Germany's transition to renewable energy: lessons for Canada

Emma Scully

2018

Bachelor of Commerce Best Business Research Papers

UVic Libraries ePublishing Services

Original citation:

Scully, E. (2018). Germany's transition to renewable energy: lessons for Canada. *Bachelor of Commerce Best Business Research Papers*, *11*, 78–93.

Germany's Transition to Renewable Energy: Lessons for Canada

Emma Scully

ABSTRACT

Germany is a leader as a renewable energy economy. 50Hertz operates one of Germany's largest electric grids, delivers both solar and wind power as renewable electricity, and uses an intricate system of forecasting to predict when the wind will blow and the sun will shine. Germans are provided subsidies from the government as encouragement to sell to this power grid.

The German renewable energy movement, called *Energiewend*, is politically and economically charged. Controversy began after the nuclear disaster in Japan sparked the closure of nuclear plants in Germany. Although progressive in the renewable energy space, there is much controversy as to how Germany will maintain electricity output if use of nuclear and coal sources are eliminated. Angela Merkel's promise to meet 2020 emission targets is failing, as power production in total has increased over the years due to increase in renewable power production and maintaining production of lignite coal. Pricing models require work, as high electricity rates paid by the consumer will interfere with affordability.

In Canada, Hydro One delivers some forms of renewable energy; however, a large amount of electricity still comes from nuclear power. With nuclear plants nearing the end of their useful lives, Ontario faces a challenging future in terms of renewable energy, and should look to Germany for solutions and learn from their failures. Canada's limited progress in the renewable electricity market can be attributed to a variety of aspects: political, social, geographical and cultural. Hydro One must emphasize the real business benefits of transitioning to completely renewable power; however, there is currently the inability to reliably store renewable energy, which limits both Canada and Germany's progress in the renewable sector.

INTRODUCTION

While most countries have been free riders in the push for renewable energy, Germany has advanced as one of the world's first renewable energy economies. Although Canada has great appreciation for the environment, Germany is progressive in terms of current and future renewable energy production initiatives. As the foundations of the Canadian economy are based on natural resources, this presents a fundamental conflict.

The energy sector faces great risk as a generally intensive area of business. While most countries have been slow to follow suit with experimenting in renewable energy initiatives, Germany's energy producers and providers have advanced. Two like companies are examined to emphasize the importance of competitive advantage: 50Hertz and Hydro One. 50Hertz is a regulated monopoly that operates one of Germany's largest electric grids. This grid delivers Germany's renewable power to 49 percent of the Northeast quadrant from the Baltic Coast to the Czech boarder ("About us - 50Hertz Transmission GmbH"). Hydro One is an electricity transmission and distribution company serving Ontario, and delivers hydroelectric, natural gas, wind, solar and nuclear renewable energy through traditional methods, unlike Germany's progressive grid ("About us"). The following research and critical analysis looks to explore what prompted the movement to renewable energy in Germany, and how these German energy companies, such as 50Hertz, have been able to facilitate this energy revolution to a greater degree than the energy equivalents, like Hydro One, in Canada.

SECTION 1: The History of Germany's Aggressive Renewable Energy Movement

The German "Energiewende" movement in support of renewable energy is a revolution that scientists say all nations must develop if the state of the world's climate is to be saved (Kunzig, 2017). This movement is supported by a vast 92 per cent of the German population (Kunzig, 2017). Renewable energy is now supplying nearly one-third of Germany's electricity, has created 370,000 jobs, decreased carbon emissions by 23 per cent from 1990, and is contributing to over 80 per cent of the Germany's GDP (Kunzig, 2017). German energy companies have the responsibility of catering to the needs of the public, which now is the vast public support for renewable energy.

The move towards how renewables in Germany came to be so substantial is important to address, as it was the push to eliminate nuclear energy that drove the movement initially, due to safety issues that culminated in action in 2000. At this time, there was no desire to replace nuclear power with more coal, as there was certainly enough awareness of environmental issues; therefore, the movement then began towards alternative energy sources. After Japan's nuclear disaster of 2011, Angela Merkel, the chancellor of Germany, ordered that eight of 17 nuclear plants be shut down immediately, with the remainder to be shut down by 2022 (Staudenmaier, 2017). There is disagreement in Germany about the timing of this nuclear phase-out, as the coal and auto industry are heavily protected by unions with much power (Reuter & Wecker, 2017). Loss of coal means loss of jobs, and as such, Germany's aggressive renewable energy movement is highly integrated with the German political climate.

Renewables took off very quickly after 2000 due to the German government introducing a subsidy for those that sold their energy to the grid, which was guaranteed for 20 years, and was essentially passed onto German customers (Staudenmaier, 2017). To make the subsidy more attractive, a whopping 23 billion Euros was paid by consumers on their energy bills as renewable surcharges in 2016 (Ball, 2017). As displayed in Appendix 1, Figure 1, since 2006, energy rates in Germany have increased by about 50 per cent, which corresponds roughly with the increase in renewable surcharges, as also shown by the blue section displayed in Figure 1.

Certainly, it was a great success initially that so many German individuals took advantage of this opportunity to sell power to the grid; however, one mistake may have been that it took an extended period of time (not until 2010) for the government to reduce the subsidies, even after solar panels became very cheap to install. Since these subsidies are guaranteed for 20 years, and are passed onto customers, it has proven to be an extremely costly transition, and possibly unnecessarily so:

> *'While the big four power companies own most conventional generation (hard coal, lignite, nuclear, and natural gas), they own only about 5 percent of renewable resources. Private citizens, including farmers own 46 percent of renewable generation in Germany, followed by project developers, industry, and banks.'* (Bayer, 2015, p. 5)

50Hertz, a transmission system operator in Germany, is involved in connecting all of these providers to the grid (Ball, 2017). 50Hertz spends a large amount of money on engineering, installing, and updating their renewable electricity assets in order to maintain leadership in the growing global renewable electricity sector (Ball, 2017). It has been lucrative for the individuals who took advantage of the opportunity to tap into the grid, but it has been at the expense of the consumer at the other end, since the subsidies are earned by the producer are paid for by the consumer. Additionally, it is a challenge for 50Hertz to control the energy surges on the grid on days when renewables are producing more electricity than the norm, and the renewable producers are paid for their energy even if it goes to waste, which ends up being yet another added cost to the consumer (Ball, 2017).

Traditional coal plants cannot alter their production as readily in sync with the rise and fall of renewables. This is one of the reasons that consumers across Germany pay different rates for electricity, and that the grid operators, like 50Hertz, have a large role to play in managing that cost, even though it is a cost for passing electricity through the grid (Ball, 2017). This is a crucial lesson learned for other countries looking to adapt a similar grid method: as

technology improves and renewables take over, it will be possible to lessen this effect. 50Hertz' pricing models still need to take this cost into account. At some point, high electricity rates paid by the consumer will start to interfere with economic development and affordability. In addition, the German government guarantees the grid operators a minimum return on their investment, which is passed onto the customers; therefore, all of the improvements necessary for this transition are borne by the customer (Ball, 2017). There must be a limit as to how much can be funded by consumers, and it may all be coming to a head in Germany now.

