driven by large scale infrastructure changes, and technological adoptions. Global and local emphasis on managing climate change has undeniably prompted consumers, and businesses across several industries, to partake in initiatives to reduce their CO2 emissions. As a result, there has been substantial growth in both consumer and industry initiatives to decarbonize

(Brouwer et al. 2013). However, a transition from high to low carbon technologies does not inherently reduce overall energy demand; rather it changes the type of energy demanded.

The potential effect for low-carbon technologies to increase electricity demand can be made especially apparent by examining the electrification of transportation. Brouwer et al. (2013) suggest that an increase in electric vehicles on the road will undeniably generate a greater demand for electricity, noting that "a single electric vehicle has the potential to increase a household's electricity demand by 50%" (Brouwer et al. (2013). More of these vehicles being sold will invariably lead to an increasing portion of the demand for gasoline and diesel used in transportation being transferred to electricity. In Canada, electric vehicle sales have grown over 65 percent between 2016 and 2017 (Lambert, 2018). Additionally, several municipalities, and public services, have also opted to pursue electric regional transportation alternatives to replace aging diesel fleets. It should also be noted that transportation is only one of a few notable processes that are moving towards electrification. Other processes and industries such as residential and commercial heating, and various types of manufacturing are also replacing older fossil fuel technologies with more efficient electric alternatives.

Renewable Energy Overview

Renewable energy technologies take advantage of naturally occurring processes to harness energy with minimal environmental impact (Heiman et al. 2004). Unlike fossil fuels which are replenished infrequently over a long time-period; or nuclear energy which poses many inherent risks; renewable energy stocks are plentiful and are typically not consumed in the generation process. Relying on renewable energy to meet long-term electricity generation needs will likely place significantly less stress on the natural environment than fossil-fuels and nuclear energy, with the added benefit of mitigating ecological disasters which may threaten human life.

In Ontario, hydroelectricity, wind and solar are the most technologically mature forms of renewable energy generation. This makes them the most likely candidates to replace nuclear energy as Ontario long-term energy solution. It is unlikely that other forms of renewable generation, like geothermal and biofuel, will soon be capable of reaching the scale necessary to meaningfully contribute to addressing Ontario's energy demand. The following section details some of the known benefits and drawbacks associated with hydro, solar, and wind energy resources in Ontario.

Hydroelectricity

Hydroelectricity will forever be recognized as the first renewable energy resource to supply green electricity in Ontario in significant quantities. The development of large scale hydro projects in the region date back as far as the early 1900's and continue today (The Canadian Encyclopedia, 2013). Currently hydro accounts for approximately 23% of installed capacity in Ontario (IESO, 2018). This type of generation is also entirely emission free and produces no harmful or toxic by-products unlike nuclear. Hydroelectricity is also currently the cheapest form of renewable electricity available in Ontario, costing approximately 4.8 cent/ kWh (Ontario Energy Board, 2017).

Relying more heavily on hydroelectricity to meet demands for electricity is certainly a strategy worth considering in Ontario. However, should the decision be made to improve Ontario's capacity to generate its own hydro there are negative social and environmental implications that must be considered. New hydro developments will undoubtedly threaten to disturb some biophysical systems. Hydro plants require the construction of dams and reservoirs in bodies of moving water, often resulting in: habitat loss, flooding, noise pollution, soil erosion, and even potential disruption of the hydrologic cycle (Zelenakova et al. 2018). Brubaker (1992) noted flooding as an issue of concern in Ontario related to dam construction, highlighting that,

> "In 1943 Ontario Hydro diverted water from the Albany River in northwestern Ontario… Flooding for the diversion wreaked havoc on parts of northwestern Ontario... A tremendous number of people have suffered for that extra power production" (Brubaker, 1992)

Additionally, several present hydroelectric developments threaten to infringe on Aboriginal land and water usage rights. Many proposed hydroelectric programs across Canada have already been met with significant resistance from Aboriginal communities due to conflicting views on rights to the water resources (Lorinc, 2016). The proximity of proposed hydroelectric projects to Aboriginal communities may destroy hunting and fishing grounds and negatively impact the lifestyle of residents (Fortin, 2001). Brubaker (1992), notes that although hydroelectric projects consume virtually no water in their generation process, they can still destroy the water requirements for fish and other wildlife. Because of the potential for irreversible damage, even with appropriate levels of consultation with Aboriginal communities, it can be difficult to reach suitable compromises which allow development to proceed (Fortin, 2001; Wilt, 2016).

Solar-Photovoltaics (P.V.)

Solar technology has evolved significantly in the last 30 years. What was once a prohibitively expensive method of electricity generation, has become significantly more cost-effective. As a result, solar has seen relatively stable growth worldwide as a method of electricity production, with several countries offering significant political support for its development (Rosenbloom & Meadowcroft, 2014). In Ontario, favorable energy policies have provided financial incentives to spur solar implementation, leading to a strong uptake of solar PV relative to the rest of Canada (Rosenbloom & Meadowcroft, 2014). In 2014 it was estimated that Ontario housed approximately 99 percent of Canada's total installed capacity for solar PV (Rosenbloom & Meadowcroft, 2014).

