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RESTARTING CANADA'S ENERGY SECTOR

INNOVATION AND THE SPIRIT OF THE COUREUR DES BOIS

By Andrew Pickford

Ever since humans first set foot on what is now Canada, they have dealt with the very real problem of keeping warm in winter and sourcing calories for sustenance. This has required innovative approaches to creating new technologies as well as adapting others to suit local conditions. The resulting development and subsequent export of commodities, including energy, has provided wealth and improved the lives of successive migrants. Energy has thus long been integral to Canada's economy. As former Bank of Canada Governor David Dodge recently noted, "Fossil fuels and other resources held the economy aloft, particularly through the 2008-09 recession."[1] Why, then, has Canada's heritage of energy innovation and development been downplayed and at times denigrated?

For many, the legacy of fishing, trapping, agriculture, and commodities is an embarrassment.[2] These are part of the "old economy," annoying and redundant relics. More sophisticated arguments will refer to a "staples trap" or "staples dependency."[3] Some contemporary opinion makers tend to look down on the natural resources sector, as does a certain portion of the general population. Yet we should be proud of this sector that has contributed so much to Canada's economic growth.

CELEBRATING CANADA'S HISTORY OF ENERGY INNOVATION

This paper takes an alternative view. It argues that the development of resources is crucial to modern Canadians and should be celebrated as an integral aspect of national identity. The true character of Canada's entrepreneurial spirit and resourcefulness also needs to be explicitly linked to innovation and progress in the energy sector.

We should look for inspiration to the coureurs des bois, who travelled across what was then New France trading furs. These independent entrepreneurs bypassed formal channels and predefined boundaries to go deeper into the wilderness to trade.[4] Like inventors throughout history, they moved faster than the state and achieved results without being constrained by existing frameworks. Learning indigenous languages, adopting indigenous clothing, and drawing on European technologies, these individuals blazed new trails. They responded to local challenges to create local solutions. It is easy to look back at the coureurs des bois from the comfort of 2021 and criticise their approach and methods, but they were products of their time. They often worked hard in the remote wilderness to improve the lives of the next generation.

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The MEI's **Energy Series** aims to examine the economic impact of the development of various energy sources and to challenge the myths and unrealistic proposals related to this important field of activity.

Similarly, nearly all innovations in the energy sector have occurred outside Ottawa and established institutions. This paper documents these breakthroughs with a *Database of Energy Innovation in Canada*.[5] The spirit of the coureur des bois can be found in Abraham Gesner, the inventor of kerosene; in Thomas Ahearn, who built Canada's first water-powered generating station; and in those working today in Western Canada to produce hydrocarbons. These entrepreneurs, innovators, and inventors unlock new forms of energy which over time are cleaner, cheaper, and more sustainable. At the same time, jobs are created, export income is generated and, most importantly, living standards continue to improve.

Nearly all our grandparents probably cut, stored, and used wood for heating in winter. While not as environmentally friendly as hydropower, they used this energy (and lots of it) to stay warm. In fact, the extraction and consumption of ever-increasing volumes of energy has long been a positive; it need not be viewed in a negative light. Previously, Canadians both indigenous and non-indigenous viewed their country as an "unlimited storehouse of natural resources."[6] As far back as 1800, Canadians consumed roughly six times the energy per person as the English and Welsh.[7] This was for good reason. Historians Unger and Thistle conclude the higher energy needs of Canadians can be attributed to their colder, darker environment.[8]

An external observer may puzzle as to why Canadians have turned their backs on this rich heritage. There are two important reasons, one short-term and one long-term. The short-term driver is COVID-19 and the temporary decimation of energy and commodity demand, except for lumber.[9] The longer-term challenge relates to the lack of consensus on energy use and policy paralysis on the energy and climate files.

Both of these factors drive capital away from Canada to the extent that Canadian energy export companies will export themselves to friendlier locations.[10] This loss of investor capital not only decreases the number of jobs that are available, but also reduces the critical mass of associated technical specialists, engineers, designers, and researchers. When one part of the energy sector declines, the entire sector is diminished. In other words, when investment in Albertan oil sands dries up, it limits the improvement of hydro breakthroughs and the deployment of solar and wind, as well as the creation of unknown, new clean energy technologies.

COVID-19 DEMAND SHOCK AND POLICY PARALYSIS

The impact of the demand shock caused by COVID-19 cannot be overstated. For a short time, crude prices went negative on key US benchmarks and oil fell 70% over the first four months of 2020.[11] In Canada, crude oil output fell by 20% in the first half of 2020 (see Figure 1).[12] This has flowed through to decisions on future production, with Canadian oil and gas capital expenditure down 54% for the second quarter of the year.[13] While a key global benchmark for crude oil, West Texas Intermediate, has been trading around US$40 since the middle of 2020,[14] Western Canadian Select has been in a much lower range due to discounting related to a lack of pipeline access. Without pipeline options to move significant volumes of oil or gas to markets in the Indo-Pacific, the discounts will be factored into investment decisions and will alter the economics of planned projects. Should the global recovery not unfold as expected, or subsequent waves restrict reopening plans, oil prices could retreat further. Policy decisions in early 2021 in the US by the Biden Administration indicate more restrictive policies toward fossil fuels, yet emerging market demand (and demand growth) is returning. The outlook thus remains very unclear. This, however, does not necessarily mean the end of the Canadian energy sector. It has survived other crashes and busts, and can restructure and reorganize at a speed few other sectors can match.

