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DEPARTMENT OF NATIONAL DEFENCE ARCTIC REAL PROPERTY: A BRIDGE TOO FAR IN THE GREENING GOVERNMENT STRATEGY

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INTRODUCTION

> *Net-zero is a moon shot and a moon shot is not the same as just throwing ideas out there and seeing what sticks.*
>
> — The Honourable Seamus O'Regan, MP, Minister of Natural Resources

Earth's climate is warming[1]! Canada is expected to experience a temperature rise of 9.5 degrees Celsius by the year 2100 and the effects of global warming will impact the economy, the ecosystem, our natural resources, and Canadian's health and safety[2]. According to leading climate scientists, human activity is the cause of recent changes to the earth's climate[3]. Anthropogenic climate change is a major cause of the sharp rise in global temperatures, damaging the environment in Canada and around the world[4]. The burning of fossil fuels in electrical power generating and heating systems, releases carbon dioxide and other greenhouse gases into the atmosphere, which subsequently traps solar radiation[5]. Normally, a balance of different gases in the earth's atmosphere moderates the amount of the earth's solar gain, keeping the earth within a standard temperature range. Compared to the pre-industrial era, the global atmospheric carbon dioxide concentration has increased by approximately 42 percent[6]. Increased carbon dioxide in the atmosphere has amplified the solar radiation gain of the earth and over the last century, has increased

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[1] Environment and Climate Change Canada, *Key Issues with Climate Change* (Ottawa: Government of Canada, 2015).

[2] Ibid.

[3] Margaret Purdy and Leanne Smythe, "From Obscurity to Action: Why Canada must Tackle the Security Dimensions of Climate Change," *International Journal (Toronto) 65, no. 2* (1 April 2010), 411-433, https://www.jstor.org/stable/25681119.

[4] David Suzuki Foundation, "What is Climate Change," last accessed 25 November 2020, https://davidsuzuki.org/what-you-can-do/what-is-climate-change/.

[5] Ibid.

[6] Ibid.

the global temperature by 0.7 degree Celsius[7]. Global warming affects in Canada are almost double compared to other regions on earth, causing significant changes to Canada's weather patterns, sea level rise, and the release of even worse greenhouse gases such as methane[8]. Climate change and the resulting global warming is threatening Canada's critical infrastructure, and Canada's resilience as a state[9].

In 2017, the Canadian Government introduced the Greening Government Strategy (GGS) in an effort to fight the effects of climate change, and reduce the impact of global warming on Canada's resilience and security[10]. This strategy will adapt all of the Government of Canada's operations to better combat climate change and is applicable to all federal departments[11]. The federal government is focusing the strategy targets on operations that are considered high greenhouse gas emitters: mobility and fleets, climate-resilient services and operations, procurement of goods and services, and real property and workspaces[12]. As the largest greenhouse gas emitter in the federal government, the Department of National Defence (DND) is especially interested in the GGS real property targets. The DND real property assets located in the Canadian Arctic region represent a disproportionately higher contribution to the DND's greenhouse gas emissions, as the

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[7] Canadian Metrological and Oceanographic Society, "The state of science Canada's climate is changing dramatically," last accessed 06 March 2021, https://www.cmos.ca/site/ps_pos_statements?a=5#:~:text=Canada's%20climate%20is%20changing%20dramatically,occurred%20within%20the%20past%20decade.

[8] Canadian Metrological and Oceanographic Society, "CMOS Climate Change position statement," last accessed 06 March 2021, https://www.cmos.ca/site/ps_pos_statements?a=9.

[9] T.J. Gardner, "Climate Change: The Security of Canada's Critical Infrastructure, Food Supply, Indigenous Culture, and Natural Resources" (Joint Command and Staff Program Course Paper, Canadian Forces College, 2020), 11-12.

[10] Treasury Board of Canada Secretariat, *Greening Government Strategy: A Government of Canada Directive* (Ottawa: Treasury Board Secretariat of Canada, 2017), 1.

[11] Ibid., 4.