Learning that so many private individuals are profiting from linking into the grid begs the question of how are the traditional electricity producers are being affected. E.ON and RWE are Germany's largest traditional utilities, and they appear to be struggling to come to terms with the transition. RWE, even as late as 2012, was skeptical that solar power could be effective in Germany (Amelang, 2017). As a result, RWE is very late to adapt to the renewable shift.

There is some controversy over the extent to which Germany's electricity output can be maintained if coal and nuclear are both phased out. Since solar and wind energy cannot be produced consistently throughout the year, and there is no reliable way to store this type of energy as of yet, there are times during the year when traditional sources of energy remain essential. As displayed in Appendix 2, Figure 2, in January 2017, very little of the required power consumption was produced by solar, wind, and water; however, this could be changing. If successful, Elon Musk's promise to build a large battery to store various types of renewable energy in Australia to power the entire country could be a promising invention for the future of the renewable energy industry (Guardian Staff, 2017)

SECTION 2: 50Hertz and the Current & Future of Renewable Energy in Germany

Electricity, once produced by producers, whether by renewable sources or conventional means, is fed into a transmission grid (comparable to the likes of a highway) for transporting to distribution operators who then provide it to customers. 50Hertz is responsible for building, operating, monitoring and maintaining a portion of the high-voltage transmission grid in Germany (i.e. managing that highway), and is federally regulated (Ball, 2017). Germany has four transmission operators, and each is responsible for a certain designated area - 50Hertz' area is in the northeast quadrant and serves 18 million people (Ball, 2017). The other three transmission operators are Amprion, Transnet BW (EnBW) and TenneT. The way 50Hertz earns revenue is to charge a grid usage fee, which is government controlled, and is included in the power price paid by the ultimate consumer (Ball, 2017).

The transmission grid operation is extremely complicated, as it involves the use of sophisticated forecasting methods (essentially based on erratic weather patterns) to ensure that power is stable for all of Germany, regardless of its source, and that excess power generated is exported, if possible (Ball, 2017). 50Hertz is a leader in the renewable energy field, and in 2016, was able to integrate 40 per cent of the installed wind power capacity created in all of Germany into their grid ("Wind Power"). 50Hertz has a subsidiary called 50Hertz Offshore. The subsidiary's purpose is to link wind farms that have been built in the Baltic Sea into the 50Hertz grid ("Collecting wind in the Baltic Sea - how electricity makes its way to land"). 50Hertz has been extremely successful, partly because of its very sophisticated forecasting methods which compensate for the variability in renewable energy produced, as well as its forward-thinking approach to connecting with renewable energy sources.

Germany is a net exporter of electricity, meaning that they produce more than can be consumed domestically - this in itself means that there is no incentive economically to eliminate coal production, as it can be exported and sold outside of the country (Kunzig, 2017). There are two forms of coal- lignite and hard coal- lignite is much more pollutant to burn than hard coal (Schwägerl, 2015). To add to the predicament, one of the major factors slowing down the elimination of coal is the number of jobs that will be lost as a result (Kunzig, 2017).

Unfortunately, it is predicted that Germany's emissions goals are not going to be met for 2020, as greenhouse gas emissions have been on the rise since 2009, as displayed in Appendix 3, Figure 3. This is partly because traditional

plants cannot easily vary their production in response to the variability of renewable energy sources, and often, there is so much power available that the price becomes negative for commercial customers (Martin, 2016). Figure 4 in Appendix 3 shows that power production in total has increased over the years, and that coal and lignite have not reduced by a significant amount. Nuclear energy has reduced because of the closing down of plants. Carbon dioxide emissions will not decrease if Germany continues to create both renewable and coal energy, and continues to ship the excess to other nations. Part of the explanation for this continuation of production is that coal energy is so deeply engrained in the German economy. It is cheap, employs many people, and is easily sold abroad to the secondary wholesale renewables market, which is why total electricity production is increasing by the total amount of renewable energy produced (Appunn, Bieler & Wettengel, 2017). Hard coal mines are slated to close by 2018; however, there is no plan to close lignite (brown coal) facilities, which are the 'dirtier' of the two. Not meeting Germany's 2020 targets is major downfall, which has led to much conflict among the political parties (Hockenos, 2017).

All of this uncertainty and disagreement has caused problems for Angela Merkel's new government. Merkel was faced with the task of forming a mixed party, which makes it difficult to come to agreement due to the coal plant dispute and the strong unionization and economics surrounding it. Merkel, although touted as being a world leader in this area, has been unable to form a coalition, and as a result, talks have collapsed (Oltermann, 2017). Part of the issue she is facing is the disagreement over how and when to phase out Germany's coal plants, which is a major contributor to Germany's predicted failure of meeting 2020 emission targets (Wehrmann, 2017). The phasing out of coal is a complicated issue that is limiting Germany's progress and causing major political upheaval. The use of hard coal, the dirtier of the two forms of coal, has decreased substantially, but the use of lignite has remained constant, which is still a major contributor to carbon emissions (Kunzig, 2017). The public has not taken legislative action well, as most recently, when an emissions levy on outdated coal plants was enforced by the German government, demonstrators protested their outrage outside of the ministry (Kunzig, 2017). Germany is struggling to find the appropriate way to phase out their coal use completely. As Germany is not a very resource-rich country, the country relies on lignite substantially, further contributing to the highly difficult phase-out process (Kunzig, 2017).

The pricing and financing of electricity in the future is a point of much debate, and regulators, such as Merkel, are struggling to design an appropriate system to distribute electricity costs to German customers appropriately. Currently, the Renewable Energy Act (EEG) surcharge is paid by customers with their power bills, and finances the feed-in tariffs, also known as the government set subsidy; however, as the levy continues to rise, this puts a burden on customers' power bills (Amelang & Wettengel, 2017). Auctions are now being introduced, which means that power producers will place bids to compete for renewable energy projects (Martin, 2016). This is a useful new method, as it forces the market to determine the price, rather than the government, meaning that carbon produced power will be sold to other European countries so it is profitable to maintain (Martin, 2016). Despite these efforts, many argue that this method of payment will not be enough to lower costs for consumers (Wettengel, 2017). Some argue that pricing carbon emissions more heavily would be a more efficient way to finance and encourage Germany's renewable energy movement (Wettengel, 2017). Regardless of the appropriate solution, major investments, both financial and time, will be required to successfully penetrate this new phase in renewable energy, and many believe that Germany's current systems are not prepared for the challenge.

It is likely difficult for voters to understand how it is possible for these huge costs to be borne by consumers, and yet, greenhouse emissions are still increasing, and coal plants are still producing 40 per cent of the Germany's electricity (Wehrmann, 2017). Although the jury is still out as to the success of Germany's efforts to be leaders in this area, there is no doubt that there are already lessons to be learned by other countries that are watching and waiting to be the second movers.

There are downsides to every source of energy, renewable or not. Wind turbines are extremely noisy, are unsightly, and need to be replaced far more frequently than traditional plant equipment. In addition, they are responsible for

killing many birds and upsetting ecological environments. Solar panels also need to be replaced frequently and disposed of. Even hydroelectric power, which is very common in Canada, often requires the flooding of valuable farmland and an enormous capital investment, which is an added cost contributing to the electricity rates.