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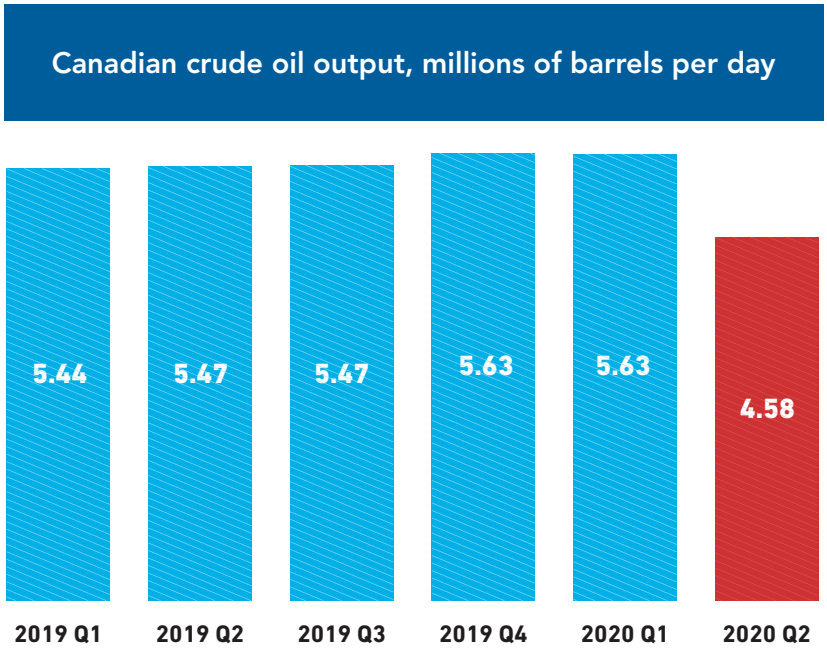
A larger problem for the energy sector is that there is no longer a consensus on energy extraction and use. This plays out in various debates, especially on climate policy. There are now fundamental disagreements, and confusion, about the role of energy in society.[15] This has reached the point where rationing is even entertained for consumption of a hypothetical energy source that is 100% renewable (and that is without any carbon footprint). Consumption itself is now being debated.[16] One reason may be our changing relationship with energy. While many older Canadians may have experienced the repetitive task of stacking cord upon cord of wood for winter, the link between energy generation and personal circumstances is now focused on the monthly heating bill.

While urbanisation is partly responsible for this, so too is a post-modern ideology which pervades academic institutions and is now seeping through many other public and private institutions.[17] While post-modernism is a vague term that is hard to define, the proponents of this theory tend to reject accepted truths or even the premise that there is a single truth. This theory also rejects the human-centred understanding of the world.[18] Without a grounding belief system, or even an agreement that human enrichment and comfort is a desirable objective, energy consumption can be debated. When matched with the worst aspects of radical environmentalism, the needs of individuals can be traded off against other abstract aims.[19]

Another element of Canadian energy and resource use relates to debates over the development of major projects. Opposition to such projects may be for deeper cultural or personal beliefs, but it has been particularly evident since the beginning of the 21st century. For outsiders, it is remarkable that so many contemporary discussions about Canadian natural resources and commodities, especially when slated for export, are obsessed with process and administration. End user needs, preferences, aspirations, or expectations never really factor in discussions. Canada operates as if there were no constraints or limitations on the export of commodities, which could thus happen on a schedule that suits glacial decision-making measured in years or decades. If this were true, Canada could choose when and how to develop, and the world would wait. But anyone working in global commodities understands that conditions change. In the 2020s, lithium and graphite demand is higher than it used to be.[20] Asbestos demand is lower.[21] Similarly, British Columbians now realize that global natural gas demand has cycles. The world's commodity markets will not wait for Canada.[22]

Figure 1



Source: Scott Carpenter, "Canadian Crude Oil Production Fell 20% in First Half of 2020," *Forbes*, July 18, 2020.

The confusion about consumption, energy use, and exports has tended to manifest around climate change debates and the more amorphous and ever-changing concept of sustainability. In Canada, this has resulted in fierce political debates and election contests. Certainly, this has a regional dimension, but there are also debates within provinces, and conflicting positions between federal political parties as well as between federal governments and provinces.[23]

As a result of the uncertain regulatory framework, investment in the entire Canadian energy industry has declined.

Given that Canada competes for capital, the impact has been predictable. As a result of the uncertain regulatory framework, investment in the entire Canadian energy industry has declined. The passing of C-69 and other Trudeau government policies can be described as a "policy frenzy." While claims were made this would provide clarity, it is merely a continuation of paralysis and confusion, but through an institutional process. This policy paralysis is the outcome of the inability to reach a resolution or consensus. Legislation, commentary, and regulation have not clarified if the federal government is for or against energy production. Instead, protracted (and changing) approval processes and appeal options have yielded predictable results.