Unlike most other forms of renewable generation, PV projects are highly adaptable, and can take form in residential, commercial, or utility applications, with each offering their own unique benefits. Homeowners and businesses alike may benefit from reduced electricity costs by choosing the explore solar-powered facilities and private generation. Additionally, in remote locations, where grid connection is unfeasible, PV offers an opportunity to decarbonize energy services, and reduce reliance on other sources of energy like diesel (Rosenbloom & Meadowcroft, 2014). Under the right circumstances – some of which will be discussed later in this paper – utilities are also able to make use of solar generation to add reliability to the grid with a constantly available supply of green energy (Rosenbloom & Meadowcroft, 2014). In 2010, Wiginton et al. (2010) suggested that rooftop solar PV, scaled appropriately, had the potential to meet up to 24 percent of total annual electricity demand in Ontario.

Current installed capacity for solar Ontario's transmission system hovers around 380 MW, and solar energy provides just one percent of the current energy supply (IESO, 2018). At the present prices, solar energy in Ontario is still an expensive resource relative to other conventional and green energy supplies (Ministry of Energy, 2011). Also, despite numerous benefits, solar PV has had mixed reception in Ontario. Its inclusion in the energy supply, has been explicitly linked to pricing increases for ratepayers and even job loss in numerous sectors (Ministry of Energy, 2011). Additionally, relying on homeowners and businesses to drive solar PV with rooftop applications will likely be difficult without significant public-sector investment. However, rapid innovation, low environmental impact, and grid infrastructure changes, are reducing the costs associated with solar electricity provisions. Reduced cost coupled with high versatility make PV an energy solution worth a long look as a future alternative to nuclear energy in Ontario.

Wind Energy

Wind energy is presently one of the most cost-competitive forms of renewables energy available in Ontario. Commercial wind farms can supply electricity at costs as low as four cents per kWh (Barrington-Leigh et al. 2017) making it competitive with both hydro and nuclear as a low-cost method of producing electricity. Like both solar and hydro, wind energy takes advantage of a naturally occurring process to generate energy and does not produce any greenhouse gas emissions during the generation process. Ontario presently supports approximately 4900 MW of installed capacity for wind energy (Canadian Wind Energy Association, 2017). This allows for a supply of approximately 7.5 percent of electricity demanded within the region (Canadian Wind Energy Association, 2017). Presently, this makes wind energy substantially cheaper than solar; a competitor to hydro; and the best candidate to produce low-cost green electricity in Ontario during a nuclear phase-out. Barrington-Leigh et al. (2017) suggests that approximately three percent of Canada's total land area has high potential for wind energy generation. They go on to state that, although unrealistic, if all this area was utilized by wind farms, we would be able to produce electricity equivalent to 200 percent of total amount demanded by Canadians.

Like hydroelectricity, and solar, there are social dimensions of wind energy which may limit implementation in Ontario. Many communities have expressed concerns about the health implications associated with wind turbines being placed near their homes (Walker et al. 2008). Christidis (2016) reveals research that shows a significant social preference for wind energy to nuclear in Ontario. However, in some communities where the wind turbines are proposed to be built there is overwhelming resistance to the projects (Christidis 2016). In fact, numerous wind projects in Ontario have been halted or due to opposition from both municipal governments and community residents alike. Projects like the 2008 Kingsbridge-2 wind farm expansion project in Goderich Ontario, are famous for generating significant amounts of municipal and resident opposition. This is despite the potential for overwhelming economic and environmental benefit. Had the Kingsbridge-2 project been successfully implemented, it would have provided enough clean electricity to power 50,000 homes (IESO, 2007).

Prompting the Green Electricity Transition

Renewable electricity, despite its merits, has historically been plagued by several limitations to its widespread deployment. In addition to the issues associated with each type of renewable technology discussed above there are also concerns about: the stability of the energy supply; the ability of renewables to meet growing and changing demands for energy; public, industrial, and political support; and the cost of infrastructure development. Therefore, for an initiative to successfully increase the potential for renewable generation in Ontario it must address most, if not all, of these issues. The following sections discuss three areas where utilities are undertaking and participating in initiatives to improve renewable electricity generation capabilities in Ontario. These sections attempt to assess the efficacy of initiatives in these areas to meaningfully contribute the growth of renewable energy penetration in Ontario's energy supply.

Voluntary Contribution programs

Increased media connectivity and access to information ensures that even those not directly affected by the harmful effects of climate change are kept aware of its implications. Some utilities in Ontario have begun to take advantage of the shift in consumer and industry perception of renewable energy and electricity consumption behavior; creating business models which attempt to capitalize on both the economic and environmental benefits of consumer conscience. These models represent approaches to increasing green electricity production that take advantage of green consumer demand and use it to facilitate the growth of the supply pool. Premium priced green electricity programs represent arguably the most prominent voluntary contribution method of driving green electricity generation.

