





Major Craig-Allen Cloete

**Canadian Energy Security** 

# JCSP 47

# **Exercise Solo Flight**

## Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

© Her Majesty the Queen in Right of Canada, as represented by the Minister of National Defence, 2022

# **PCEMI 47**

# **Exercice Solo Flight**

#### Avertissement

Les opinons exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite.

© Sa Majesté la Reine du Chef du Canada, représentée par le ministre de la Défense nationale, 2022

# Canadä

# CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

# JCSP 47 – PCEMI 47 2020 – 2022

Exercise Solo Flight – Exercice Solo Flight

# Major Craig-Allen Cloete

## **Canadian Energy Security**

"This paper was written by a student attending the Canadian Forces College in fulfilment of one of the requirements of the Course of Studies. The paper is a scholastic document, and thus contains facts and opinions, which the author alone considered appropriate and correct for the subject. It does not necessarily reflect the policy or the opinion of any agency, including the Government of Canada and the Canadian Department of National Defence. This paper may not be released, quoted or copied, except with the express permission of the Canadian Department of National Defence." "La présente étude a été rédigée par un stagiaire du Collège des Forces canadiennes pour satisfaire à l'une des exigences du cours. L'étude est un document qui se rapporte au cours et contient donc des faits et des opinions que seul l'auteur considère appropriés et convenables au sujet. Elle ne reflète pas nécessairement la politique ou l'opinion d'un organisme quelconque, y compris le gouvernement du Canada et le ministère de la Défense nationale du Canada. Il est défendu de diffuser, de citer ou de reproduire cette étude sans la permission expresse du ministère de la Défense nationale."

## **CANADIAN ENERGY SECURITY**

## **INTRODUCTION**

The costs of energy insecurity on a country's macroeconomics can be seen in contemporary South Africa, where rolling large scale blackouts on the electrical grid have resulted in Gross Domestic Product (GDP) losses of up to 5%.<sup>1</sup> Similarly but on a smaller scale, the 21 May 2022 Derecho<sup>2</sup> storms that crippled Southeastern Ontario, and dismantled multiple redundant electrical grids, showed how energy-dependent Canada is, much like the outages that crippled Texas in February 2021 from an ice storm<sup>3</sup>.

At a time when Canada has committed to the reduction of harmful emissions through a robust and ambitious plan, energy security during the transition away from fossil fuels (FF), toward more renewable sources, is of great concern. Recent global conflicts have been tumultuous for the global oil and gas sector. The third-largest global oil supplier, Russia, has placed immense strain on global energy markets and created global energy security concerns. Canada, in line with allies, banned Russian energy imports, which have increased energy prices globally. The International Energy Agency (IEA) has reported steady increases in monthly spending for transportation and heating, during the first quarter of 2022, by up to 35% in developed nations, and up to 55% in developing nations.<sup>4</sup>

<sup>&</sup>lt;sup>1</sup>Simon Trace, "South Africa's Crippling Electricity Problem," Oxford Policy Management, January 31, 2020, https://www.opml.co.uk/blog/south-africa-s-crippling-electricity-problem.

<sup>&</sup>lt;sup>2</sup>Raymond, Ted. "What Is a 'Derecho'? Climatologist Explains Saturday's Powerful Storm." Ottawa. CTV News, May 22, 2022. https://ottawa.ctvnews.ca/what-is-a-derecho-climatologist-explains-saturday-s-powerful-storm-1.5914534.

<sup>&</sup>lt;sup>3</sup>Monica Gattinger, "Energy Security and the Road to Net Zero by 2050" (Calgary: Canadian Global Affairs Institute, April 2021): 1,

https://d3n8a8pro7vhmx.cloudfront.net/cdfai/pages/4685/attachments/original/1619468633/Energy\_Security\_and\_th e\_Road\_to\_Net\_Zero\_by\_2050.pdf?1619468633.

<sup>&</sup>lt;sup>4</sup>The International Energy Agency, "A 10-Point Plan to Cut Oil Use – Analysis - IEA," IEA, March 1, 2022, last accessed 4 April 2022, https://www.iea.org/reports/a-10-point-plan-to-cut-oil-use.

The paper will show that maintaining Canadian Energy Security during the transition to net-zero emissions will be a compromise between fossil fuel use and investment, and the development of renewable energy and emissions reductions. Firstly, the paper will look at net-zero and some challenges Canada will have to overcome, followed by a brief look at Canada's energy makeup and how rapid divestment from FFs is a challenge. Lastly, a brief overview of alternate sources of energy and emissions mitigation that could help divest from FFs albeit not without challenges themselves.

## **NET-ZERO AND ENERGY SECURITY CHALLENGES**

Net-zero describes conditions where the production of greenhouse gasses (GHG) is counterbalanced by other technologies thereby not increasing their atmospheric content.<sup>5</sup> In short, the amount of GHGs in the atmosphere is not increased regardless of GHG production. A realistic target toward net-zero will however mean that some emissions will still occur, while GHG sequestration will be achieved through initiatives like increased forestation and carbon capture.<sup>6</sup> To put this into context, Canada set a lofty goal of a 30% reduction of 2005 emissions by 2030, and at the end of 2019, it was well below target at only achieving 1.2%.<sup>7</sup> The global impact of increasing temperatures cannot be overstated, as there is a limited opportunity to keep

https://economics.td.com/domains/economics.td.com/documents/reports/ff/A\_Just\_Transition\_for\_Energy\_Workers. pdf.; Canada. "Net-Zero Emissions by 2050 - Canada.ca." Canada.ca, 2021, last accessed 24 May 2022, https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html.

<sup>6</sup>Climate Council, "What Does Net Zero Emissions Mean? | Explainer," Climate Council (n.p., October 26, 2021), last accessed 20 April 2022, https://www.climatecouncil.org.au/resources/what-does-net-zero-emissions-mean/.; Jason Dion et al., "Canada's Net Zero Future: Finding Our Way in the Global Transition," Climatechoices.com (n.p.: Canadian Institute for Climate Choices, February 2021): 2-5, https://climatechoices.ca/wp-content/uploads/2021/02/Canadas-Net-Zero-Future FINAL-1.pdf.

<sup>7</sup>J Hughes, "Canada's Energy Sector Status, Evolution, Revenue, Employment, Production Forecasts, Emissions and Implications for Emissions Reduction" (Vancouver: Corporate Mapping Project, June 2021): 15, https://policyalternatives.ca/sites/default/files/uploads/publications/BC%20Office/2021/06/REPORT ccpa-bc-

<sup>&</sup>lt;sup>5</sup>Beata Caranci, Francis Fong, and Yasmine El Baba, "Don't Let History Repeat: Canada's Energy Sector Transition and the Potential Impact on Workers" (n.p.: TD, April 6, 2021): 2-3,

cmp\_canadas-energy-sector.pdf.

the temperature rise within 1.5 degrees Celsius by centuries end.<sup>8</sup> Balancing carbon emissions and striving for their atmospheric reduction is vital for future generations, but so too are the energy needs of developing and developed nations to continue advancement to net zero.