There have been expenditure cuts across all sectors, but most evidently in oil sands in recent years.[24] In fact, investment in Canadian energy markets has fallen since 2014, with oil and gas extraction, as well as expenditure on oil sands, in decline.[25] This has negatively impacted production. For instance, from 2000 to 2017, Canadian natural gas production fell 13%, while the world's production increased by 51% on average (see Figure 2).[26] This has resulted in limited job opportunities. Canada created 1,610 oil and gas jobs between 2009 and 2018, compared to 95,000 in the United States over the same period (see Figure 3).[27] While policy paralysis on energy and climate files may be viewed as a victory by radical environmental groups, it has had a negative material impact on the lives of Canadians. And these victories are best described as Pyrrhic. Despite wishful thinking, oil and especially natural gas will continue to be a large component of supply for decades to come. Energy transitions never happen overnight.

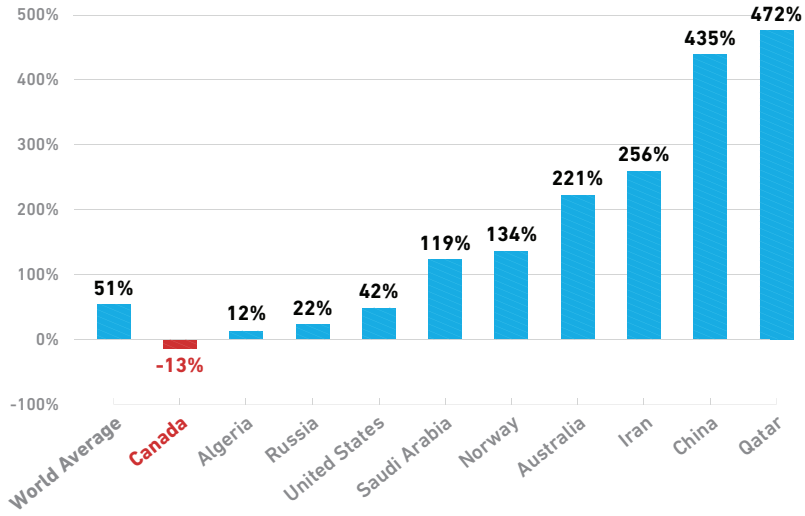
If one wants to reflect on missed opportunities, the Canadian Liquefied Natural Gas (LNG) sector is a perfect example.[28] This runs in contrast to the significant success of international pipeline sales of non-liquefied natural gas to the US.[29] The main difference is that LNG gas is cooled and shipped in liquid form, often by sea, rather than put into a pipeline. Given the shale gas revolution and the declining attractiveness of US gas markets, LNG is merely another mechanism to move gas molecules and one that, on paper, seems highly suitable for Canada.

In the late 1970s, neither Australia nor Canada had an LNG sector. Faced with increasing energy demand and few natural resources, Japan considered its options for major LNG supply agreements. In the early 1980s, proponents in Western Australia, supported by its Prime Minister, sought to sign a deal with Tokyo. Ultimately, Australia was successful and delivered its first load of LNG in 1989.[30] In the early 2010s, over US$200 billion flowed into LNG capital investment[31] and by 2019 Australia was the world's second largest LNG exporter, bringing in over AU$50 billion in export earnings per year.[32] Canada has made a late start to LNG, but how much larger could the sector be if it had started in the 1980s?

Aside from producing significant jobs, royalties, and export earnings, much of the growth in LNG demand has occurred in countries where gas is displacing coal.[33] Furthermore, in July 2019, Shell delivered the first load of carbon neutral LNG from Gladstone in Queensland, Australia to Tokyo Gas in Japan.[34] Also, the Australian LNG sector has been a major partner in efforts to create a hydrogen export sector which would result in low and zero carbon forms of bulk energy export. These new industries, and potentially zero carbon exports, are only possible given Australia's large existing LNG sector.

Figure 2

Natural gas production increase or decrease by country, 2000 to 2017



Source: Mark Milke and Lennie Kaplan, "Missing Out: Natural Gas and Canada's exports - A worldwide snapshot, 2000 to 2017," Canadian Energy Centre, May 31, 2020, p. 1.

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The story of LNG does not mean that Canada does not have an advanced and celebrated energy sector; it just illustrates that LNG could be at a scale comparable to its current net natural gas pipeline exports of over 50 billion cubic metres per year.[35] Restarting Canada's energy sector will require a technical policy shift, but more importantly, it will require a psychological shift.

HOW TO RESTART?

The twin crises of COVID-19 and policy paralysis provide an opportunity for reflection on the role of energy in Canadian life and the broader economy. This requires reviewing and drawing on Canadian energy history, which is a story of innovation, adaptation, and improving living standards. The energy sector is the inheritor of the coureur des bois tradition, which helps explain the success of modern Canada. These insights can help prepare the nation for a comprehensive energy "restart."