[12] Ibid., 1-2.

departments operations in the Arctic are solely reliant on fossil fuels to power their electric and heating systems[13].

The GGS target for all Government of Canada real property operations is to reduce all carbon emissions to net-zero carbon by 2050[14]. This is key to understanding the energy challenge faced by the department, and specifically the fuel-thirsty Arctic real property portfolio. Net-zero carbon refers to the balance between emitting and removing human-caused greenhouse gases from the atmosphere, and can include residual greenhouse gas emissions that are offset by carbon absorbing or sink operations[15].

Based on current decarbonizing technology that is commercially available, this target is likely achievable by the target date for DND real property located in more temperate zones in Canada[16]. The extremely harsh climate and seasonal challenges of the Canadian Arctic prevent the same decarbonizing technology from being used by the DND to achieve the strategy targets for real property located in the region. Any emerging energy technology that is on the horizon that is being considered to decarbonize remote Arctic communities will not be ready for the GGS target date of 2050.

I argue that current renewable energy technologies are not capable to reach the net-zero carbon emissions target for the DND's real property located in the Canadian

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[13] The Arctic region consists of the three territories and the northern parts of the Provinces of Newfoundland and Labrador, Quebec, and Manitoba. The term "Arctic" will be used for the remainder of this paper to refer to the Arctic region.

[14] Ibid., 2.

[15] Canada Energy Regulator, Canada's Energy Future: Infrastructure Changes and Challenges to 2020, (Ottawa: National Energy Board, 2020), 16.

[16] For this paper, zones that are more temperate are considered non-Arctic locations that have ready access to provincial or territorial power grids, daily sunlight and conditions more favourable to proven renewable energy technology.

Arctic. The current renewable energy technologies that are commercially available to decarbonize the federal real property portfolio are not capable to perform in the extremely harsh Arctic environment. Wind turbines are susceptible to extreme cold weather conditions, and solar photovoltaic will not work in the winter season due to the total lack of sunlight. Hydroelectric and tidal energy technology is not accessible in the high Arctic due to extremely low temperature constraints, and geothermal is terribly inefficient in the Arctic due to the significant depth at which sufficient heat-energy is available. Too further hinder the targets set by the GGS, the emerging technologies proposed by Canada's Energy Regulator will not be ready for implementation in remote Arctic locations by the strategy target date.

DISCUSSION

At first glance, the GGS provides a path to net-zero carbon emissions. This is likely the case for non-Arctic regions in Canada with sufficient access to grid-tied renewable energy sources such as hydroelectric power or wind turbine farms. What follows is a discussion on the failures of the strategy and the defence policy to take into account the extreme environment found in the Arctic and the challenging energy nexus that exists in remote communities.

Greening Government Strategy. The GGS necessitates two actions: to reduce the emission of greenhouse gases into the atmosphere, and to increase the resilience of Canadian Government assets, services, and operations in order to adapt to the outcome of climate change[17]. For real property operations, the first action entails the mitigation of

[17] Treasury Board of Canada Secretariat, *Greening Government Strategy: A Government of Canada Directive* (Ottawa: Government of Canada, 2017), 1.

operations such as real property electrical generating systems to reduce the root cause (carbon) of climate change[18]. An example of this would be to replace existing electrical generating systems such as diesel generators with net-zero carbon producing systems such as solar or wind energy technologies. As climate change is caused by greenhouse gas emissions, this action would reduce the carbon released into the atmosphere, reducing Canada's greenhouse gas contribution to future climate change.

The second action for real property operations can be described as the adaptation of building systems to ensure Canadian Government operations can continue unhindered with the increase of global temperatures, the rise of sea level and increased storm frequency[19]. As global temperatures increase, adaptation will be utilized to maintain resiliency of Canadian Government assets, services, and operations in order to adjust to the changed environment[20]. An example of adaptation would be to increase the insulation of the building envelope of a real property asset to reduce the heat-gain of a building during periods of extreme heat, increasing the asset efficiency while making the building more resilient to increased global temperatures[21].

