

CANADA'S NORTH

DISCOVERING HOW STANDARDS CAN CONTRIBUTE TO SAFETY, SUSTAINABILITY & ECONOMIC GROWTH

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CSA GROUP™



CSA GROUP RESEARCH

In order to encourage the use of consensus-based standards solutions to promote safety and encourage innovation, CSA Group supports and conducts research in areas that address new or emerging industries, as well as topics and issues that impact a broad base of current and potential stakeholders. The output of our research programs will support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and help to demonstrate our on-going commitment to building a better, safer, more sustainable world.

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3 **FOREWORD**

5 **INTRODUCTION**

5 A CHANGING REGION WITH UNIQUE CHALLENGES

6 OBJECTIVE AND METHODOLOGY

8 **IDENTIFIED NORTHERN CHALLENGES AND OPPORTUNITIES**

8 INCLUSION OF NORTHERNERS AND NORTHERN PERSPECTIVES

9 BASIC HUMAN NEEDS AND SUSTENANCE

11 SOCIETAL SYSTEMS

14 PHYSICAL INFRASTRUCTURE AND SUSTAINABLE ECONOMIC DEVELOPMENT

19 **HOW CAN STANDARDS CONTRIBUTE TO SAFETY, SUSTAINABILITY & ECONOMIC GROWTH?**

19 HISTORICAL ROLE AND APPLICATION

21 OPPORTUNITIES TO HELP ADDRESS KEY NORTHERN CHALLENGES

24 **SUMMARY**

25 **ACKNOWLEDGMENTS**

26 **ANNEX A: KEY STAKEHOLDER GROUPS CONSULTED**

27 **ANNEX B: REFERENCES**

FOREWORD

This paper presents the results of consultations with stakeholders and a review of literature to identify and better understand broad-based societal challenges facing Canada's North, with the end goal of highlighting areas where standards can contribute to the sustainability of the North and its people. Thirty-five different opportunities for standards have been identified across a wide range of topics and issues. The intent was to provide useful information for all those with an interest in the sustainability of Canada's North and the well-being of those living in, working in and visiting this region of Canada.

Prior CSA Group work that has focused on Canada's North include contributions to the *Northern Infrastructure Standardization Initiative* (NISI)[1], led by the Standards Council of Canada, and contributions to the *"True North, Adapting Infrastructure to Climate Change in Northern Canada"* study published in 2009 [2]. Four CSA Group Standards specific to the North have also been published. These include documents specific to the use of thermosyphons for buildings, moderating the effects of permafrost degradation for existing buildings, managing changing snow load risks for buildings, and the planning, design, and maintenance of community drainage systems.

CSA Group intends to continue to support northerners and the sustainable development of the northern economy by developing and facilitating the use of standards that promote health, safety and sustainability. CSA Group is continuously pursuing partnerships and organizations to collaborate with who share similar goals, and where efforts and outcomes are complementary. CSA Group priorities revolve around topics and issues that pertain to:

- Human health and safety
- Improving the living conditions and self-sufficiency of Northerners
- Adapting to climate change
- Advancing the utilization and standardization of critical climate data and modelling
- The engagement of northerners in the development and application of standards


YUKON
TERRITORY
NORTHWEST
TERRITORIES
NUNAVUT
QUEBEC



INTRODUCTION

A changing region with unique challenges

Canada's North[1], a vast and beautiful part of the world, is also a region that has been experiencing significant environmental, social and economic changes over recent decades, with these changes expected to continue into the future. Crossing nearly all of these spheres are the effects of climate change, which is amplified in the Arctic. Sea ice is melting at an increasing pace, permafrost is thawing and degrading, climate and weather patterns are changing, and the geographical range of plants and animals are shifting, with many resulting societal and economic impacts. These impacts, past, present and future, range from those affecting the sustainability of infrastructure, to changes in navigation and the opening up of new transit routes through the Arctic waters, to impacts on food availability and security, as well as many others [2, 3].