History provides real life examples of how innovative Canadians solved problems and changed the world. We draw on the pioneering work of Harold Innis and his "staples thesis" but introduce a progressive and positive narrative of how Canadians conquered a hostile climate and enhanced the extraction, use, and export of staples. The fact that Canada still exports commodities, while no longer focused on fur, is something that devotees of Innis dwell on. Staples are, by definition, needed by others and if Canada can do this at greater efficiency and profitability than other nations, then this should be celebrated. Efficient commodity production not only improved domestic conditions but enriched the nation through exports. For Canadians to overcome the challenges presented by climate change, partisan politics, and stagnating living standards, they need to draw on the nation's rich history of innovating to solve energy problems. We refer to this as a restart given that there is an existing sector that can flourish once again. This is not a change, as much as a return to normal.

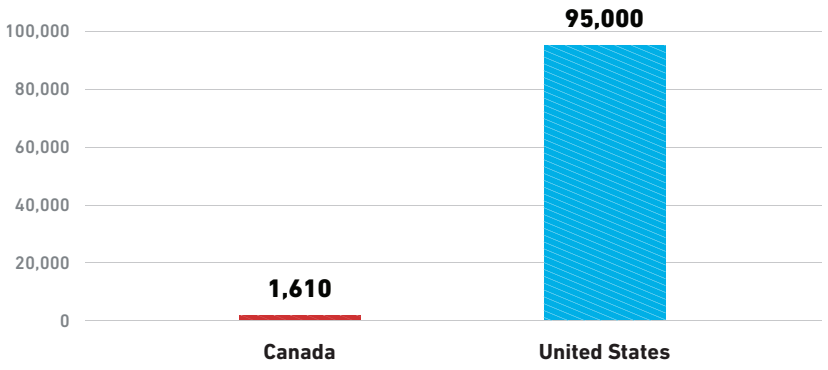
COVID-induced economic urgency presents an opportunity for this restart providing potential areas for consensus between opposing camps. Such bipartisanship was witnessed in Australia in the wake of COVID-19 turmoil. The need to invest and stimulate economic activity saw traditional adversaries compromise and seek common ground to facilitate investment in gas, with unions, industry, manufacturers, and infrastructure funds finding areas of agreement.[36] The fault lines of yesterday need not be the fault lines of tomorrow.

Canadian politicians do not need to have all the answers to end the partisan standoff. Different approaches may be taken by industry, unions, regions, and workers who have a direct interest in forming a new consensus.

In addition to the need for consensus building to replace partisanship and deadlock, efforts are needed to radically increase productivity and accelerate new innovations. The temptation may be for Ottawa to become actively involved in the energy sector. Instead, Canadian policy-makers merely need to create a framework that allows innovation. Matt Ridley's *How Innovation Works* details the evolution of energy, which was the result of continuous innovation over centuries. The story of innovation and adaptation is a rich one and relevant for this analysis. Ridley defines innovation as an incremental process. He shows how innovations are frequently serendipitous products of trial and error, often characterised by multiple individuals making simultaneous breakthroughs. The process of innovation typically sees an expensive, impractical product slowly refined and shaped into an affordable, useful one.[37]

Figure 3

Jobs created in oil and gas extraction from 2009 to 2018, Canada vs. United States



Note: Even accounting for the roughly 9-fold population difference, the United States created around 7 times more jobs per capita than Canada in this sector during this period.
Source: Mark Milke and Lennie Kaplan, "Comparing U.S. and Canada on oil and gas jobs: 2009 to 2018," Canadian Energy Centre, April 17, 2020, p. 1.

Understanding the organic nature of innovation is crucial to Canada's energy sector. Innovation can both solve problems and create new technologies, often at the same time. Should Canada wish to continue improving its living standards and reduce its environmental impact, new technologies are necessary. Such new technologies will ultimately provide solutions to energy problems and will be the quickest way to develop a large-scale, clean sector.

Governments generally do not have scope for innovation; the best they can do is create a framework for individuals, scientific bodies and organizations that encourages innovation.

The increasing use of the term "innovation" by governments has seen it distorted. Few in society will define innovation in the way Ridley does. While governments increasingly use the term, bureaucracy-driven innovation is almost non-existent. Within government, the lack of tolerance for trial and error, and more broadly a lack of tolerance of failure, is one limiting factor to state innovation.[38]

Governments generally do not have scope for innovation; the best they can do is create a framework for individuals, scientific bodies and organizations that encourages innovation. Central governments can create energy systems and plants on a mass scale. Evidence suggests that they rarely do so efficiently, however, and that they favour existing energy technologies.[39] The private sector can deploy faster with localized solutions and do not become wedded to legacy technologies. Consider how long it would take a Crown corporation to create and deploy the consumer technologies that Tesla offers.

Before analyzing historical innovation in the energy sector, it is also necessary to reposition the individual at the centre of public policy arguments. In his latest book, *Gardeners vs. Designers: Understanding the Great Fault Line in Canadian Politics*, Brian Lee Crowley considers this very issue. He describes how Canada slowly and incrementally evolved into a society that is the envy of the world. Crowley explains why Canada is not a problem to be fixed, but rather has a rich inheritance to be enjoyed and cautiously, incrementally adjusted to embrace new ideas and experiences. He draws a key conclusion not fully understood by most politicians and bureaucrats, which is that Canada was not imposed from the top down but built from the bottom up. This historical legacy belongs to Canadians, and their energy innovation, over centuries, is the story of Canada.[40]

DATABASE OF ENERGY INNOVATION IN CANADA

Based on the lack of a comprehensive documentation or compilation of energy innovation in what is now Canada, we have created a database to identify and capture key developments. The *Database of Energy Innovation in Canada* is by no means complete but is the first instance where this approach to the country's energy history has been published. In this database,

specifically created for this study, a picture emerges of how individuals, tribes, and companies have innovated and delivered energy solutions and services which enriched the lives of Canadians.