SECTION 3: Hydro One and Canada's Efforts in Renewable Energy

Hydroelectric power is renewable and used extensively in parts of Canada, as is not the case in Germany (Muise, n.d.). The difference in geography of Canada versus Germany must be considered as to why this is the case. Ontario provides a representative example of Canada's renewable energy efforts as a whole. Ontario (and BC) has ready access to sources of water for this purpose, whereas Germany does not. Germany does have rivers, but the geographical area is much more densely populated, and thus, it is not possible to flood valleys, which is required for hydroelectric power.

In 2015, Ontario's electricity generation was 30 per cent renewable at 24 hydroelectric and 6 wind with no coal production ("Ontario's energy mix at the end of 2015"). Compared to Germany's statistics, this appears to be quite positive. What could be viewed as alarming is Ontario's reliance on nuclear power.

A possible explanation for nuclear reliance is that Ontario has run out of places for dam creation to facilitate hydroelectric power generation. Most recently, the Site C Dam creation required billions of dollars of funding, and now professionals cannot decide whether to continue with creation or back out completely (Kurjata, 2017). This has spurred much controversy across the country, as the farmland environment surrounding the dam was flooded, and now is effectively ruined for farming purposes. As Ontario is nearing the end of its useful life of nuclear production, Canada is struggling to determine the most appropriate way to eliminate nuclear waste (Beauregard-Tellier, 2005). This is most concerning, and nuclear waste be an enormous expense to dispose of; however, since Canada does not have a coalition government, it may be easier to come to an agreement than Angela Merkel's governmental situation in Germany.

Based on data available, we are able to come to some conclusions based on comparisons between Germany and Canada at the years 2000 and 2015, and 2016. In order to understand Canada's different approaches, we set a foundation by comparing where both countries stood a short time ago in 2000. As displayed in Figures 5 and 6 in Appendix 3, we can see the distribution of gross power production in Ontario and Germany at the year 2000. Germany's estimated gross power production mix values, as displayed in Appendix 3, Figure 6, are estimated based on the chart of gross power production values in Germany from 1990-2016 in Figure 4. Since values are not listed on this chart for the year 2000, approximate estimates have been made based on the data listed for the year 2000, and based on values at year 2016 and their corresponding bar sizes. Using the gross power production chart, Germany's estimates of distribution of power production in 2000 can be made, and are presented in Appendix 3, Figure 6 of about Nuclear 29%, Lignite 25%, Hard Coal 25%, Gas 8%, Renewables 8%, and Other including mineral oil 5%. Ontario's distribution of values are presented in Figure 5 based on Statistics Canada data for 2000.

If we compare these figures to Appendix 4, Ontario's 2015 data on energy sources in gross power production in Figure 8, and Germany's 2016 equivalent data in Figure 7, we find clear evidence of different approaches between Ontario and Germany in terms of renewable energy production distribution strategy. It is clear from these estimations that Ontario eliminated coal and shifted to nuclear over the years, whereas Germany is phasing out its nuclear production and increased its renewable production, but is unable to eliminate coal at the moment. Ontario, since 2000, has only added 4 per cent to renewables, and replaced coal or oil with nuclear, and a margin of gas. Ontario's methods are cleaner, but not renewable, and came with a huge increase in rates, causing outraged customers in a far worse situation than Germany.

There is an understandable explanation as to why the feed-in-tariffs were not successful, which are the subsidies that the individuals were guaranteed for 20 years. It appears that Ontario has made most of the same errors as

Germany, and to an even greater degree. Customer rates have doubled in the last ten years due to all of the guaranteed subsidies in Ontario (Morrow & Cardoso, 2017). In Germany, subsidies have increased by 50 per cent (Ball, 2017). Ontario has only 6 per cent wind to account for the large rate increases (Morrow & Cardoso, 2017). Similar to Germany, power is overproduced in Ontario (Staff, 2013). The main difference here is that a large portion of this power, in the form of wind turbines, is not even connected to the grid- only about 1,500 of 5,800 mega-watts; however, this production is still costing consumers expense (Staff, 2013). 50Hertz and their expertise in this area is something that Ontario has missed out on, and provides a learning opportunity for HydroOne, Ontario's electricity transmission and distribution utility.

In terms of consumption and lifestyle, Canadians use more energy per capita than many other nations. In fact, Canadians use more than twice the energy per capita than used in Germany (Wilson, n.d.). We can attribute lifestyle differences to this variance. In terms of home-life, Germans rarely use air conditioning or fans, most do not have dryers, and most prefer to have their homes dimly lit as a rule, and are extremely diligent about turning lights off (Grantham, 2014). German homes are also smaller on average than those in North America- most live in apartments rather than full homes, which allows for sharing of heat with their neighbors (Grantham, 2014).

Analysis of climates and average temperatures (Grantham, 2014) reveals that Toronto is only slightly cooler, and has brighter and more sunlight than Berlin, which emphasizes a similar climate- this means that greater energy use in Canada can be attributed to simply lifestyle differences, rather than temperature variances. Additionally, Germany's much higher price of electricity encourages conscious energy consumption, as it is extremely expensive to over-use energy (Grantham, 2014). High energy prices have also contributed to Germany's earlier adoption of energy-saving appliances, as it makes that much more economic sense to invest to decrease energy bills (Grantham, 2014). Unfortunately, many "normal" aspects of North American life require excessive amounts of energy outlay. As a result, Canadians require substantial lifestyle changes in order to reduce our energy expenditure per capita.

SECTION 4: Takeaways for Canada: Germany's Transition from Coal to Renewables

Every country begins the journey to renewable energy production at different stages, as presented numerically by the comparison of Ontario's and Germany's energy sources in gross power production in 2000, and 2015 and 2016. Germany shifted out of coal production when nuclear plants were forced to be shut down, while total energy generation capacity continues to grow. There has been a shift from coal to nuclear, as hard coal is being phased out, and lignite remains produced and sold. Conversely, Ontario has been focused on phasing out coal and shifting to nuclear, with different consequences to do with end-of-useful-life for these nuclear plants. Regardless of the differences in progress, Canadian energy companies have much to learn from Germany's failures and accomplishments, given Germany's substantiated presence in the renewable energy sector.

Germany has only partially transitioned to renewable energy, and it appears that the most difficult phase is yet to come. The biggest technical stumbling block towards a full transition is the inability to reliably store renewable energy, which by definition is variable. In particular, wind, solar, and other renewables are the way of the future; however, each country has vastly different dynamics in terms of geographic, economic, political, lifestyle factors. Transitioning to renewables will be a different process for each country and will take time. It is not possible to phase out traditional energy sources overnight, particularly when they are so strongly entrenched in the form of unions and economic contribution.