The GGS also includes the ability of federal departments to utilize offsets within the real property portfolio that are performing better than net-zero[22]. If the DND's Arctic real property will not reach the net-zero target, the likely hood of finding energy offsets in any government real property asset located in the Arctic will be a significant challenge.

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[18] Treasury Board of Canada Secretariat, *Greening Government Strategy: A Government of Canada Directive* (Ottawa: Treasury Board of Canada Secretariat, 2017), 1.

[19] Ibid.

[20] Ibid.

[21] Ibid.

[22] Ibid.

The DND's Arctic assets account for approximately 4.83% of the department's real property portfolio when comparing building area, but account for over 10% of the department's total greenhouse gas emissions[23]. This is key to understanding the disproportionate energy challenge faced by the DND in the reduction of carbon production in the Arctic to net-zero[24].

In a report on Canada's Energy Futures from Canada's Energy Regulator, the regulator discusses the potential pathways to decarbonize remote communities located in Canada's North[25]. These pathways include key trends and key uncertainties involved in changing the carbon scheme in remote and Arctic communities[26]. The pathways identified by the regulator also apply to the department's remote Arctic sites as they share the same energy nexus.

The regulator identifies the movement away from fossil fuels for electrical production and heating of buildings, and the exploration of renewable energy technologies such as wind, solar, biomass and other hybrid systems as key trends in these remote areas[27]. More importantly, the report also identifies key uncertainties in transitioning these remote communities away from fossil fuel dependence[28]. The most important key uncertainty is the pace at which the development of the key emerging technologies are advancing. In order to meet the strategy's targets, these emerging

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[23] Treasury Board of Canada Secretariat, *Government of Canada Greenhouse Gas Emissions Inventory* (Ottawa: Treasury Board of Canada Secretariat, 2020).

[24] Ibid., 2.

[25] Canada Energy Regulator, *Canada's Energy Future: Infrastructure Changes and Challenges to 2020*, (Ottawa: National Energy Board, 2020), 86-87.

[26] Ibid.

[27] Ibid.

[28] Ibid.

technologies will be needed earlier than expected due to the required Aboriginal engagements and the logistical challenges that will extend construction project timelines[29].

The regulator recognizes the vulnerability of current renewable energy technology in the extreme cold, the lack of sunlight for almost half of the year, and the increased costs associated with transporting renewable energy equipment to remote Arctic communities by commercial airlift or annual sealift operations[30]. The report on Canada's Energy Futures also identifies energy supply security as a critical factor in providing energy to remote communities[31]. Energy supply security is critical because the low population density, extreme environment, remoteness and high transportation costs associated with remote Arctic communities creates a poor economy of scale for energy provision[32].

As identified in this section, the GGS offers a two-pronged approach (adaptation and mitigation) to combating climate change, but the strategic level action plan does not account for the insurmountable challenges faced by Arctic communities in achieving the target. The energy regulator recognizes that the current renewable energy technologies are not Arctic capable, while offering no mature technological alternatives[33]. The strategy

[29] Logistics, land claims, Aboriginal engagement, and the extremely harsh climate all add significant time to Arctic construction projects. Typical construction projects completed in the Arctic take up to 4 times that of similar projected constructed in non-Arctic regions.

[30] Canada Energy Regulator, *Canada's Energy Future: Infrastructure Changes and Challenges to 2020*, (Ottawa: National Energy Board, 2020), 86-87.

[31] Ibid., 82.

[32] Ibid.

[33] Ibid.

will fail in the Arctic without a commercially viable energy plan championed by the inhabitants of the Arctic, industry and the energy regulator.

Greening Defence. In fiscal year 2020, the DND produced over half of the Canadian Government's total greenhouse gas emissions compared to all other federal departments combined[34]. Of the 515.4 kilotonnes of greenhouse gas emissions the DND released in fiscal year 2020 for the operation of all defence real property facilities across Canada, 55.576 kilotonnes were released while operating all of the defence real property facilities located in the North[35]. A key enabler of the DND's ability to meet the GGS is the defence policy. The current defence policy does not fully align with the GGS as the defence policy states that the DND is committed to reducing their emissions to 40 percent of 2005 levels by the year 2040[36]. The emission reduction targets identified in Canada's defence policy are much lower than the targets identified in the GGS.