Many of the technologies and developments Canadians take for granted were unintended products of trial and error. The technologies fuelled the improvement in the country's living standards. New technologies were rapidly shared, improved upon, and deployed across regions, provinces, and then the whole nation. In some cases, these technologies were deployed globally.

Drawing on existing technologies, Canadians adapted them to suit their harsh local environment. The freedom to trade and exchange ideas has been a constant ingredient in successful innovation. Canada's ability to attract skilled migrants and the ideas and perspectives they bring has also served the country well for centuries. It too is a key ingredient of innovation.

It is doubtful if any of these projects would be approved in 2021, yet all continue to have an impact on reducing the carbon intensity of the North American power system.

Flexibility, the willingness to repurpose old technologies, and predictable regulatory frameworks are recurring features of Canada's energy history. The former two features often result in the adaptation of seemingly redundant technology to serve a modern purpose, while the latter provides security for potential investors. History shows that stability attracts investment.

Throughout Canadian history, the building and deployment of energy related infrastructure has largely been limited by capital availability and geography. It was only during the 20th century that this became a controversial matter. The *Database* captures a variety of these critical projects. Consider the 1957 natural gas pipeline in British Columbia connecting to the US market, the St. Lawrence Seaway connecting the Great Lakes to the Atlantic Ocean, and the 735-kilovolt high-voltage power transmission lines in Quebec.[41] It is doubtful if any of these projects would be approved in 2021, yet all continue to have an impact on reducing the carbon intensity of the North American power system.

In the instance of the 735-kilovolt high-voltage power lines, it shows that Canada can be a leader in the bulk movement of electricity. In the 21st century, energy may increasingly be moved in the form of hydrogen or locked in other molecules. The leader in high-voltage transmission is now the People's Republic of China.[42] Such technology gives China the ability to integrate ever increasing amounts of renewable energy and move it to demand centres. A larger energy sector in Canada may result in these types of breakthroughs, which could aid in further reducing carbon intensity, and also supply cleaner energy to fast-growing Asian nations.

Deregulation has consistently resulted in innovation, investment, and competition. The benefits of these are well-documented and have served Canadians well in the past.[43] A more prosperous future version of Canada will need to embrace them anew.

One of the key themes arising from the *Database of Energy Innovation in Canada* is that innovation is a constant activity, not an outcome. Energy transitions can rarely be driven by diktat, central administration, or ideology. They are often driven by those who seek to solve a problem and build on the work of others. A system which fosters, encourages, and facilitates innovation will create many more energy solutions than trying to design them in an Ottawa department.

The one exception to the private sector driving change in the energy sector is the radical transformation of infrastructure and generation capacity facilitated by governments during World War II and the Cold War.[44] The urgency for industrial expansion and continental depth for energy and infrastructure may be a reason for the fast pace of change. It shows that when necessary, governments can clear impediments and limitations on energy and related infrastructure.

BLUEPRINT FOR RESTARTING CANADA'S ENERGY INDUSTRY

Based on our analysis and findings, the blueprint for restarting Canada's energy sector is very simple. Nearly all the breakthroughs and advances were the work of individuals or companies, which had the pressure of dealing with an immediate problem or constraints that required a new approach. The question should be about what should be done, and not done, by government.

Ideally Ottawa and the provinces should allow for trial and error in new energy solutions. This would require accepting a greater variety of outcomes and performance than may be comfortable, but over the longer term it will create a better result. One critical thing that government can do is reduce approval times for major new projects and developments. Canada already missed out on the first wave of LNG investment, and largely the second. This matters if Canada wants to be a leader in cleaner and new technologies such as hydrogen.

Looking at electricity provision, it could be argued that the dominance of Crown corporations has crowded out a generation of inventors. The structure and ownership of these entities is beyond the scope of this paper, yet

how much red tape would an Abraham Gesner or a Thomas Ahearn face if they wanted to connect a new service to the grid today?

Nearly all the breakthroughs and advances were the work of individuals or companies, which had the pressure of dealing with an immediate problem or constraints that required a new approach.

The next breakthrough in energy technology may originate in remote Newfoundland, rural Alberta, or the former industrial city of Trois-Rivières. Despite the rhetoric of looking to future energy sources, will the provincial and federal governments give them the space for trial and experiment, or will inventors give up or look to more interested jurisdictions south of the border? The choice is clear, and the coureurs des bois show just how much can happen on Canadian soil.