Energy Security discussions suffer from a vague concept; however, the IEA offers that energy security is the unbroken supply of reasonably priced energy sources as well as renewable energy.<sup>9</sup> Canada is a nation with abundant resources, however, there are several factors that could threaten its energy security during the transition to net-zero if they are not managed correctly. With the recent release of Canada's Climate Action plan (Bill C-12), Environment and Climate Change Minister Steven Guilbeaut<sup>10</sup> needed to balance economic health with energy security and environmental factors.<sup>11</sup>

Oil holds a substantial share in most countries' energy makeup, especially within the transportation sector, and it will continue to be a major component of global energy requirements for the foreseeable future.<sup>12</sup> The USA has a strategic petroleum reserve(SPR) in place to limit economic damage from global energy disturbances when insufficient imports of oil and gas could disrupt local economies.<sup>13</sup> Canada, not having an SPR, is at the mercy of the global

<sup>9</sup>The International Energy Agency, "Energy Security -Areas of Work - IEA," The International Energy Agency (n.p., December 2, 2019), last accessed 18 May 2022, <u>https://www.iea.org/areas-of-work/ensuring-energy-security</u>.; Petra Dolata, "Understanding the Shift in Energy Security," Canadian Global Affairs Institute (Calgary: Canadian Global Affairs Institute, April 2017): 1, https://www.cgai.ca/understanding\_the\_shift\_in\_energy\_security. <sup>10</sup>Canada, "Canada's Climate Plan - Canada.ca," Canada.ca (Canada, 2022), last accessed 6 April 2022, https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan.html.; Tom Mulcair,

"Trudeau's Phony War against Climate Change: Tom Mulcair," CTVNews (CTV News, April 5, 2022), https://www.ctvnews.ca/politics/tom-mulcair-trudeau-s-phony-war-against-climate-change-1.5848812.

<sup>11</sup>Noha Razek, "As the World Moves Away from Fossil Fuels, Canada's Energy Security May Be at Risk," The Conversation (n.p., November 11, 2021): para 14-16, https://theconversation.com/as-the-world-moves-away-from-fossil-fuels-canadas-energy-security-may-be-at-risk-169794.

<sup>&</sup>lt;sup>8</sup>Henry Stoch et al., "How Canada Can Decarbonize by 2050 | Deloitte Canada," Deloitte Canada (n.p.: Deloitte Canada, 2021), last accessed 24 May 2022, https://www2.deloitte.com/ca/en/pages/strategy/articles/how-canada-can-decarbonize-by-2050.html.

<sup>&</sup>lt;sup>12</sup>The International Energy Agency, "Energy Security -Areas of Work ...

<sup>&</sup>lt;sup>13</sup>United States of America, "Strategic Petroleum Reserve," Energy.gov (Office of Fossil Energy and Carbon Management, 2020), https://www.energy.gov/fecm/strategic-petroleum-reserve.

market, and is therefore significantly affected by decisions of the energy hegemons like Saudi Arabia, Qatar, USA and Russia. A case in point is how negatively Canada was impacted when the US pivoted against pipeline construction, and the Albertan Oil sector and the economy suffered. The current war in Ukraine is also affecting Canadian Energy Security as the country is seeing record fuel prices and fluctuations, which will have second and third-order effects on the economy.<sup>14</sup> The Energy transition, while ensuring energy security, cannot be achieved by being dismissive of the real issues. Oil production will still be required during this transition, to ensure Canada can fund, develop, and invest in renewable energy technologies, by maintaining a healthy economy.<sup>15</sup> The carbon footprint would however need to be reduced during oil and gas production, through technological efficiencies and carbon release mitigation strategies, to truly benefit from green energy advancements in green hydrogen, electrical storage, and nuclear energy.<sup>16</sup> The government has committed to reducing emissions from FFs, however its has also promoted energy diversification and funding for natural gas and oil, because gas, as an energy source, has been touted as a cleaner source than oil and is seen as invaluable in the energy transition, making it more of a challenge to remove FFs from the energy calculus moving forward.<sup>17</sup>

The rapid change of work postures during COVID highlighted the demands on electricity through digital technologies and communications infrastructures, requiring reliable and stable electricity supplies.<sup>18</sup> Increased meteorological events due to climate change threatens

<sup>&</sup>lt;sup>14</sup>Mark Zacharias, "There Is Only One Path to Long-Term Energy Security and Affordability: Clean Energy - Clean Energy Canada," Clean Energy Canada (n.p., April 1, 2022), https://cleanenergycanada.org/there-is-only-one-path-to-long-term-energy-security-and-affordability-clean-energy/.

<sup>&</sup>lt;sup>15</sup>Monica Gattinger, "Energy Security and..., 3.

 <sup>&</sup>lt;sup>16</sup>RBC - Thought Leadership, "The \$2 Trillion Transition: Canada's Road to Net Zero," RBC Thought Leadership (n.p., October 20, 2021), last accessed 20 May 2022, https://thoughtleadership.rbc.com/the-2-trillion-transition/.
 <sup>17</sup>Noha Razek, "As the World Moves..., para 18; Petra Dolata, "Understanding the Shift..., 3.

<sup>&</sup>lt;sup>18</sup>K. H. Juutilainen and Ugne Grikinyte, "Impact of COVID-19 on NATO Energy Security - View on Fuels, Gas and Renewable Energy," NATO Energy Security Centre of Excellence (n.p.: NATO Energy Security Centre of

infrastructure, as witnessed by the large-scale destruction of electrical distribution grids by the Derecho storm affecting Ontario and Quebec in May 2022. Electricity generation costs are comparatively low for most of Canada, as opposed to other nations due to hydropower and the alternate green energy generators of solar and wind, but continued destruction of infrastructure may cause price increases.<sup>19</sup> Conversely, Remote Canadian communities suffer from energy poverty due to insufficient infrastructure of electrical distribution, relying on FFs, driving up costs.<sup>20</sup> Like northern communities, once the electrical grids were down after the Derecho storm, FFs became the de-facto fallback energy source for electrical generation.<sup>21</sup> As Canada transitions toward net-zero electricity sources, electricity providers will have to solve, grid distribution, capacity and intermittency concerns as demands fluctuate while significant storage capacity is unavailable.<sup>22</sup> Like any commodity, increased demand will require investments in electrical infrastructure and component manufacture.

While Canada is embarking on a voyage toward renewable energy, it runs the risk of limiting allied interoperability, if alternate military energy sources are not developed in unison within alliances like NORAD and NATO. NATOs energy security while greening the military has been setback by COVID, making renewable energy transition less of a priority while financial recovery is underway, even though climate change has been labelled as a significant threat to the alliance.<sup>23</sup> Canada's vast landmass and international commitments, requiring remote

Excellence): 16, last accessed 20 May 2022, https://www.enseccoe.org/data/public/uploads/2021/08/nato-ensec-coe-impact-of-covid-19-on-nato-energy-security-view-on-fuels-gas-and-renewable-energy.pdf.

