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The Role of the Electricity Sector in Reaching Net-Zero: A National Phase-out Strategy for Natural Gas

Author: Amber Couse

Introduction

For the first time, the International Energy Agency (IEA) released its new World Energy Outlook (WEO-2021) for free to the public in preparation for the 26th Conference of the Parties (COP26), held in Glasgow, United Kingdom in November 2021. Despite the Parties efforts to enhance their Nationally Determined Contributions (NDCs) under the Paris Agreement, the intended commitments were still insufficient to reach emissions reduction targets needed to limit global average temperature rise within an acceptable threshold (UNEP, 2021). The IEA refers to this shortfall as an 'ambition gap' to illustrate the disparities between "cumulative pledges that have been announced by governments and what's needed to achieve a 1.5-degree Celsius stabilization in global average temperatures" (Cozzi & Gould, 2021). According to the WEO-2021, "accelerating the decarbonization of the electricity mix is the single most important lever available to policy makers: it closes more than one-third of the emissions gap" (p.17). The affordability and reliability challenges of achieving a fully renewable grid, however, are compounded by a growing divestment trend putting pressure on the legacy grid system, which society still largely relies on for basic needs. Whether there is enough capacity to replace the reliance on natural gas supplies is a legitimate concern facing governments.

This essay will therefore explore the feasibility of a national phase-out strategy for natural gas as a step in the transition to a non-emitting electricity sector. In doing so, the paper will seek to address the following research questions: *(a) how does framing natural gas as a transition fuel jeopardize Canada's commitments to reach net-zero emissions by 2050, and (b) how can the phase-out of natural gas from the electricity*

sector enable decarbonization in other sectors of the economy? These questions will be explored through key themes of affordability, reliability, and sustainability, which are core values in managing electricity systems in Canada.

First, the essay will provide a conceptual framework for phasing-out natural gas in the context of recent divestment trends. Second, an economic analysis will be provided to explore the impacts of a clean energy transition on electricity markets. Third, the electricity sector in Canada will be examined to offer insights on the different ownership models and market structures that exist depending on the province. The fourth section will suggest some lessons learned from Ontario's phase-out of coal power, which has implications for the rest of Canada as provinces plan to phase-out coal generation from their electricity sectors. The fifth section will explore two pathways for decarbonization and highlight the policy implications of implementing a national phase-out strategy for natural gas. Lastly, the essay will address geopolitical risk given the substantial amount of trade between Canada and the United States.

Framing the Narrative

Rosenbloom and Rinscheid (2020) argue that "in order to meet the climate targets set by the Paris Agreement, societal systems such as the electricity sector, will need to be actively decoupled from greenhouse gas (GHG) emissions" (p.1). This requires a deliberate decline in the use of fossil fuels as a source for generating electricity and implies a responsibility of governments to provide consistent policy direction to achieve climate goals. The authors explore the concepts of "divestment, destabilization, and phase-out as different yet complementary ways of approaching intentional decline in the context of decarbonization" (Rosenbloom and Rinscheid, 2020, p.2). This conceptual framework is helpful in recognizing the underlying forces that are driving the socio-technical transition away from fossil fuels toward clean energy. Conversely, framing the narrative in terms of 'net-zero' allows flexibility in whether natural gas can be included in the mix of energy supply (see Thomas and Green, 2022). According to the Pembina Institute, a net-zero grid "consists only of non- or low-emitting electricity generation supply, with any remaining emissions fully offset" (Jeyakumar, 2022, p.1). Therefore, if Canada is to pursue a non-emitting grid (i.e., zero-emissions),

there is a lot of work to be done in forming the ''delegitimizing storylines' needed to discredit the use of natural gas in the electricity sector (see Rosenbloom, 2017). This is important since "electricity generation from low-carbon technology will need to jump from 38% in 2020 to 70% in 2030 to align with the IEA's net-zero by 2050 pathway" (IEA, 2021). According to the Canadian Renewable Energy Association's (2021) 2050 Vision, this translates into an "almost ten-fold increase in wind, solar, and energy storage capacity over the next three decades in Canada" (p.6).

Stages of a Phased-Approach

Each discursive strategy acts to reinforce the momentum for decarbonization where multiple actors convene in pursuit of a common goal. The divestment trend has particularly gained attention recently as a driver in decarbonization with activist groups like Greenpeace Canada exposing the role of the financial sector in perpetuating reliance on fossil fuels by funding projects like the Coastal GasLink pipeline (see Bergamo, 2021). The exposure in the media effectively encourages greater accountability from actors like RBC due to reputational risk and added pressure from shareholders. Consequently, Canada's Big Six banks announced their joining of former Bank of Canada governor Mark Carney's Net-Zero Banking Alliance, which "commits signatory banks to align their lending and investment portfolios" (Bickis, 2021) with net-zero emissions targets.

The investment trends in the financial sector are signaling a fundamental reallocation of capital, which makes the case for phasing-out natural gas more compelling as fossil fuel companies find it increasingly difficult to access funds. Trudeau's commitment to "phasing-out inefficient fossil fuel subsidies" (IISD, 2021) under the Glasgow Climate Pact also puts pressure on the industry, which has historically benefited from financial supports including direct spending, tax-breaks, and royalty credits from the government. Moreover, the increasing stringency of Canada's carbon price is narrowing the gap between fossil fuels and renewables, putting additional constraints on carbon-intensive industries to remain profitable (see Gignac and Sawyer, 2021; ECCC, 2017).

Risk Analysis: Near-Term and Long-Term

The IEA “estimates stranded capital in gas at US$75 billion,” (Henderson, 2021) which puts companies like Enbridge at risk in Canada with the “latest financial statements valuing its gas mains and related services at $12.5 billion, equivalent to about 10% of the book value of its total assets” (Lorinc, 2021). This can be considered a ‘transition risk’ as some sectors are not easily adaptable and can experience challenges due to policy uncertainty (see Bank of Canada and Office of the Superintendent of Financial Institutions, 2022). As a result of climate change, there is also upstream risk due to extreme weather events causing damage to physical assets and disrupting production more frequently. This was seen with the atmospheric river in November 2021, which shut down the Trans Mountain pipeline in British Columbia and resulted in gas rationing in the province (see Woo and Hunter, 2021; Brend, 2021).

Despite the exposure to physical and transition risk, Bryan Purcell, The Atmospheric Fund’s Vice-President of Policy and Programs says, “gas utilities will continue to invest hundreds of millions of dollars each year in expanding and renewing gas distribution infrastructure…until there are clear enough policy signals for a transition off of fossil gas” (Lorinc, 2021). According to the United Nations Environment Programme’s annual production gap report (2021), “global fossil fuel production remains dangerously out of sync with Paris Agreement limits. Of the three fossil fuels, gas production was expected to increase the most between 2020 and 2040” (Meredith, 2021). This is problematic given as Dr. Michael Webber (2021) Professor in Energy Resources, Mechanical Engineering, and Chief Technology Officer at Energy Impact Partners says, “power plants can have 25-to-100-year product cycles” so it’s important to consider the longevity of assets in the context of climate change – to assess whether infrastructure projects are consistent with meeting 2030 and 2050 goals. For example, a coal-fired power plant in New Brunswick was denied an extension to operate past 2030 by federal Minister Steven Guilbeault, despite it having a design capacity that would have allowed it to continue operations until 2040. The province proposed that the “plant reduce its annual output and spread the same volume of emissions over a longer period, which would allow them to avoid building a new natural gas plant to make up for lost electricity generation” (Poitras, 2021).

There is a window of opportunity for governments to set expectations on natural gas, as provinces seek alternative resources in the process of phasing-out coal generation from the electricity sector**.** Setting clear policy direction can help to ensure alignment between federal and provincial policies, which is needed considering there is shared jurisdiction over the electricity sector in Canada (see IEA, 2022, p.157). Anne-Raphaelle Audouin, CEO at WaterPower Canada (2021) says “provincial electricity market regulators aren’t replicating the same federal decarbonization targets in their projections for load growth...which restricts utilities in what they can do.” This illustrates how inconsistent policy can have ripple effects at the local level with the “system operator or utility (or local distribution company) lacking clear mandates and incentives to pursue decarbonization or long-term climate resilience in the sector” (Hastings-Simon and Kanduth, 2021, p.3). This mismatch in direction can stall progress on reaching net-zero targets as it contributes to a lack of investor confidence with uncertain policy and regulatory environments.

The Lifecycle of Energy Assets

Thinking in terms of asset lifecycles at the procurement stage can help to align the normative goals of provinces with the reality of physical assets on the ground to avoid carbon lock-in for the next 25-to-100 years. It can be beneficial to integrate the lifecycles of energy infrastructures into climate models or scenarios such as the Intergovernmental Panel on Climate Change’s (IPCC) Representative Concentration Pathway’s (RCP) (See Hausfather, 2021). This could help to define the timeframes of achieving decarbonization more accurately in the electricity sector based on the age of assets and how that corresponds to either a best-case (2.6 RCP) or worst-case (8.5 RCP) scenario. For example, Dr. Webber (2021) says, “a lot of thermal assets in the United States are slated to retire by 2035.” This makes the probability of reaching a fully renewable grid in the United States more likely, simply because the fossil fuel infrastructure is reaching the end of its useful life and will not need to be replaced. The City of Toronto has taken a similar approach in its Net-Zero by 2040 proposal (2021), which would prohibit “new natural gas furnaces from being installed after 2030, since it takes at least 10 years for the stock of equipment to turn over” (p.62). The economic

concepts, principles, and market forces affecting natural gas will be discussed in the following section to provide context for further analysis.

Economic Analysis of Commodity Markets: Natural Gas

Natural gas is a global commodity that is influenced by fluctuations in supply and demand and is therefore subject to price volatility. The recent October 2021 energy crisis in Europe and Asia is an example that illustrates the effects of demand outpacing supply (see Cohen, 2021). The COVID-19 pandemic caused an unexpected demand shock, which produced historically low prices with oil hitting negative in April 2020 (Smith, 2021). This meant an inability to meet the sudden increase in demand from economic recovery, resulting in a shortage of natural gas supplies (See Smith, 2021). This caused electricity prices to surge and risked rolling blackouts to help alleviate demand on the grid and avoid a system-wide power outage (see Fleming, 2021).

In deregulated wholesale electricity markets, such as in Alberta and Ontario, supply and demand determine which resources (i.e., wind, solar, natural gas, nuclear, coal, and/or hydro) are supplied onto the grid based on the least-cost principle. This means that the carbon intensity of resources (referring to the GHG per unit of electricity) is not presently considered, which reflects the lack of environmental values in traditional economics. The cost of renewables, however, is trending downwards with "the levelized cost of energy from wind and solar now being the least-cost way of generating electricity" (Harper, 2021). Furthermore, the increasing cost of carbon (caused by the federal government's national carbon tax) is also causing natural gas to lose competitiveness in comparison to electricity. This creates new challenges for matching supply and demand in the electricity sector since "a grid operator cannot control when renewables deliver power, unlike fuel-based generation… this non-dispatchability can be a huge concern for reliability" (Harper, 2021). Furthermore, author Robert Bryce in his address to the United States Senate Committee on Energy and Natural Resources says, "the levelized cost does not include the dispatchability of renewables" (ENR Committee, 2021). This reflects the 'renewable energy paradox' as

> system operators activate ramping resources more frequently to handle the intermittency of variable renewable energy. These flexible plants are typically

> more expensive to operate, therefore, higher deployment can raise total system costs even as renewable [generation] costs decline (Murray, 2019).

Consequently, Tim Gould from the IEA says, this is prompting a "shift away from a system based on operational and/or fuel costs towards a model with less operational expenditures but higher upfront investments" (ENR Committee, 2021). These upfront costs tend to increase electricity rates for consumers as companies seek to recover the costs of their capital investments. The changing landscape indicates a potential need to rethink how electricity systems are managed in the market, seen with the Independent Electricity System Operator's (IESO) Market Renewal Program (MRP) that is "introducing fundamental reforms to improve how electricity is supplied, scheduled and priced to meet Ontario's future needs at the lowest cost" (IESO, 2021).

Although traditional economic concepts and principles offer a simple model for understanding the market economy, they are based on a set of assumptions that do not always accurately represent reality. For example, the GHG-emissions released during fossil fuel production are a negative externality that are not properly priced into cost structures. To compensate for this, governments intervene in the market (i.e., through carbon prices or carbon border adjustments) to reduce GHG-emissions, which can also cause disruptions and subvert market functions in the economy. Therefore, the longstanding view by neoclassical economists is to limit government intervention to avoid the unintended consequences that follow (see Frank, 2015). This highlights the limitations of relying on conventional economics in the context of climate change, which will be explored in the following section.

Alternative Policy Frameworks for Complex Systems

The Organization for Economic Co-operation and Development (2017) suggests using a 'complexity economics lens,' which views the economy as a complex system, "to address long-held concerns about economic assumptions, theories, and models, which would emphasize the important interactions, unintended consequences, policy buffers, and safeguards that play a critical role in the economy (p.10-11). The complexity lens also aligns with views of climate change as a 'wicked problem' where "solutions can, and often do, create myriad and interrelated new problems" (Pal et al.,

2021, p.5). This framework can be useful for supplementing conventional economic tools used in the electricity sector as it evolves in response to different climate hazards and/or stressors. For instance, the IEA (2021) says, “the move towards a more variable generation mix (i.e., solar and wind) in which over half of electricity is variable will require changes in the way electricity systems are designed and operated” (p.64). The following section will provide an overview of climate change impacts on the electricity sector, which serves as the underlying scientific basis for phasing-out fossil fuels.