Often overlooked is the difference in energy consumption habits between Canadians and Germans. Although we have similar living conditions in terms of weather and technological advancement, Canadians consume twice as much electricity per capita than that of Germany (Wilson, n.d.). Part of the reason for Canada's over-consumption may be the fact that energy efficient and eco-friendly products are marketed so well. As a result, purchasing these products ironically fuels the over-use of electricity. Although eco-friendly products are also well-received in Germany, it is German culture to be more minimalist and energy conscious than Canadians. As such, Canadians

must become less consumerist with their energy consumption habits in order to be on-par with Germany's consumption per capita. Unfortunately, this is a heavily engrained adjustment that, arguably, is nearly impossible in North America's consumerist society.

It is important to emphasize the intangible business knowledge and value that 50Hertz can provide for Hydro One. 50Hertz exhibits particular expertise as a pioneer in the renewable energy sector of business, as it has developed very sophisticated predictive techniques to control the flow of energy, such that it is stable on the grid. It is this proactivity in connecting various sources of renewable power, and the development of this intricate grid, that allows for 50Hertz to hold great competitive advantage. Hydro One can learn much from 50Hertz's advancements. The company would be wise to adapt similar predictive techniques and technologies, as to better utilize wind and solar energy. Although Canada sells a margin of its energy to the USA, in terms of overproduction in Ontario, 50Hertz's method of selling to the secondary energy market could be adapted by Hydro One to utilize the 4,300 megawatts of energy unconnected to the grid.

Regardless of any advancement on the grid, the inability to store renewable energy is a giant limitation in the renewable energy sector. Storage of renewable energy, particularly solar and wind, is currently not possible for the long-term, and is a massive road block for the world to major advancements in clean energy. Germany's carbon emissions are a fraction of China and the USA, so Germany becoming completely carbon neutral will not change the world (Rogers & Evans, 2011). It will, however, prove to other nations that it is possible to achieve, and set the stage for a green future. Until storage of certain renewable energy is possible, traditional sources will continue to play a role in filling in the gaps. It may be wise to move to gas energy as an interim measure, as it is less toxic than coal; however, this too is problematic, as one cannot easily slow down and speed up energy production at nuclear, gas, or coal plants.

There is an important lesson to be learned from Germany's attempt to decrease carbon emissions by solely adding wind and solar power. As Germany added wind and solar power to the grid, their carbon emissions did not decrease- coal production was still maintained. Germany is now trying to slow down the production of wind turbines, as the nation is dealing with too much power and carbon emissions (Hockenos, 2017). As of May 2016, the nation's emissions were actually on the rise (Wettengel, 2016). The feed-in-tariffs have encouraged the increase in wind and solar power (Hockenos, 2017). Financially, this may explain why the shift to renewables has been such a huge expense for Germany, and perhaps may not have been for other countries as second movers. This alone is a major lesson for Hydro One's adaptation.

The pricing model of renewable energy is all important. In Germany, the subsidies provided to individuals up until 2010 had a 20-year life, and were awarded at the expense of the end user, even after the cost of solar panels had dropped dramatically. At some point, rates paid by consumers will be a drag on the economy, even though environmentalism is a high priority for both Germany and Canada. Our need for electricity is bound to increase, especially as a likely shift to electric cars hangs in the balance (Moulson, 2017). As such, economic models should be created in advance that are able to somewhat accurately predict the effect that individuals as energy producers will have on traditional utilities.

Canadian power companies, such as Hydro One, must realize and emphasize the real business benefits of transitioning to completely renewable power, and translate this to their consumers. Hydro One must commit to renewable energy as much as possible, as the case for investing in cleaner power for stakeholders is growing stronger. Since energy prices fluctuate most erratically, in order to protect business margins, it may prove wise to invest in renewable energy solutions that are cheaper and more reliable. IKEA recently announced its goal to become 100 per cent renewable by 2020, in hopes of becoming more energy independent and tightly controlling its profit margins ("IKEA- Energy & Resources"). Keeping up with the transition to renewables is also crucial for Hydro One's bottom line to avoid extra expenses: if left too late, penalties could be faced due to government

regulation increase. If Hydro One wishes to remain competitive in a business sense, they must continue to advance in creating cleaner energy.

In terms of second-order value, a greater investment in renewables will create demand in other sectors; for example, better renewable services could encourage innovation in products like Hyperloop, a proposed high-speed transit service relying mostly on solar power ("Hyperloop One"). Additionally, increased efforts in solar and battery power systems could make urban power more effective and durable in power outages and natural disasters ("What The Fire Of London Can Teach Us About Resilient Cities"). Any increase in resilience could offer massive savings for economies around the globe. It makes good business sense for Hydro One to take advice from 50Hertz's progress and failures, as investing in these renewable alternatives will likely lead to increased returns, but also make the company a good corporate citizen in investing in a better future for all.

CONCLUSION

Energy technology would not have advanced as quickly as it has in terms of wind turbines and solar energy had Germany not taken this approach as a world leader. If technology advances to the point that wind and solar become viable options to provide vast amounts of power, then there will certainly be options for nuclear plants with limited lives in Ontario, and we will have German initiative to thank for it.

There seem to have been oversight in terms of the beneficiaries of the transition in Germany, which regulators in Ontario can also learn from. There is, perhaps, so much emphasis on greenhouse gases that it is perceived as if once those are taken care of, the job is done; however, every source of energy will damage the environment in some way. Hydroelectric power is very expensive to finance, and the controversy over the Site C dam in British Columbia and the billions of dollars that it will cost and have to be paid for by customers at some point exemplifies this point: shifting more power to hydroelectric is not something that can be achieved easily.

Canada also must conserve our use of electricity, whatever the source, and this will take a huge cultural shift that will be difficult for a consumerist society. Canadian energy companies, such as Hydro One, can utilize the business case for sustainability in encouraging Canadians to make this shift, and pave the way for a greener future.
Time will tell whether Germany has made the right choices, and whether technology can catch up in time to allow for the complete phase-out of coal and nuclear at the same time - in which case, the world will follow.

REFERENCES

About us - 50Hertz Transmission GmbH. (n.d.). Retrieved December 11, 2017, from http://www.50hertz.com/en/50Hertz/About-us

About Us. (n.d.). Retrieved December 11, 2017, from https://www.hydroone.com/about

Amelang, S. (2017, January 26). How can Germany keep the lights on in a renewable energy future? Retrieved December 11, 2017, from https://www.cleanenergywire.org/factsheets/how-can-germany-keep-lights-renewable-energy-future

Amelang, S. (2017, May 16). Utilities and the energy transition. Retrieved December 11, 2017, from https://www.cleanenergywire.org/dossiers/utilities-and-energy-transition

Amelang, S., & Wettengel, J. (2017, February 23). Debate on financing renewables in new ways gathers pace in Germany. Retrieved December 11, 2017, from https://www.cleanenergywire.org/news/debate-financing-renewables-new-ways-gathers-pace-germany

Appunn, K., Bieler, F., & Wettengel, J. (2017, November 30). Germany's energy consumption and power mix in charts. Retrieved December 11, 2017, from https://www.cleanenergywire.org/factsheets/germanys-energy-consumption-and-power-mix-charts

Ball, J. (2017, March 14). Germany's High-Priced Energy Revolution. Retrieved December 11, 2017, from http://fortune.com/2017/03/14/germany-renewable-clean-energy-solar/