<sup>&</sup>lt;sup>19</sup>Just Energy, "The Average Cost of Electricity, Country by Country," justenenery.com (Just Energy, October 24, 2013): para 5, last accessed 10 May 2022, https://justenergy.com/blog/the-average-cost-of-electricity-country-by-country/.

<sup>&</sup>lt;sup>20</sup>Petra Dolata, "Understanding the Shift..., 1.

<sup>&</sup>lt;sup>21</sup>CBC. "Some Ottawa Gas Stations Running out of Fuel amid High Demand, Long Lineups," May 24, 2022. https://www.cbc.ca/news/canada/ottawa/gas-fuel-lines-shortage-ottawa-gatineau-storm-1.6463665.

<sup>&</sup>lt;sup>22</sup>The International Energy Agency, "Electricity Security ....

<sup>&</sup>lt;sup>23</sup>K. H. Juutilainen and Ugnė Grikinytė, "Impact of COVID-19..., 20.

military operations, results in large diesel and propane usage to provide operational energy.<sup>24</sup> Operational fossil fuel usage have been demonstrated to be halved through technological innovations in heat recovery systems, but they have not been totally eliminated.<sup>25</sup> Positive tests by the US Navy using a mixture of traditional fuel and biofuel did not result in global adoption of a new fuel standard, while a military biofuel standard has been hampered by high prices and unreliable supply chains.<sup>26</sup> The military will have to find ways to produce, transport and store alternate energy sources and products, requiring new critical energy infrastructures.<sup>27</sup> In the short term, FFs will provide significant energy generation for military operations, while progress toward its removal has slowed significantly.<sup>28</sup> The Canadian military apparatus is slow in acquiring new equipment and tends to operate aircraft, land vehicles and ships for several decades. The timeframe between procurement approval and implementation is often several years.<sup>29</sup> Modifying current and imminent air, land, and sea vehicles, to operate on alternate fuels, will take time and come at a considerable cost.<sup>30</sup> There is a high likelihood that any large system recently acquired, will still be operated near or in 2050, utilizing FFs as their energy source.<sup>31</sup>

# CURRENT STATE OF ENERGY SECURITY, RENEWABLES AND FORECASTS

<sup>&</sup>lt;sup>24</sup>Suzanne Cassolato et al., "Operational Energy a Multi-Faceted Government Approach" (n.p.: Defence Research and Development Canada, May 2018): 20, https://cradpdf.drdc-rddc.gc.ca/PDFS/unc304/p806435\_A1b.pdf.
<sup>25</sup>Ibid., 17-18; Natural Resources Canada. "NATO Science for Peace and Security Camp Energy Efficiency Project." Nrcan.gc.ca, 2018. https://www.nrcan.gc.ca/energy/energy-offices-and-labs/canmetenergy/canmetenergy-

varennes/northern-remote-infrastructures/nato-efficiency-project/24174.

<sup>&</sup>lt;sup>26</sup>K. H. Juutilainen and Ugnė Grikinytė, "Impact of COVID. -19..., 20.

<sup>&</sup>lt;sup>27</sup>NATO Energy Security Centre of Excellence, "Web Conferences on Climate Change and Energy Security for NATO Nations" (n.p.: NATO Energy Security Centre of Excellence, May 27, 2021): 18-21,

https://enseccoe.org/data/public/uploads/2021/10/web-conferences-on-climate-change-and-energy-security-for-nato-nations.pdf.

<sup>&</sup>lt;sup>28</sup>National Defence. "Strong, Secure, Engaged: Moving to Sustainable Defence Operations." Canada.ca, 2020. https://www.canada.ca/en/department-national-defence/maple-leaf/defence/2020/02/strong-secure-engaged-moving-to-sustainable-defence-operations.html.

<sup>&</sup>lt;sup>29</sup>National Defence, "Defence Equipment Purchases and Upgrades - Canada.ca," Canada.ca (Canada, 2018), https://www.canada.ca/en/services/defence/defence-equipment-purchases-upgrades.html.

<sup>&</sup>lt;sup>30</sup>Johnathan Holladay, Zia Abdullah, and Joshua Heyne, "Sustainable Aviation Fuel Review of Technical Pathways" (n.p.: U.S. Department of Energy, September 2020): 1, https://www.energy.gov/sites/prod/files/2020/09/f78/beto-sust-aviation-fuel-sep-2020.pdf.

<sup>&</sup>lt;sup>31</sup> National Defence, "Strong, Secure, Engaged....

Global superpowers, the United States and China, competing for technological and economic hegemony, are leveraging nationalism to drive climate discussions and negotiations, and therefore, their economic competitiveness for energy security has, at times, come at the expense of climate action.<sup>32</sup> Combined, both countries produce approximately 43 percent of the planets carbon emissions.<sup>33</sup> Canada's ambitious net-zero plan places the country as a key stakeholder in emissions reductions and efficient energy production, that could open market and partnership opportunities with the largest polluters on the planet. Canada ranks 6<sup>th</sup> in the world for primary energy production, with the US taking 90 % of its energy exports.<sup>34</sup> The Canadian Energy sector encompasses Crude oil, Refined petroleum products, Coal, Uranium, Electricity (renewable sources) and Natural Gas.<sup>35</sup> Less than a quarter of Canada's electrical demand is provided by some variant of fossil fuel, mainly in Saskatchewan and Alberta.<sup>36</sup> The remainder (82% at the end of 2018, placing Canada as the world leader in green electrical generation) was generated by renewable sources like hydro (60%), nuclear (15%), wind and solar (7%), with 8% of electricity exported to the US market.<sup>37</sup> Even with the transition away from coal, starting in 2001, and many advancements in electrical generation, the majority of Canada's emissions come from energy generation.<sup>38</sup> This is due to its varied meteorological conditions, populace dispersion and extensive landscape. Concurrent with globalization and increased market access, the majority of Canadian emissions come from the oil and gas, and transportation sectors, with

 <sup>&</sup>lt;sup>32</sup>Lydia Powell, "Climate Superpowers," 21st Century Diplomacy (The Wilson Center, September 30, 2019): 13, https://diplomacy21-adelphi.wilsoncenter.org/article/climate-superpowers.
 <sup>33</sup>Ibid..

<sup>&</sup>lt;sup>55</sup>101a,.

<sup>&</sup>lt;sup>34</sup>Canada, "ENERGY FACT BOOK 2020-2021," Government of Canada (n.p. Natural Resources Canada, 2021): 2-6, https://www.nrcan.gc.ca/sites/nrcan/files/energy/energy\_fact/2021-2022/PDF/2021\_Energy-factbook december23 EN accessible.pdf.