Geographically and economically, Canada's North can also be viewed as Canada's 'hinterland' – i.e., a region rich in natural resources, but yet far removed from large population centres, sparsely populated, and, in many locales, inaccessible [4]. With many locations reliant on air transport, winter roads or on a handful of regional and interregional roadways, transportation is often a major barrier and exacerbates other issues. The overwhelming reliance on air transport also contributes to significantly higher costs of living for northerners, increased costs for northern industry and business and energy and food insecurity [5, 6].

The ethnic makeup of the North is also an important factor. Whereas 23 percent of the population in the Yukon Territory identify themselves as Indigenous, this rises to 52 percent in the Northwest Territories and 86 percent in Nunavut [7]. The Indigenous population is also diverse in and of itself. In the Northwest Territories, for example, the majority of those identified as Indigenous are First Nations in ethnicity, followed by Inuit and then by Métis. In Nunavut, meanwhile, the vast majority are Inuit.

[1] For the purposes of this paper, 'Canada's North', also termed 'the North' throughout, is defined as all Canadian geographical areas above the 60th degree of latitude. Reference is also made in some sections to the 'Arctic', particularly when speaking of specific geographical features such as 'Arctic waters' or where existing regulations or associated government departments use the word Arctic.

Socially and culturally, the region, however, has also been experiencing significant changes. While there are still large segments of the population that rely on the local environment for food and habitat, there has been an increasing reliance on imported food, equipment, energy resources and material for local consumption as well as for industrial production. This has contributed significantly to issues of food insecurity [8], energy insecurity [6], as well as an over reliance on expensive imported goods generally [9]. Socially, there are also major challenges related to high unemployment [10], a chronic shortage of housing and inadequacies in the housing available [11, 12], reduced access to health services and health professionals [13], as well as a generally lower level of educational attainment – especially when considering Indigenous populations [14].

There is increasing recognition that initiatives undertaken to help deal with such challenges must not only benefit the North, but must in fact be embraced by and include northerners, northern perspectives and, in many cases, northern data and information. Whereas historically there was a tendency for solutions for the North to be imposed by or based on circumstances in the South, there is now more attention and importance given to northern perspectives and peoples generally [15].

Objective and methodology

The objective of this paper was to identify key challenges facing Canada's North and to investigate the potential role for standards[2] to help address these. A broad perspective was taken to help determine opportunities where standards could help contribute without limiting the investigation to certain sectors or technologies. Therefore, the research involved consulting literature and stakeholders across a wide range of economic sectors and topic areas.

A literature review of several key macro-level studies was conducted initially in order to help identify and better understand key northern challenges, with relevant sources cited throughout this paper. A three-pronged consultation approach was then used to help further determine areas where standards could benefit, validate the key issues of importance, as well as to understand if there could be a role for standards in helping to address these opportunities. This included consulting:

- Stakeholders who could provide a high level review and validation with regards to the identification of key challenges
- Organizations and individuals with more technical or sector-specific expertise on the particular challenges identified
- CSA Group staff and members[3] with experience and expertise pertaining to the key challenges identified

The next step involved assessing and prioritizing ideas of where standards could help contribute to resolving the challenges identified. Three key criteria were used to help prioritize these topics:

- The possible *societal benefits* of addressing the challenge
- The *urgency* of the issue
- The *feasibility* for standards to play a contributing role