Premium green electricity pricing mechanisms function as a type of carbon offset for those who purchase it. When consumers purchase green electricity, it does not substitute their existing electricity supply mix but rather inputs more green electricity into the energy supply grid (Conte et al. 2016), i.e. the energy supply for a customer in Ontario would still be made up predominantly of nuclear and natural gas. In increasing the total supply of green electricity to the grid, it effectively acts as an offset for their consumption. This is because the expectation is that the newly produced green electricity will then substitute more harmful methods of energy production somewhere down the line.

Green electricity programs allow households and businesses to voluntarily contribute to the development of renewable electricity by purchasing green electricity through their local utility or a specialized green electricity retailer (Conte et al., 2016). This can be done by either paying an additional amount on the monthly utility bill or paying a fixed dollar amount related to a set amount of kWh of green electricity produced (Conte et al., 2016). However, because green electricity programs are voluntary and provide a societal benefit, with minimal benefits to the purchasers, individuals may abstain from purchasing as they will benefit from the purchases of others – the free-riding effect (Clark et al., 2003). When assessing premium priced electricity programs as a method of increasing green electricity generation it is important to first assess the existing and target consumer demographics for this service. This is because the scalability of these programs is directly related to the number of people who are willing to participate. Authors like Menges and Traub (2009), Clark et al. (2003), Nyborg et al (2006) and Lin and Huang (2012) assess different aspects of green consumers and present arguments for what motivates green consumption – some specific to premium priced green electricity. An analysis of their research helps to better contextualize the ability for green electricity programs to scale appropriately in Ontario and contribute to a wider electricity system transition.

Clark et al. (2003) discuss the internal and external influence on pro-environmental behavior, specifically related to participation in green electricity programs. They suggest that an understanding of why individuals chose to undertake such projects – typically incurring additional costs to do so – is important to policy makers addressing problems that require behavioral change (Clark et al. 2003). They note that economic and psychological analysis of these problems typically yield differing results. An economic analysis of a consumer decision to pursue environmentally sustainable alternatives typically aims to identify the links to regulation, risk, or reward that would motivate behavior – this is based on the presupposition of rational self-interest governing human actions (Clark et al. 2003). Psychological analyses on the other hand suggest that the motivation is linked to "values, beliefs, and attitudes of the individual consumer" (Clark et al. 2003). Clark et al. (2003) argue that an analysis of these decisions should adopt an interdisciplinary perspective, which looks at both the cognitive variables, as well as the demographic determinants of behavior that displays environmental concern. Clark et al. (2003) note that rational-choice models assume that, when governed by voluntary action in the private provision of a public good, free-riding will dominate. They highlight that modeling contributions, based on individual opinions of the public good and income, suggests that individuals with high income, and a positive opinion of the public good will make contributions, while individuals with either low income and/or a negative opinion of the public good will choose to free-ride (Clark et al. 2003). However, they also note that empirical observations reveal levels of participation above what the models suggest, and identify this discrepancy as an area of interest, in which psychological evaluations play an increased role. The research for this paper analyzes participation in Detroit Edison's (DTE Energy) green electricity program.

The program DTE green electricity program required individuals to lease one a 100-W block of solar electricity service for and additional fee of $6.59 per month, independent of what the household was already paying for other electricity services (Clark et al. 2003). The first part of the study consisted of an analysis of 900 participants and non-participants. The internal variables for the study were altruistic and environmental attitudes measured by the Schwartz – norm-activation model and the New Ecological Paradigm Scale (Clark et al. 2003). The external variables were income, and socio-demographic characteristics (Clark et al. 2003). The second part of the study consisted of an analysis of only participants; analyzing their specific motives for participation: asking questions related to: ecosystem health, personal health, environmental quality, and intrinsic satisfaction (Clark et al. 2003).

Clark et al.'s (2003) survey revealed that participants were primary motivated by the environmental benefits of the programs regarding environmental sustainability – reducing the cost of future solar energy and reducing reliance of fossil fuels were particularly strong motivators while personal benefits was a weak motivator (Clark et al. 2003). Results also revealed that non-participants refrained primarily because they either did not see the environmental benefits of investing or could not afford to incur the additional costs (Clark et al. 2003). They unsurprisingly conclude that, "altruistic and environmental attitudes, along with greater ability to pay, reliably predict participants in a premium-priced, green electricity program." (Clark et al. 2003).