The current defence policy includes commitments for the DND to address climate change. These defence policy initiatives include the disposal of underutilized or obsolete buildings (mitigation), the installation of energy performance contracts at defence sites to improve resiliency of the facilities (adaptation), and the construction of new facilities to the silver level of the Leadership in Energy and Environmental Design (LEED) (adaptation and mitigation)[37]. LEED is a global rating standard championed in Canada by the Canada Green Building Council, which aims to create high-performing, healthy,

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[34] Treasury Board of Canada Secretariat, *Government of Canada Greenhouse Gas Emissions Inventory* (Ottawa: Treasury Board of Canada Secretariat, 2020).

[35] Ibid.; William Wyman (Real Property Operations – North, Environment Officer), telephone conversation with author, 23 February 2021.

[36] Department of National Defence, *Strong, Secure, Engaged – Canada's Defence Policy* (Ottawa: Department of National Defence, 2017), 75-76.

[37] Ibid., 75.

green buildings and communities[38]. Building new facilities to the LEED silver level will green the Northern defence portfolio, however, this initiative will not achieve the GGS target of net-zero carbon production by 2050.

How Green is LEED? A 2011 study of 984 commercial buildings located in New York City, New York determined that of all the buildings studied, the 21 buildings certified to the silver or gold level in LEED consumed the same amount of energy and emitted the same level of greenhouse gas as other non-certified comparable buildings.[39] Natural Resources Canada conducted a re-analysis of the same data from the 2011 study and found that on average, that LEED buildings used 18-39% less energy per floor than conventional buildings of similar design and construction[40]. The researcher also found that 28% to 35% of LEED buildings consumed more energy that similar conventional buildings[41].

Even if we can green all of the DND buildings in the Arctic, human behaviour may not allow the department to achieve the federal government's targets. Authors of a 2009 study that examined pro-environmental behaviours in occupants of LEED certified green buildings, determined that human behaviour is a critical component of achieving

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[38] Canada Green Building Council, "Leadership in Energy and Environmental Design - Why LEED?," last accessed 2 April 2021, https://www.cagbc.org/CAGBC/LEED/Why_LEED/CAGBC/Programs/LEED/_LEED.aspx?hkey=5d7f0f3e-0dc3-4ede-b768-021835c8ff92.

[39] John Scofield, "Efficacy of LEED-certification in reducing energy consumption and greenhouse gas emission for large New York City office buildings," *Energy and Buildings* 67 (December 2013): 523–524. https://www.sciencedirect.com/science/article/pii/S037877881300529X.

[40] National Research Council, *Do LEED-Certified Buildings Save Energy? Yes, But*… (Ottawa: National Research Council, 2009), 14.

[41] Ibid.

the green energy goals attributed to a green building[42]. The authors further determined that the complexity of a green energy component of the building and the ease of operation were key factors in the prevalence of usage by occupants[43]. If an energy saving system was difficult to operate or the purpose of the energy saving system was not well understood by the occupants, the system was not likely to be operated by occupants[44]. The results of this study also determined that the ease or difficulty of the pro-green energy behavior (how easy or hard a new energy saving behaviour was to learn) was directly related to the success of the desired behavior[45]. The success of the GGS will also be dependent on a change in culture in the occupants and maintenance operators of the department's sites in the Arctic.

The defence policy initiatives relevant to decarbonizing of real property do not identify a clear path to the GGS 2050 target, nor does it identify any initiatives to tackle the unique challenges that exist in the Arctic[46]. Implementing the silver level for LEED, reducing excess assets, executing energy performance contracts, and changing the culture towards green buildings will significantly increase the efficiency of the real property assets in the Arctic, but it will not be enough to meet the targets set by the GGS.