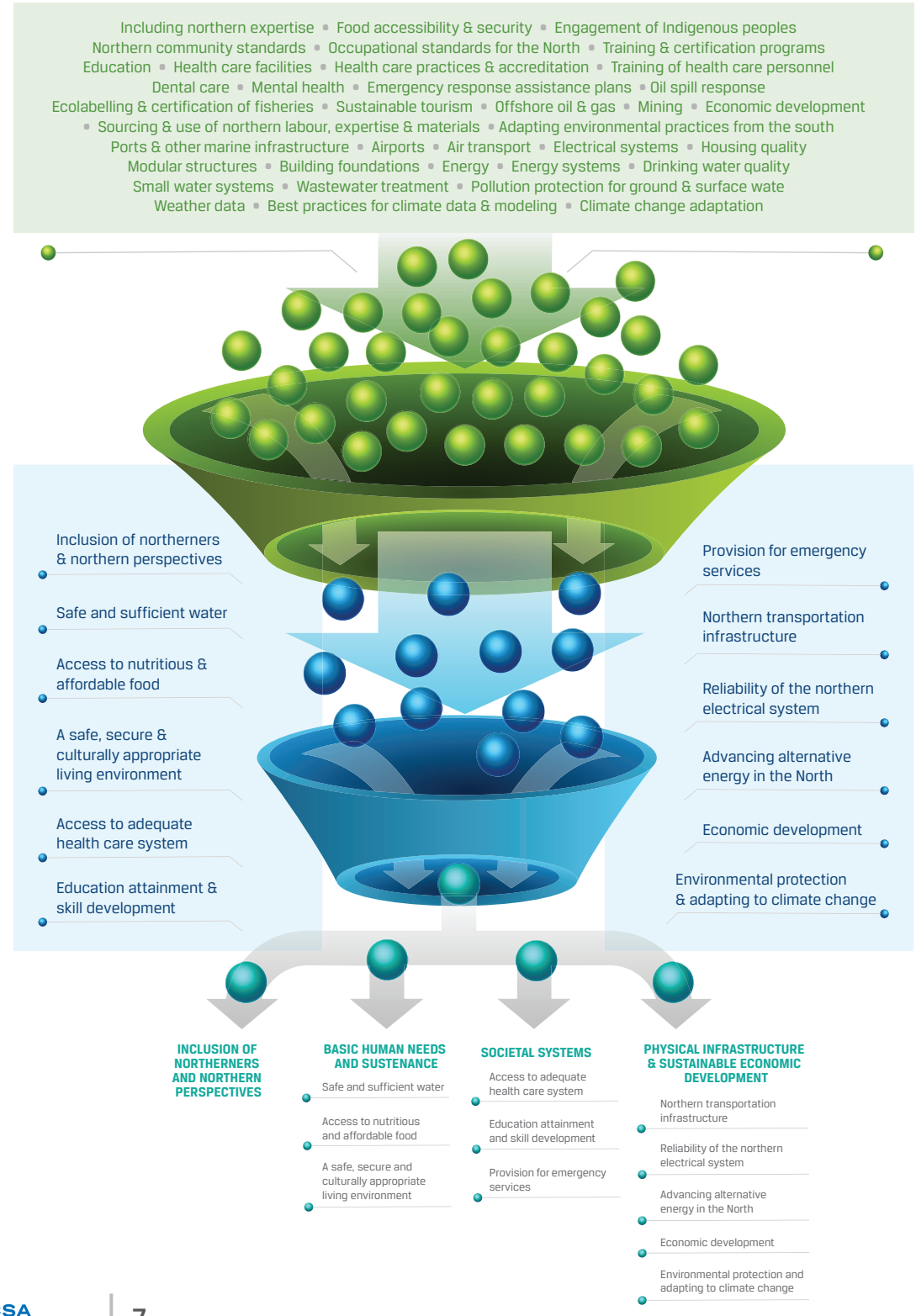
With respect to possible societal benefits, attention was focused on two main factors: the protection of human health, safety and well-being and the protection of the environment. Feasibility was considered largely in terms of whether the topic area was ready for standards to be developed and applied to the topic.

Over the course of this study, CSA Group had ongoing contact with a wide range of professionals and organizations active and involved with the North. These organizations are listed in Annex A of this paper.

[2] Standards can be understood as documents developed by a committee of interested experts and published by a recognized Standards Development Organization that provides independent guidance.

[3] CSA Group members play an essential role in the development of standards that contribute to safety, social good and sustainability. Over 9,000 members representing diverse industries and stakeholder groups volunteer their time, technical knowledge and experience to develop over 3,000 codes and standards which define the requirements for safety, quality, or performance that affect the products and services we use every day.