Bayer, E. (2015, February). Report on the German power system. Retrieved December 11, 2017, from https://www.agora-energiewende.de/.../downloads/.../Agora_CP_Germany_web.pdf

Beauregard-Tellier, F. (2005, September 25). Ontario's Electricity System: Is There Light at the End of the Tunnel? Retrieved December 11, 2017, from https://lop.parl.ca/content/lop/researchpublications/prb0534-e.html

Collecting wind in the Baltic Sea - how electricity makes its way to land. (n.d.). Retrieved December 11, 2017, from http://www.50hertz.com/en/Grid-Extension/Offshore-projects

Grantham, J. (2014, December 1). Why do German households use so little electricity compared to those of North America? Retrieved December 11, 2017, from https://www.quora.com/Why-do-German-households-use-so-little-electricity-compared-to-those-of-North-America

Guardian Staff (2017, July 07). Tesla to build world's biggest lithium ion battery in South Australia. Retrieved December 11, 2017, from https://www.theguardian.com/australia-news/2017/jul/07/tesla-to-build-worlds-biggest-lithium-ion-battery-in-south-australia

Hockenos, P. (2017, November 13). Germany Is a Coal-Burning, Gas-Guzzling Climate Change Hypocrite. Retrieved December 11, 2017, from http://foreignpolicy.com/2017/11/13/germany-is-a-coal-burning-gas-guzzling-climate-change-hypocrite/

Hyperloop One. (n.d.). Retrieved December 11, 2017, from https://hyperloop-one.com/

IKEA- Energy & Resources. (n.d.). Retrieved December 11, 2017, from http://www.ikea.com/gb/en/this-is-ikea/people-planet/energy-resources/

Kunzig, R. (2017, June 27). Germany Could Be a Model for How We'll Get Power in the Future. Retrieved December 11, 2017, from http://www.nationalgeographic.com/magazine/2015/11/germany-renewable-energy-revolution/

Kurjata, A. (2017, October 31). Independent report sets stage for Site C dam to be killed or carry on. Retrieved December 11, 2017, from http://www.cbc.ca/news/canada/british-columbia/independent-report-sets-stage-for-site-c-dam-to-be-killed-or-carry-on-1.4379382

Martin, R. (2016, May 24). Loading up on wind and solar is causing new problems for Germany. Retrieved December 11, 2017, from https://www.technologyreview.com/s/601514/germany-runs-up-against-the-limits-of-renewables/

Morrow, A., & Cardoso, T. (2017, January 8). Why does Ontario's electricity cost so much? A reality check. Retrieved December 12, 2017, from https://www.theglobeandmail.com/news/national/why-does-electricity-cost-so-much-in-ontario/article33453270/

Moulson, D. M. (2017, November 03). Carmakers join forces in Europe to make electrics widespread. Retrieved December 11, 2017, from http://www.timescolonist.com/carmakers-join-forces-in-europe-to-make-electrics-widespread-1.23083619

Muise, S. (n.d.). Hydro Power. Retrieved December 11, 2017, from https://www.studentenergy.org/topics/hydro-power?gclid=EAIaIQobChMI5ryt-8bb1wIVRWV-Ch3zVAVfEAAYASAAEgITpfD_BwE

Oltermann, P. (2017, September 25). Merkel faces tough coalition talks as nationalists enter German parliament. Retrieved December 11, 2017, from https://www.theguardian.com/world/2017/sep/24/angela-merkel-faces-stark-choice-between-coalition-or-minority-rule

Ontario's energy mix at the end of 2015. (2017, October 25). Retrieved December 11, 2017, from https://www.ontario.ca/document/2017-long-term-energy-plan-discussion-guide/ontarios-energy-mix-end-2015

Ontario's System-Wide Electricity Supply Mix: 2000 Data. (2002, March 5). Retrieved December 11, 2017, from http://cf.oeb.ca/documents/electricity_mix.pdf

Rogers, S., & Evans, L. (2011, January 31). World carbon dioxide emissions data by country: China speeds ahead of the rest. Retrieved December 11, 2017, from https://www.theguardian.com/news/datablog/2011/jan/31/world-carbon-dioxide-emissions-country-data-co2

Rueter, G., & Wecker, K. (2017, February 10). Pressure on Germany to ditch coal intensifies. Retrieved December 11, 2017, from http://www.dw.com/en/pressure-on-germany-to-ditch-coal-intensifies/a-40778356

Schwägerl, C. (2015, July 07). Brown coal wins a reprieve in Germany's transition to a green future. Retrieved December 12, 2017, from https://www.theguardian.com/environment/2015/jul/07/brown-coal-wins-a-reprieve-in-germanys-transition-to-a-green-future

Staudenmaier, R. (2017, June 15). Germany's nuclear phase-out explained. Retrieved December 11, 2017, from http://www.dw.com/en/germanys-nuclear-phase-out-explained/a-39171204

Staff (2013, September 11). Ontario pays wind turbines not to produce power. Retrieved December 11, 2017, from https://globalnews.ca/news/832647/ontario-pays-wind-turbines-not-to-produce-power/

Thalman, E., & Wehrmann, B. (2017, February 16). What German households pay for power. Retrieved December 11, 2017, from https://www.cleanenergywire.org/factsheets/what-german-households-pay-power

Wehrmann, B. (2017, October 16). Auctions bring German solar power price to new record low. Retrieved December 11, 2017, from https://www.cleanenergywire.org/news/auctions-bring-german-solar-power-price-new-record-low

Wettengel, J. (2016, December 20). German carbon emissions rise in 2016 despite coal use drop. Retrieved December 11, 2017, from https://www.cleanenergywire.org/news/german-carbon-emissions-rise-2016-despite-coal-use-drop

Wettengel, J. (2017, July 13). Germany ponders how to finance renewables expansion in the future. Retrieved December 11, 2017, from https://www.cleanenergywire.org/factsheets/germany-ponders-how-finance-renewables-expansion-future

What The Fire Of London Can Teach Us About Resilient Cities. (2016, September 29). Retrieved December 11, 2017, from http://www.theonebrief.com/what-can-the-fire-of-london-teach-us-about-resilient-cities/