<sup>&</sup>lt;sup>35</sup>*Ibid*, 21.

<sup>&</sup>lt;sup>36</sup>Mark Zacharias, "There Is Only One Path....

<sup>&</sup>lt;sup>37</sup>Canada, "ENERGY FACT BOOK..., 33.

<sup>&</sup>lt;sup>38</sup>*Ibid*, 28-33.

year on year emissions increasing between 2000 and 2019.<sup>39</sup> This aligns with total energy production in Canada's, where nearly three quarters are a product of FFs.<sup>40</sup> At the height of the COVID pandemic, Environment and Climate Change Canada estimated that there were reductions of 26.3 megatons and 25.7 megatons of carbon equivalent emissions in the transportation, oil and gas sectors respectively.<sup>41</sup> To put that in perspective, combined, in a singular year, that would have been equal to removing over 58 million passenger vehicles or over 2 million tanker trucks' worth of gasoline, from our roads.<sup>42</sup> Clearly the greatest gains to be made for net-zero would be achieved in these two sectors, but they also account for Canada's largest requirements of energy, and are currently the largest contributors toward GDP in the energy sector.<sup>43</sup>

Canada has not rested on its laurels concerning renewable energy. Combined funding between Federal, Provincial and Territorial (P&T) governments for Research, Development and Demonstration (RD&D) was more than C\$600 million since 2014. In the fiscal year of 2018/2019, expenditures rose to a lofty C\$1,159 million.<sup>44</sup> These investments in Canada's energy future are mainly spread across three key areas: Energy end-use, including energy

<sup>43</sup>Canada, "ENERGY FACT BOOK..., 8.

<sup>&</sup>lt;sup>39</sup>Canada, "ENERGY FACT BOOK..., 34; Canada, "GREENHOUSE GAS EMISSIONS CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS" (Gatineau: Environment and Climate Change Canada, 2022): 6 & 8, https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/ghg-emissions/2022/ghgemissions-en.pdf.; Vaughn Maclellan and Jacquelyn Scott, "Reimagining Canada's Role in Global Energy Security: Practical Considerations for a Low Carbon Transition" (n.p.: Macdonald-Laurier Institute, March 21, 2022): 31 https://macdonaldlaurier.ca/wp-

content/uploads/2022/03/Mar2022\_Reimagining\_Canadas\_Role\_in\_Global\_Energy\_Security\_Kucharski\_Exner-Pirot\_PAPER\_FWeb.pdf.

<sup>&</sup>lt;sup>40</sup>Canada, "ENERGY FACT BOOK..., 4 & 36.

<sup>&</sup>lt;sup>41</sup>Canada, "GREENHOUSE GAS EMISSIONS ..., 22.

<sup>&</sup>lt;sup>42</sup>Canada, "Greenhouse Gas Equivalencies Calculator | Natural Resources Canada." Nrcan.gc.ca, 2022. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm#results.

<sup>&</sup>lt;sup>44</sup>*Ibid*, 18-20.

efficiencies in transportation and industry; Hydrocarbons, including Carbon Capture Storage and Utilisation (CCUS); and Renewable and clean energy, including nuclear.<sup>45</sup>

Energy RD&D technological advancements and advancements in multiple sectors have all been made possible by the oil and gas sector. Petroleum by-products are the basic feedstock chemicals required to produce up to 6000 products in use today, such as plastics, fertilizers, digital devices, medical equipment, composites, and various epoxies.<sup>46</sup> Increased demand for renewables has seen an increasing demand for thermal insulation, solar panels, batteries, and wind turbines, in Canada and abroad, all of which use petroleum by-products.<sup>47</sup> The IEA has predicted that petrochemicals will make up over a third of oil use by 2030, and half by 2050.<sup>48</sup> Dr. Fatih Birol, Executive Director of the IEA stated:

"Our economies are heavily dependent on petrochemicals, but the sector receives far less attention than it deserves. Petrochemicals are one of the key blind spots in the global energy debate, especially given the influence they will exert on the future energy trends. In fact, our analysis shows they will have a greater influence on the future of oil demand than cars, trucks, and aviation."<sup>49</sup>

The Canadian Energy Regulator's report on Energy demands and forecasts for 2050,

seems to support Dr. Birol's statement. The report, aimed at understanding the current state of

Canadian Energy Security, as well as energy projections enabling future planning.<sup>50</sup> The report

assessed that between a half and three-quarters of energy production will still be from FFs by

<sup>46</sup>Ranken Energy, "Products Made from Petroleum | Ranken Energy Corporation," Ranken-energy.com (n.p., 2016), https://www.ranken-energy.com/index.php/products-made-from-petroleum/.; The International Energy Agency, "Petrochemicals Set to Be the Largest Driver of World Oil Demand, Latest IEA Analysis Finds - News - IEA,"

<sup>&</sup>lt;sup>45</sup>*Ibid*, 21.

IEA.com (The International Energy Agency, October 5, 2018), https://www.iea.org/news/petrochemicals-set-to-be-the-largest-driver-of-world-oil-demand-latest-iea-analysis-finds.

<sup>&</sup>lt;sup>47</sup>Adelodun, Adedeji A. "Plastic Recovery and Utilization: From Ocean Pollution to Green Economy." Frontiers in Environmental Science 9 (July 9, 2021): "Introduction". https://doi.org/10.3389/fenvs.2021.683403.

<sup>&</sup>lt;sup>48</sup>The International Energy Agency, "Petrochemicals Set....; K. H. Juutilainen and Ugne Grikinyte, "Impact of COVID-19...., 9.

<sup>&</sup>lt;sup>49</sup>The International Energy Agency, "Petrochemicals Set....

<sup>&</sup>lt;sup>50</sup>Canada, "CER – Canada's Energy Future 2020," Cer-rec.gc.ca (Canada Energy Regulator, 2020): 20 & 35, https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/index.html.

2050, even with an almost doubling of electric generation from renewable sources.<sup>51</sup> The report demonstrates that the Canadian economy and the energy system are directly linked. Energy demand and supply are directly influenced by population growth, economic growth, and inflation, as well as industrial output. COVID has undoubtedly affected all those variables, but indications are that pre-COVID demand will return, one just needs to look at the aviation sector to see a rapid return of air travel.<sup>52</sup> Canada's economy and the energy sector cannot be drastically separated from FFs without dire consequences. The emissions targets of 2050 could be met, but it would require cutting fossil fuel production to levels well below those forecast by the energy regulator, and diminished energy returns. Without further advances and investment in the oil and gas sector to reduce or sequestrate emissions, while also gaining greater efficiencies in energy generation and use, Canada will fall short of reduced emissions targets and energy requirements.<sup>53</sup>

### **ENERGY SECURITY GLOBAL STEWARDS**

Several research areas present some promise in both energy security and emissions reductions or sequestration. Alternate low carbon fuels, CCUS, hydrogen, Small Modular Reactors (SMR), and direct air capture with carbon storage (DACCS) are either currently in use or under development, along with research in mitigation strategies with natural climate solutions.<sup>54</sup> Canada is leading the way globally in CCUS and DACCS, running 17 % of global CCUS projects, which are yet to reach commercial scale. While the technologies are viewed as being on the cusp of a breakthrough in reducing and capturing emissions in industrial processes,

<sup>&</sup>lt;sup>51</sup>*Ibid*, 62-64.; J Hughes, "Canada's Energy ..., 51-53 & 55.