FIGURE 1


Including northern expertise • Food accessibility & security • Engagement of Indigenous peoples
Northern community standards • Occupational standards for the North • Training & certification programs
Education • Health care facilities • Health care practices & accreditation • Training of health care personnel
Dental care • Mental health • Emergency response assistance plans • Oil spill response
Ecolabelling & certification of fisheries • Sustainable tourism • Offshore oil & gas • Mining • Economic development
• Sourcing & use of northern labour, expertise & materials • Adapting environmental practices from the south
Ports & other marine infrastructure • Airports • Air transport • Electrical systems • Housing quality
Modular structures • Building foundations • Energy • Energy systems • Drinking water quality
Small water systems • Wastewater treatment • Pollution protection for ground & surface wate
Weather data • Best practices for climate data & modeling • Climate change adaptation
Inclusion of northerners & northern perspectives
Safe and sufficient water
Access to nutritious & affordable food
A safe, secure & culturally appropriate living environment
Access to adequate health care system
Education attainment & skill development
Provision for emergency services
Northern transportation infrastructure
Reliability of the northern electrical system
Advancing alternative energy in the North
Economic development
Environmental protection & adapting to climate change
INCLUSION OF NORTHERNERS AND NORTHERN PERSPECTIVES
BASIC HUMAN NEEDS AND SUSTENANCE
Safe and sufficient water
Access to nutritious and affordable food
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Access to adequate health care system
Education attainment and skill development
Provision for emergency services
PHYSICAL INFRASTRUCTURE & SUSTAINABLE ECONOMIC DEVELOPMENT
Northern transportation infrastructure
Reliability of the northern electrical system
Advancing alternative energy in the North
Economic development
Environmental protection and adapting to climate change

IDENTIFIED NORTHERN CHALLENGES AND OPPORTUNITIES

Using the methodological approach outlined in section 2.2, more than 40 different northern issues for which there could be opportunities that could contribute to the sustainability of the North and its people were first identified. To organize and present these more effectively, they were first categorized according to 12 different 'thematic areas' that reflect either key themes or subjects. These 12 thematic areas were then grouped into four 'macro areas':

- *Inclusion of northerners and northern perspectives*
- *Basic human needs and sustenance*
- *Societal systems*
- *Physical infrastructure and sustainable economic development*

The depiction of northern opportunities is presented in Figure 1.

In the subsections that follow, a general overview is provided of key challenges posed to the North, organized by the four macro areas and 12 thematic areas as presented in Figure 1.

Inclusion of northerners and northern perspectives

Crossing nearly all the challenges and opportunities investigated, one central theme is the need for the involvement of northerners, and particularly the Indigenous population, in helping to address these. The inclusion of northern perspectives is an opportunity that is receiving increasing attention more broadly, with recognition that this can help ensure the applicability, acceptance and ultimate success of northern-focused initiatives [16] [17].

One key reason underpinning the value for the inclusion of northerners' input is that these stakeholders often retain pivotal knowledge on the geo-physical, cultural and socio-economic realities of Canada's North gained through direct observation as well as passed along inter-generationally [18-21].

Nonetheless, there are a number of related challenges and barriers that have proven difficult in allowing for the inclusion of both northern perspectives and data in northern-based policy and decision making [22], many of which also pertain to standards development.

Those involved specifically with the development of standards have expressed that they face uncertainty and limitations in how to best engage northerners on these initiatives. A number of factors have been cited, including:

- *Remoteness* of communities and stakeholders, not only in terms of geography but also in terms of lifestyle and culture.
- *Response times*, which can be much slower due to both geographical distance as well as cultural factors.
- *A limited pool of experts* as historically defined by standards developers.

Both cultural and technical factors contribute to and exacerbate the above factors. Culturally, the lifestyles of many northerners, particularly those outside of the main population centres, is strongly impacted by the need to hunt and fish. At the same time, not only might there be poor internet connectivity, there also may be limitations in the use of computers or cell phones that can be used for communications.

These factors also might impact other practitioners within other sectors, including those in research, policy making, or other areas. Furthermore, the definition of 'expert' may also need to be expanded, not only for standards development but more broadly, to include holders of traditional knowledge and Indigenous perspectives since, historically, 'experts' have been viewed largely as those gaining knowledge through academic study, research, business activities or a combination thereof.

While the inclusion of northerners and northern perspectives weaves its way through many thematic areas, the next macro area focuses on distinct topics that form the basic building blocks for human existence.