Nyborg et al. (2006) discuss the role of public perception in influencing moral decision making, and green consumption. They highlight that surveys of the United States market for green electricity suggested that between 52 and 95 percent of private households would have been willing to pay a premium for power generated using renewable technologies (Nyborg et al. 2006). However, when the products became available, only one percent of eligible households opted to purchase renewable power at a premium (Nyborg et al. 2006). They note that customers motivations to take on responsibility as a green consumer was in some facets dependent on their perception of the actions and beliefs of others in their immediate social group. Nyborg et al. (2003) reference evolutionary biology, and game theory to highlight that, in scenarios where consumers do feel satisfaction from a consumption behavior, they may opt to mimic the actions of another person in their immediate environment who appears to be achieving greater satisfaction payoff through a different behavior. The result is that the adoption of strategies that yield a high satisfaction payoff increase more over time (Nyborg et al. 2006). They suggest that this can lead to one of two results with regards to green electricity. If initial investment in green consumption is low, and people are satisfied by their decision to not invest, then the market may cascade to no green consumption or stop at some intermediate group; on the other hand, if the initial uptake for green consumption is high, and people are satisfied by their decision to invest, then it may attract others to adopt similar behavior (Nyborg et al. 2006). This behavior is however highly contingent on the observability of the participation of others in the type of green consumption (Nyborg et al. 2006). They note, however, that others' purchases of green electricity are not easily observable, and therefore may not significantly motivate other adopters (Nyborg et al. 2006).

The findings of Menges and Traub (2009) also suggest that it may be possible for models that rely on premium priced green electricity to be somewhat commercially viable. They conduct a study which compares willingness to pay and willingness to donate for increases in the level of green electricity. They identify willingness to pay (WTP) for green electricity as contributions made by everyone with limited 'free-riding' – in this scenario the public voted collectively on an acceptable level of green electricity (Menges & Traub, 2009). Willingness to donate (WTD) was a contribution made as an individual as a participant in the market, in the presence of 'free-riding' (Menges & Traub, 2009). The findings of the study highlight that consumers demanded a larger increase in the level of green electricity as a percentage total electricity production in an individual choice scenario than in a public choice scenario (27.23 % for public choice and 43.33% for individual choice). However, they also found that consumers were willing to pay almost three times as they are willing to donate for their preferred level of green electricity in a public choice scenario opposed to an individual choice scenario (58.52 euros for public choice and 19.13 for individual choice). They note that since environmental quality is a public good, economic theory suggests that people will "free-ride on other people's contributions" (Menges & Traub, 2009). However, the study highlights that people may still contribute voluntarily even if 'free-riding' is possible.

Lin and Huang (2012) identify five (5) values - functional, social, emotional, conditional, and epistemic which determine a consumer's likelihood to purchase a product. The functional value focuses primarily on the physical utility of a product; the social value encompasses the perceived utility of using a product on a particular demographic; the emotional value refers to the emotional response that using or purchasing a product invokes; the conditional value is the utility obtained from a product in specific scenarios; and finally the epistemic value refers to the value that is obtained from a product or service that 'satisfies a desire for knowledge' (Lin and Huang, 2012). Lin and Huang (2012) noted that 'green' purchasing, specifically, is primarily driven by qualitative pairings of these values. They identify three primary conditions that, when met, typically lead a consumer to purchase a green product. The first is a prioritization of functional with emotional, conditional and social value attached - 'green' products that offer general and conditional utility, have quantifiable social benefits, and invoke an emotional response when bought or used like an electric car. The second is a prioritization of social value, with epistemological and emotional value attached - 'green' products that provide a quantifiable social benefit, have emotional value attached, and are also new or unusual like meat alternatives. The final combination is like the second, however, the buyer may not perceive any social value. If the five values underlying green purchasing are used to evaluate consumer likelihood to partake in green electricity initiatives, and thus the prospective scalability of such programs, it reveals that such initiatives may lack appeal, even to green consumers. This is because premium green electricity programs offer social benefit, with indiscernible benefits in the other four categories – though some consumers may find emotional value in purchasing green electricity.

The research presented by Clark et al. (2003), and Nyborg et al. (2006), and Menges and Traub (2009) suggests that there is the potential for premium green electricity retail strategies to promote some demand for green electricity. However, their ability to meaningfully contribute to a clean electricity transition is still limited, especially within Canada. Bullfrog Power, one of Canada's largest retailers of green electricity, reported having approximately 8000 residential and 1500 industry customers Canada-wide after eight years of operation (Green Energy Future, 2013).

With no immediate utility being provided to consumers to justify additional costs, green electricity offsets are unlikely to generate support beyond what has already been seen. Therefore, green electricity retail strategies that rely explicitly on voluntary contribution from consumers to create a demand for green technologies will have limited effect in addressing any of the key issues limiting the growth of renewables in Ontario. Therefore, the contribution of premium green electricity programs to an energy transition in Ontario regardless of the number of initiatives will likely be minimal. However, voluntary contribution programs still provide a viable option to a small market of consumers who are seeking a low-effort method of contributing to the large system change.