<sup>&</sup>lt;sup>52</sup>Canada, "CER – Canada's Energy Future 2020..., 17-18 & 35.

<sup>&</sup>lt;sup>53</sup>Canada, "CER – Canada's Energy Future 2020..., 62-64; J Hughes, "Canada's Energy ..., 51-53 & 55.

<sup>&</sup>lt;sup>54</sup>Henry Stoch et al., "How Canada ..., "Emerging technologies."

it runs the risk of reduced investment as economies attempt to divest from the mining sector.<sup>55</sup> Proponents of the technology have suggested that once implemented; along with blue hydrogen, it will be transformative for the oil and gas sector and the greater economy. Blue hydrogen requires CCUS, therefore having installations like the Alberta Carbon Trunk Line (ACTL), which can transport 14 million tonnes of carbon dioxide per year, accounting for up to 20 % of the emissions from oilsands, is vital for its energy RD&D.<sup>56</sup> It is clear that continued investment in the energy sector's largest emitters, will be required to advance technologies to further Hydrogen as an energy source as well as reducing emissions at the source and capturing GHGs from the atmosphere.

Canada must overcome some challenges to removing emissions from the Oil and Gas, and Transportation sectors, including solving energy density equivalence and low or no carbon alternate fuels. Let us assume that suitable replacements have been found for petrochemical byproducts i.e., lubricants, conventional plastics replaced by 100 % bioplastics<sup>57</sup>, plastic reclamation projects<sup>58</sup>, and alternate epoxies. One would also have to assume that electricity will be end use-energy and used in an energy conversion pathway for biomass processing for gaseous and liquid fuels.<sup>59</sup> Full-scale electrification with the current generation of lithium-ion batteries at an energy density of 250 Wh/kg cannot compete with Jet fuels energy density of 12,000 Wh/kg (which doesn't account for further weight penalties associated with thermal runaway protection

<sup>&</sup>lt;sup>55</sup>Nnaziri Ihejirika, "The Role of CCUS in Accelerating Canada's Transition to Net-Zero" (n.p.: Oxford Institute for Energy Studies, September 2021): 19, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/09/The-Role-of-CCUS-in-Accelerating-Canadas-Transition-to-Net-Zero.pdf. <sup>56</sup>Ibid. 2.

<sup>&</sup>lt;sup>57</sup>BIOME Bioplastics, "Bioplastics - Biome Bioplastics," Biome Bioplastics (n.p., August 12, 2020),

https://biomebioplastics.com/bioplastics/.

<sup>&</sup>lt;sup>58</sup>Adelodun, Adedeji A. "Plastic Recovery ..., "Plastic Recovery" & "Pyrolysis of Plastics."

<sup>&</sup>lt;sup>59</sup>Gray, Nathan, Shane McDonagh, Richard O'Shea, Beatrice Smyth, and Jerry D Murphy. "Decarbonising Ships, Planes and Trucks: An Analysis of Suitable Low-Carbon Fuels for the Maritime, Aviation and Haulage Sectors." Advances in Applied Energy 1 (February 13, 2021): 2. https://doi.org/10.1016/j.adapen.2021.100008.

and other safety functions).<sup>60</sup> At a small scale like passenger electric vehicles, this issue is solved with large battery packs built into lighter vehicle bodies. As the size of the vehicle, truck, ship, or aircraft increases so do the energy requirements and the weight and size of the battery pack become overwhelmingly large.<sup>61</sup> While full electrification, without rapid advancements in battery technology is unfeasible, sustainable aviation fuels (SAFs) and Biofuels, could hold the answer to decarbonizing the sector. The international aviation sector would like to see 2 % SAFs being used by 2025, however current and proposed SAF producers account for only 1 %.62 The EU has proposed that 63 % SAF blends will be required by 2050, but the US through their Sustainable Aviation Fuel Grand Challenge is aiming for a total replacement by SAFs by 2050.63 Unlike the EU and the US, Canada has opted for the Clean Fuel Standard that aims to reduce the carbon intensity of fuels by 13 % below 2013 levels by 2030, however aviation fuels are exempt from this policy.<sup>64</sup> Current forecasts put SAF production at half a billion litres, in Canada by 2030, however, the Canadian aviation sector used more than 8 billion litres of aviation fuel in 2019, while the CER predicts usage to rise to 10.6 billion litres by 2030, implying SAFs only accounting for 4.5 % of the market.<sup>65</sup> Clearly energy generation in the aviation sector will still require FFs for the foreseeable future, until sufficient production of SAFs materialize and clear policy is mandated from the government.

<sup>&</sup>lt;sup>60</sup>Warwick, Graham, and Theirry Dubois. "What Are the Electric-Propulsion Challenges in Commercial Aviation? | Aviation Week Network." Aviationweek.com, (April 30, 2021): para 2. https://aviationweek.com/special-topics/sustainability/what-are-electric-propulsion-challenges-commercial-aviation.

<sup>&</sup>lt;sup>61</sup>Johnathan Holladay, Zia Abdullah, and Joshua Heyne, "Sustainable Aviation..., vi & footnote.

 <sup>&</sup>lt;sup>62</sup>The International Energy Agency, and Yannick Monschauer. "Aviation – Analysis - IEA." IEA, (n.p., November 2021): "Near- to medium-term decarbonisation solutions and challenges". https://www.iea.org/reports/aviation.
 <sup>63</sup>Ibid, "Near- to medium-term decarbonisation solutions and challenges."

<sup>&</sup>lt;sup>64</sup>Canada, "What Is the Clean Fuel Standard? - Canada.ca," Canada.ca (Environment and Natural Resources, January 20, 2022), https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard/about.html.; Deloitte. "Reaching Cruising Altitude a Plan for Scaling Sustainable Aviation Fuel." (n.p., n.d.): 15 Accessed May 18, 2022.

https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/strategy/ca-en-strategy-sustainable-aviation-pov-aoda.pdf?icid=sustainable-aviation\_en.

<sup>&</sup>lt;sup>65</sup>Deloitte. "Reaching Cruising Altitude..., 8.