Current Site Technologies. The DND operates 58 sites across the Yukon, North West and Nunavut Territories, and the Province of Newfoundland and Labrador[47].

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[42] A. Hill et al., "Empirical Examination of Pro-Environmental Behaviors in Traditional, Green Featured, and LEED Certified Buildings," *Energy Procedia* 158 (February 2019), 3982-3983. http://dx.doi.org/10.1016/j.egypro.2019.01.843.

[43] Ibid.

[44] Ibid.

[45] Ibid., 3986.

[46] Ibid.

[47] The sites operated by National Defence in the Arctic are: a total of 47 North Warning System sites located across the Arctic and North region; one site in Happy Valley-Goose Bay, Labrador; one site in

Approximately 12% of these sites receive electricity from power plants operated by the provincial or territorial power provider in the local communities. In addition to the fossil fuels consumed by the community power plants, these sites burn a variety of types of fossil fuels for heating purposes. These DND sites were responsible for the release of approximately 35 kilotonnes of greenhouse gases in fiscal year 2020. The remaining facilities (88%) are considered remote as the sites generate their own electricity and heat from onsite fossil-fuel powered electrical generating systems and heating equipment. These remote sites consumed a combined total of 8 million litres of either jet propulsion, diesel or number-two heating oil for fiscal year 2020, all of which had to be transported to the sites by barge or aircraft[48]. The greenhouse gas emissions from operating the real property for these sites totalled over 20 kilotonnes for the same period[49]. The fuel consumption and subsequent greenhouse gas emissions for these remote sites do not take into account the emissions related to the manufacturing or transportation of the fossil fuels consumed.

The burning of diesel or other light oil in an internal combustion engine or a fuel-fired heating system is a proven and reliable method of providing electricity and heat at remote Arctic sites. The current site technologies meet the unique energy nexus that exists in the Arctic. However, with a thermal efficiency of 40% to 45% for a conventional diesel engine and the high greenhouse gas emissions associated with

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Alert, NU; one site in Eureka, NU; one site in Gascoyne Inlet, NU; one site in Nanasivik, NU; one site in Resolute Bay, NU; one site in Rankin Inlet, NU; one site in Iqaluit, NU; one site in Inuvik, NWT; one site in Yellowknife, NWT; and one site in Whitehorse, NWT.

[48] William Wyman (Real Property Operations North Environment Officer), telephone conversation with author, 23 February 2021.

[49] Treasury Board of Canada Secretariat, *Government of Canada Greenhouse Gas Emissions Inventory* (Ottawa: Treasury Board of Canada Secretariat, 2020).

burning of fossil fuels, another solution must be found in order to reach the net-zero carbon target for the DND's real property[50].

Proven Decarbonizing Technologies. Renewable energy technologies that are at a maturity level that could be considered as a low-carbon alternative to fossil fuels in the Arctic include wind, solar, hydro, geothermal and tidal power[51]. These technologies are limited by the seasonal availability of natural resources near the remote communities or DND sites, as is the case for tidal, geothermal, hydropower or solar photovoltaic. Wind turbines suffer from extreme cold weather related operational limits due to material and engineering factors. Although the researchers of a paper for the Arctic Yearbook identified that wind turbine technology had a 20% increase in efficiency in cold temperatures, the cost to install wind turbines in the Arctic was estimated at 2 to 3 times the industry cost for non-Arctic regions[52]. Technical challenges associated with icing or frosting of the wind turbine blades have yet to be overcome by industry[53]. The authors also point out that solar photovoltaic cells are a seasonal option due to the lack of sunlight in the Arctic in the winter[54]. The authors also determined that solar photovoltaic cells do benefit from the solar radiation reflected off the snow during the shoulder seasons[55]. Cold temperatures do benefit photovoltaic panel performance, but when you combine the

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[50] Alias Noor *et al*, *Technologies for Waste Heat Energy Recovery from Internal Combustion Engine: A Review* (Istanbul: International Conference on New Trends in Multidisciplinary Research & Practice, 2015), 1. https://www.researchgate.net/publication/283732724_Technologies_for_Waste_Heat_Energy_Recovery_from_Internal_Combustion_Engine_A_Review.