Basic human needs and sustenance

Maslow's "hierarchy of needs" identifies that physiological needs for food, water, warmth and rest must be addressed before humans can focus on higher order needs [23]. This paper discusses a number of topic areas related to basic human needs and sustenance with particular relevance for the North, including:

- Safe and sufficient water
- Nutritious, safe, and affordable food
- A safe, secure, and culturally appropriate living environment

Safe and sufficient water

A topic area of great concern in northern communities is having a safe and sufficient supply of water. Some of the greatest challenges include climate change effects, infrastructure deficiencies, inconsistent testing and monitoring of source water, and difficulties in retaining trained and certified water treatment plant operators [24, 25].

Climate change is resulting in increased precipitation, warmer temperatures and permafrost degradation, with some of the most serious impacts being the increased risk for contamination from wastewater treatment effluents and leaching from solid waste sites. Furthermore, permafrost degradation can lead to structural failures in water and wastewater infrastructure components, as well as solid waste disposal sites.

Compounding the challenges posed by climate change, infrastructure issues, due to inappropriate design, construction and maintenance processes, also impact water and wastewater treatment and distribution [26].

In order to treat source water, many small northern communities use small-scale water treatment units [24]. Ideally these should be operated by trained and certified operators, however, many communities experience great difficulties in training and retaining certified operators.

The testing and monitoring of source water quality also plays a critical role in the effective treatment of drinking water. Testing has been found to be inconsistent in northern communities, resulting in an increased risk of incomplete treatment of source water, and, therefore, unsafe drinking water [24, 25].

Another key challenge surrounding water treatment is preventing the overflow and leaching of wastewater from treatment lagoons into the environment (often a result of early and unplanned release). Many remote communities use "passive" wastewater treatment systems, such as lagoons, or a lagoon/wetland system, whereby water is stored and treated before being released into the environment [24]. Nonetheless, although experts agree that such systems are the best wastewater treatment option, there is little guidance available for the design, construction and operation of such systems.

Solid waste facilities also represent a major concern. Most solid waste facilities in northern communities were built without an engineered liner in place, relying instead on permafrost as a natural barrier to prevent leaching of contaminants into groundwater and other freshwater sources [24, 25, 27]. Such sites are highly susceptible to permafrost degradation. In many of the facilities that do have liners, the liners may be inappropriate for the facility or may not have been designed and installed according to cold climate conditions. Additional concerns surrounding waste disposal sites include the inappropriate disposal of hazardous waste, the overfilling of waste sites, and challenges posed by composting in the North.

Water quality and access is a basic physiological need that could benefit from addressing the unique needs of northern communities. Nutritious, safe, and affordable food falls into the same category and is addressed in the next section.

Nutritious, safe, and affordable food

With many northerners lacking adequate access to nutritious, safe, and affordable food, food security, especially amongst the Indigenous population, is a prominent socio-economic challenge that confronts policy makers [5, 8]. One of the underlying factors contributing to food insecurity in the North is that an increasing amount of food is imported from other regions. This is contributing to very high food prices, unpredictable access to fresh food, and also reducing the nutritional content of foods generally compared to that of traditional diets.

The traditional food source for many northerners, and particularly for the Indigenous, is what is often termed "country food" (the Inuit name that describes traditional foods like Arctic char, seal meat, whale, caribou, etc.). While this continues to contribute to the diet of many northerners, there are a number of factors reducing the accessibility to and availability of traditional foods and, in turn, increasing the reliance on imports.

For one, climate change is impacting the geographical range of plant and animal species as well as herd migrations, thereby affecting those who depend on hunting and fishing to harvest their food. Other compounding factors are that northerners may have less opportunity to hunt and fish when this conflicts with weekday employment. In addition, northerners may lack access to hunting and fishing equipment, both because these may be too expensive or due to their availability. Thus, there has been a transition away from country foods.