Climate Change Impacts on the Electricity Sector

The Intergovernmental Panel on Climate Change (IPCC) projects that “global warming is effectively irreversible. There will be an increase in the frequency, intensity, and duration of extreme weather events, such as floods, droughts, and heat waves, through the 21st century” (Moudrak et al., 2020). These events accelerate the degradation of energy infrastructure assets, which are already in poor condition due to decades of underinvestment (see Canadian Institute for Climate Choices, 2021). This increases the likelihood of there being power outages and/or interruptions in electricity due to increased vulnerabilities on the bulk power system. Increased climate variability also makes it more difficult to match electricity supply and demand. For example, Dr. Webber (2021) says, “in Texas things are getting warmer, which means a higher baseline winter temperature, but also more frequent polar vortices.” This is what caused the Texas cold snap in February 2021 where “4.7 million homes and businesses lost power partly due to frozen gas supplies and water intakes, which were unable to feed power plants” (Chung, 2021). According to the Canadian Institute for Climate Choices (2021), “the warming climate will shift peak demand from winter to summer for most provinces by mid-century in a high-emissions scenario” (p.57). These impacts contribute to a dynamic where increased demand for electricity (i.e., due to electrification or population growth) will need to be met by decreasing supplies of energy.

This suggests that in the future, provinces may need to accommodate changes in the mix of their energy supplies and could benefit from a portfolio approach to procurement. This could mean a broadening of trade between regions to secure supplies where they’re available. Rob Gramlich, President of Grid Strategies says,

> we can decarbonize at low costs if we appropriately measure and value all resources' contributions to resource adequacy. Assembling a full balanced portfolio to serve load at all times and places is going to take a lot of work from all parties in all regions (Potter, 2021).

The complicated patchwork of electricity systems and energy markets in Canada will be explored in the following section.

The Electricity Sector in Canada

The electricity sector in Canada can be thought of as a complex system consisting of different ownership models and market structures depending on the province. For example,

> either publicly- or privately-owned utilities, or a mix of the two in the case of Alberta and Ontario, generate and distribute most of the electricity in Canada. Deregulated wholesale electricity markets exist only in Alberta and Ontario where pricing is determined by supply and demand forces (Canada Energy Regulator, 2021).

Generally, there has been a gradual unbundling of transmission, distribution, and generation services over time, which further complicates the coordination of any national climate strategy involving the electricity sector. The disparity in provincial electricity systems reflects the division of powers outlined in the Canadian Constitution, with electricity and natural resources largely falling under provincial and territorial jurisdiction. However, there is an exception with responsibility for interprovincial and cross-border transmission lines falling under federal jurisdiction. This highlights the need for collaboration across levels of government to deliver on shared climate goals in the electricity sector. According to Dusyk et al. (2021) in a report by the Pembina Institute, "provinces and territories hold much of the power and therefore share the responsibility. Although climate success does not require a uniform approach for every province and territory, it does require a strong policy framework under which regionalized elements can fit" (p.8).

Each province has a diverse energy supply mix depending on their access to available resource. For example, Canada generally has an abundant supply of

hydrological resources, particularly in the provinces of “British Columbia, Manitoba, Quebec, Newfoundland and Labrador, and Yukon, which each generate over 80% of their electricity from hydroelectricity” (Government of Canada, 2016). This has contributed to the overall success of Canada’s grid being “one of the cleanest electricity systems in the world, despite electricity generation being the fourth-largest source of GHG-emissions” (Canada Energy Regulator, 2021). The western provinces of Alberta and British Columbia are responsible for 97% of natural gas production and therefore have the highest shares of natural gas in electricity supply, representing 46.3% and 39.2% respectively (Canada Energy Regulator, 2021). Learning from the energy crisis in Europe, Tim Gould says,

> the countries that had the lowest increase in electricity prices, were countries that invested heavily in renewables in the Nordic states…by contrast, the highest increase in electricity prices were those that had a large share of natural gas in the electricity mix with relatively poor interconnection with their neighbours (ENR Committee, 2021).

Phasing-out natural gas can therefore help to avoid energy price volatility in regions with high shares of natural gas and can also provide public health benefits by reducing GHG-emissions. For instance, “high levels of sulphur dioxide in Alberta and Saskatchewan, primarily from burning fossil fuels, negatively affects cardiovascular, reproductive, respiratory, neurological, and gastrointestinal systems…so when deciding on infrastructure projects, place-based context is critical (Bulowski, 2021). Although a phase-out of natural gas can have direct and indirect effects on employment, there are also substantial benefits that can be achieved in public health. The valence, or emotional quality, of health in garnering support for a policy will be explored in the following case study (Cox and Beland, 2013).

Lessons Learned from Ontario's Phase-Out of Coal

The success of Ontario's phase-out of coal-fired power plants can be attributed to a set of advocacy groups, mainly the Ontario Clean Air Alliance and the Ontario Medical Association, who advanced narratives associating coal to a public health crisis. This framing was supported by the Ontario Medical Association's (1998) report, which served as a "credible evidence base linking [coal] with the prevalence of smog days in the region" (Rosenbloom, 2017, p.4-5). The intersections between health and environment elevated the argument to phase-out coal and made it a key topic during the 2003 provincial election. However, to compensate for lost coal generation, the province increased supplies of natural gas.

The Green Energy Act (GEA) was introduced in 2009 to "increase Ontario's use of renewable energy, largely through subsidized electricity purchase contracts – called Feed-in-Tariffs – providing long-term guarantees of above-market rates for power generated by those renewables" (McKitrick and Green, 2014). The subsidized contracts however, had the unintended consequence of raising electricity costs for ratepayers. This led to the "cancellation of over 750 renewable energy projects under Premier Doug Ford, who campaigned on promises to lower electricity bills in late 2019" (McIntosh, 2021). Ultimately, the GEA was repealed, leaving a legacy of "over 33,000 green energy contracts mostly with 20-year terms for wind, solar, and bioenergy generators…paid at significantly higher than average price for electricity" (Skinner, 2021).

Additionally, Paul Acchione, P.Eng., former President, and Chair of the Ontario Society of Professional Engineers (OSPE) says, "the province exports larger amounts of surplus clean electricity to neighbouring jurisdictions at a lower price than the total cost of production" (OSPE, 2017). This occurs because clean electricity is produced at times when it is not needed and cannot easily be stored without long-duration batteries or similar alternatives. There are also occasions where power is 'curtailed', which means the electricity is generated but cannot be exported – so supplies are wasted (OSPE, 2017). This suggests a potential opportunity to re-allocate excess supply of clean electricity towards other uses, such as in the production of green hydrogen, rather than export at a loss. Staff at the OSPE (2017) say, "because Ontario is contractually

obligated to pay for most of the production costs of curtailed and exported energy, it would be better to find productive uses for the surplus clean electricity to displace fossil fuel consumption in other economic sectors."

Transitional Solutions or Dead-End Pathways?

The province plans to increase natural gas supplies to compensate for the retirement of Ontario Power Generation's (OPG's) Pickering Nuclear Generation Station and other nuclear refurbishments. According to the Ontario Clean Air Alliance (2020), this would cause "Ontario to lose roughly 40% of the pollution reduction benefits it achieved by phasing-out its dirty coal plants." Due to the composition of natural gas being 94.7% methane on average according to Enbridge (2017), there is a risk of increasing near-term GHG-emissions through leaks and other fugitive emissions. A report by Carbon Tracker (2021) says, "switching from the use of one fossil fuel to another is unlikely to be a long-term success strategy for decarbonization" (p.6). There are also several incentive programs, including the Natural Gas Expansion Program in Ontario, which "supports approximately 8750 connections in 43 rural, northern, and Indigenous communities" (Dempsey, 2021). This illustrates the tensions between providing for immediate needs (i.e., energy access and security) and achieving long-term climate goals (i.e., decarbonization and reaching GHG-reduction targets). According to the IEA's Roadmap (2021), "no investment in new fossil fuel supply projects can occur today to achieve net-zero emissions in global electricity by 2040." Therefore, there is an opportunity for Ontario communities to apply lessons learned during the phase-out of coal, to advocate for decarbonizing the electricity sector during the upcoming provincial election in June 2022.

The IESO: Assessing the Impacts of Phasing-Out Natural Gas Generation by 2030

On October 7, 2021, the IESO released their preliminary findings from a technical assessment on the feasibility of phasing-out natural gas by 2030. The study was conducted in response to over 30 Ontario municipalities, "passing resolutions that requested the Government of Ontario to phase-out gas plants by 2030" (Ontario Clean

Air Alliance, 2020). According to IESO's conclusions, phasing-out gas would cause "frequent and sustained blackouts and would cause monthly electricity bills to increase by 60%...a result of the $27 billion that would be needed to install new sources of supply and upgrade transmission infrastructure" (p.1-2).

Despite the IESO's findings, Todd Smith, who is the new Minister of Energy in Ontario, issued a letter calling on the IESO to "evaluate a moratorium on the procurement of new natural gas generating stations and develop an achievable pathway to zero emissions in the electricity sector" (Ministry of Energy, 2021, p.1). In consideration of the challenges outlined by the IESO's report, the next section will examine two key pathways to approach decarbonization in the electricity sector.

Pathways to Decarbonization

The electricity sector is a crucial component to unlocking decarbonization across sectors given the infrastructure interdependencies in healthcare, transportation, telecommunications, and buildings, which all depend on reliable power supply. Efforts to reduce GHG-emissions in these sectors could be undermined by the power sector if electricity is being supplied from the use of fossil fuels. There are numerous pathways to achieving decarbonization however, this essay explores green hydrogen and grid integration as two potential strategies that focus on building partnerships. The extent to which Canada decarbonizes its electricity sector will depend on its ability to collaborate and leverage the strengths of clean energy across the country.

Natural gas has predominantly been framed as a 'transition fuel' due to its operational flexibility, which can support the integration of variable resources like wind and solar onto the grid. It can also be easily stored and ramped up during periods of peak demand when the sun isn't shining, or wind isn't blowing. For these reasons, natural gas serves a reliability function on the grid. Proponents argue that natural gas is a bridge between dirtier fuels, like coal, and renewables and can therefore facilitate the transition to a clean-energy future (see Gürsan and Gooyert, 2020). Alternatively, many environmental activists argue that this framing serves a 'discourse of delay' and only perpetuates a reliance on fossil fuels (see Lamb, 2021). These contradictory frames can

be problematic if they produce inconsistent policy and regulation, effectively reducing confidence in energy infrastructure investments.

Green Hydrogen

Green hydrogen is a potential solution to the 'transition fuel' debate since it's produced using renewable energy and can allow businesses to re-use or retrofit existing natural gas infrastructures to avoid the risk of stranded assets. For this reason, green hydrogen is a promising pathway to decarbonize the industrial sector, which is the largest consumer of natural gas in Canada (see Canada Energy Regulator, 2021). Transitioning the industrial sector, therefore, is key to staying within 1.5C temperature goals since Travis at Calpurs says, "80% of global emissions from industry comes from only 167 companies" (Global Risk Institute, 2021). Marcia Moffat, Country Head of Canada at BlackRock sees 'transition finance' as an investment opportunity in the fossil fuel industry. Allocating capital to "high emissions businesses would facilitate necessary retrofits, fuel switching, and shifting production to lower polluting activities…while also improving valuations within equity markets" (Global Risk Institute, 2021).

Additionally, Harvard Business School Professor Lauren Cohen says, "due to their deep expertise and history in the energy sector, these companies are uniquely positioned to develop renewable energy solutions…with about 75% of all clean technology investment in Canada coming from the natural gas and oil industry" (Senz, 2021; Cox, 2021). To illustrate an example, hydrogen is being used to store renewable energy as an alternative to batteries or compressed air energy storage (CAES). Paul Browning, President, and CEO of Mitsubishi Power Americas says, "hydrogen will be stored in salt caverns in Utah for long periods of time so that it can be used when the grid needs the electricity instead of when it's produced" (Petrova, 2020). The role of hydrogen in the clean energy transition is supported by British Petroleum (BP) as it views "clean hydrogen delivering about 16% or more of the energy mix, which is about the same as natural gas in today's energy mix. Developing hydrogen projects around industrial clusters would help build scale and lower costs, which is crucial for difficult-to-decarbonize areas" (S&P Global, 2021). This would also encourage carbon intensive

industries to transition, creating synergies by locating in proximity to existing industry creating ‘hydrogen hubs’ as currently being proposed by the Biden administration.

Despite the growing momentum for hydrogen, there are still challenges from a technological and regulatory standpoint that can impede on growth. For example, the state of New York recently

> denied permits for two natural gas plants that intended to run on hydrogen in the future or renewable natural gas. The Department of Environment Conservation (DEC) said the plans were speculative and therefore, were not a sufficient basis to approve the permits. The denial set a precedent for other new gas proposals that are inconsistent with the state’s climate law (Reuters, 2021).

This highlights the importance of governments to provide regulatory stability to guide companies in their decisions to decarbonize. This would help to avoid the potential for dead-end pathways, which have “short-term incremental GHG reductions but are incompatible with the scale of decarbonization required to achieve net-zero emissions and could lock-in carbon intensive infrastructure” (Meadowcroft, 2021, p.iv). A regional approach to decarbonizing the electricity sector will be explored in the following section.

Grid Integration

The Canadian electricity sector currently has “35 electric transmission interconnections with the United States, which allows for mutually beneficial trade between regions” (Canadian Electricity Association, 2018). Anne-Raphaelle Audouin (2021) says, “our grid is more connected to the United States than it is east-west within Canada,” which suggests there are opportunities to expand interprovincial trade to leverage renewable energy capacities and mitigate intermittency challenges. The IEA (2021) says, “interconnectivity within and between regions is an important source of flexibility because it creates larger markets that can draw on a wider range of resources, helping to smooth out weather patterns and balance electricity supply and demand” (p.48).