Community Renewables

Conventional, approaches to energy systems change will often be limited in efficacy due to the numerous politico-economic constraints and frequent disagreements between social, industrial, and political parties (Mallett, 2018). The processes involved in most conventional energy system change initiatives are often slow and will likely produce solutions which are favorable for some groups but unfavorable for others (Walker et al. 2008). As a result, driving increases in renewable energy production by relying on the power of local communities to create and implement their own renewable energy plans is something that has become a point of interest for several utilities and governments in recent years. Relying on more flexible, community-based approaches to increasing renewable energy generation can produce beneficial results within the larger energy systems in the regions where these communities exist (Walker et al. 2008).

Communities in support of an initiative have huge potential to drive the development of renewable energy infrastructure. This is especially true of projects where the benefits to the community are overwhelmingly apparent (Wustenhagen et al. 2007). Local resistance to, and unawareness of large scale renewable development initiatives are key factors which can limit implementation potential (Wustenhagen et al. 2007). Individual and group opposition to renewable projects are often due to a lack of understanding about the immediate benefits of the project to the individual or group most affected by its physical development (Bauwens & Devine-Wright, 2018). Bauwens and Devine-Wright (2018) note that all over the world there are examples of overwhelming public support for the growth of renewable energy generation being overshadowed by vocal opposition to project implementations. This suggests that there is effectively a disconnect between 'social acceptance' ("general attitudes towards renewable energy") and 'community acceptance' ("attitudes towards locally installed technologies") of renewable energy (Wustenhagen et al. 2007). Essentially, most people support and prefer renewable generation 'only' if it is not in their 'backyard'. This creates scenarios that can make it difficult for energy projects to proceed in a timely manner.

Community renewable projects can take advantage of the fact that there is greater potential for public involvement in the decision-making processes (Walker et al. 2008). This means that projects, once approved, are unlikely to be halted by community resistance. As a result, several Ontario utilities have recognized and now actively support community renewable energy projects as a necessary part of driving future increases in generation capabilities. Instead of analyzing the costs and benefits of energy projects at the macro level, community-based approaches conduct a more individualized analysis of the benefits to residents of specific communities is instead. Engaging the community in the decision-making process has the benefit a fostering more positive attitudes towards renewable developments and enables developers and policy makers to have a better idea of the specific concerns of the communities (Walker et al. 2008, Bauwens & Devine-Wright, 2018). This allows for the development of stronger, more geographically specific solutions, with higher benefits to the communities most affected by the developments.

The Toronto Renewable Energy Co-op (TREC), noted that community participation and ownership are integral to maximizing the economic benefit of clean energy sources (TREC, 2016). They note social license to develop as one of the key advantages community renewable project have over commercial projects. Polling conducted by the TREC highlighted that community ownership would drastically increase the willingness of community members to support wind and solar projects (TREC, 2016). This is likely because of the increased economic and social benefits of keeping renewable energy development in the community (Wustenhagen et al. 2007). Renewable projects undertaken within the community provide jobs for local businesses and ensure that the benefits of undertaking the development are predominantly kept within the community (Wustenhagen et al .2007). Conversely commercial developments do not provide as much benefit to the local economy as contracts are typically given to outside contractors (TREC, 2007).

Karimi and Kazerani (2017) discuss the incorporation of renewable energy resources in northern Ontario communities. They first identify the implications of continued reliance on diesel energy for electricity generation, specifically its costs, generation limitations, and greenhouse gas emissions (Karimi & Kazerani, 2017). Additional, they note that the load restriction imposed by diesel electricity generation capacity restricts continued growth in several of these communities. The study primarily analyzes the environmental and economic effect of introducing renewable energy generation and energy storage systems in the Kasabonika Lake First Nation community, which encompasses a population of roughly 1100 people. Prior, to engaging in the renewable energy project the community primarily relied on three diesel generators, to meet the average energy demand of approximately 12.9 MWh/day. The project introduced several solar panels, and four wind turbines in to supply a portion of the community's electricity consumption. Karimi and Kazerani (2017) found that introducing the renewable energy infrastructure, even on a small scale, led to significant cost savings associated with electricity production, and unsurprisingly the reduced reliance on diesel reduced greenhouse gas emissions by approximately 6.2 percent with associated energy storage systems and 3.5 percent without (Karimi & Kazerani, 2017).

The potential for community development of renewables in Ontario to contribute to a system change is certainly worth considering. However, there are significant limitations to what can be achieved solely by relying on local communities. Community renewables are often dependent on the availability of provincial government and utility incentives to materialize. The 2009 Feed-In-Tariff (FIT) program was one of the most effective drivers of renewable energy infrastructure development initiatives at the community scale in Ontario. Under the FIT program, households, businesses, and communities could be financially compensated for renewable electricity supplied to the grid (Government of Ontario, 2018). This was intended to incentivize the voluntary development a renewable energy infrastructure and was hugely beneficial to communities seeking to transition their energy supply. However, applications for rebates from FIT program are no longer being accepted, which removes this as an option for new community energy developments.