Beyond measures to safeguard and support the harvesting of traditional food, another area where there is an opportunity is that of actually growing food in the North. Until recent years, knowledge of how to grow food in cold climate environments has been limited, but there are now numerous examples of researchers and entrepreneurs working on greenhouses that can be built to withstand such conditions [29, 30]. This presents a unique opportunity that could help reduce the reliance on imported food, as well as increase the availability of fresh food products. However, the resources and infrastructure needed for greenhouse food production in the North remain limited.

The final human physiological needs reviewed in this paper are warmth and rest, both of which are dependent on having a safe, secure and culturally appropriate living environment, as addressed in the next section.

A safe, secure, and culturally appropriate living environment

Fundamental to human existence is a safe, secure, and a culturally appropriate living environment. However, a number of distinctive issues related to northern buildings and their construction, an obvious key component of the living environment, have been identified.

Cold-climate conditions make constructing buildings in the North a challenge. Permafrost conditions necessitate unique construction requirements and permafrost degradation further complicates construction [2]. Climate change impacts construction methods and requires consideration of changing snow loads, wind, rain and other northern conditions [31].

Sourcing building systems and materials, as well as replacement parts, is challenging due to the relative lack of local materials and the long distances and costs involved in importing these materials.

As buildings become more complex, achieving the proper operation of mechanical systems (e.g., heating systems), quality indoor environments (e.g., air quality, humidity levels) and proper building maintenance becomes more difficult. This is especially true given the harsh environmental conditions, such as building on permafrost, as well as given the limited materials readily available in the North.

Designing culturally-appropriate architecture is also a challenge [32]. Neighborhoods are, in many cases, designed around southern interpretations of community and houses are designed around southern concepts of how different rooms are used.

The technical challenges highlighted above are partially responsible for chronic and well documented housing shortages [12]. The need for northern housing policies and programs is being explored by various organizations [11, 33]

The *National Building Code of Canada* [34], which is adopted by governments throughout the North, references some standards including those published by CSA Group that contain regional variations and northern climatic conditions (e.g., fenestration energy performance, etc.). However, system flexibility and adaptation will remain challenges that will need to be addressed given the rate of climate change.

In the next section, we build on the discussion of some of the challenges facing the provision of basic physiological needs such as water, food, and shelter and move on to higher order needs encompassed by societal systems and 'soft infrastructure'.

Societal systems

Societal systems, sometimes also referred to as 'soft infrastructure', typically refer to the institutions that are required to maintain the economy, to provide health and educational services and to set the social standards of a country or region. This paper focuses on three such societal systems and the services they provide:

- Access to adequate health care
- Educational attainment and skills development
- The provision of emergency services

In the subsections that follow, these topics are discussed individually.

Access to adequate health care

Northerners face significant challenges related to health care access. Some of the more significant issues include the remoteness of communities and the distance away from health care services, the range and quantity of services available, and other socioeconomic realities such as generally lower levels of income and educational attainment [13].

Exacerbating these challenges are harsh weather conditions which make road or air travel dangerous or impossible for days at a time. Additionally, travel can be stressful and costly when wage-earners or community leaders must be absent for extended periods of time to receive medical treatment at locations far away from their home location.

Long-term care facilities and services are also limited in Canada's North, creating potentially stressful situations as family members need to care for elderly persons without adequate support [35]. Alternatively, families are often faced with placing elderly relatives in institutions located in larger communities far from their homes. This challenge is further exacerbated by chronic shortages of health professionals and staff, particularly in smaller Indigenous communities [36].

Challenging working conditions in northern communities creates difficulty in attracting and retaining health care workers, which leads to high turnover [35]. These challenges include:

- Long working hours
- A lack of colleagues to share the workload
- The lack of educational preparation focused on northern realities
- Difficulties obtaining routine continuing education[4]

[4] These challenges apply to the full spectrum of health care services, including primary and preventative medicine, emergency care, long-term care, dentistry and mental health.



> Northerners face significant challenges related to health care access. Some of the more significant issues include the remoteness of communities and the distance away from health care services.

To alleviate this situation, a few research units affiliated with Canadian universities, along with several nursing and medical educational programs, are preparing newly graduated practitioners with the training needed for northern and rural practice [35]. Without such initiatives, residents of Canada's North will continue to encounter unique challenges to access health care.