This Interconnectivity can also enable opportunity for regional advantages. For example, Alberta is in the process of building the “largest solar farm in Canada…with

about 320 sunny days each year, southern Alberta and Saskatchewan are located in Canada's sunbelt, which is arguably the most appealing place in North America for renewable energy projects" (Dunn, 2021). The business case is supported by Murray (2019) who says, "to cost-effectively scale up renewables, they must be sited where they are most productive." This illustrates the competitive advantage offered in clean electricity that can serve to attract investment and create regional hubs for employment, capacity building, and knowledge sharing. For instance, Ian MacLellan, CEO of Ubiquity Solar says,

> it's becoming very important in the solar business, and in all businesses, to get to being carbon neutral… It's a real competitive advantage to have no greenhouse gases in the electricity we're using in production, compared to solar panel manufacturers in China, a country that relies heavily on coal-fired electricity. Our potential customers are interested in having products that have much lower embodied greenhouse gases (Morden, 2021).

These synergies can be achieved between Ontario and Quebec and in the Atlantic provinces where the 'Maritime Link' and 'Atlantic Loop' are delivering renewable energy supplies to the region through grid integration. According to Francis Bradley, President, and CEO of the Canadian Electricity Association (CEA), "the more bulk power interconnections we have between states, between provinces, between regions, the greater resilience we're able to have. Interconnectivity, regulation, and power mix all play a role in making grids resilient" (Chung, 2021). Real-time balancing of electricity supply and demand through transmission interties can help to solve the intermittency of renewables and can also help to secure energy supplies in emergency situations, since natural gas generators tend to be used as a backup source of power in emergencies. In Quebec for example, "imported power is only used as a last resort for the province" (Chung, 2021) when domestic supplies are exhausted. This last resort principle can help to encourage buy-in by ensuring that domestic suppliers are not negatively impacted.

Geopolitical Challenges

Increasing energy trade between provinces and states can cause additional congestion or constraints on transmission lines (e.g., due to voltage limitations) with competing sources of demand for electricity. According to Ahmadi et al. (n.d.), “in a congested system, the low-cost generation units may not be able to be fully dispatched, which may lead to higher energy prices compared to the uncongested system” (p.1). Therefore, existing infrastructures will need to be modernized to improve efficiencies and limit the amount of energy wasted. This can be complemented by demand-side management to reduce pressures on the grid during peak hours.

The expansion of transmission lines is also needed to meet increasing demand, which is projected to double with the electrification of heating and transportation by 2050 (see NRCan, 2020; Canadian Renewable Energy Association, 2021). Local opposition to transmission expansion projects, however, is a key barrier preventing the interconnection of provincial and cross-border grid systems. This was seen in Maine, where a transmission line called the ‘New England Clean Energy Connect’ was “rejected by voters and would have supplied up to 1,200 megawatts of Canadian hydropower from Quebec” (Bergeron and Rolland, 2021). Furthermore, the siting of transmission lines is a concern for Indigenous communities with the expansion of large infrastructure that impedes on traditional lands and local ecosystems. Therefore, equity considerations are central to the success of expanding interconnections that ensures respect and adherence to the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and requirements under Duty to Consult.

Due to the federal government having jurisdiction over interprovincial and cross-border transmissions, there is also a concern that grid integration would expand federal authority over provinces. Drew Clarke, Chairman of the Board of Directors of Australian Energy Market Operator says, “the success of their national grid depended on having “consensus between state and federal levels of government by allowing states to approach integration in their own ways. Proving a compelling economic case was also key to trumping the resistance to grid integration” (Reseau Canada Grid, 2021). Another solution to local opposition was to provide “ongoing benefits to host communities in

Australia's Renewable Energy Zones (REZs). These zones allowed capacity auctions with clear economic incentives in specific geographic areas…with strong connection to existing transmission lines," (Reseau Canada Grid, 2021) which meant that the development of new lines could be limited.

Due to the substantial amount of trade between Canada and the United States, phasing-out natural gas would impact the revenues that Canada receives as a net-exporter. However, the United States has committed to reaching a fully renewable grid by 2035, which would likely decrease the natural gas supplies needed from Canada to generate electricity. The United States has also been increasing energy independence, which is causing the "share of Canadian natural gas exports to decrease" (NRCan, 2020) and creating an opportunity to trade in clean electricity surplus. According to Leonard Kula, Vice-President of Planning, Acquisition and Operations and Chief Operating Officer at IESO, "the risk and potential impact of interconnectedness is a fraction of the benefits that we get from being well connected with our neighbours" (Chung, 2021).

Conclusion

This essay has attempted to illustrate how clean energy trends are creating new challenges for managing provincial electricity systems in Canada. The need to decarbonize the electricity sector is putting pressure on provinces to consider the phase-out of natural gas despite it being an important load balancing resource. Nonetheless, there is significant risk of missing the 1.5 C goal if Canada increases reliance on natural gas to displace coal albeit it being a 'cleaner fossil fuel.' Therefore, green hydrogen and grid integration are two promising pathways that can address the challenge of disentangling provincial electricity systems from fossil fuels. The country cannot afford another missed opportunity by continuing its' path dependency on fossil fuels. By joining the Beyond Oil & Gas Alliance, Canada can show leadership in climate action and signal to the global community that it is committed to providing non-emitting electricity; a 'safe bet' in reaching Canada's 2030 targets (Canadian Climate Institute, 2021).

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Reevaluating Algonquin Provincial Park's Strategic Objectives: A Multi-Objective Analysis

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1.0 Introduction

Algonquin Park is Ontario's oldest Provincial Park, which was originally established in 1893 as Canada's first national park, later becoming a provincial park in 1913. The Park encompasses 7725km² of rugged landscapes, pristine waters, and abundant wildlife (Runtz, 2008). Algonquin Park is situated in the middle of Ontario, about a three-hour drive from either Toronto or Ottawa. Today the Park has 12 developed campgrounds and dozens of hiking and interpretative trails along the highway 60 corridor. Further, the Park also offers 2,000km of backcountry canoe routes in the park's interior (Friends of Algonquin Park, n.d.). The Provincial Park presents a unique amount of biodiversity due to the area possessing both Boreal and Carolinian forests (Runtz, 2008). Algonquin Park also has historical and cultural importance to Canada and Ontario, possessing a long history of logging and being the resting place of Tom Thomson (the famous Canadian painter who was vital in forming the Group of Seven). Given its historical and environmental importance, Algonquin Park was named a national historic site of Canada in 1992. Further, Algonquin is often referred to as the jewel of the Ontario Parks system. Today Algonquin Park is unique among the Ontario Parks system as it allows for active forestry within the limits of the park. Given this uniqueness, there are many different opinions about how to best manage Algonquin Park.

1.1 The Issue

It has been 25 years since Algonquin Park replaced its old master plan with the Algonquin Provincial Park Management Plan in 1998, which governed the management and development of the park. The Algonquin Park Management Plan outlines the Park's overall goals and objectives. In this plan, it states that Algonquin Park's overall goal is

> " To provide protection of natural and cultural features, continuing opportunities for a diversity of low-intensity recreational, wilderness, and natural environmental experiences; and within this provision continue and enhance the Park's contribution to the economic, social, and cultural life of the region." (Ontario Parks, 1998, pg 6).

The plan sets out five key objectives for Algonquin Provincial Park to achieve this goal: to provide protection for unique environments, to promote and provide recreation opportunities, to promote cultural heritage, to promote tourism, and resource management (Ontario Parks, 1998). The first four objectives were developed to fulfill the needs of the Ontario Parks system, while the fifth was meant to fulfill the resource utilization of the park.

The current management plan has been amended in the 25 years it has been active, such as the Joint Proposal for Lightening of Ecological Footprint of Logging in Algonquin Park in 2008, which led to increasing the protected lands of the park from 22.1% to 34.7% (Ontario Parks, 2013). However, despite amendments, the plan was only meant to have a life span of 20 years. Therefore, there is a requirement to develop a new Algonquin Park Management Plan for the 2020s. Currently, the 2020-2030 Management plan is being developed. As such, it is crucial to understand the key objectives of Algonquin Parks' many stakeholders and rights holders.

1.2 Purpose & Structure

This paper aims to conduct a multi-objective analysis to help Algonquin Park develop a new Park Management Plan that fits the objectives of Ontario in the 2020s. This analysis will first identify key stakeholders and rights holders who would be affected by changes in Algonquin Parks policies. In doing so, identify their key

objectives related to the development of Algonquin Park for the foreseeable future. Then, this analysis compares the stakeholders' objectives according to the 1998 park objective to better understand the priorities of continued park management based on the key stakeholders and rights holders. Finally, weigh the importance of each objective to provide Algonquin Park with a better understanding of the objective priority in the 2020s.

2.0 Key Stake & Rights Holder Objectives

In developing a multi-objective analysis, it is essential to first identify the key stakeholders and rights holder and their potential objectives. In developing and scoping the groups, it is important to note that many people and communities are indirectly impacted by Algonquin Park because it provides eco-services to the regional environment. For example, Algonquin Park is vital to regional waterways within Ontario, being the source of the Madawaska River. Despite the importance of indirect eco-services, this report will only focus on the key stakeholders that could be directly affected by any potential changes to Algonquin Parks policies. To this end, the report focuses on four key stakeholder groups that could be affected by changes in park objectives and policy. These four stakeholder groups consist of the park itself, park users, the forestry industry, and the surrounding communities. Equally as critical, Indigenous peoples are rights holders to the parkland. The five key stakeholders may also be subdivided into subgroups that may have overlapping objectives or jurisdictions, such as the Ontario Ministry of Environment Conservation and Parks (MECP) and the Ontario Ministry of Natural Resources and Forestry (MNRF).

2.1 The Park

Algonquin Park itself is a key stakeholder in any decision related to the policies and practices of the park. This key stakeholder can be subdivided into the government, such as Ontario Parks and the charity that helps run the Park, the Friends of Algonquin Park. These two subgroups should be identified as important to the development of Algonquin Park. However, the government is the bigger of the two subgroups that make up this key stakeholder.

2.1.1 Ontario Parks

The government is responsible for managing the provincial park. The governance structure of Algonquin Park is more complex than any other provincial park. The jurisdiction of park management is under the Ontario Parks. However, Ontario Parks does not currently have full agency within the provincial government. When the original management plan was developed, Ontario Parks was under the MNRF mandate but was transferred over to the MECP in 2018 (Provincial Parks and Conservation Reserves Act, 2006).

Ontario Parks is one of the primary employers within the park, employing park wardens, rangers, and gate staff. Ontario Parks is mandated to manage 44 parks across Ontario through the Provincial Parks and Conservation Reserves Act (2006). Under this Act, Ontario Parks is mandated to achieve four objectives related to the Provincial Parks, which can be summarized as the following. The first is to permanently protect representative ecosystems, biodiversity, and provincially significant cultural heritage. In doing so, they are to manage the ecological integrity of any park. Second, to provide ecological and sustainable outdoor recreation opportunities and encourage their economic benefits (Provincial Parks and Conservation Reserves Act, 2006). Third, to provide education, knowledge, and appreciation of Ontario's natural and cultural history. Fourth, to provide scientific research to support the monitoring of ecological change in the regional environment (Provincial Parks and Conservation Reserves Act, 2006). When evaluating this key stakeholder's objectives for Algonquin Park, it is essential to note that Ontario Parks' motives and ideas about park management may have changed between the original park management plan and today. This change may be due to the mandate switching from MNRF, a more natural resource-oriented department, to the more environment-oriented MECP in 2018. This change in jurisdiction could result in more park preservation than natural resources development in the management of the park. Further, the Provincial government has shifted attitudes toward promoting the tourism value in Ontario Parks in the 2020 budget, providing six million dollars in additional funding for the park systems (Ontario Ministry of Finance, 2020).

2.1.2 Friends of Algonquin Park

The other key stakeholder involved in the direct management of the Park's services is the non-governmental charity Friends of Algonquin Park. This non-governmental charity was initially created in 1983 with the responsibility of selling and reprinting official park publications, of which the proceeds went directly back to the park (Friends of Algonquin Park, n.d.a). Since then, the organization has become the leading distributor of educational and interpretive programs within the park. The Friends of Algonquin Park has also raised millions of dollars for the park through the sale of park souvenirs and donations. The Friends of Algonquin park employs 16 people within the park at either a full-time or seasonal status and has hundreds of active volunteers (Friends of Algonquin Park, n.d.b). Their key objectives can be summarized as supporting the ecological and cultural importance of Algonquin park.

These two key stakeholders can be identified as the governance and management stakeholders for Algonquin Park. Ontario Parks would conduct any management plan, given that they are mandated to do so under the direction of the MECP and the Provincial Park and Conservation Reserves Act 2006. At the same time, Friends of Algonquin Park should be consulted on any matter that could impact the ability to maintain educational and interpretive programs within the park.

2.2 Park Users

Park users are essential to consider when adjusting the overall objectives of Algonquin park, as they are the group that physically uses the recreation provided. This group can be subdivided into three different types of users, which could all have similarities in objectives but may deviate based on activity. It is also important to note that this stakeholder is heavily influenced by seasonal demand, as the recreation of the park peaks from May to June (Ontario Parks, 2012a). These three subgroups are day-users, campers, and backcountry users. Much of the available information about park use was provided by the 2011 Ontario Parks user survey regarding park use.

2.2.1 Day-users

Day-users represent those who do not stay within the park limits for an extended period of time. Respondents to the 2011 day-use survey, which consists of 1717 surveys across 94 operating provincial parks, showed that day-users may be season pass holders or day pass holders. Of the 1717 respondents, 206 were visiting Algonquin Park, representing 12.08% of all respondents (Ontario Parks, 2012a). Algonquin Park is the third most visited Provincial Park for day-use activities and the largest average one-way driving distance at 208.2 km (Ontario Parks, 2012a). In addition, Algonquin Park represents one of the highest return rates, with an average of 15.5 years visited (Ontario Parks, 2012a). When assessing the key objectives for day-users, the 2011 survey results show that day-users chose Algonquin Park due to the natural beauty (98%), unspoiled nature (98%), availability of hiking trails (87%), the ability to see wildlife/appreciate nature (95%), and availability of backpacking (84%) (Ontario Parks, 2012a). Thus, we can discern several key objectives related to day users, such as protecting natural beauty, maintaining outdoor recreational opportunities, and observing the natural environment.