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APPENDIX: DATABASE OF ENERGY INNOVATION IN CANADA

Period	Stimulus	Location	Summary	Insights
1200s	Changing climate in eastern Siberia and the Artic.	Northern Canada	The eastward expansion of the Paleo-Innuit across the Arctic region was facilitated by new transport technologies and hunting tools. This so-called "Thule Expedition" expanded their footprint across the north. During the summer and early fall these new settlers would intensively harvest whales.[1] **They would burn sea mammal fat to provide heat and light**.[2] Many of the tribes would use semi-subterranean living quarters such as the Ipiutak house.[3]	New technologies and tools can expand the areas suitable for human habitation and flourishing, especially in hostile northern climes.
1700s	Transport requirements in New France	New France	The establishment of the Royal Dockyard on St. Charles River, Quebec City, created a local ship-building industry. Throughout the first half of the 1700s, at least twelve ships were built on site. Expanding demand saw a second Royal Dockyard built, this time on the St Lawrence River. This resulted in rapid improvement in the size and quality of ships and lower transportation costs.[4]	Technology transfer and **the use of local energy sources, which in this case was wind, can result in more efficient travel and transport systems.**
1780s	Increased demand for food associated with growing population	Ontario	The British Crown built some of the earliest flour mills in Upper Canada following the influx of Loyalists from the United States, including sawmills and grist mills in Niagara. **These flour mills were water powered**.[5]	A connection to foreign capital and migrant technical skills are important to unlock calories and energy from domestically produced food sources.
1820s-1860s	New settlements and high transportation costs	British Columbia	Hudson's Bay Company established mills starting in the 1820s. The settlements of Victoria, Langley, Hope, Kamloops, and Alexandria all installed water-powered mills from the 1840s to the 1860s. The isolated locations and distance to industrial centres made waterpower more suitable than the increasingly popular use of steam power.[6]	In specific circumstances, the deployment of an existing, mature technology may be superior to other forms of energy technologies. **Local context is important**.
1820s	An identified need for large capital investment to unlock a known energy source	Nova Scotia	In 1825, the Crown granted the Duke of York exclusive rights to Nova Scotia Coal which he leased as a monopoly to a London-based firm, the General Mining Association.[7] Prior to the Duke of York being granted exclusive rights, a small number of lease-holders with licences from the Crown mined modest amounts of coal for trade to New England.[8]	The assignment of exclusive rights over a specific geography facilitated investment and further expansion in what was a cottage industry. **This led to a significant growth in coal production for domestic consumption and international sales.**
1830s	Urbanisation demand for more reliable and lower cost city lighting	Quebec	**Coal Gas was first used in streetlamps in Montreal, Quebec.** It was used as a replacement for carbon-arc lamps. This was facilitated by an 1836 by-law which granted permission for the Montreal Gas Company to supply the city with gas lighting.[9] The lighting allowed more pedestrians to safely walk the streets at night and expanded commercial opportunities.	Legislation and a predictable regulatory framework are important to provide commercial justification to invest in major network infrastructure. In addition to cost savings for the consumer, public lighting of cities can have health and safety benefits.
1850s	Whale oil price spike and odour	Nova Scotia	Long used for domestic lighting, during the 1840s whale oil became expensive.[10] One alternative, coal oil, could not be used for indoor lighting as it had a smoky flame. [11] Accordingly, **Abraham Gesner invented kerosene in 1846**, which proved to have better illuminating properties.[12] Extracted oil from the "Albertite" of New Brunswick, kerosene was initially manufactured from coal tar and shale.[13]	**Innovation can occur outside major industrial centres and can be led by non-professionals.**