Based on discussions with stakeholders involved with northern health care and a review of relevant literature, advancements will likely involve the following:

- Incorporating traditional practices into health care
- Developing more cost-appropriate ways of delivering health care, including the use of technology
- Shifting increasingly to community-based versus hospital-based care
- Greater attention given to mental health and addiction

Like health care, education is another societal system with unique needs in the North. Educational attainment and skills development is discussed in the next section.

Educational attainment and skills development

Two of the greatest concerns pertaining to education and working in the North are low levels of educational attainment and low essential skills development, particularly within the Indigenous population [37, 38]. Lower education and skill levels impede the potential of individuals in the North and northern economic development overall. Some of the challenges can be traced back to socioeconomic realities, as well as incompatibilities of education systems with the lifestyles and living conditions of northerners. For example, many northerners still rely on hunting and fishing for food and clothing, impeding their availability for school and work. Other contributing factors include socioeconomic issues such as the lack of child care, inadequate programs and content, a lack of coordination among relevant stakeholders and other systemic issues [39].

In Nunavut, 40 percent of the adult population have not obtained a high school diploma and in the Northwest Territories 25 percent have not obtained this educational level [40]. A study by the Conference Board of Canada concluded that key contributing factors to lower levels of educational attainment in the North, and particularly for Indigenous populations, include language and culture, family and community support, traditional economic roles, and infrastructure and governance [37]. These unique characteristics of northern populations need to be taken into account when providing educational services and ensuring that these are accessible to all [39].

Providing educational services to a sparse and varied population spread over an enormous geographical area is also difficult and expensive. Northerners, especially those located outside of major population centres, have limited access to post-secondary education because there are few higher education learning centres outside of Yellowknife and Whitehorse. Lower incomes are also a barrier. Access to technology, especially high speed internet, is all the more important to provide access to distance education opportunities.

In addition to low educational attainment, many northerners, predominantly within the Indigenous population, face barriers to employment due to insufficient skills, impeding their ability to participate in the labour market and achieve financial and social well-being [14, 38].

Although government programs and resource development projects have implemented targeted efforts to increase northern skills, many opportunities still exist for training. This is especially the case with the employment of northerners in sectors expected to experience strong growth in the future, such as fisheries and tourism.

Overall, data that could be used to help benchmark education and skills attainment in the North are scarce [14]. More work is also needed to support skills assessment of northern students and adults in the labour force, particularly in Nunavut and the Northwest Territories. Furthermore, there is a need to increase trades training and apprenticeship programs as this would help to expand skilled trades and to build capacity.

[5] Specifically, Canada is a participating country member on ISO TC 67/SC8 – 'Arctic Operations'.

(EPPR) Working Group.

Another societal system that has unique requirements in northern climates and with northern populations is emergency response. This is addressed in the next section.

Provision of emergency services

The remoteness of northern Canada, as well as its harsh environment, results in unique requirements related to emergency response, including ensuring that the performance of processes, equipment and technologies meet these difficult conditions. These needs are heightened given expectations of increased vessel movement through Arctic waters due to climate change.

The mandate for establishing regulations for Canadian Arctic maritime emergency response falls under Transport Canada, which has adopted the International Maritime Organization's (IMO) Polar Code for ship operations in Arctic environments. Canada is involved in other relevant international efforts through the International Organization for Standards (ISO)[5] as well the Arctic Council[6].

The entities in Canada that could be involved in an emergency/response situation in the North include:

- Canadian Air Force (CAF)
- Canadian Coast Guard (CCG)
- Canadian Coast Guard Auxiliary Vessels
- National Search and Rescue Secretariat (NSS) (through Public Safety Canada)[7]

The CAF, for example, has the capability to provide aeronautical and maritime search and rescue (SAR) services into the farthest and most remote locations in the Arctic region. The CCG is capable of providing SAR services on a seasonal basis through the deployment of icebreakers and some science vessels [41]. Nonetheless, although Transport Canada does set forth rules and regulations for shipping, no separate set of regulations exist for SAR to respond to an Arctic event.