2.2.2 Campers

Campers can be classified as users who attend Algonquin Park to camp for one or more nights at a designated camping area. Algonquin Park is the second most visited park for campers in Ontario and has the second-longest one-way trip average at 355.9 km (Ontario Parks, 2012b). The data for campers was pulled from the 2011 campground online survey which had 65,908 respondents; of that, 6,016 respondents were designated from Algonquin Park, representing 9.15% of the survey (Ontario Parks, 2012b). When assessing key objectives for campers in Algonquin Park, respondents emphasized the importance of natural beauty (96%), unspoiled nature (92%) and the opportunity to view wildlife/appreciate nature (92%), the importance of hiking (75%), good canoeing (69%), and cultural/historical feature (51%) (Ontario Parks, 2012b). Thus, we can identify the key objectives of campers as protecting natural beauty, maintaining outdoor recreational opportunities, protecting cultural/historical features, and observing the natural environment.

2.2.3 Backcountry users

Backcountry users are users that make trips into the interior of a given provincial park. These areas are often not developed and thus are not the same as campers. Algonquin Park also has the largest percentage of last remembered trips to the backcountry at 56%, according to the 2011 survey conducted by Ontario Parks at 19 of the provinces' backcountry sites (Ontario Parks, 2012c). When assessing their key objectives, respondents again emphasized the importance of the scenery (99%), unspoiled nature (98%), and good canoeing (92%). Additional backcountry users also prioritize the importance of remoteness (93%), lack of crowding (88%), and many access points (46%) (Ontario Parks, 2012c). Therefore, we can again identify key objectives of protecting natural beauty; however, the backcountry users are unique in the objective of remoteness and lack of crowding.

Within the park users, the subgroups all have the same goal objective, enjoying their trip in the park, which is fulfilled by the objectives of protecting the natural beauty, observing nature, and maintaining outdoor recreation. Backcountry users deviate slightly on objectives such as remoteness, accessibility and cultural and historical protection. Finally, although willingness to pay is relatively inelastic in Algonquin Park compared to other parks, maintaining a stable gate price should also be considered an objective of park users.

2.3 Forestry Industry

Algonquin Park has a deep history related to the forest industry, as there were many logging communities before it was designated a national park in 1893. Today, the forestry industry consists of provincial authorities responsible for managing forestry, contractors who produce logs, and multiple mills throughout central Ontario. Therefore, forestry is very important to many local communities that have relied on forests in Algonquin Park for generations. Algonquin Parks provides approximately 44% of the volume harvested on crown forests in Central and Eastern Ontario (Algonquin Forestry Authority [AFA], n.d.a). The harvested wood supplies local mills, with nine mills relying on the park for the regular supply, and another 15-20 receive periodic shipments. 285

people are directly employed in Algonquin forestry services while contributing to another 4,000 employed in mills across Ontario. The 2020-2021 harvest level of 417,207 km³ in Algonquin Park contributed 350 million dollars to the Ontario economy (AFA, n.d.a). Therefore, the forestry industry in Algonquin Park should be considered a key stakeholder group when assessing the objectives of the Park in future development. This analysis has identified two significant decision-makers within this group.

2.3.1 Algonquin Forestry Authority

Currently, the governance and management of forestry within the park is the responsibility of the Algonquin Forestry Authority (AFA), which was created under the Algonquin Master Plan in 1974, their primary objective is to manage the sustainable forestry within the park limits. Under the 1974 Algonquin Park Master Plan, 75% of the park was available for logging. (Ontario Ministry of Natural Resources and Forests [MNRF], 1974.). The AFA is a Crown Agency with the sole authority to manage the timber rights within the park. In 1983 the MNRF transferred forest management, silviculture, wood measurement, and maintenance of public access roads to the AFA (AFA, n.d.b). Therefore, AFA is now the only organization responsible for forestry governance in Algonquin Park under the mandate of the MNRF. The AFA states that less than 55% of the park is available for logging, as the logging plan does not discern between forested areas and water bodies, and that harvesting is limited to 1% per year (AFA, n.d.b). The Algonquin Forestry Authority Act, RSO 1990, sets out four different objectives related to the logging industry in Algonquin Park. These four consist of ensuring the sustainable management of the Park's forests, planning all forestry operations, harvesting and distributing wood products to mills, and monitoring and reporting on forestry operations (AFA, 2021). Thus, the AFA has objectives to maintain the sustainability of forest management while also providing wood to the mills for development.

2.3.2 Local Lumber Mills

The local lumber mills are also a subgroup of this key stakeholder, which represents the private industry related to the forestry of Algonquin Park. Over 15 mills in

Ontario receive lumber from Algonquin Park, and local mills such as Huntsville, Whitney, Madawaska, Killaloe, Pembroke, Eganville, and Palmer Rapids rely on regular deliveries (AFA, n.d.a). These mills represent the private industry subgroup that should be consulted about any changes to Algonquin Park regarding forestry management, as it could have adverse effects on their business. Therefore, we can discern that the private mills' objective for Algonquin Park is the continued supply of wood for the mill.

Thus, the forestry industry represents a key stakeholder, consisting of two subgroups, the Crown Authority and the privately-owned mills. In combining their objectives, it is clear that their main objective is to maintain the sustainable lumbering of Algonquin Park.

2.4 Surrounding communities

As mentioned for the forestry industry, communities around Algonquin Park have the potential to be heavily impacted by changes to the Park's management. For example, many small townships rely on the lumber industry within Algonquin Park to supply their mills. However, in viewing many of the counties' objectives related to future development, these counties should be split into two subgroups as their geography makes them have slightly different objectives related to the development plans of Algonquin Park. In evaluating the impacts on these communities, we will be using relevant public consultation information, official development plans, and 2016 census data provided by Statistics Canada.

2.4.1 Eastern Side Counties

Renfrew County is the main jurisdiction east of Algonquin Park. Renfrew County contains twelve townships and five towns, accounting for approximately 106,365 people as of 2021 (Statistics Canada, 2022). These townships include Admaton/Bromley, Bonnechere Valley, Lyndoch & Raglan, Greater Madawaska, Head, Clara & Maria, Horton, Killaloe, North Algona/Wilberforce, and Whitewater Region (County of Renfrew, 2020). The towns include Arnprior, Deep River, Laurentian Hills, Petawawa, and Renfrew (County of Renfrew, 2020). Additionally, Barrie's Bay is the closest semi-urbanized centre east of the Park's east gate. Renfrew County's economic base is

mixed between agriculture, resource mining, forestry, manufacturing, and retail. According to Statistics Canada, 1,490 people are employed in either forestry, agriculture, or fishing, representing 3% of their total workforce in 2016 (Statistics Canada, 2016a). Further, another 3,490 people are employed in manufacturing, which could indicate mill importance, as this represents 10% of their total workforce (Statistics Canada, 2016a). In researching Renfrew County, the primary objective related to Algonquin Park is to maintain and grow the county's economy.

The need to maintain the economy presents two sub-objectives which Renfrew County looks to achieve, maintaining the forestry industry within Algonquin Park and increasing tourism. For example, Renfrew County expressed concern about potential impacts on communities related to the eventual 2013 amendment of the Algonquin Park management plan (Government of Ontario, 2009). In the public consultation of the proposal for Lightening the impact of Logging in Algonquin Park, Renfrew County was worried about the potential negative socio-economic impacts reducing forestry in the park could have on wood mills, stating it could make them unaffordable (Government of Ontario, 2009). Renfrew County is also trying to diversify their economy primarily through tourism promotion. In surveying their official website, the only economic development goal is tourism. Therefore, Renfrew County's objective is to maintain their communities' economic viability by maintaining the logging industry and developing the tourism industry.

2.4.2 Western Side Counties

The western side counties consist of two major counties, Haliburton County and Muskoka District. These two counties are different from the east side due to their proximity to Toronto, resulting in a much more diversified economy. Therefore, they are still considered key stakeholders in Algonquin Park, as changes to the management could affect them, but do not face the same adverse effects of the east.

Haliburton County is directly west of Algonquin Park, which has approximately 20,571 people (Statistic Canada, 2022b). According to Statistics Canada, 90 people were employed in forestry, agriculture, or fishing within the county in 2016, representing 1% of the labour force. A further 305 people were employed in manufacturing (Statistics

Canada, 2016b). The largest employment sector within the county is construction which employs 1,240 people, representing 16% of the labour force in 2016 (Statistic Canada, 2016b). The high amount of construction could result from the county's proximity to Toronto. This different dichotomy is further shown through the County of Haliburton's Official plan from 2017 emphasizes the importance of developing a stable, diversified year-round economy through residential development (County of Haliburton, 2017). While Algonquin Park does impact the county, it is less dependent on it for forestry needs due to development. Thus, Haliburton's key objective is also maintaining the viability of its communities. However, they are less reliant on logging to maintain their economy.

Muskoka District is another major county west of Algonquin Park, with approximately 60,599 people (Statistic Canada, 2022c). Muskoka's economic profile has 295 people working in forestry in 2016, representing 1% of the labour force (Statistic Canada, n.d.b). A further 1720 people work in manufacturing, accounting for 6%; this could represent the lumber mill in Huntsville (Statistic Canada, 2016c). Construction represents the highest labour force at 15% (Statistic Canada, n.d.b). Muskoka district's main objective is to maintain the economic viability of their communities through economic diversification (District Municipality of Muskoka, n.d.). Similar to Haliburton County, Algonquin Park does impact them, specifically in the Huntsville mill, but their economy is much broader. Therefore, the primary objective of Muskoka District would be to maintain economic viability by relying heavily on tourism with some stakes in forestry.

Impacts from changes in management strategies of Algonquin Provincial Park could have adverse effects on the Counties of Renfrew, Muskoka, and Haliburton. Despite some minor differences in the sub-objectives, these three counties have a clear objective to maintain the economic viability of their communities when regarding the Algonquin Parks Management Plan.

2.5 Rights Holders

Algonquin Park sits on the unceded territory of the Algonquin Peoples. Indigenous communities have a long history related to Algonquin Park. The primary

organization representing the rights holders regarding Algonquin Park is the Algonquins of Ontario (AOO), which comprises 10 Algonquin communities (Algonquins of Ontario [AOO], n.d.a). The AOO land claim includes 9 million acres between the Kichisippi and Mattawa River watersheds within Ontario (AOO, n.d.a).

The AOO must be consulted in any changes to the Algonquin Park Management Plan as they have inherent rights to the park's land. The AOO has two major objectives related to Algonquin Park: to enhance the economic opportunities of Algonquins and ensure Algonquin Park remains a park (AOO, n.d.b). For example, when public consultation for the 2013 management amendment was held, nine of the ten Algonquins of Ontario's communities participated. Overall, they supported the amendment; however, they did express some concerns (Government of Ontario, 2009). The main concern of the Algonquins communities was related to road access to Algonquin Park, as many of the communities wanted the logging roads left open once forestry had ceded in the area to facilitate cultural hunting activities. Further, the AOO expressed concern about the management of silviculture monitoring by the AFA (Government of Ontario, 2009). AOO was also concerned with the potential of economic disruption to communities dependent on lumber from Algonquin Park (Government of Ontario, 2009). The AOO has indicated they would like to be involved in any development related to Algonquin Park and have traditional knowledge that can help balance the protection and viability of forest operations (Government of Ontario, 2009). Therefore, the main objectives of the rights holder are the protection of traditional forests, maintaining economic opportunities for Algonquins, and maintaining Algonquin Park as a provincial park.

3.0 Evaluation of Algonquins Parks Objectives

As we have identified the key stakeholders and rights holds, we can reevaluate Algonquin Park's 1998 objectives for the 2020s. These objectives were to provide protection of unique ecosystems, to promote and provide recreational opportunities, to promote cultural heritage, to promote tourism, and resource management. In order to do this, we will apply weight to each objective relating to the importance of stakeholders. This weighting system will consist of "3" points per stakeholder and rights holder to

adjust for users having three subgroups. Thus, “1.5” for most subgroups represents that the 1998 Algonquin Park objective meets the subgroup's objective today; for a maximum of “3” points per stakeholder and rights holder. A “0” designates that the 1998 Algonquin Park objective did not achieve the subgroup's objectives, nor did it negatively impact them. A “-1.5 “designates that the 1998 Algonquin Park objective negatively impacts the objective of that subgroup. For example, Ontario Parks could see recreation as a positive, thus achieving a “1.5” in the recreation objective, adding to the total available for that stakeholder. At the same time, they might see resource management as negatively impacting their objectives and thus rate it as “-1.5” for that objective. As such, the maximum rating any objective could achieve is “15” points, which results in a maximum benefit of “70” point across all stakeholders and rights holders. The results of this test can be observed in table 1.

Table 1- Algonquin Park Objectives Ratings

Stake Holder/Rights Holder	**Protection of Unique Environments**	**Promote and Provide Recreational Opportunities**	**Promote Cultural Heritage**	**Promote Tourism**	**Resource Management**
The Park	**3**	**3**	**3**	**3**	**-3**
Ontario Parks	1.5	1.5	1.5	1.5	-1.5
Friends of Algonquin	1.5	1.5	1.5	1.5	-1.5
Park Users	**3**	**3**	**3**	**3**	**-1**
Day users	1	1	1	1	0
Campers	1	1	1	1	0
Backcountry	1	1	1	1	-1
Forestry industry	**0**	**0**	**0**	**0**	**3**
AFA	1.5	0	0	0	1.5
Local Mills	-1.5	0	0	0	1.5

Local Communities	**0**	**3**	**0**	**3**	**3**
Eastern Communities	0	1.5	0	1.5	1.5
Western Communities	0	1.5	0	1.5	1.5
Algonquins of Ontario	**3**	**0**	**0**	**0**	**3**
Total Importance	**9**	**9**	**6**	**9**	**5**

As shown in Table 1, The Algonquin Park 1998 objectives of protecting unique environments, promoting and providing recreational opportunities, and promoting tourism all score the highest amongst the stakeholders and rights holders at “9” points out of “15”. Promoting cultural heritage was ranked the fourth most important objective with a “6” out of “15”. Finally, Resource management was ranked last with a “5” out of “15”. The total benefit achieved for all the stakeholders and rights holders is “40” out of “75”.