Finally, the potential of community renewable projects is also hampered by the geography of communities seeking to participate. It is important to note that not every community that wants to own a wind or solar farm is positioned appropriately to do so geographically. Also, the projected cost savings from local generation projects is largely what incentivizes rural communities to pursue community renewables (Karimi & Kazerani 2017). While there are several renewable energy projects being undertaken in urban settings with the aid of municipalities and utilities, communities close to, and within, major cities have less incentive than those farther away to partake in community renewable developments. It is important to note, as highlighted by Karimi and Kazerani (2017), that many of the large-scale community renewable programs in Ontario are being used as replacement for expensive off-grid diesel generation, rather than to offset the use of nuclear generation. Therefore, despite the evidence that community renewables can aid in the development of renewable energy infrastructure, their contribution to a system-wide shift will likely be minimal.

Grid Modernization

In recent years energy delivery infrastructure in Ontario has been undergoing rapid modernization led primarily by major utilities. Electricity distribution networks have historically been limited in their capacity to incorporate renewable technologies while simultaneously maintaining reliability and cost-economy (Briones et al. 2012). Also, given the numerous benefits that can be linked to a more efficient and clean energy distribution systems there is perhaps sufficient motivation for utilities to pursue such actions. Inefficiencies in the present distribution system costed Ontario approximately $1.25 billion dollars between 2015 and 2016 years (Ontario Society of Professional Engineers, 2017). When coupled with increased political and consumer attention to both the monetary and social costs of electricity production and distribution it is a wise decision for utilities to take the necessary steps to modernize their transmission systems. The process of modernizing the grid will provide the best opportunity for adapting the distribution network to better facilitate the growth of renewable electricity generation.

In Ontario, smart grid has emerged as one of the most innovative and promising initiatives regarding energy efficiency and renewable energy. An effective Smart Grid allows for communication between appliances that use electricity and the electricity grid (Briones et al. 2012). Smart grid applies monitoring, analysis and communication technologies to the energy grid which provides various information about energy use. It prioritizes two-way flows of information and energy across the grid, which informs utilities and consumers about energy usage in real time (Mallet et al., 2018). This allows for a more efficient use of distributed electricity, which may simultaneously reduce the costs associated with transmission and increase transparency between consumers and utilities (Meadowcroft et al. 2018). Additionally, smart grid systems are designed to be adaptable, and allow for greater flexibility regarding connection to the grid (Alectra Utilities, 2018). Research by Wolsink (2012); and Meadowcroft et al. (2018) suggest that smart grid technologies will allow for better integration of distributed generation which ultimately allow for deeper renewable energy penetration.

Public concerns about the integration of more renewable electricity could also be addressed using a smart grid system. If a surplus of electricity was supplied to the grid by distributed generation, under existing FIT contracts private generators of renewable electricity would effectively be paid for unusable energy (Sioshansi, 2012). The surplus energy is usually exported if possible to minimize waste, but often at a loss to the province (Sioshansi, 2012). Smart grid technologies would limit this loss by communicating information with utilities that ensures that only as much energy as is demanded is supplied. This could be used to ensure that as much of demand as possible is met by renewable energy before falling back on conventional energy sources to supply the balance (Sioshansi, 2012). Coupled with the falling prices of renewable technology, this would remove the loss incurred for over-generation, increase renewable supply on the grid, and increase reliability through increased access to distributed energy resources (Sioshansi, 2012).

In theory the ways in which grid improvement initiatives benefit the advancement of renewable technologies in Ontario are numerous. Alectra Utilities – one of the largest retailers of electricity in Ontario – noted that use of highly computerized distribution systems will enable them to better manage their renewable resources. The company has proposed to begin making use a micro-grid technology – a subset of smart grids to promote safe and reliable service. They have also noted that by frequently monitoring changes in demand load they can more easily determine when to bring renewable resources online to maximize their effectiveness (Alectra Utilities, 2018).

A modernization of the grid to better incorporate renewable technologies would be hugely beneficial to the goal of phasing out nuclear energy. However, despite the clear benefits of increasing Ontario's supply of clean electricity, most advanced grid innovation technologies are still in a stage of relative infancy (Ontario Smart Grid Forum, 2015). While several utilities have opted to incorporate various innovations from the smart grid system, none have fully explored possibilities available (Ontario Smart Grid Forum, 2015). This is likely due to numerous barriers which have emerged primarily regarding cost, and the maturity of the technology (Ontario Smart Grid Forum, 2015). Utilities are tasked with shouldering most of the financial burden for smart grid innovation (Ontario Smart Grid Forum, 2015). This may lead to more conservative research and development as it is currently difficult to financially quantify the benefits of proposed grid innovations (Ontario Smart Grid Forum, 2015).