Air transportation is vital for isolated remote communities in Canada, therefore cleaning up aviation emissions will go a long way toward net-zero. The problem though lies in remote communities not being connected to an electrical grid, requiring diesel for heating and electric generation, resulting in increased emissions per capita of the local population.<sup>66</sup> Renewable energy sources are helping reduce some reliance on diesel, however seasonal variability of wind and solar has limited full-scale replacement. Biomass and biofuels are other potential alternatives for northern energy security<sup>67</sup>; however, they would only benefit communities with all year road access.<sup>68</sup> Like SAFs, biofuels will compete for arable land in the agricultural sector and must strike a balance with Canada's food security.<sup>69</sup> Northern communities could therefore be best served by Small Modular Reactors (SMRs)<sup>70</sup>, notwithstanding reluctance of the world to accept an increase in nuclear proliferation – many seaports deny entry of nuclear vessels and nuclear fuel is a highly regulated commodity.<sup>71</sup> SMRs are a fledgling technology, still under development, with the earliest large scale implementation forecasts between 2035 and 2042 producing up to 900MW.<sup>72</sup> Even amid global competition to achieve economically sustainable SMRs, remote communities energy needs will continue to be derived primarily from FFs, requiring GHG offsets to achieve net-zero emissions.

<sup>&</sup>lt;sup>66</sup>Canada, "CER – Canada's Energy Future 2020..., 82.

<sup>&</sup>lt;sup>67</sup>Melanie Zurba and Ryan Bullock, "Bioenergy Development and the Implications for the Social Wellbeing of Indigenous Peoples in Canada," Ambio 49, no. 1 (March 21, 2019): 299–300, https://doi.org/10.1007/s13280-019-01166-1.

<sup>&</sup>lt;sup>68</sup>Canada, "CER – Canada's Energy Future 2020..., 87.

<sup>&</sup>lt;sup>69</sup>Nathan Gray et al., "Decarbonising Ships, Planes..., 9.

<sup>&</sup>lt;sup>70</sup>Canada, "CER – Canada's Energy Future 2020..., 87.

<sup>&</sup>lt;sup>71</sup>Nathan Gray et al., "Decarbonising Ships, Planes..., 5.

<sup>&</sup>lt;sup>72</sup>Bouffard-Nesbitt, Audrey, Stephen Furlan, and Sean C. O'Neill. "Canadian Power - SMRs: Canada Places a Bet That Its Future Could Be Nuclear." (McCarthy Tétrault, March 29, 2021): "Canadian Technology and Funding Updates". https://www.mccarthy.ca/en/insights/blogs/canadian-energy-perspectives/canadian-power-smrs-canadaplaces-bet-its-future-could-be-nuclear.

## CONCLUSION

Recent conflicts in Europe and energy insecurity in developing nations highlight the need for planning and a controlled, methodical transition toward renewables and net zero in Canada. Adverse weather events in Canada and the US, disabled electricity grids, proving dependence on FFs for immediate emergency energy backup. The fossil fuel industry is inextricably linked to the Canadian economy and achieving net-zero is not as simple as cutting off oil and gas production. The vast landmass and dispersed population will undoubtedly require multiple energy solutions. Alternate technologies, like large-scale batteries, CCUS, DACCS, blue hydrogen, SAFs and SMRs, are not advanced enough to rely on for energy in the oil and gas, and transportation sectors, meaning FFs will be required for some time to come. Blue hydrogen is reliant on CCUS, requiring continued investment in the oil and gas sector to advance the technologies to commercial scales. The same could be said for remote northern communities that rely on diesel generators for their energy needs, while biofuels and SAF production are not forecast to meet the demand to reduce dependence on FFs, in multiple sectors. The by-products of the petroleum industry are vital in current and developing technologies in the transition to renewables with both the CER and IEA forecasting their use will increase and continue to makeup large portions of oil production in 2050. The CER has reported continued investment and production of FFs, even with significant advances in renewable energy and energy efficiencies, while National Defence admits that FFs will continue to supply energy operational needs and air, land, and sea vehicles for some time to come. The downturn of GHG emitters during the height of the pandemic showed which sectors could be targeted for the greatest reductions, however, those sectors are Canada's greatest energy sinks. While not an exhaustive analysis, this paper has shown that energy security, while transitioning to net zero and renewable energy, will require investment and the use of fossil fuel.

## BIBLIOGRAPHY

- Adelodun, Adedeji A. "Plastic Recovery and Utilization: From Ocean Pollution to Green Economy." Frontiers in Environmental Science 9 (July 9, 2021). https://doi.org/10.3389/fenvs.2021.683403.Barrett, John. "Energy Security and Canadian Foreign Policy: A Role for Nuclear Energy," 2021. https://d3n8a8pro7vhmx.cloudfront.net/cdfai/pages/4584/attachments/original/16099013 22/Energy\_Security\_and\_Canadian\_Foreign\_Policy\_A\_Role\_for\_Nuclear\_Energy.pdf?1 609901322.
- Billard, Richard T. "Canada as a Global Energy Superpower? How Un-Canadian: A More Realistic Energy Strategy for Canada." Master of Defence Studies. Accessed February 28, 2022. <u>https://www.cfc.forces.gc.ca/259/290/295/286/billard.pdf</u>.
- BIOME Bioplastcis. "Bioplastics Biome Bioplastics." Biome Bioplastics. n.p., August 12, 2020. https://biomebioplastics.com/bioplastics/.Blank, Stephen J. "The Balkans and Euro-Atlantic Energy Security." Orbis 66, no. 1 (2022): 58–77. https://doi.org/10.1016/j.orbis.2021.11.006.
- Bouffard-Nesbitt, Audrey, Stephen Furlan, and Sean C. O'Neill. "Canadian Power SMRs: Canada Places a Bet That Its Future Could Be Nuclear." McCarthy Tétrault, March 29, 2021. <u>https://www.mccarthy.ca/en/insights/blogs/canadian-energy-perspectives/canadian-power-smrs-canada-places-bet-its-future-could-be-nuclear</u>.
- Briscoe, Ivan. "Non-Conventional Armed Violence and Non-State Actors: Challenges for Mediation and Humanitarian Action." Norwegian Peacebuilding Resource Centre, May 2013.
- Canada. "Canada's Climate Plan Canada.ca." Canada.ca. Canada, 2022. <u>https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan.html.</u>
- Canada, Service. "Net-Zero Emissions by 2050 Canada.ca." Canada.ca, 2021. https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/netzero-emissions-2050.html.
- Canada. "Canada's Energy Sector Status, Evolution, Revenue, Employment, Production Forecasts, Emissions and Implications for Emissions Reduction." Vancouver: Corporate Mapping Project, June 2021. <u>https://policyalternatives.ca/sites/default/files/uploads/publications/BC%200ffice/2021/0</u> <u>6/REPORT\_ccpa-bc-cmp\_canadas-energy-sector.pdf</u>.
- Canada. "CER Canada's Energy Future 2020." Cer-rec.gc.ca. Canada Energy Regulator, 2020. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/index.html.