3.1 Protection of Unique Environments objective

The Protection of Unique Environments objective is strongly supported, scoring a “9” out of “15” in importance ranking. This objective continues to rank high because it meets the objectives of the park, park users, and AOO groups.

For the parks group, it meets the Ontario Parks mandated objective to permanently protect representative ecosystems and biodiversity (Government of Ontario, 2006), while also meeting the objective prioritized by the Friends of Algonquin Parks to support ecological importance (Government of Ontario, 2006). This objective also achieved all the park user group’s objectives by allowing for the existence of unspoiled nature. This objective also scores a “3” by the AOO because it meets their objective to maintain Algonquin Park. Despite having a potential negative impact on mills' objective to maintain the supply of lumber, this is offset by the AFA's mandate to

maintain the sustainability of forests within Algonquin Park, resulting in an overall score of “0” for the forestry group. This Algonquin Park objective scored “0” on the local communities’ group, as we could not find any objectives relating to maintaining the integrity of the park within any of the community’s plans. However, this score could be improved if research identified a definitive correlation between Algonquin Park’s environmental protection and increased local tourism. If this were achieved, the score for the local communities would achieve a “3”. However, we are assuming there is no definitive correlation for this analysis.

Total results show Algonquin Park’s objective of protection of unique environments would potentially be well supported by a majority of stakeholders and rights holders while only negatively impacting the lumber mills subgroup.

3.2 Promote and provide recreational opportunities

The objective of promoting and providing recreational opportunities is strongly supported, as it scored “9” out of “15” in the rankings. Thus, Algonquin Park’s 1998 objective meets the objectives of the park, park users and local communities’ group.

"Promote and provide recreational opportunities" meets Ontario Park's objective of providing ecological and sustainable outdoor recreation opportunities and the Friends of Algonquin Park's objective of supporting ecological importance. This objective also meets the park user group’s objectives by maintaining outdoor recreation. Further, this objective also scores the maximum on the local communities’ score, as it meets the objective of promoting tourism through the availability of recreational opportunities. On the other hand, this objective did not achieve any objectives for the forestry industry or the AOO.

This objective does not have much opportunity to improve in the ranks as it is doubtful that the forestry industry will have objectives related to outdoor recreation. Moreover, although cultural practices such as hunting and fishing are key objectives for the AOO, this is often through logging maintenance routes and thus not counted toward the promotion and maintaining outdoor recreation objectives. Regardless, promoting and providing recreational opportunities is an essential objective for a majority of stakeholders while not resulting in any negative impacts for any of the groups.

3.3 Promoting Tourism

Promoting tourism is another strongly supported objective, scoring “9” out of “15” in the rankings. This objective is similar to the recreation objective as it is supported by the park, park users and local communities group.

The objective achieves Ontario Park’s objective to promote outdoor recreation for the economic benefit of the park and the Friends of Algonquin Park's objective to support the ecological and cultural importance through tourism. This objective also achieves the park users' objective of providing outdoor recreational opportunities through tourism. Finally, it also achieves the local communities’ objective of diversifying their economies by promoting tourism within Central Ontario.

This objective might have reached its ceiling at “9” points as the forestry group and AOO are unlikely to have tourism objectives. In addition, the tourism objective is unique, as it could potentially negatively impact the user group if tourism increases users to the point of crowding. Regardless, the promotion of tourism objectives remains a strong objective that many stakeholders support without negatively impacting other stakeholders or objectives.

3.4 Promote Cultural Heritage

The promoting cultural heritage objective only scored “6” out of “15” points in the ranking scenario, as it only fulfills the objectives of the parks group and the user group. The promotion of heritage achieves the mandate of Ontario Parks to provide education, knowledge, and cultural heritage of Ontario. It achieves the objective of Friends of Algonquin Park to promote the cultural importance of Algonquin Park. Further, this objective also achieves the objectives of park users of protecting cultural heritage. However, this objective does not achieve any identified objective of the local communities, the AOO, and the forestry industry.

This objective does have an opportunity to grow in importance by identifying a correlation between cultural history and tourism, which would fulfill the objectives of local communities. This objective could also be supported by the AOO if Algonquin

cultural importance was prioritized for the park. Regardless, the objective of promoting cultural history remains one of the less supported objectives of Algonquin Park.

3.5 Resource Management

The resource management objective is the least supported objective of the 1998 Algonquin Park Management Plan, as it scored only 5 out of 15 on the ranking test. This objective did achieve the objectives of three of the stakeholders and rightsholder groups, but it also negatively impacted the objective of the park and park users. The objectives it did achieve were related to the forestry industry by achieving the objective of the AFA to sustainability manage resources in the park while providing lumber to mills. It also meets the mill's objective to maintain the supply of lumber from Algonquin Park. This objective also achieves the local communities' objective to maintain the economic viability of local communities through the forestry industry. It also achieves the AOO objective of maintaining economic opportunities for Algonquins.

This objective directly impacts all other objectives as it is mutually exclusive. If resource management is happening in the area where tourism, outdoor recreation, and the protection of the unique environment are occurring, they would all be negatively impacted. As a result, it negatively impacts the park group as it diminishes four of the Ontario Parks' objectives and diminishes the importance of ecology in Algonquin Park. It further diminishes the objective of park users as it diminishes the natural beauty and unspoiled landscapes, which is a key sub-objective of the users' group. The diminishment of objectives is slightly mitigated as day-users and campers often stay near the highway 60 corridor, away from forestry activities. However, backcountry users are affected. Therefore, the natural resource objective represents a controversial objective in Algonquin Park but is also crucial for local communities.

4.0 Discussion

As shown in identifying key stakeholders and rights holders and their objectives, many people rely on Algonquin Park. By ranking the 1998 Algonquin Management Plan to those stakeholders' and rights holders' objectives, it is clear that Algonquin Provincial Park should work to reevaluate their objectives in its next management plan. Objectives

such as protecting unique environments, promoting and providing recreational opportunities, and promoting tourism should remain core objectives of Algonquin Park. At the same time, the promotion of cultural history must be redeveloped with the AOO to promote the Algonquin peoples' cultural importance. Moreover, there must be a reevaluation of the resource management objective within the strategic goals of Algonquin Park. To that end, this project has developed four scenarios Ontario Parks could pursue in the next management plan regarding natural resource management.

4.1 Scenario One: The Status Quo

Ontario Parks could maintain the current objectives and management of the park, resulting in a total achievement of “40” out of “75”. This scenario would be the easiest to achieve as it would not threaten to adversely affect any key stakeholders or rights holders. However, the potential for improvement in objective achievement is low. Therefore, this scenario represents a neutral risk of economic impact and a low chance for park improvement.

4.2 Scenario Two: Phaseout of Logging in Algonquin Park

Ontario Parks could phase out logging within the park boundaries. This scenario represents the hardest to achieve, given the history of pushback related to the reduction of logging in Algonquin Park. Take, for example, the 2013 Amendment to Lighten the ecological footprint of Algonquin Park; the original proposal was to protect 55% of the park from logging. However, due to economic concerns, the protected area was reduced to 34.7% (Government of Ontario, 2013). This scenario has the potential to adversely affect the forestry industry, local communities, and AOO. Further, this scenario would potentially be economically devastating to the local community subgroup of Renfrew County. Given the adverse socio-economic risk, this scenario would cause a loss of “9” points in the rankings while only gaining back “4”, resulting in a total achievement score of “35” out of “75”. Thus, this scenario represents a net negative achievement score for all stakeholders and rights holders. Therefore, this scenario represents a high risk of economic impact with only modest improvements to the Park's objectives.

4.3 Scenario Three: Phaseout of Logging Paired with the Expansion of the Highway 60 Corridor

Ontario Parks phases out logging in the park paired with an expansion of the highway 60 corridor. This scenario could potentially provide the benefits associated with the phaseout of logging while mitigating the socio-economic impacts on local communities. As indicated in the identification of the local communities as key stakeholders, their main objective is to maintain the economic viability of their communities, which they achieve by maintaining the forestry industry and promoting tourism. If Ontario Parks committed to expanding day use and camping opportunities along the highway 60 corridor, allowing for more users of the park, it would potentially improve tourism in the local communities. This scenario would still adversely affect the forestry industry and AOO and, therefore net a loss of “6” points while gaining back “4” points, resulting in a mitigated net achievement score of “38” out of “75”. However, this plan could also impact the backcountry users as developed parkland encroach on backcountry environments. Ontario Parks would also have to conduct studies on the effects of road expansion in the park, as the damage caused could hinder their environmental objectives Despite those risks, this scenario represents a moderate risk to economic impact with a potentially significant benefit due to the increase in tourism.

4.4 Scenario Four: AOO rights to logging paired with the expansion of the Highway 60 Corridor

Ontario Parks gives AOO exclusive rights for logging within the park while also expanding the highway 60 corridor. This scenario builds on the benefits of scenario three while further isolating the impacts of the loss of logging. The only key stakeholder group negatively impacted is the forestry industry by giving AOO the exclusive rights to log in to Algonquin Park. It would allow the rights holder access to continue logging. As a result, this could reduce the amount of logging in the park while still maintaining it for the rights holder to maintain economic opportunities for Algonquins. This scenario would only lose “3” achievement points while gaining “4” back, resulting in a positive net total achievement of “41” out of “75”. Therefore, this scenario represents a moderate risk to

economic impact while respecting the objective of the rights holders and increasing tourism.

5.0 Limitations

This report was developed to give the reader a general understanding into the complexity of stakeholders' and rights holders' objectives related to the development of the Algonquin Park Management Plan. However, this report has had to make some assumptions to do so. These assumptions are primarily in the identification and summarization of objectives. Some of the identified objectives in this report may not be as equally important as this report has stated due to the lack of direct information related to local communities. Further, the ranking of the objectives is subject to assumptions such as the correlation between tourism and user objectives. It is also important to note that this report holds tourism as equally tradeable with the forestry industry, which may not be completely justifiable given that tourism for the park peaks in the summer. At the same time, logging is utilized all year long. Despite this limitation, we believe this report gives a reasonable basis for approaching the objectives of Algonquin Park.

6.0 Recommendations

This report makes three recommendations to Ontario Parks and the government of Ontario that would improve the objectives of multiple stakeholders and rights holders.

1. The government of Ontario should prioritize developing an in-depth analysis of the impacts of tourism Algonquin Park has on local communities to further understand if forestry in the park can be reduced by offsetting socio-economic impacts with tourism.
2. Ontario Parks and Algonquin Park should conduct an environmental impact assessment related to the possible expansion of the highway 60 corridor to ensure expansion does not conflict with their environmental objectives.
3. Ontario Parks and Algonquin Park should coordinate with the AOO to promote the cultural importance of the Algonquins people within the park to be equally represented with the settler cultural history of the park.

7.0 Conclusion

In closing this report, it is essential to reiterate the significance of Algonquin Provincial Park to the province of Ontario. Its natural beauty, rich biodiversity, cultural importance, and eco-serves cannot be understated. Millions of Ontarians have been inspired by the park since it opened in 1893, from Tom Thomson to A.Y. Jackson, to Pierre Elliot Trudeau. Therefore, it is crucial that Ontario Parks work to preserve the beauty and importance of the park for future generations to enjoy. This preservation starts with a new management plan that replaces the 25-year-old plan that governs the objectives of Algonquin Park.

This report has developed a multi-objective analysis of the key stakeholders and rights holders within the park. These groups consisted of five major groups, the park, the park users, the forestry industry, the local community, and the rights holders. This report then ranked their objectives compared to the 1998 Algonquin Park Management Plan objectives. Moreover, it provided alternative scenarios to understand the trade-offs between groups and objectives better.

This report hopes to inform people about the complexity related to the management of Algonquin Park and inspire more research into the management of Algonquin Park. Algonquin Park inspired the author of this report to have a deep passion for the environment. It has profoundly impacted so many Canadian and is thus one of the most important things to protect in Canada, so future people can be inspired by the natural beauty of nature.

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Addressing CO2 Emissions in the Aviation Industry: Promoting the Uptake of Sustainable Aviation Fuels

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Introduction

As the climate crisis progresses many industries within the transportation sector are making headway towards electrification, such as cars, public transit buses, and trains. However, the aviation industry is lagging due to its requirement for high power output and energy-dense fuels (IEA, 2020). This means the industry is one of the most energy-intense forms of consumption, accounting for approximately 2.6% of annual anthropogenic carbon dioxide (CO_2) emissions and a predicted growth rate of roughly 5% per annum (Staples et al., 2018). Given this relatively small fraction of total emissions, one could argue that policymakers should focus their attention on larger-emitting sectors, such as iron and steel. However, in a net-zero context, no piece of the puzzle, no matter how small, can be neglected if climate targets are to be met.

To address the aviation industry's emissions, the International Air Transport Association's (IATA) has set a target of net-zero emissions by 2050. While there seems to be many options for decarbonization of this sector, such as policies and regulations, operations management, electric batteries, hydrogen, and sustainable aviation fuels (SAFs), no one option is powerful enough currently to achieve targets. This is due to technical infeasibilities, high costs, and international complexities. Considering this fact, a combination of all the above will be required for 2050 goals.

Despite the importance of each decarbonization tool, for reasons that will be explained below, there is one option that shows great potential over the others – sustainable aviation fuels (SAFs). With tactful policy work, the true promise and upscaling of this fuel could be realized to help SAFs be a powerful tool in achieving the

aviation industry's climate goals. This paper will examine the various policy tools and strategies to promote the uptake of SAFs, while highlighting the need for each.