[51] Magnus de Witt, Hlynur Stefánsson, and Ágúst Valfells, "Energy security in the Arctic: Policies and technologies for integration of renewable energy," *The Arctic Yearbook – Redefining Arctic Security*, (2019), 2. https://arcticyearbook.com/arctic-yearbook/2019/2019-briefing-notes/329-energy-security-in-the-arctic-policies-and-technologies-for-integration-of-renewable-energy.

[52] Ibid., 3.

[53] Ibid.

[54] Ibid.

[55] Ibid.

limited seasonal usage with a panel efficiency of 20%, solar photovoltaic technology is not the net-zero carbon solution for the energy nexus of the Arctic[56].

Defence Research and Development Canada (DRDC) studied ground sourced geothermal for use at Canadian Forces Station Alert[57]. The study determined that a high number of heating degree-days combined with the constant permafrost would make ground sourced heat recovery a poor performing energy technology[58]. Although not studied, similar results would be expected for ground sourced heat recovery at the remainder of the Arctic defence sites.

These decarbonizing technologies work in limited capacity in the Canadian Arctic. Their use at remote Arctic sites would reduce the dependency on fossil fuels, but the percentage of fossil fuels they can replace is unknown as this technology is typically paired with fossil fuel fired equipment to perform peak shaving of utility costs during high demand periods, or used in the summer for seasonal work sites.

There is hope. Utilizing funding from the GGS fund, DRDC is developing a hybrid system to test the resiliency and capability of decarbonizing technology in the Canadian Arctic. The DRDC project, titled "Advanced Micro grids towards Arctic Zero Emissions" will be installed at the North Warning System long-range radar site at

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[56] Anthony Patt, Stefan Pfenninger, and Johan Lilliestam, "Vulnerability of Solar Energy Infrastructure and Output to Climate Change," *Climatic Change* 121, no. 1 (2018): 95. https://search.proquest.com/docview/1445181862.

[57] Martin Kegel *et al, Power and energy conservation in the Arctic: A case study on the Canadian Force Station Alert*, (Chambery: 13th Conference of International Building Performance Simulation Association, 2013), 2547. https://www.researchgate.net/publication/264416566_Power_and_energy_conservation_in_the_arctic_A_case_study_on_the_canadian_forces_station_alert.

[58] Ibid.

Cambridge Bay in 2022[59]. Although DRDC has not estimated the percentage of fuel or greenhouse gas reduction that will be achieved by the replacement of diesel generators with a micro grid system at the radar site, a similar mitigation project in development for Canadian Station Alert in Nunavut estimated a 37% reduction in fuel usage and a corresponding reduction in greenhouse gas emissions[60].

Emerging Technologies. In 2018, Canada developed a road map to bring together industrial, provincial, territorial, and federal partners to examine the energy landscape in Canada and to determine the viability of small modular nuclear reactors as an alternative to fossil fuels[61]. Although this technology would greatly advance the DND's struggle to meet the GGS targets of net-zero by 2050, the technology is in its infancy. According to the small modular reactor-working group, the technology is still in the theoretical phase, and not ready for commercial use[62]. Theoretically, small modular reactors do have the potential to power the federal government's real property in the Arctic and meet the GGS targets; however, the suggested financial cost is also unproven and may bankrupt the government during development[63]. If small modular reactors do mature in time to meet the GGS targets, Aboriginal communities may not welcome their use in the Arctic. Although a researcher had difficulties in collecting enough data from Aboriginals located in Northern Territories to determine societal attitudes towards

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[59] Department of National Defence, *DRDC sets AMAZE-ing goal to reduce Greenhouse Gas Emissions in Arctic facilities* (Ottawa: Defence Research and Development Canada, 2020).

[60] Ibid.