- Canada. "ENERGY FACT BOOK 2020-2021." Government of Canada. n.p: Natural Resources Canada, 2021. <u>https://www.nrcan.gc.ca/sites/nrcan/files/energy/energy\_fact/2021-2022/PDF/2021\_Energy-factbook\_december23\_EN\_accessible.pdf.Energy.gov</u>.
- Canada. "GREENHOUSE GAS EMISSIONS CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS." Gatineau: Environment and Climate Change Canada, 2022. <u>https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/ghg-</u> emissions/2022/ghg-emissions-en.pdf.
- Canada. "What Is the Clean Fuel Standard? Canada.ca." Canada.ca. Environment and Natural Resources, January 20, 2022. <u>https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard/about.html</u>.
- Canada. "Strong, Secure, Engaged: Moving to Sustainable Defence Operations." The Maple Leaf, 2020. https://www.canada.ca/en/department-national-defence/maple-leaf/defence/2020/02/strong-secure-engaged-moving-to-sustainable-defence-operations.html.
- Caranci, Beata, Francis Fong, and Yasmine El Baba. "Don't Let History Repeat: Canada's Energy Sector Transition and the Potential Impact on Workers." n.p, TD, April 6, 2021. <u>https://economics.td.com/domains/economics.td.com/documents/reports/ff/A\_Just\_Transition\_for\_Energy\_Workers.pdf</u>.
- Cassolato, Suzanne, LCol Lloyd Chubbs, Ed Andrukaitis, Vivier Lefebvre, and Martin Kegel. "Operational Energy a Multi-Faceted Government Approach." n.p.: Defence Research and Development Canada, May 2018. <u>https://cradpdf.drdcrddc.gc.ca/PDFS/unc304/p806435\_A1b.pdf</u>.
- Climate Council. "What Does Net Zero Emissions Mean? | Explainer." Climate Council. n.p., October 26, 2021. <u>https://www.climatecouncil.org.au/resources/what-does-net-zero-emissions-mean/</u>.
- Deloitte. "Reaching Cruising Altitude, a Plan for Scaling Sustainable Aviation Fuel." Accessed May 18, 2022. <u>https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/strategy/ca-en-strategy-sustainable-aviation-pov-aoda.pdf?icid=sustainable-aviation\_en</u>.
- Dion, Jason, Anna Kunduth, Jeremy Moorehouse, and Dale Beugin. "Canada's Net Zero Future: Finding Our Way in the Global Transition." Climatechoices.com. n.p.: Canadian Institute for Climate Choices, February 2021. https://climatechoices.ca/wpcontent/uploads/2021/02/Canadas-Net-Zero-Future\_FINAL-1.pdf.
- Gattinger, Monica. "Energy Security and the Road to Net Zero by 2050." Calgary: Canadian Global Affairs Institute, April 2021.

https://d3n8a8pro7vhmx.cloudfront.net/cdfai/pages/4685/attachments/original/16194686 33/Energy\_Security\_and\_the\_Road\_to\_Net\_Zero\_by\_2050.pdf?1619468633.

- Gray, Nathan, Shane McDonagh, Richard O'Shea, Beatrice Smyth, and Jerry D Murphy.
  "Decarbonising Ships, Planes and Trucks: An Analysis of Suitable Low-Carbon Fuels for the Maritime, Aviation and Haulage Sectors." Advances in Applied Energy 1 (February 13, 2021). https://doi.org/10.1016/j.adapen.2021.100008.
- Holladay, Johnathan, Zia Abdullah, and Joshua Heyne. "Sustainable Aviation Fuel Review of Technical Pathways." n.p.: U.S. Department of Energy, September 2020. https://www.energy.gov/sites/prod/files/2020/09/f78/beto-sust-aviation-fuel-sep-2020.pdf.
- Hughes, J. "Canada's Energy Sector Status, Evolution, Revenue, Employment, Production Forecasts, Emissions and Implications for Emissions Reduction." Vancouver: Canadian Centre for Policy Alternatives, June 2021.
   <u>https://policyalternatives.ca/sites/default/files/uploads/publications/BC%200ffice/2021/0</u> <u>6/REPORT\_ccpa-bc-cmp\_canadas-energy-sector.pdf</u>.
- Ihejirika, Nnaziri. "The Role of CCUS in Accelerating Canada's Transition to Net-Zero." n.p.: Oxford Institute for Energy Studies, September 2021. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/09/The-Role-of-CCUSin-Accelerating-Canadas-Transition-to-Net-Zero.pdf.
- Just Energy. "The Average Cost of Electricity, Country by Country." justenenery.com. Just Energy, October 24, 2013. <u>https://justenergy.com/blog/the-average-cost-of-electricity-</u> <u>country-by-country/</u>.
- Juutilainen, K. H., and Ugnė Grikinytė. "Impact of COVID-19 on NATO Energy Security -View on Fuels, Gas and Renewable Energy." NATO Energy Security Centre of Excellence. n.p.: NATO Energy Security Centre of Excellence. Accessed May 20, 2022. <u>https://www.enseccoe.org/data/public/uploads/2021/08/nato-ensec-coe-impact-of-covid-19-on-nato-energy-security-view-on-fuels-gas-and-renewable-energy.pdf</u>.
- Larose, Patrick. "A BOLD IDEA to LAUNCH CANADA'S ENERGY FUTURE Lieutenant-Commander Patrick Larose." Canadian Forces College, 2020. <u>https://www.cfc.forces.gc.ca/259/290/22/305/Larose.pdf</u>.
- Latif, Khalid, Muhammad Yousaf Raza, Ghulam Mujtaba Chaudhary, and Adeel Arshad.
   "Analysis of Energy Crisis, Energy Security and Potential of Renewable Energy: Evidence from Pakistan." Journal of Accounting and Finance in Emerging Economies 6, no. 1 (2020): 167-182.
- Maclellan, Vaughn, and Jacquelyn Scott. "Reimagining Canada's Role in Global Energy Security: Practical Considerations for a Low Carbon Transition." n.p.: Macdonald-Laurier Institute, March 21, 2022. <u>https://macdonaldlaurier.ca/wp-</u>

content/uploads/2022/03/Mar2022\_Reimagining\_Canadas\_Role\_in\_Global\_Energy\_Sec urity\_Kucharski\_Exner-Pirot\_PAPER\_FWeb.pdf.