Background

As mentioned above, there are many strategies one could take to achieve emissions reductions in the aviation industry. From a policy side, the reduction of flights, for example, would be key to curbing and cutting emissions; however, necessary supplies, goods and services will continue to need to be transported by airways to fill society's needs (Santos & Delina, 2021). Therefore, a policy such as limiting flights will only have such a limited impact.

Taking a more operational approach could consider options such as improving air traffic management through optimizing flight paths and landing routines (Ahmad & Xu, 2021), or going as far as an entire fleet replacement (Dube & Nhamo, 2019). Better management of landing routines, for example, could reduce CO_2 emissions by reducing congestion and avoiding unnecessary wait times for landing. However, this would only decrease a small fraction of a flight's emissions and is an unlikely tool to achieve net-zero. Maintaining a young fleet and modernizing aircraft is important for improving and optimizing efficiency, but the growth of the industry may negate these efforts (Santos & Delina, 2021). Furthermore, airlines operate in a highly competitive market with relatively tight margins. Despite high ticket prices, due to costs of fuel, labour, aircraft, and various other expenses, airlines make a very small profit, namely just over $6 per passenger (IATA, 2019). Hence the frequent replacement of the fleet would be unprofitable and impractical for airlines.

Turning to a more technical strategy, Energy Transitions Commission (ETC) outlines four options for sustainable flights: electric batteries, green hydrogen, hydron-powered electrofuels, and biofuels (also known as sustainable aviation fuels (SAFs) (Santos & Delina, 2021). The most feasible of these options today remains SAFs due to the drawbacks of hydrogen fuel and electric batteries. With regards to hydrogen, the energy requirements to produce this fuel as well as the costs associated with its necessary infrastructure remain extensive. For example, it is estimated that for hydrogen fuel usage, each airport would require enough energy equivalent to a small

nuclear reactor to create all the hydrogen needed for flights – two infeasible engineering and economic challenges at this time (Moseman, n.d.).

In addition, despite passenger vehicles seeing success from electric batteries, the aviation industry faces unique challenges. Significant advances in battery technology will be required before the electrification of medium-long distance flights. This is due to the impractical size of the batteries needed to fulfill energy requirements (Moseman, n.d.). Given current battery technologies, replacing 1 kilogram (kg) of jet kerosene translates to more than 50 kg of batteries needed, resulting in a very heavy and inefficient flight (World Economic Forum, 2020).

Conversely, SAFs are considered to be a clean and practical substitute for fossil fuels. These fuels are produced from sustainable feedstocks, such as waste oils from a biological origin, agriculture residues, or non-fossil CO_2 (Jiang & Zang, 2021), and require limited infrastructure and equipment modifications (IEA, 2020). They are characterized as drop-in fuels, meaning that they can be blended with conventional aviation fuel, enhancing their practicality (Jiang & Zang, 2021). Moreover, depending on the technology, feedstock, and transportation, SAF could in theory reduce life-cycle emissions by up to 99% (World Economic Forum, 2020).

Despite SAF's viability of leading the industry to net-zero emissions, there exist many challenges that prevent the uptake of this fuel type. Some of these include a lack of availability, a limited number of production facilities, environmental impacts of production and distribution, technical uncertainty, as well as economic factors (Ahmad & Xu, 2021). With the goal to reduce the aviation industry's CO_2 emissions, this paper will consider policy measures designed to promote the large-scale deployment of SAFs.

Current Practices

Under the Paris Agreement, which aims to restrict the increase of global mean surface temperatures to a preferable 1.5°C, only domestic emissions from aviation are accounted for under states' Nationally Determined Contributions (NDCs), which leaves out the approximate 65% of total flight emissions coming from international aviation (Lee, 2018). Emissions from international flights were excluded due to the difficulty and complexity of attributing emissions to a particular nation. Instead, the United Nations Framework Convention on Climate Change (UNFCCC) mandated the International Civil

Aviation Organization (ICAO) to be responsible for carbon reduction initiatives in this sector (Dube & Nhamo, 2019). In 2016, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was adopted by the ICAO to address international aviation (IATA, 2021a).

CORSIA was developed through governments, industry, and international organizations as a short- to medium-term strategy (2021-2035) to achieve carbon-neutral growth in the international aviation industry (IATA, 2021a). The principal idea behind the agreement is to use offsetting programs, such as wind energy, forestry, or carbon capture sequestration (CCS) during the time that low-emission technologies such as SAFs, electric batteries, and hydrogen-powered technologies are being further developed and scaled up. In the first phase of this agreement (2021-2026), only flights from voluntary states are subject to offsetting requirements. As of September 2021, 107 states have agreed to participate in CORSIA, including Canada, the United States, and many small island and lower-income countries in the global South (ICAO, 2021). In the second phase, beginning in 2027, essentially all international flights will be subject to the offsetting requirements, with the exceptions of flights to and from Least Developed Countries (LDCs), Small Island Developing States (SIDS), and Landlocked Developing Countries (LLDCs) (IATA, 2021a).

While CORSIA will be a helpful strategy to account for international aviation emissions, given their current lack of use, the deployment of SAFs will need to be accelerated to create greater CO_2 emission reductions, if the 1.5°C warming target is to be met. In February of 2021, the first passenger flight took off that was partly fuelled by SAFs (IEA, 2021). Currently, however, SAFs account for less than 0.1% of jet kerosene consumption, mainly since their costs are more than twice that of conventional fuels because of low production levels (IEA, 2021). Without the aid of policy measures, the uptake of SAFs could be stalled by the recurrent cycle of high costs leading to low demand, low demand leading to low production, low production leading to high costs, and ultimately no large-scale uptake.

Future of Aviation

The global aviation industry is expected to double its current number of passengers by 2036 to about 7.8 billion (IATA, 2017). This staggering estimate presents itself as a huge challenge to the IATA's goal for the global air transport industry to reach net-zero carbon emissions by 2050 (IATA, 2021c). To accommodate this number of passengers all the while making massive emission reductions in this sector is difficult to imagine with current practices. Policies and regulations to reduce and restrict travel would be beneficial to contain emissions, however, the public may see this as going against human rights. After all, air travel has been a large driving factor of globalization and has provided many social and economic benefits. It has allowed for global access to goods and services and has given people the chance to experience many new countries and cultures, often enriching one's life (World Economic Forum, 2020). So, the question then becomes: how can the aviation industry continue to provide these benefits while being environmentally sustainable?

One vision of the IATA is to abate 65% of carbon emissions through SAFs, 13% through new hydrogen technology, 3% with efficiency improvements, and the rest being accounted for with CCS and offsets, as prescribed by CORSIA (IATA, Oct 2021). However, for SAFs to cover this large portion of emissions, extensive work will be required to increase production and lower costs.

Policy Tools and Mechanisms

Policies will play an invaluable role in the scaling up of SAFs. Without their support, the aviation industry will be stuck in the same cycle of large costs, low demand, and low levels of production. To break this recurrence, policies need to be designed in a way that can support SAF consumption. That is, policies should bring about an increase in demand to boost production to a level that will realize economies of scale. Possible policies, which will be examined below, include clear schedules for SAF adoption from airlines and airports, low-carbon fuel standards and blending mandates, government-based price floors, absolute emission reduction targets, and carbon pricing (IEA, 2021). It is important to note however that not one individual policy will be powerful enough to

drive the uptake of SAFs on its own. Furthermore, policies will vary from region to region and will need to be catered towards a region's geography, economic, social, and political characteristics (World Economic Forum, 2020). The following section will expand on some of these various policy tools and mechanisms.

Blending Mandate

To begin, the central idea behind many of the above-listed policy tools and mechanisms is to increase the demand and production of SAFs. One way to ensure this is through blending mandates. A blending mandate would require fuel suppliers, blenders, airports, and/or airlines to have jet fuel composed of a certain percentage of SAFs (World Economic Forum, 2021). These mandates will serve to provide a clear long-term demand signal for production facilities. This is important since SAFs are a relatively new concept, meaning that new businesses that are producing the fuels will have no previous data to base their production levels off, making it difficult to predict demand. In general, new businesses tend to be reluctant to expand facilities and increase production without a clear signal that demand is increasing and will remain high. Thus, demand forecasting is critical for expanding SAF production facilities, allowing producers to price their fuels correctly, as well as understanding how to proceed with expanding future operations (McClendon, 2020).

One example of a blending mandate is ReFuelEU – a proposal included in the European Commission's, "Fit for 55" that was released in July 2021 (IATA, 2021b). The mandate requires all aviation fuel supplied to aircraft operators in the European Union (EU) to contain a specific share of SAFs that will increase at five-year intervals. Beginning in 2025, fuel blends must contain a minimum volume of SAF at 2%, increasing to 63% by 2050 (IATA, 2021b). Their goal for this mandate is to "spur the market uptake of the most innovative and sustainable fuel technologies" (European Commission, 2021, p. 2) by allowing production capacity to scale up and costs to lower over time. Providing early demand signals to production facilities allows them to safely expand in time to successfully supply the aviation industry, avoiding supply shortages. If other jurisdictions follow suit, this will provide an even greater demand forecast for suppliers, ensuring the increasing uptake of SAFs. Although, care must be taken when

designing blending mandates to avoid a case where demand resulting from mandates outpaces supply-chain capabilities (World Economic Forum, 2021).

Contract-for-Difference Schemes

Another policy option that has the potential to scale production is to establish contract-for-difference (CfD) schemes (World Economic Forum, 2021). In this case, SAF producers would enter a contract with the government to produce a fixed quantity of fuel or CO_2 savings over a set period. From here they could then work in one of two ways which both involve the government compensating the producer. The first way is to use a reverse auction approach where the government will compensate the SAF producer whenever the market value of the fuel is lower than the price floor determined through the auction (Pavlenko, 2021). The other consists of an agreement where the government will fund the difference between the market price of conventional fuels and the price needed to produce SAFs (World Economic Forum, 2021). With either program, long-term certainty is provided to investors by securing demand to return capital investments through financial support. As an added benefit, the SAFs produced using CfDs could even support blending mandates in their early years.

CfDs have already seen success in the United Kingdom (UK) (Department for Business, Energy & Industrial Strategy, 2020) and have driven the deployment of renewable energy technologies at scale while reducing their costs. Thus far, the UK has awarded three rounds of CfD contracts, supporting approximately 16 gigawatts (GW) of new renewable electricity capacity, composed mostly of offshore wind, and is now working on their fourth round (Department for Business, Energy & Industrial Strategy, 2020). The CfDs have resulted in greater certainty and stability of revenues by reducing the volatility of prices and protecting consumers. According to the UK government, CfDs have “delivered substantial new investment and significant cost reductions in several renewable technologies since [they were] introduced in 2014” (Department for Business, Energy & Industrial Strategy, 2020, p. 8). Given their success, the scheme should be considered and transformed to support the uptake of SAFs, providing greater certainty for many actors including investors, producers, and consumers. However, in the design, policymakers should look out for complications resulting from the long-term

agreements that may be needed to support SAFs. These could involve technological lock-in effects and large financial burdens on government budgets (World Economic Forum, 2021). For example, if the government is locked into a 15-year agreement and during said agreement hydrogen fuel becomes a viable and affordable option for flights, the CfDs may slow hydrogen's uptake, resulting in a missed opportunity for further emission reductions.

Conventional Fuel Pricing

The final type of policy tool to be considered in this paper will be directed towards conventional jet fuel, aimed to indirectly affect SAF uptake. Increasing the price of SAFs' immediate alternatives allows SAFs to be more competitive when prices are similar. Options could include a domestic carbon price or cap-and-trade mechanism, a ticket price-in cost of CO_2 emissions, or the removal of subsidies and indirect tax incentives that are currently suppressing conventional fuel prices in some jurisdictions (World Economic Forum, 2021). As with any policy tool, many of these options come with criticism, however. Carbon pricing schemes could result in jurisdictional disputes over who is responsible for what CO_2 emissions, since assigning the responsibility for emissions becomes difficult when international flights are involved. One way to evade this is for these flights to be exempted from carbon pricing or the cap-and-trade mechanism. Although, leaving out international flights neglects a large fraction of CO_2 emissions, resulting in a much less effective scheme.

To avoid regional disputes, an aviation ticket tax could be used instead as a tool to promote SAF uptake. This type of taxation already exists in various countries around the world, including many EU Member states (Faber, 2018). In the EU, a single rate is applied for all EU destinations, however, this method of applying ticket taxes should be rethought by policymakers before employing it in other jurisdictions. A flat rate does not take into consideration the actual emissions of a flight, based on distance, fleet efficiency, and type of seat (van Geuns, 2021). To implement a more effective ticket tax, policymakers should consider the average lifecycle emissions of fuels the airline used previously, the distance to the destination, as well as the type of passenger seat, as priority seats take up more space than economy seats. Then from the revenues

generated, one possibility could be for the government to direct the taxes towards subsidies for the deployment of SAFs (van Geuns, 2021), which would help to reach the goal of promoting SAF uptake.

Conclusion

As seen throughout the paper, the aviation industry poses a threat to the 1.5°C global heating target. The growing number of passengers along with the low percentage of flights that currently use SAFs present a huge challenge for the industry to limit and reduce its CO_2 emissions. In the meantime, while hydrogen fuel and electric batteries are being researched and developed, the options to stay in line with climate goals include CORSIA and the uptake of SAFs. While the offsets required under CORSIA are not harmful to IATA's goal to reach net-zero carbon emissions by 2050, they do not necessarily directly target or encourage the reduction of emissions by the aviation industry itself. That is, the use of offsets instead of fuel blend mandates or offtake agreements, for example, is much less effective to prompt changes within the industry that are significant enough to reach climate goals. Therefore, aside from CORSIA, actors within the aviation industry and government must push for the large-scale deployment of SAFs.