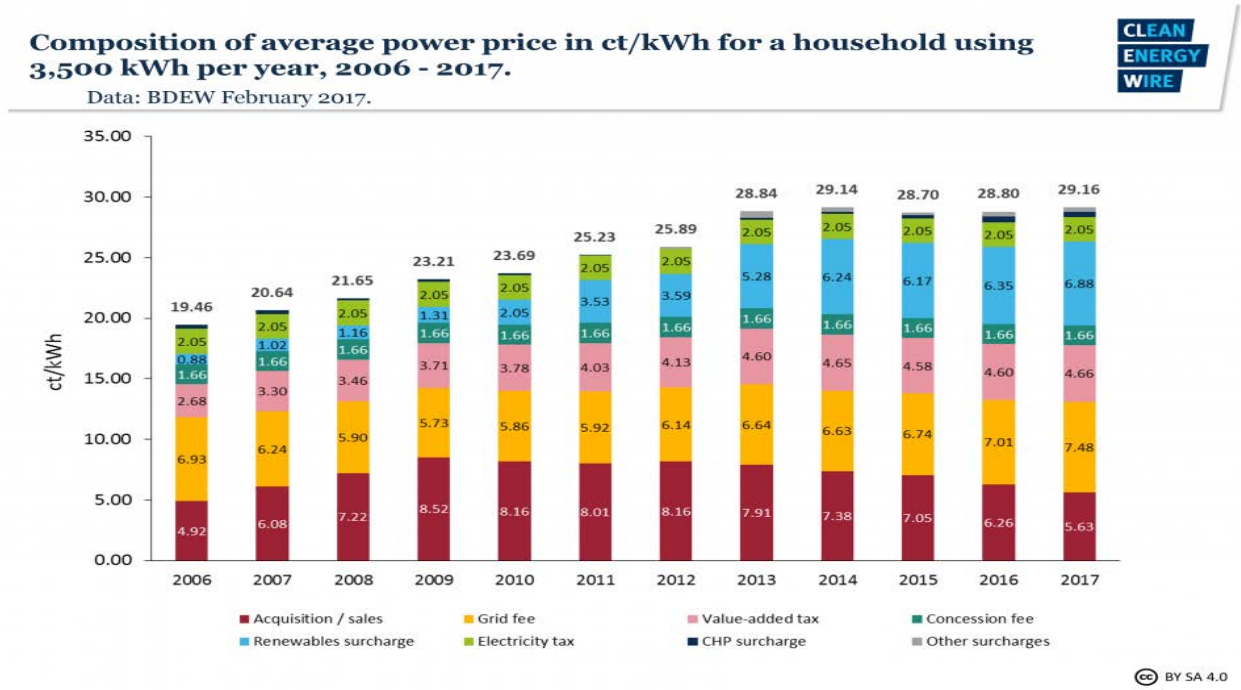
Wilson, L. (n.d.). Average household electricity use around the world. Retrieved December 11, 2017, from http://shrinkthatfootprint.com/average-household-electricity-consumption

Wind Power. (n.d.). Retrieved December 11, 2017, from http://www.50hertz.com/en/Grid-Data/Wind-power

APPENDICES

APPENDIX 1

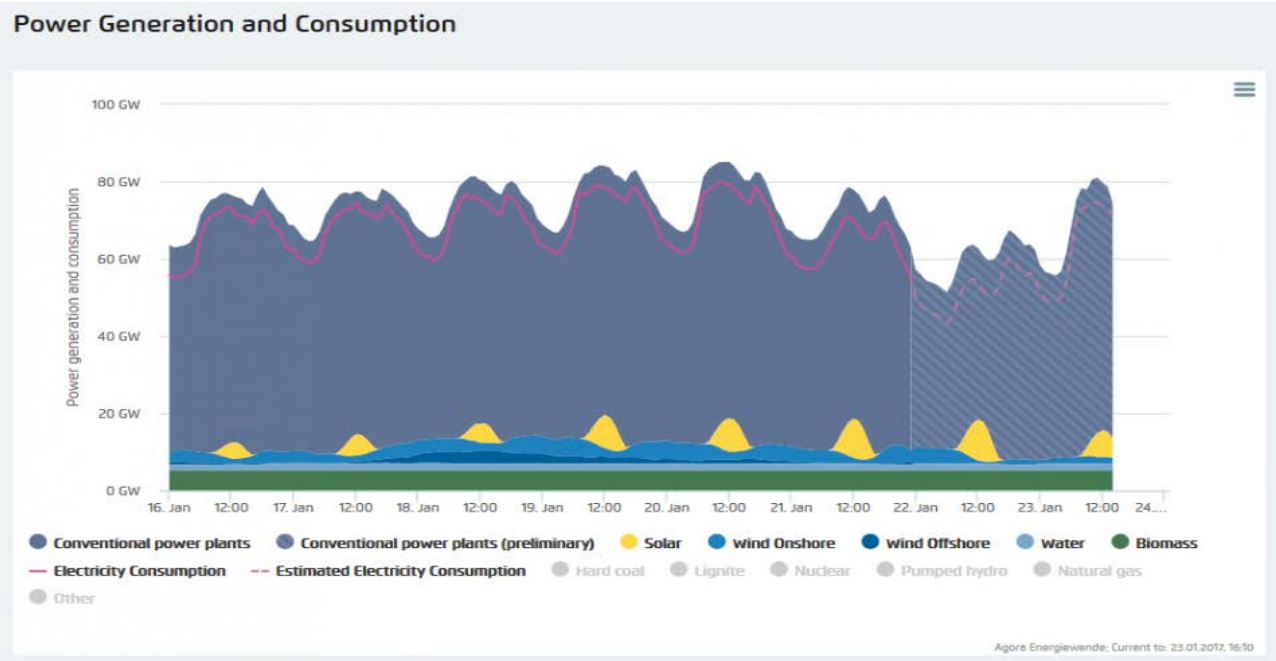
Figure 1: Average power price per ct/kWh for a household using 3,500 kWh per year, 2006-2017



(Thalman & Wehrmann, 2017)

APPENDIX 2

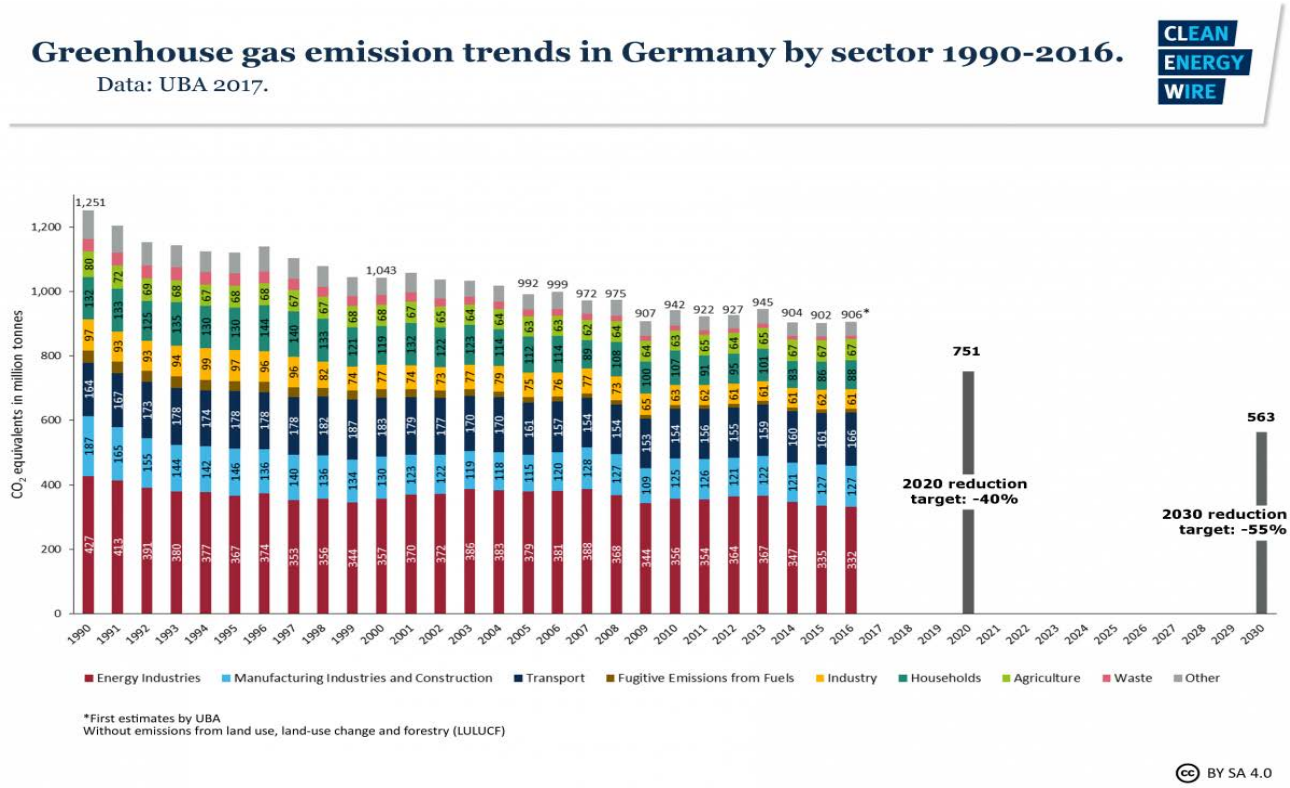
Figure 2: Power Generation and Consumption in Germany, January 2017