Renewables in Ontario's Energy Policy

Energy policy will undeniably play an integral role in increasing the scale of renewable electricity generation in Ontario. In 2010 the Government of Ontario put forth their first long-term energy plan; a roadmap for progression regarding energy provision across the province. The long-term energy plan was intended to provide a forecast for the energy market in Ontario. The analyses supporting the 2010 long-term energy plan assessed a range of scenarios, regarding the demand for electricity and fuels over the period ending in 2035. These included low demand scenarios, where the provincial demand for electricity declines below current levels, "flat growth" or constant demand scenarios, where the province could sufficiently meet future demand with existing infrastructure, and "high demand" scenarios where the province would need more energy resources to meet demand (Government of Ontario, 2010). Of these scenarios a high demand scenario was deemed most likely and chosen to inform decision making and public policy. The report suggested that there would likely be an increase in demand of approximately 15 percent between 2020 and 2030 due to projected population growth, industrial growth, and the rapid electrification of various technologies in several industries. In preparation to accommodate the projected increases in demand, the government has since set numerous goals, and begun undertaking initiatives to strengthen the energy distribution system. Among the goals detailed in the plan was to double the supply of renewables in the province to 15,700 MW by 2025. The increase in renewable energy generation was suggested as a necessary part of a transition to a cleaner energy supply.

When the 2010 long-term energy plan was proposed the government noted that the void in generation left by phasing out coal could tentatively be filled by increasing nuclear and hydroelectric generation. However, they also suggested a potential need for an increase in generation from non-hydroelectric renewables as more nuclear facilities were taken offline to be retrofitted (Government of Ontario, 2010). Figure 1.1 outlines prosed changes in electricity generation composition between 2010 and 2030. The graphs depict a decreased reliance on nuclear energy and increases in the generation of electricity using both wind and solar.

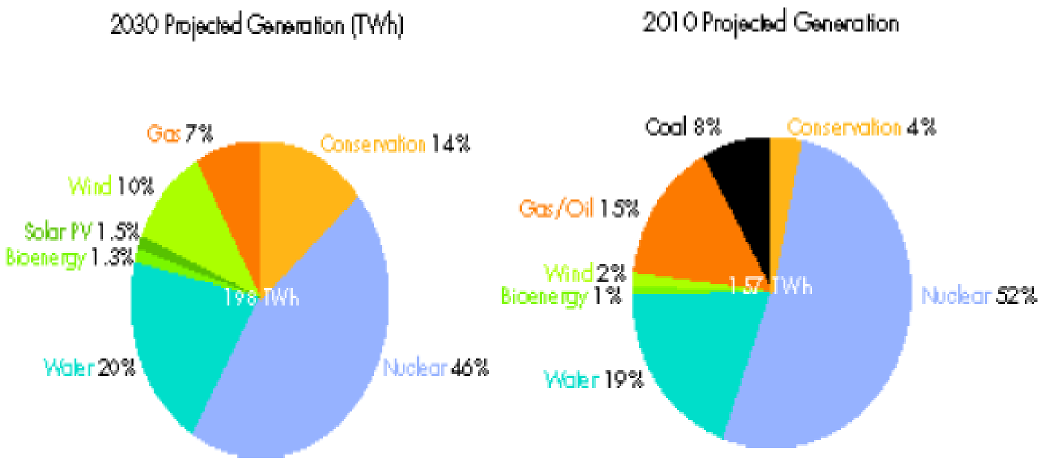

Figure 1.1 – Projected energy supply charts based on Ontario's 2010 and 2017 long-term energy plans. (Government of Ontario 2010, 2017)

Support for the development and scale of renewable electricity generation technology to address demand growth is still apparent in more recent policy documents. The most recent version of the long-term energy plan, which was released in 2017, suggests that Ontario intends to help maintain and facilitate the growth of the renewable energy sector. The government forecasts a contribution of over $5 billion to Ontario's GDP from the renewable energy sector between 2017 and 2021 (Government of Ontario, 2017).

The Green Energy and Economy Act

Ontario's 2009 Green Energy and Economy Act (G.E.E.A) is one of the more well-recognized attempts by the province to drive the development of non-nuclear renewable technologies. The policies created under G.E.E.A. are intended to facilitate the development of green electricity initiatives and promote green jobs within Ontario. In its inception, the Green Energy and Economy Act, proposed several residential and commercial programs, intended to incentivize a switch to cleaner and more renewable sources of electricity, primarily wind, solar, and hydroelectricity.

Of the projects created under the G.E.E.A. few have been irrefutably successful. While the F.I.T. and other green electricity generations projects achieved their goal of propelling the development of green electricity technology, they were heavily criticized for their contribution to unfavorable social and economic conditions. In a 2017 news interview, Ontario Energy Minister Glenn Thibeault noted that the G.E.E.A has less than optimal outcomes for consumers and businesses alike (Hill, Global News, 2017). Thibeault noted significantly increased hydro prices, and inability to meet its projected totals for the number of green jobs to be creates under the G.E.E.A. as two of the more notable failings of the Act (Hill, Global News, 2017). In 2011 the Ministry of Energy reported that for every job created by renewable energy projects, two to four jobs in other industries are lost (Ministry of Energy, 2011). Additionally, several of the jobs created by the project were short term, with construction contracts typically lasting only between one and three years (Ministry of Energy, 2011). There were also concerns of increased energy prices for all ratepayers reflective of the cost to pay generators to produce renewable energy (Ministry of Energy, 2011). This was further exacerbated by claims that much of the energy produced by renewable sources was simply surplus energy beyond what was required to meet demand (Ministry of Energy, 2011).