Moreover, considering IATA's vision to abate 65% of carbon emissions with SAFs, the current market for these fuels will need to change drastically. Policy tools and mechanisms will be key if this target is to be met. The policies examined in this paper are only a handful from the pool of potential options and more research will be required to find the best tools and mechanisms to be tailored to each specific region. As a takeaway, the aviation industry is a major roadblock in reaching the Paris Agreement's goals; if the required progress is to be made, more attention should be drawn to this industry, and policymakers and government officials must act now to avoid more of the irreversible damage caused by the climate crisis.

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The Lagging Strand of Genetic Protections: Current Challenges in Genetic Testing in Canada

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Introduction

Since the complete sequencing of the human genome by the Human Genome Project in 2003, genetic testing technology has evolved at a rapid pace (Moraes & Góes, 2016). While that international genetic sequencing project took approximately 15 years and cost upwards of US$2.7 billion dollars to complete, sequencing of a whole genome can now be done in weeks instead of months, for a fraction of the cost, and with greater accuracy (Kulski, 2016). Collective scientific knowledge about human genetics has also increased over time, leading to further innovations in gene sequencing research. Individuals are now able to get their genetic material easily sequenced in a healthcare setting or from an online company that performs the test and creates an analytical report for consumers.

This increased accessibility and accuracy of testing has enormous potential for human health and well-being. Precision medicine, a field of medicine where details like genetic testing data can be used to inform clinical treatments and prevention methods, could result in better patient outcomes and more economically efficient health care (Nill & Laczniak, 2020). Genetic testing results could also provide useful data to better inform clinical decisions like drug choice and dosage (Nill & Laczniak, 2020). Direct-to-consumer (DTC) tests are also widely available, ensuring that individuals are more knowledgeable about their health than ever before (Yadav et al., 2017).

However, this rapid evolution in testing abilities has resulted in numerous potential concerns for patients and customers. One of the most pressing concerns for most DTC testing customers is personal privacy, as the sharing of genetic data by these DTC companies in recent years has attracted a large amount of media attention, like the

2018 arrest of the “Golden State killer” as a result of shared genetic data (Hendricks-Sturrufhealthcarep et al., 2019). The quality and validity of results generated from DTC tests have also been questioned by some health care providers, as there are currently no regulatory requirements for these types of tests in Canada (Majumder et al., 2021). Also, while it will be beneficial to include genetic testing in the healthcare setting for precision medicine purposes, there are currently not enough genetics-focused medical professionals in place to support the increase in demand (Stoll et al., 2018).

As genetic testing continues to develop, it is important for public policy to proactively adapt to new information to ensure that the concerns associated with genetic testing are addressed. Canada could address privacy concerns by including specific language related to genetic testing in already-established privacy laws. Regulations around the standards of DTC tests and their marketing or reporting information could also be developed to ensure the accuracy and validity of results presented to customers. Creating certification or regulation surrounding genetic counsellors or other health care providers with genetic training could also ensure that patients have trained professionals to further consult about their testing results. Canada has the opportunity to develop policies to ensure that the genetic innovations being developed can be made widely available to the public and that the data revealed is not being misused or misunderstood.

Foundations of Genetic Sequencing

Human Genetics Fundamentals

As early as the 17th century, people were noticing how certain traits and disorders were inherited through families (Harper, 2008). However, for decades, what exactly was passing on this hereditary information was unknown. Deoxyribonucleic acid (DNA) was first discovered in 1869, but it was not until the 1950s that DNA was definitively shown to be the hereditary material and recognized as one of the most important molecules in the cell (Harper, 2008; Moraes & Góes, 2016). DNA is made up of four different nitrogenous bases: adenine (A), guanine (G), cytosine (C), and thymine (T), which connect with other molecules to form nucleotides, and are then combined to

form a single strand of DNA (Strachan & Read, 2011). It is the order of these nucleotides that encodes the necessary genetic information for human life (Lodish, 2013). DNA is essentially a storage molecule, storing genetic information in smaller segments of DNA called genes (Lodish, 2013). Each person has two copies of a gene and during gene sequencing, the goal is to elucidate the order of the nucleotides to uncover different genes and different versions of these genes, called alleles (Weinberg, 2014).

Many of the nucleotides are in the same order in everyone, but at certain sites in the genome, there are sections called single nucleotide polymorphisms (SNP) where the nucleotide order can vary based on the individual (Strachan & Read, 2011). For example, on an allele for flower colour in plants, the SNP may have two common possible nucleotides at a specific site on the gene. In a simplified example, if there is an A at one site, this could mean that a plant's flowers will be pink, while a plant that has a G at the same spot will instead have white flowers. These genetic differences are a natural part of life and are necessary for species to evolve and survive (Lodish, 2013). Sometimes mutations can result in alleles that have a positive impact on a person's life, such as making an enzyme more efficient or conferring some other evolutionary advantage (Weinberg, 2014). Other times, the mutation may cause a benign change, resulting in a change in eye or hair colour (Lodish, 2013). However, these mutations can also be deleterious, predisposing someone to, or even directly causing someone to develop, a certain disease or disorder (Strachan & Read, 2011).

Human Genome Project and Genetic Sequencing for Disease

In 1990, encouraged by the new technologies and research being done in the field of genetics, the Human Genome Project (HGP) was launched (Moraes & Góes, 2016). The HGP was an international research program with the goal of sequencing all 3 billion bases of the human genome (Bentley, 2000). At the time of the HGP, the sequencing method for the whole involved small individual segments of DNA being sequenced before a computer algorithm assembled these fragments into the proper order (Moraes & Góes, 2016). Today, this same method is used for assembling large segments of sequenced DNA, but the technology itself has been advanced, making it

much faster and more accurate (Kulski, 2016). In addition, advancements in computer processing power have allowed the algorithms that reassemble fragments of DNA into large sequences to become more proficient, again improving accuracy and reducing the time required to develop large sequences of DNA (Kulski, 2016). By sequencing these larger segments, researchers and healthcare professionals can identify the genes responsible for various diseases.

Some of the most cited examples of genetic disorders and genes that are used to explain the utility of genetic information are Huntington's disease, cystic fibrosis, and the BRCA1/2 gene for breast cancer. In Huntington's disease, a neurodegenerative disease, only one copy of a mutated allele is required to cause the disease while in cystic fibrosis, two copies are necessary (Strachan & Read, 2011). Conversely, a certain allele of a gene may just make someone more likely or susceptible to develop a given trait or illness, but it is not always certain that they will (Strachan & Read, 2011). This is the case for people with the mutant allele of the BRCA1/2 genes, where having the gene just makes it more likely that a person will develop breast cancer (Strachan & Read, 2011). There are numerous ways in which mutations can impact a person's health and these differences can be seen in the results of a genetic test.

Genetic Testing in the Modern Era

The technological advances and knowledge made available from the completion of the HGP have resulted in researchers being able to better understand the human genome (Hammond, 2020). Using the knowledge gained from the HGP and in the years since that project was completed, genetic tests can now be done to look at a number of genes (Williams et al., 2006). As a result, there has been a rapid expansion in the types of genetic tests available for use, including both diagnostic tests, such as for disorders caused by a single gene like cystic fibrosis, and predictive tests that assess a person's risk level associated with the development of a disease (Law et al., 2018). The two main settings where people receive genetic tests are in a healthcare environment or through direct-to-consumer (DTC) tests which are often ordered online. With both methods being conducted regularly, genetic testing has become more prevalent in the lives of Canadians in recent years.

Genetic Testing in a Health Care Setting

Genetic tests conducted in a health care setting are facilitated by a medical professional, using clinically-tested, laboratory-based testing methods (Williams et al., 2006). Often these types of tests are ordered by a physician with a specific purpose. For example, in some cases, genetic testing results will be used to diagnose a patient with a specific disorder or outline genes that may predispose an individual to a given disease (Hammond, 2020). Examples of this include the breast cancer-associated BRCA mutation, where based on family history, a physician may prescribe genetic tests to evaluate a patient's future risk level (Williams et al., 2006).

In the healthcare setting, the results of tests are often discussed with a healthcare provider or medical geneticist who has been given education and training regarding human genetics and genetic disorders (Majumder et al., 2021). In addition, genetic counsellors are trained professionals who can interpret a person's genetic results combined with their medical histories, educate individuals about the role genetics plays in disease, and support the patient to make decisions based on their risk level (Abacan et al., 2019). Genetic counsellors and other healthcare professionals can provide one-on-one service with a patient that incorporates other factors, like family history, that contribute to disease to help patients better understand their risk levels and disorders (Boothe et al., 2021).

Direct-to-Consumer Genetic Testing

The second avenue for genetic testing is through direct-to-consumer (DTC) tests. In recent years, new genetic sequencing methods have been developed that make sequencing less expensive, faster, and more accurate (Kulski, 2016). Numerous companies have taken advantage of these advancements, allowing consumers to order these tests online at any time. The DTC genetic testing industry is now a multi-million dollar industry, with over 20 million tests being completed to date by over 200 companies (Majumder et al., 2021; Nill & Laczniak, 2020). These kinds of tests are made accessible to the average person, with recent testing kits costing as little as $60 (Majumder et al., 2021). Most tests provide the necessary materials for customers to

collect a saliva sample, which is then sent off to be sequenced (Horton et al., 2019). The DTC company receives the raw data from sequencing, analyzes this data, and then sends a report with the results back to the customer (Nill & Laczniak, 2020).

The objective and marketing promises of DTC tests vary. Some tests are marketed similarly to a personality quiz, claiming that they will be able to assess and determine things like an individual's personality or athletic ability (Horton et al., 2019). Other tests may be for ancestry purposes, with companies like Ancestry claiming that they provide information about a person's "geographic origins" and that they will be able to identify potential relatives based on others who have also taken the same test (Ancestry, 2021). Others claim that it can provide data related to carrier status for genetic diseases and risk profiles for diseases like Alzheimer's and diabetes (Majumder et al., 2021).

Genetic Testing Considerations

Genetic Testing Benefits: More Informed Individuals and Precision Medicine

With newfound knowledge about genetics and genetic diseases come newfound opportunities. This includes the more frequent use of genetic testing in the medical field, allowing health care providers to have more data available to them when making decisions. This allows for precision or precision medicine, a field of medicine that takes into account a person's unique genes, lifestyle, and environment to determine the best treatment or prevention methods, to be better integrated into healthcare (Stoll et al., 2018). Another benefit of these advancements is the new prevalence of DTC genetic testing, which makes genetic testing more accessible for individuals and allows them to have more information about their own health.

Precision medicine allows for treatment and prevention strategies to be better tailored to each individual with the potential to create a more cost-effective healthcare system (Miller & Tucker, 2018). A better understanding of a person's genetic makeup can facilitate a more accurate selection of both drug type and dosage once a person has a diagnosis. For example, the drug Trastuzumab (Herceptin) targets

overexpression of the gene Her2Neu in breast cancer (Williams et al., 2006). If genetic tests reveal that the cause of a patient's tumour is linked to overexpression of Her2Neu, the doctor will be able to prescribe Trastuzumab to target the tumour, while the drug would not be effective against breast cancers caused by other genes. Choosing the drug or dosage based on genetic results has the potential to result in better patient outcomes.

In addition, having the result of genetic tests can allow patients to be more informed about their health and empower them to make decisions with this data in mind. This can include certain precautionary measures put in place to reduce the risk of certain diseases in the future based on the risk profile outlined to a patient as the result of a genetic test. One example of this is seen in the BRCA1/2 gene implicated in breast cancer. Patients with this gene are more likely to experience a reoccurrence of cancer following treatment (Yadav et al., 2017). However, those with the BRCA1/2 mutant allele who undergo a contralateral prophylactic mastectomy, or removal of healthy breast tissue in the opposite breast, are at a reduced risk of cancer reoccurrence and can show improved survival outcomes (Yadav et al., 2017). While surgical intervention decisions are complex and have numerous factors involved for both patients and physicians, research has demonstrated that knowing whether a patient has the BRCA1/2 mutation makes a significant impact on their decision (Yadav et al., 2017).

Genetic Testing Concerns: Privacy, Testing Standards, and Access to Professional Advice

While there are many benefits to genetic testing, there are also numerous risks involved. A person's genetic code is the ultimate identifier. A strand of hair or tube of saliva is all that is needed to complete comprehensive genetic sequencing, revealing a genetic sequence that is unique to a single person (Horton et al., 2019). The potential implications of genetic testing mean that there are several concerns related to this rapidly advancing technology. First, DTC genetic testing done by private companies brings up large privacy concerns. Another concern with DTC genetic testing is that while genetic testing increases the accessibility of genetic tests, it does not ensure that the results or reports provided will be accurate and reliable, or that the customers will fully

grasp the information being presented to them. In addition, while the increase in genetic testing provides opportunities for greater integration with healthcare, the current system is not prepared to fully integrate the information provided by genetic testing.

One of the largest concerns with genetic testing being conducted by private corporations are concerns for a customer's privacy. For individuals who elect to complete a genetic test from a DTC company, a core concern is how their data will be used outside of the report generated for them. For example, while 23andMe is advertised primarily as a genetic testing site, its core business model involves attracting research partners and selling their data to these partners for their use (Majumder et al., 2021). While the data is provided anonymously, DNA is a unique identifier of a person, and it will always be possible to link a person back to their DNA. DTC testing companies are often critiqued for their impenetrable privacy policies which have been found to have gaps relating to the use of a person's data by third parties (Majumder et al., 2021). It is often unclear how or if individuals will be contacted if there is a security breach, or what would occur with regard to data in the case of bankruptcy, or if the DTC company was sold (Majumder et al., 2021). Further, these privacy policies can be changed at the discretion of the DTC companies, with no requirements for the company to notify customers who have their genetic information saved on their servers (Majumder et al., 2021).