(Amelang, 2017)

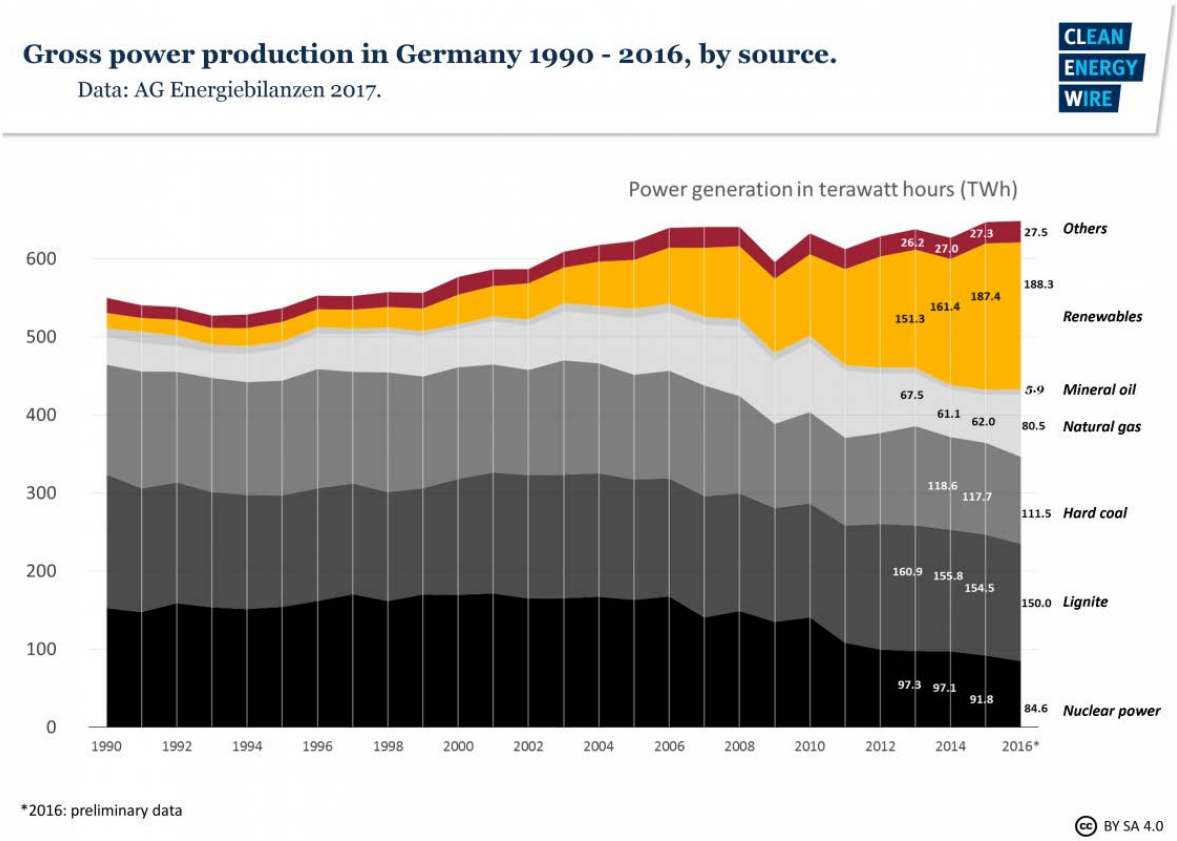
APPENDIX 3

Figure 3: Greenhouse gas emissions trends in Germany by sector 1990-2016



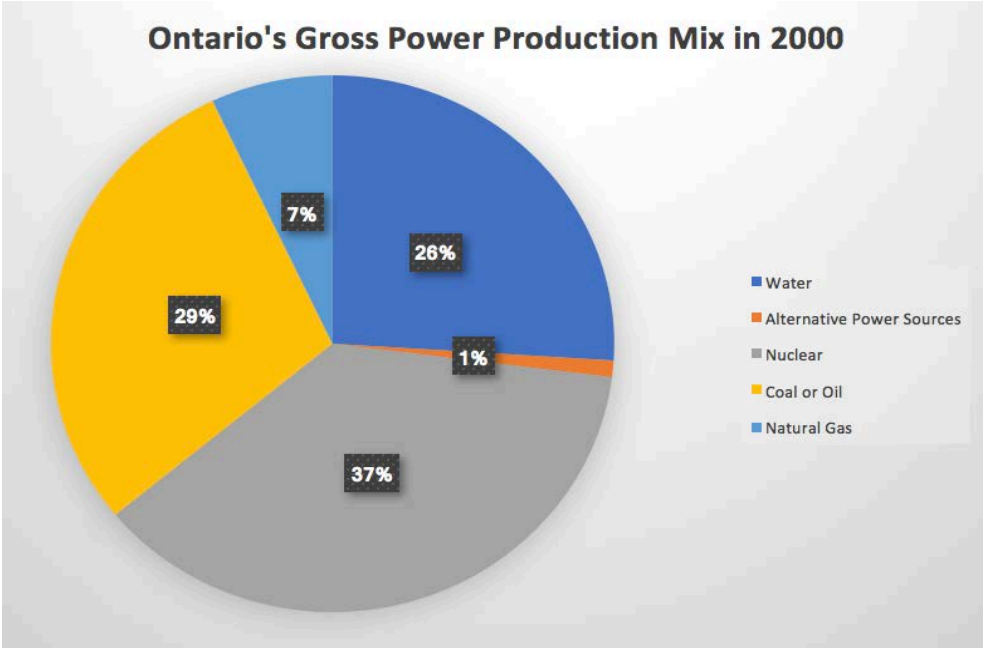
(Wettengel, 2016)