[61] Canadian Small Modular Reactor Roadmap Steering Committee, *A Call to Action: A Canadian Roadmap for Small Modular Reactors*, last accessed 20 April 2020, 4-5, https://smrroadmap.ca/wp-content/uploads/2018/11/SMRroadmap_EN_nov6_Web-1.pdf?x64773.

[62] Ibid., 22.

[63] Brennain Lloyd, "Roadmap for Small Modular Reactors Drains the Public Purse," *Peace Magazine* 35, no. 1 (January 2019): 24, http://peacemagazine.org/archive/v35n1p24.htm.

nuclear power, the researcher determined that the social acceptance of a new technology plays a critical role in the successful introduction into society[64].

The Hydrogen Strategy for Canada suggests that hydrogen could be utilized as a fuel for electrical power and heat generation in the medium to long-term[65]. Although hydrogen is also an emerging energy technology being considered by Canada's Energy Regulator, the regulator examined hydrogen technology as an interim fuel primarily for use in vehicle fleets[66]. The use of hydrogen as a co-combustion, or direct replacement for diesel fuel, in electrical power generation systems would provide a reduced carbon intensity solution that would bridge the gap between fossil fuels and another technology that truly meets the net-zero carbon emission targets[67]. Canadian interest in hydrogen fuel cells peaked in 2008, but with renewed interest internationally, hydrogen fuel cells may be another emerging technology that will assist Canada in reaching the GGS targets[68]. Targeting Arctic sites for hydrogen fuel cells or adapting existing internal combustion type diesel engines in the Arctic to run on hydrogen may be a solution that Aboriginal and other Arctic residents would accept over nuclear technology.

The theoretical nature of small modular reactor technology, as an option to replace diesel powered electrical generating systems at remote sites in the Canadian

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[64] Sam-Aggrey Horatio. Challenges of Measuring the Determinants of Aboriginal Attitudes Toward Nuclear Power Generation in the Northern Territories. *CNL Nuclear Review* 6, no. 1 (2016): 135-137. https://doi.org/10.12943/CNR.2016.00003

[65] Natural Resources Canada, *Hydrogen Strategy for Canada – A Call to Action*, (Ottawa: Natural Resources Canada, 2020), 73-75.

[66] Canada Energy Regulator, *Canada's Energy Future: Infrastructure Changes and Challenges to 2020*, (Ottawa: National Energy Board, 2020), 86-87.

[67] Natural Resources Canada, *Hydrogen Strategy for Canada – A Call to Action*, (Ottawa: Natural Resources Canada, 2020), 57.

[68] Lisa Johnson, "Net-zero emissions by 2050 is the goal. So how do we get there?," *CBC News*, August 22, 2020, https://www.cbc.ca/radio/whatonearth/net-zero-emissions-by-2050-is-the-goal-so-how-do-we-get-there-1.5694015.

Arctic, will deliver a net-zero solution too late in the future to be of any tangible help in meeting the GGS targets. Unless another emerging energy technology such as hydrogen is matured quickly, the plan to utilize immature technology such as small modular reactors will be the Achilles heel of the strategy.

CONCLUSION

The goals set by the GGS for the DND buildings located in the Canadian Arctic can only be met by an innovative solution. Unless there is a significant and ground breaking discovery that will swiftly and cheaply replace the current fossil-fuelled technologies used in the Arctic, the DND will not meet the GGS net-zero carbon targets by 2050. The development of small modular reactors will need to increase beyond the theoretical and prototyping stage, and hydrogen fuel technology will need to be embraced by industry as an interim fossil fuel replacement technology. Compounding the challenge is the lack of matching greening targets in a defence policy that does not go far enough to address the GGS and excludes the Arctic as a region that requires specific attention to achieve the targets. Finally, the extreme climate, logistical challenges, human behavior challenges, local acceptance of emerging technology, and Aboriginal engagement requirements will impede any GGS construction projects attempted in the Arctic, further compounding the problem. Even if the Canadian Government is successful with a moon shot, the extremely challenging Arctic operating environment will add significant delays and costs to any project aimed at decarbonizing the Arctic energy nexus.

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