Period	Stimulus	Location	Summary	Insights
1850s	Demand for improved lighting at a lower cost	Ontario	The popularity of kerosene led to efforts to find alternative inputs into the refinement process.[14] Charles N. Tripp obtained a chemist's report indicating that **crude oil could be used to produce solvents, lamp fuel and other chemicals**. This led Charles N. Tripp to build the first asphalt production plant and then to sell his mining and manufacturing company to James Miller William. His 15 metre-deep well in 1858 was producing significant quantities of crude oil. This was the first integrated petroleum company in North America.[15]	Innovation in corporate organization and industrial processes can expand energy availability at lower costs.
1870s	Need for warmth in harsh winter and cost-effective fuel	Quebec	A wood shortage and high prices in the early 1870s, especially in January 1872, saw a crisis emerge over heating options in Montreal. For immediate relief, railway magnate Asa B. Foster gave away 100 cords of firewood, and the Grand Trunk Railway subsidized wood at an eighth of its market value.[16] This ultimately led to the opening of rail infrastructure to supply competitively priced wood to the growing urban centre of Montreal. Energy historian MacFadyen describes this general trend: "Almost every town had 'coal & wood' dealers, and in the 1870s, as Canada began its second wave of railway expansion, **some lines were built**, and partly subsidized, **for the purpose of bringing rural firewood to urban markets**."[17]	The private sector has the capacity to address short- and long-term energy supply issues. **Price signals are important to allow for suitable investment into infrastructure** which places downward pressure on energy costs.
1870s	Demand for better lighting sources	Manitoba	In 1873, an electric arc light was demonstrated in Winnipeg, Manitoba. The *Manitoba Free Press* reported that "...the (electric) lamp...lights up the streets probably more than the lamp of the newly incorporated gas company will for centuries to come."[18] **The light appeared before the first US demonstration of electric light** was exhibited in New Jersey in 1877.[19]	Demonstration and trials of new energy services and technologies can help change public expectations and demand.
1880s	Demand for coal driving exploration efforts	Alberta	Canadian Pacific Railway (CPR) workers inadvertently discovered natural gas when drilling for water during coal explorations near Medicine Hat. In 1883, CPR drilled what became the first gas-producing well in Alberta. The discovery and utilisation of gas subsequently attracted a range of industries including plaster and brick manufacturing, as well as meat processing to Medicine Hat. [20]	Initially, natural gas was considered a nuisance because it was dangerous to use and difficult to refine. **This accidental discovery changed attitudes toward gas** and spawned the development of the natural gas industry in Canada.
1880s	Growing energy demand from new industrial centres	Ontario	**In 1881, Thomas Ahearn installed Canada's first water-powered electricity generating station at the Chaudiere Falls**.[21] This generation was designed and installed under the protection of multiple patents. This innovation significantly increased Ottawa's electricity generation potential: Within a year, Ottawa's parliament buildings were completely run by electricity, a full year before the equivalent milestone was reached in the US. By 1885, the entirety of Ottawa's streets was lit via electricity – the first city in the world to achieve the feat.[22]	Ahearn's patent-enabled developments saw electricity generation shift from coal to hydro, and overall electricity generation capacity increase significantly. Innovation, when supported by patent protection, can lead to a rapid shift to cleaner energy sources.
1880s	Growing demand for natural gas	Ontario	Commercial exploitation of natural gas began in Canada in 1889 when mining engineer Eugene Coste established the Ontario Natural Gas Company. By 1890 Coste was exporting gas from a field near Niagara Falls and from the Essex fields in 1894 to Detroit.[23]	**Access to international markets assists with making Canadian enterprises economically viable.**

Period	Stimulus	Location	Summary	Insights
1890s	High cost energy providing incentives for local entrepreneurs	Nova Scotia	In 1891, E.D. Davison built a powerhouse water turbine with four turbines for his sawmill in Nova Scotia, including all parts and labour for $1000. **This was one of the first water turbines to be built at such a low cost.** Water Turbines were smaller (than steam power equivalents) and could be fabricated and mass-produced relatively easily. They were substantially cheaper to buy and install than traditional water wheels.[24]	Price signals and experimentation are important to drive down capital costs for energy generation assets.
1890s	Needed more electricity for a fast-growing population	Alberta	**The first hydro-generator in Alberta was built along the south bank of the Bow River and Price's Island in the 1890s.** The barrier altered the flow of the river and pooled water so that it could be channelled through the plant. It was initially built to supplement the company's wood-fuelled steam plant. Subsequently, it was connected to a generator that provided electricity to Calgary.[25]	Commercial innovation, borne out of incentives to improve business practices and increase profits, can lead to societal benefits. It can also result in the deployment of services faster than government management or public budgets allow.
1890s	Gold discovery	Yukon	Miners applied their own labour and unlocked energy from wood to mine gold. The equipment needed for the sub-Arctic climate was too heavy to reach the mining area. **The miners devised an approach using wood fires to soften the ground to a depth of approximately eight inches** and then remove the resulting gravel.[26]	Old technology can again have its uses. Technology must also be useful to its specific environment—there is not a one-size-fits-all energy source.
1910s	Oil demand	Alberta	A 1914 oil exploration resulted in a major oil discovery at Turner Valley. It was the first major strike in western Canada. As a result, over 500 companies were registered in the following months and 50 wells were drilled, with many more commencing throughout the 1920s.[27]	**Profit incentives can lead to development in new energy regions.**
1930s	Gold exploration	Northwest Territories	While exploring for gold, Gilbert LaBine came across a vein containing high-grade pitchblende (uranium ore). Upon this discovery, **LaBine shifted his company's efforts from gold exploration to uranium exploration.** LaBine's discovery led to development of the Eldorado Mine and nearby townsite of Port Radium.[28]	Innovation and investment in one commodity market can directly, and inadvertently, lead to innovation and development in other markets.
1930s	Demand for lower priced radium	Saskatchewan	The opening of the Eldorado uranium mine saw Canada become the only source of radium outside the Belgian Congo. Radium salts were used for cancer treatment—Belgium's pre-existing monopoly led to exorbitant prices. **Canada's Eldorado uranium output saw global radium salt prices slashed** and opened new markets for the province of Saskatchewan.[29]	The price signal is important to spur exploration and bring new production online.
1940s	World War II	Quebec, Ontario, Alberta, and British Columbia	During this global conflict, there was a deployment of hydro power to meet war production demands, including for aluminum and related heavy industry to support the war effort. **From 1939-1945, Canadian hydro-electricity generation increased 40%.** Centralized power resulted in the creation of a "power controller." This government official was tasked with encouraging reluctant power companies to start investing and developing new projects.[30]	The private sector can rapidly respond to energy needs if governments de-risk investments by underwriting demand as well as reducing bureaucratic and jurisdictional hurdles.
1940s	World War II provided stimulus to new nuclear research and experimentation	Ontario	Canada's first nuclear reactor, ZEEP, was built and went critical on September 5, 1945. ZEEP was the world's first operational nuclear reactor outside the US. Designed by Canadian, British and French scientists, ZEEP led to the development of NRX and NRU reactors. **These reactors ultimately contributed to the development of CANDU reactors.**[31]	International collaboration is important when a new energy technology is unproven. Often conflict or crisis can produce unexpected energy technologies.