Figure 4: Gross power production in Germany 1990-2016



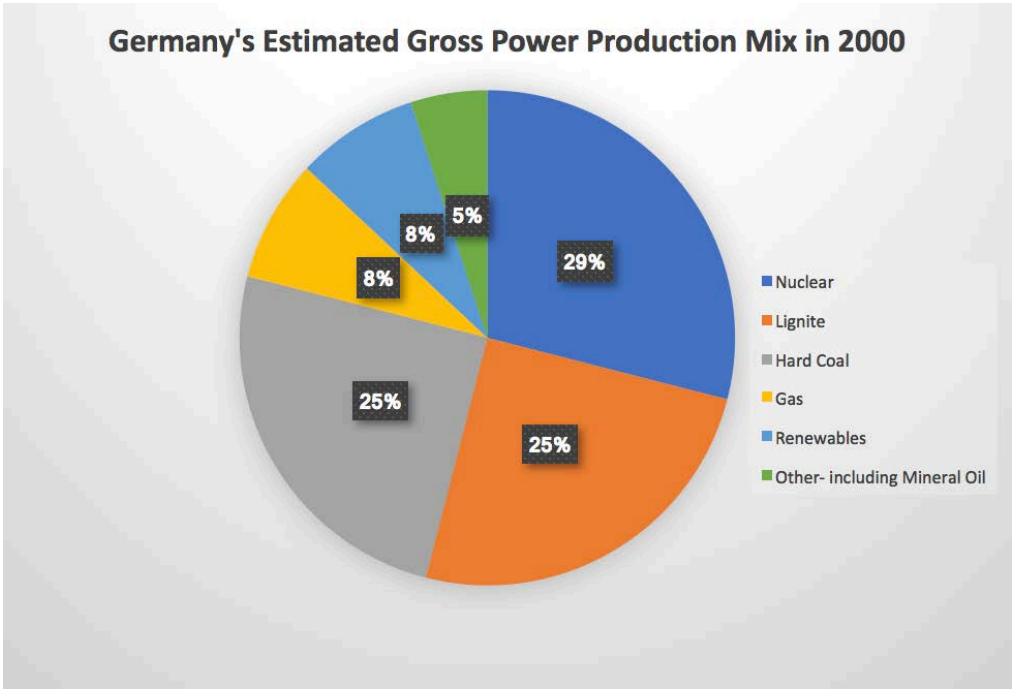
(Appunn, Bieler & Wettengel, 2017)

Figure 5: Ontario's Gross Power Production Mix at 2000 year end



("Ontario's System-Wide Electricity Supply Mix: 2000 Data")

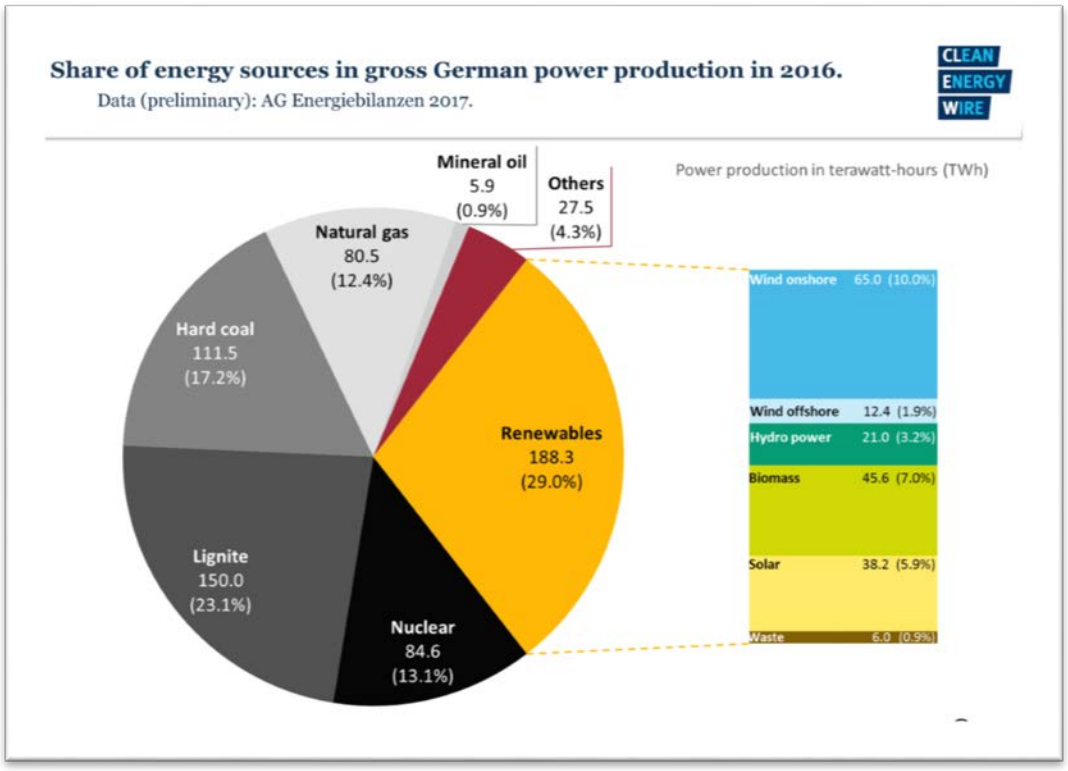
Figure 6: Germany's Estimated Gross Power Production Mix in 2000



(Appunn, Bieler & Wettengel, 2017)

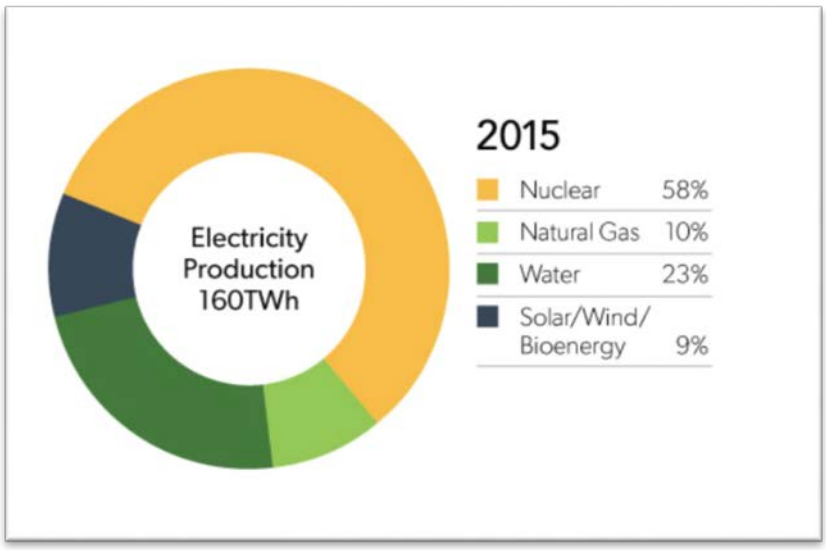
APPENDIX 4

Figure 7: Germany's energy sources in gross power production in 2016



(Appunn, Bieler & Wettengel, 2017)

Figure 8: Ontario's energy sources in gross power production in 2015



("Ontario's energy mix at the end of 2015")