- McKenzie, Janetta. "Balancing Energy Security and Climate Action in 2022." Pembina Institute. Pembina, April 26, 2022. <u>https://www.pembina.org/op-ed/balancing-energy-security-and-climate-action-2022</u>.
- Mulcair, Tom. "Trudeau's Phony War against Climate Change: Tom Mulcair." CTVNews. CTV News, April 5, 2022. <u>https://www.ctvnews.ca/politics/tom-mulcair-trudeau-s-phony-war-against-climate-change-1.5848812</u>.
- Natcher, David and Shawn Ingram. "A Nexus Approach to Water, Energy, and Food Security in Northern Canada." Arctic 74, no. 1 (2021): 1-11.
- NATO Energy Security Centre of Excellence. "Web Conferences on Climate Change and Energy Security for NATO Nations." n.p.: NATO Energy Security Centre of Excellence, May 27, 2021. <u>https://enseccoe.org/data/public/uploads/2021/10/web-conferences-onclimate-change-and-energy-security-for-nations.pdf</u>.
- Natural Resources Canada. "NATO Science for Peace and Security Camp Energy Efficiency Project." Nrcan.gc.ca, 2018. <u>https://www.nrcan.gc.ca/energy/energy-offices-and-labs/canmetenergy/canmetenergy-varennes/northern-remote-infrastructures/nato-efficiency-project/24174</u>.
- Office of Fossil Energy and Carbon Management. "Strategic Petroleum Reserve." Energy.gov. n.p., 2020. https://www.energy.gov/fecm/strategic-petroleum-reserve.Paravantis, J. A., N. Kontoulis, A. Ballis, D. Tsirigotis, and V. Dourmas. "A Geopolitical Review of Definitions, Dimensions and Indicators of Energy Security."IEEE, 2018. doi:10.1109/IISA.2018.8633676.
- Paton, Nick. "Images Show Build up of Russia's Military Presence in the Arctic." CNN, April 5, 2021. <u>https://www.cnn.com/2021/04/05/europe/russia-arctic-nato-military-intl-cmd/index.html</u>.
- Ranken Energy. "Products Made from Petroleum | Ranken Energy Corporation." Rankenenergy.com. n.p., 2016. <u>https://www.ranken-energy.com/index.php/products-made-frompetroleum/</u>.
- Raymond, Ted. "What Is a 'Derecho'? Climatologist Explains Saturday's Powerful Storm." Ottawa. CTV News, May 22, 2022. <u>https://ottawa.ctvnews.ca/what-is-a-derecho-</u> <u>climatologist-explains-saturday-s-powerful-storm-1.5914534</u>.
- Razek, Noha. "As the World Moves Away from Fossil Fuels, Canada's Energy Security May Be at Risk." The Conversation. n.p., November 11, 2021. <u>https://theconversation.com/as-the-world-moves-away-from-fossil-fuels-canadas-energy-security-may-be-at-risk-169794</u>.

- RBC Thought Leadership. "The \$2 Trillion Transition: Canada's Road to Net Zero." RBC Thought Leadership. n.p., October 20, 2021. <u>https://thoughtleadership.rbc.com/the-2-trillion-transition/</u>.
- Rioux, Jean-Sébastien, and Jennifer Winter. "Forks in the Road: Energy Policies in Canada and the US since the Shale Revolution." American Review of Canadian Studies, June 24, 2020. <u>https://www-tandfonline-</u> com.cafvl.idm.oclc.org/doi/full/10.1080/02722011.2020.1743015.
- Rumer, Eugene, Richard Sokolsky, and Paul Stronski. "Russia in the Arctic- a Critical Examination MARCH 2021 | the RETURN of GLOBAL RUSSIA." Carnegie Endowment for International Peace. Washington: Carnegie Endowment for International Peace, March 2021. https://carnegieendowment.org/files/Rumer\_et\_al\_Russia\_in\_the\_Arctic.pdf.\_\_\_\_\_.
  "The Average Cost of Electricity, Country by Country." justenergy.com, October 24, 2013. https://justenergy.com/blog/the-average-cost-of-electricity-country/.
- Stoch, Henry, Jurgen Beier, Jennifer Lee, and Sean Delsnider. "How Canada Can Decarbonize by 2050 | Deloitte Canada." Deloitte Canada. n.p.: Deloitte Canada, 2021. https://www2.deloitte.com/ca/en/pages/strategy/articles/how-canada-can-decarbonize-by-2050.html.
- The International Energy Agency. "Petrochemicals Set to Be the Largest Driver of World Oil Demand, Latest IEA Analysis Finds News IEA." IEA.com.
- The International Energy Agency, October 5, 2018. https://www.iea.org/news/petrochemicalsset-to-be-the-largest-driver-of-world-oil-demand-latest-iea-analysis-finds.Powell, Lydia. "Climate Superpowers." 21st Century Diplomacy. The Wilson Center, September 30, 2019. https://diplomacy21-adelphi.wilsoncenter.org/article/climate-superpowers.
- The International Energy Agency. "A 10-Point Plan to Cut Oil Use Analysis IEA." The International Energy Agency, March 1, 2022. <u>https://www.iea.org/reports/a-10-point-plan-to-cut-oil-use</u>.
- The International Energy Agency, and Yannick Monschauer. "Aviation Analysis IEA." IEA, November 2021. <u>https://www.iea.org/reports/aviation</u>.
- The International Energy Agency. "Petrochemicals Set to Be the Largest Driver of World Oil Demand, Latest IEA Analysis Finds News IEA." IEA.com.
- The International Energy Agency, October 5, 2018. https://www.iea.org/news/petrochemicalsset-to-be-the-largest-driver-of-world-oil-demand-latest-iea-analysis-finds.Powell, Lydia. "Climate Superpowers." 21st Century Diplomacy. The Wilson Center, September 30, 2019. https://diplomacy21-adelphi.wilsoncenter.org/article/climate-superpowers.

- Trace, Simon. "South Africa's Crippling Electricity Problem." Oxford Policy Management, January 31, 2020. <u>https://www.opml.co.uk/blog/south-africa-s-crippling-electricity-problem</u>.
- United States of America. "Strategic Petroleum Reserve." Energy.gov. Office of Fossil Energy and Carbon Management, 2020. <u>https://www.energy.gov/fecm/strategic-petroleumreserve</u>.
- Warwick, Graham, and Theirry Dubois. "What Are the Electric-Propulsion Challenges in Commercial Aviation? | Aviation Week Network." Aviationweek.com, April 30, 2021. <u>https://aviationweek.com/special-topics/sustainability/what-are-electric-propulsionchallenges-commercial-aviation</u>.
- Zacharias, Mark. "There Is Only One Path to Long-Term Energy Security and Affordability: Clean Energy - Clean Energy Canada." Clean Energy Canada. n.p., April 1, 2022. <u>https://cleanenergycanada.org/there-is-only-one-path-to-long-term-energy-security-and-affordability-clean-energy/</u>.
- Zhiznin, Stanislav Z, Vladimir M Timohov, and Velislava Dineva. "Energy Security: Theoretical Interpretations and Quantitative Evaluation." International Journal of Energy Economics and Policy 10, no. 2 (2020): 390–400. https://www.econjournals.com/index.php/ijeep/article/view/8950.
- Zurba, Melanie, and Ryan Bullock. "Bioenergy Development and the Implications for the Social Wellbeing of Indigenous Peoples in Canada." Ambio 49, no. 1 (March 21, 2019): 299–309. https://doi.org/10.1007/s13280-019-01166-1.