Period	Stimulus	Location	Summary	Insights
1940s	Private sector oil exploration	Alberta	In 1946, Imperial Oil commissioned a team of seismologists to survey the land of central Alberta. Satisfied with the subsequent results, Imperial Oil began drilling, and after 133 attempts, they struck a major oil reserve. **The reserve, now known as Leduc Number 1, transformed the Albertan economy** and signalled the start of an energy boom.[32]	Private investment in the energy industry has the potential to transform local and national economies.
1950s	Cold War	Ontario and Quebec	The St. Lawrence Seaway project saw the creation of an extensive network of locks, canals, and channels in North America, allowing for intra-continental ship transit. The Seaway created a 2,340-mile waterway from the Atlantic to Minnesota.[33] Large sections straddle the Canada-US border. This facilitated the production of hydro-electricity and increased access to iron ore reserves. **The Seaway opened Canadian and US agricultural and industrial regions to deep-draft ocean ships**, transforming the economy and opening previously inaccessible import and export markets.[34]	**Large infrastructure projects can improve access to resources and lower the cost of key commodities.** International collaborations are important in unlocking energy.
1950s	Post-war North American economic growth	British Columbia	First all-Canadian natural gas pipeline was completed by West Coast Energy Inc., extending from the northeastern British Columbia Peace River District to the well-populated lower mainland and the US.[35]	Infrastructure development has the potential to unlock new markets, leading to greater possibilities and economic benefits for Canadians. **This pipeline showed that cross-border energy infrastructure is possible.**
1960s	Large oil sands reserves that were un-economic to exploit	Alberta	Around the middle of the 1960s, Cyclic Steam Stimulation was first used in the Clearwater Formation, Alberta.[36] **The technique is effective in extracting petroleum from oil sands with very heavy crudes.** Such oil sands exist in California, where the method had been successful.[37]	Adapted foreign innovations can unlock domestic energy potential. Looking to different markets for existing solutions can save the domestic market the time and resources required to produce such breakthroughs.
1960s	Need to transport bulk electricity supplies	Quebec	The expansion of hydro-power generation in northern Quebec and increasing demand in the greater Montreal region necessitated an expansion of electricity transmission infrastructure. As increased voltage reduces energy loss, **Hydro-Québec pioneered the world's first 735-kilovolt high-voltage power transmission line.** This connected Manic-Outardes generating stations to the metropolitan areas of Quebec City and Montreal.[38]	Energy demand growth and the introduction of new supply options will require new transport corridors. The introduction of new technologies can improve the efficiency of this infrastructure.
1970s	Demand for healthier Rapeseed oil	Saskatchewan	Erucic acid-related cardiac concerns[39] motivated researchers to reduce the levels of these acids in rapeseed. In 1974 a low erucic and glucosinolate variety was registered.[40] These scientific discoveries resulted in higher yielding, more resilient crops that could grow in a variety of climates. Over time Canola has become a biofuel feedstock due to its exceptional cold weather performance.[41]	**Scientific research can lead to industry and society-wide benefits.** Scientific trials and experiments are an effective way to achieve results at little risk, and such experiments can lead to renewable energy breakthroughs.
1980s	Interventionism in the energy sector	All	The National Energy Program instituted in 1980 was wide-reaching, protectionist legislation pertaining to Canada's oil and energy market. Its many market interventions failed to have their desired effects and created a significant rift between certain Canadian provinces. Unwinding of the policy took place over the subsequent decade, with federal-provincial discussions stemming from a change in government. **The Western Accord led to oil prices being fully deregulated, while taxes and subsidies were removed.**[42]	Poor policy can be swiftly corrected. Well intentioned policy often has the opposite of the desired effects—however, rapid, collaborative action can rectify such policy.

Period	Stimulus	Location	Summary	Insights
1990s	Economic conditions required innovation in energy delivery	Alberta	In 1995, Alberta adopted the *Electricity Utilities Act* to deregulate the energy supply market. All electricity sold had to be exchanged through the power pool. Alberta was the first Canadian province to implement a deregulated electricity market. Non-industrial consumers were given the choice to enter contracts for gas supply.[43]	**Deregulating energy markets encourages private investment and therefore competition**, generally resulting in cleaner, cheaper and more reliable energy sources being realised sooner than otherwise.
1990s	New wind technologies tested	Alberta	**The Cowley Ridge wind plant, Canada's first commercial wind farm, was constructed**, consisting of 52 turbines each capable of generating 360 kilowatts of electricity.[44] This led to the start of Alberta becoming a leader in wind energy.[45]	Deregulation, and the subsequent innovation it facilitates, can lead to new energy infrastructure and investment.

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