Recently, there have been controversies surrounding the use of genetic testing information between DTC companies and pharmaceutical companies, and with law enforcement (Majumder et al., 2021). One example of this is in 2018, when the "Golden State Killer" was identified in part due to the use of genetic data from DTC companies that was shared without the customer's knowledge (Hendricks-Sturrup et al., 2019). While this was a positive outcome, it raises the question of how genetic data could be used in the future. In the pharmaceutical industry, 23andMe has partnered with GlaxoSmithKline (GSK) to identify patients within certain genetic groups and invite them to participate in certain studies for the pharmaceutical firm (Hendricks-Sturrup et al., 2019). Participation will be voluntary, but it again raises the question for participants of who, and how many people, have access to a person's genetic data.

One other major concern with genetic testing is the quality of results from DTC companies and how their results are presented to the customer. First, there are no industry standards for genetic tests and no standard procedures to establish risk profiles often generated by DTC reports (Horton et al., 2019). False positives and false negatives are common, occurring as often as 40% of the time, and in the case of patients receiving a false positive of the BRCA1/2 gene, could result in them undergoing unnecessary surgeries to reduce risks that they are not predisposed to (Horton et al., 2019; Tandy-Connor et al., 2018). This also means that the analysis provided for consumers can vary widely based on the company that is completing the analysis (Majumder et al., 2021). Further complicating this, is the complexity inherent to many traits or genetic disorders (Strachan & Read, 2011). Many traits are polygenic, meaning that they are impacted by numerous genes and also affected by environmental or lifestyle choices (Strachan & Read, 2011). Without knowing additional information like a patient's family history or lifestyle choices, risk profiles about certain diseases by DTC companies become increasingly inaccurate and potentially harmful (Horton et al., 2019).

In addition, these results are often interpreted without any oversight from a medical professional, which means that patients may not fully understand the meaning of their results (Majumder et al., 2021). Adding to this issue is that many medical professionals who may be asked to give a second opinion on genetic results, may not feel confident in interpreting the data due to the lack of clarity surrounding the clinical accuracy and utility of the tests completed by a DTC company (Majumder et al., 2021). Without additional context from a medical professional, DTC genetic test results can cause false reassurances. For example, in a study done on women who received negative results for the cancer-related BRCA1/2 allele, it was demonstrated that while the women understood the limitations of the test, these results continued to make them feel more positively about waiting to see a doctor or receive a mammogram (Majumder et al., 2021). These false assurances could result in individuals forgoing further medical treatments or diagnostic tests.

Another concern with the rise in genetic testing is that there is a lack of adequate infrastructure to support the integration of genetic testing into healthcare. Medical professionals who are educated on the topic of human genetics and genetic disorders, like genetic counsellors, are essential to ensure that genetic testing information can be properly integrated into the healthcare system in Canada. However, there is an insufficient supply of genetic counsellors for the demand being experienced with the rise of genetic testing (Stoll et al., 2018). In Ontario, a recent report by the Office of the Auditor General concluded that with the rising prevalence of genetic testing, patients hoping to meet with a genetic counsellor are experiencing long wait times (2017). There are only 5 training programs across Canada for genetic testing, with many of them admitting as few as 6 students a year (Abacan et al., 2019). Current projections expect that this will not be sufficient to deal with future demand (Stoll et al., 2018).

Current Policy: The Genetic Non-Discrimination Act

With regard to genetic testing, the only piece of legislation that Canada currently has in place is the Genetic Non-Discrimination Act (GNDA). This Act received Royal Assent in 2017 and amends the Canada Labour Code (CLC) and Canada Human Rights Act (CHRA) to prevent genetic discrimination in Canada based on genetic testing results (Hammond, 2020). Genetic discrimination refers to a person being denied rights, or opportunities, or experiencing other negative treatment as the result of their genetic test results (Hammond, 2020). The Act aligns with genetic non-discrimination legislation laid out by countries like France and Australia and was drafted in response to the growing unease in the volume of genetic data being collected by both healthcare providers and private firms (Hammond, 2020).

Canada's GNDA prohibits anyone from having to complete a genetic test to receive services or enter into a contract and it also prohibits people from being refused these items if they are not willing to complete a genetic test (*Genetic Non-Discrimination Act (S.C. 2017, c. 3)*, 2017). The Act also prohibits anyone from having to disclose the results of a genetic test that they may have previously completed to gain access to goods or services, or enter into or continue a contract (*Genetic Non-Discrimination Act (S.C. 2017, c. 3)*, 2017). This prevents third parties like insurance companies or

employers from requiring individuals to provide their results or complete a genetic test to be insured or hired. Within the Act, there are exceptions for healthcare practitioners and researchers, allowing those who provide health services or conduct research to ask for or require genetic information (*Genetic Non-Discrimination Act (S.C. 2017, c. 3)*, 2017).

The Act has faced widespread criticism in the past, including from the Quebec Court of Appeals which ruled the law unconstitutional by claiming that it infringed on provincial jurisdiction (Stefanovich, 2020). In response to this challenge by Quebec, in 2020, the Supreme Court of Canada upheld the law, arguing that it fell within federal powers (Stefanovich, 2020). Others have questioned whether genetic discrimination even exists (Hammond, 2020). However, research has shown that those who are at risk for genetic disorders, such as Huntington's disease, a fatal, neurodegenerative disorder, have faced discrimination from health and life insurance companies, as well as in areas related to adoption, blood donation, and employment (Hammond, 2020; Williams et al., 2010). In one instance, when a woman who was found to be potentially at risk of Huntington's disease applied to adopt a child with their partner, the adoption agency declined their application to adopt due to the woman's risk of potentially developing the disease (Geller et al., 1996). This data suggests that genetic discrimination is a real phenomenon and that the concerns relating to genetic testing technologies have merit.

Possible Policy Interventions

In recent decades, genetic testing technology has rapidly advanced, surpassing what was even thought to be possible during the completion of the HGP in 2003. However, with this new knowledge comes new implications and new areas for risk. It is important for Canada to proactively act to respond to this changing environment. While Canada already has the GNDA in place, genetic discrimination is only one consideration that has arisen from the widespread availability of genetic testing. Individuals are also concerned about the privacy implications of genetic testing, the insufficient and often non-existent testing standards, and the lack of access to professional advice. Currently, there are no plans to address these concerns for Canadians.

One way in which Canada could adapt to new services being offered by DTC genetic testing companies is by developing a set of standards for genetic testing results to attempt to ensure that all Canadians are accessing reliable and accurate testing services. This could be done by regulating DTC genetic tests and their marketing, in line with current regulations surrounding the pharmaceutical industry. Privacy concerns could also be addressed by requiring DTC companies to adhere to the *Personal Information Protection and Electronic Documents Act* (PIPEDA), the Canadian Act which regulates the use of personal information in Canada (Canadian Medical Association, 2017). Additionally, Canada could invest in infrastructure to integrate genetic testing more completely into the wider medical field, by increasing the training of genetic counsellors and providing licensing regulations that would help ensure Canadians are receiving credible advice. These measures seek to address the main concerns with genetics testing.

Developing Testing Standards

Governments could establish clear national or provincial standards that ensure the accuracy, reliability, and usability of DTC genetic tests in Canada. Similar to the standards put in place by Health Canada regarding medical devices, genetic tests in Canada could be incorporated into this regulatory framework. In line with this recommendation, the Government of Canada and Health Canada could look more closely at DTC genetic testing companies, regulating their tests, the information that they provide, and how they are advertised. This practice is already done in countries like the US and a similar strategy could be adopted in Canada (Majumder et al., 2021).

Since 2010 in the US, the Food and Drug Administration (FDA) has taken jurisdiction over DTC tests (Majumder et al., 2021). While tests for non-medical purposes such as ancestry, general wellness, or low-risk medical purposes are not regulated by the FDA, those that are for moderate to high-risk medical purposes are regulated to ensure the accuracy and reliability of the tests (FDA, 2019). Health Canada, the Canadian counterpart to the FDA, could adopt a similar regulatory oversight structure. Currently, in Canada, pharmaceutical marketing is closely regulated and monitored. The Pharmaceutical Advertising Advisory Board (PAAB) is an

independent non-profit recognized by Health Canada that provides regulatory guidance and approval to ensure that pharmaceutical marketing and patient materials are in line with the Code of Advertising Acceptance (Pharmaceutical Advertising Advisory Board, 2021). PAAB ensures that all marketing and educational materials are truthful, transparent, and supported by evidence (Pharmaceutical Advertising Advisory Board, 2021). Genetic testing could be incorporated under this existing framework, or a separate body could be created to deal with the concerns surrounding patient education and marketing of DTC genetic tests. These measures could help ensure that the test results presented are correct and that the claims about health risk or predisposition to disease are based on credible evidence and are communicated in a way that customers can understand.

These standards could result in some being concerned that this will delay new or updated tests being put on the market, taking away the easy accessibility and affordability that is one of the benefits of genetic testing. However, concerns related to a patient's health, such as false positive or negative results, could deleteriously impact the health and well-being of an individual in the long run, which defeats the original purpose of taking the test. In addition, regulatory requirements could only be applied to tests that are marketed as those which will provide information about a moderate or high level of medical risk. This would ensure that ancestry tests and other personality-based genetic tests, that pose less of a risk to a person's health, are still able to be easily accessible.

Addressing Privacy Concerns

Governments in Canada could additionally work to address the privacy concerns of completing DTC tests. While some may argue that privacy risks are inherent to the storage and usage of data, these concerns are especially crucial for genetic data. From genetic data, a person's health status, future risk profile, and numerous other traits can be determined (Miller & Tucker, 2018). From this information, information about a person's family genetic data can also be uncovered, potentially impacting their descendants (Miller & Tucker, 2018). This data does not and will not change substantially in the future, as a person's genes remain relatively unchanged throughout

their life (Miller & Tucker, 2018). Most important, however, is that all of the potential future uses of genetic data are not yet known (Miller & Tucker, 2018).

With the rapid pace that the molecular biology and genetics field has been advancing, there will likely be more extensive uses of this data in the future, and it is impossible to know how the privacy of one's genetic data will impact outcomes later in life. One way to protect privacy is by requiring DTC companies to be subject to PIPEDA, which currently does not explicitly refer to genetic information being included under the Act and is even less clear when it is noted that the data is often shared without any immediately identifying information (Canadian Medical Association, 2017). PIPEDA and the *Privacy Act* do not apply to data that has been de-identified, which genetic data often is (Therrien, 2022). However, genetic data can be easily identifiable, even without a person's name or social security number, due to the fact that it alone is a unique identifier of a person.

Further, a lack of privacy oversight of both public and private DNA databases poses a large concern for many individuals who have received the results of a genetic test. There are currently no privacy regulations or laws aimed at ensuring that a customer's or patient's data will be protected from a privacy breach (Joly et al., 2019). Individuals may not even be contacted when a privacy breach has occurred, putting them at great risk of their genetic data being shared without their knowledge or consent (Majumder et al., 2021). Adding to the GNDA or creating additional privacy regulations that ensure that individuals will be alerted if a privacy breach has occurred, is crucial to ensure that privacy concerns do not deter people from taking advantage of further information about their own health.

Expanding Genetic Healthcare Infrastructure

Canada could also begin investing in the infrastructure necessary to take advantage of the potential afforded by more accurate and accessible genetic testing. This includes investing in training more genetic counsellors and other genetic professionals. Recent studies have demonstrated that there is a need for as many as 1 genetic counsellor for every 75,000 people (Stoll et al., 2018). Canada, with approximately 270 genetic counsellors, has approximately half of that capacity (Abacan

et al., 2019). This could be accomplished by funding more genetic training programs or increasing enrollment numbers. In the last 2 years in the US, there have been an additional 7 training programs developed, with 5 more anticipated to be formed within the next few years (Stoll et al., 2018). Canada could follow the US's steps in investing in the future needs of the healthcare system.

Another way to ensure that not only are there more medical professionals specialized in genetics but that these specialists are qualified and will provide accurate care is through the development of licensure, registration, or other forms of legal recognition for genetic specialists. While there is a certification process offered by the Canadian Association of Genetic Counselling (CAGC), this is less regulated than other medical professions in Canada and does not offer title protection for genetic counsellors in Canada (Abacan et al., 2019). Title protection ensures that a person using that title is authorized to practice their profession and indicates that the individual has met all requirements for registration or accreditation (College and Association of Registered Nurses of Alberta, 2019). This is essential to help ensure that the quality of service provided by genetic counsellors remains consistent and accurate for all Canadians.

Conclusion

Recent trends and data suggest that the advancements in genetic testing technology represent a large opportunity for citizens (Majumder et al., 2021). However, it will be necessary for Canada to act to better support the integration of these technologies into our current healthcare system and ensure that patients can understand and make informed decisions about their testing results. While DNA was once thought to be a small component of a cell's inner material, it is now known to provide the instructions for human life (Lodish, 2013). A person's DNA can reveal superficial data like their type of earwax or eye colour, or it can reveal deeply personal data about a person's health and health risk profile, such as how likely they are to develop a certain illness (Nill & Laczniak, 2020).

It is increasingly likely that genetics and genetic testing will continue to play a larger role in the lives and health of Canadians in the future. Acknowledging both the inherent benefits and risks associated with genetic testing, Canada could develop policy

interventions to mitigate some of the current concerns. Privacy concerns could be addressed through more explicit regulation concerning the sharing of genetic data. New standards for genetic tests, their marketing, and reporting could also be created to ensure that patients are receiving accurate information. To meet the demand for genetic counsellors necessary to interpret results in a healthcare setting, Canada could invest in creating new genetic counselling programs at universities to boost enrollment and eventually, the number of counsellors in Canada. Additionally, developing a legal recognition of the profession would be beneficial in ensuring that patients are receiving care from qualified professionals.

Rapid advancements in technology have illustrated how it is not clear how the future of genetic testing will continue to progress. New uses of genetic information and genetic testing data are being discovered each day and will continue to be discovered as the complexities of this area of science continues to be studied. In the future, genetic testing is almost certain to play a larger role in the lives of Canadians and the healthcare system in Canada. It is therefore necessary for governments to consider being more proactive in both their support and regulation of genetic testing and genetic innovation.

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