The many social and economic failings associated with Ontario's clean energy projects has undeniably impacted both the public and political opinions of clean energy. This has rightfully led to wariness regarding future green electricity initiatives. Further increasing social, industrial and political trust and support for clean energy transition initiatives will be contingent on the ability of the government and utilities to provide more tangible benefits to consumers.

Analysis

Voluntary contribution, community renewables, and grid modernization are key areas of interest for various utilities in Ontario. The goal of this paper was to evaluate the capacity for initiatives at each of these levels to meaningfully contribute to the removal of nuclear generation from Ontario's present electricity supply mix by allowing for greater incorporation of renewable energy. Despite releasing no greenhouse gas emissions, nuclear energy has ecological implications that make it an unfavorable choice for meeting long-term electricity needs.

Voluntary contribution programs theoretically create additional demand for renewable energy which influences the associated supply. However, due to effects such a free-riding and limited material benefits to consumers, the potential for such projects to significantly promote renewable generation in Ontario is minimal. Community renewables have much greater potential that voluntary contribution programs to increase renewable electricity supply. However, fluctuating public policies, geography and heavy reliance on community support to materialize projects, these developments are also limited in their ability to greatly impact Ontario's present energy supply-mix. Grid-based innovations show the greatest potential for allowing a transition in Ontario's electricity system. Smart grid infrastructure if widely implemented can provide numerous benefits which will allow for a greater supply of green electricity on the grid. These include greater access to distributed energy, and less waste from over-generation of green electricity. However, changes to the grid take time, and many of these initiatives are still in relative infancy and require greater social and political support as well as technological advancement to reach their full potential.

Rosenbloom and Meadowcroft (2014) suggest that socio-economic, and political alignment, along with the presence of strong technological alternatives are the most essential components any electricity system change. They highlight the relationship between these components in Ontario's transition from coal powered generation system to the present one which primarily utilizes nuclear, gas, and hydroelectricity. Catalyzed by socio-political and economic objectives to minimize both the health risks associated with the combustion of fossil fuels, and the cost of energy generation, the previous transition was only made possible by the availability of technologically mature nuclear and hydroelectric generation systems (Rosenbloom & Meadowcroft, 2014).

Voluntary contribution, community renewable, and grid modernization initiatives all serve to further advance the development renewable technologies. However, if green electricity is to ever substitute nuclear generation in Ontario's energy supply however it will require a drastic shift in political and economic thought regarding nuclear energy. Complacency using nuclear energy to meet most of Ontario's demand, will significantly limit the potential for renewables to ever eclipse nuclear as the primary method of electricity generation. Present plans to refurbish aging nuclear facilities, as well as policy documents that support the use of nuclear electricity to meet long-term future demand will likely prevent any meaningful transition from occurring, even as innovation improves the financial and technological viability of renewables.

Conclusion

Ontario's electricity system has changed substantially in the last 20 years. Coal, as the primary method of electricity generation has been phased to create a cleaner and more reliable network. Ontario's transition from coal to nuclear generation meant that the province could continue to grow economically and provide affordable electricity to consumers, while simultaneously contributing to climate change mitigation initiatives. However, since then innovation in renewable technologies has produced new pathways to meet Ontario's electricity demand. Recently, Ontario's utilities have been exploring various pathways to allow for greater penetration of renewable electricity resources into the supply mix.

This report evaluated three areas where utilities have chosen to focus efforts to foster the growth of renewable electricity supply in Ontario. Voluntary contribution programs, community renewable initiatives, and grid modernization were all assessed based on their ability to contribute to a renewable electricity transition. Of the three, grid modernization appears to have the greatest potential to significantly increase renewable electricity supply and incentivize a transition away from nuclear. Smart grid innovations in Ontario could theoretically save utilities and consumers money, increase the integration of renewables into the electricity supply, and increase the stability of the grid. While voluntary contribution programs and community initiatives may not be as impactful as grid modernization, both still contribute to the goal of increasing renewable electricity supply.

While beyond the scope of this paper, it is important to note that there are several non-utility-based initiatives that are effectively contributing to the development of renewable electricity infrastructure. SolarShare – a renewable energy co-op that operates Canada-wide – has crafted a successful business model that allows consumers to invest in solar energy installations and receive financial returns on their investment (SolarShare, 2018). Further research on the potential for non-utility-based renewable electricity programs, such as SolarShare, to scale in Ontario may prove useful in highlighting alternate routes to a nuclear-free electricity system.

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