Another consideration associated with any increase in marine activity is the increased risk of oil and chemical spills [42]. While there has been much research and development geared towards technologies for oil and chemical spill response in Arctic marine conditions [43], this research has not been encompassed in standards that are widely available to industry and other stakeholders.

Other issues that contribute to the risk profile of the Arctic marine environment are related to the quality of navigation aids, inadequate hydrographic charts and the availability of emergency and support services (e.g., ice breakers) [44, 45].

Societal systems such as health care, education and skills development, and emergency response have been discussed. Likewise, opportunities exist to improve physical infrastructure and sustainable economic development, as discussed in the next section.

Physical infrastructure and sustainable economic development

The final macro area considered is that of physical infrastructure and sustainable economic development. Five topics that contribute strongly to the sustainability and strength of any economy, but with particular relevance for the North, are considered and discussed. This includes:

- Northern transportation infrastructure
- Reliability of the northern electrical system
- Advancing alternative energy in the North
- Economic development
- Environmental protection and adapting to climate change[8]

[6] Through Transport Canada, Canada is an active member on the Arctic Council, including participating on the Council's Emergency Prevention, Preparedness and Response

[7] NSS is also responsible for development of Canada's SAR policy, in consultation with Canada's national SAR partners - CAF, CCG, and Parks Canada and Canada's provincial/territorial partners – as well as ground SAR (GSAR) and police services (depending on the location).

[8] It is also noted that for the purposes of this paper, fossil fuel production as well as oil and gas pipelines were not explicitly focused on, not because they are not important topics, but since these areas are already well covered by existing standards or standards under development.



While these themes are discussed individually, they include many additional interlinkages that are not specified.

The first theme is northern transportation and related infrastructure.

Northern transportation infrastructure

Many of the challenges of northern transportation and related infrastructure stem from the impacts of climate change. Longer term impacts of climate change will likely be significant and have major impacts on operation and maintenance costs, as well as on the design and planning of capital projects that involve infrastructures with a long life cycle. Understanding what the future impacts may be will put governments in a better position in terms of design, construction, and operation of transportation systems and infrastructure. However, potential impacts and needs have not been extensively documented yet. Below, this paper discusses the impacts of climate change on ground, water, and air transportation.

With climate change, shorter and warmer winters are accelerating permafrost degradation, in turn affecting the structural integrity of roadways and increasing maintenance costs [2]. Changing weather patterns are also resulting in more freeze thaw cycles which is contributing to increased damage to road and highway surfaces and increased maintenance costs. Increased precipitation and permafrost degradation have also led to an increase in landslides onto northern highways [46].

Increasing navigability of Arctic marine waters is a another significant issue that is leading to opportunities and potential challenges [42]. For example, whereas diminishing sea ice may allow for greater navigability, more water traffic presents risks to coastal communities from oil and chemical spills, as well as possible accidents and emergencies. Canada's North also has few docks and small ship harbours, which adds to the cost of shipping since materials and supplies must be first off-loaded to barges or landing craft, then transferred to the beach and off-loaded again.

In terms of air transportation, much of the northern airport infrastructure dates back to the 1950's and 1960's [47, 48]. In addition to aging infrastructure, another common challenge is the length of airport runways, as this limits the types of aircraft that airports can receive and the maximum aircraft payload which results in increased cargo and passenger fees. For most

small airports though, lengthening runways can be prohibitively expensive, if not physically impossible. Permafrost degradation also results in "mushy runways" that are unsafe because of frequent freezing and thawing cycles. Along with these physical infrastructure challenges, additional areas that need to be addressed are capacity/capabilities for weather monitoring/prediction at specific airports.

In addition to transportation-related challenges, another physical infrastructure challenge is the reliability of the northern electrical system, as discussed below.

Reliability of the Northern electrical system

Electrical systems in Canada are well covered by the *Canadian Electrical Code* (CSA C22.1, *Canadian Electrical Code*). This is a very mature document, with the first edition published in 1927 and the current (23rd) edition published in 2015. The five Parts of the Code cover a wide array of electrical systems and processes: the safety of electrical installations, the evaluation of electrical equipment or installations, power distribution and transmission circuits, industrial or institutional installations, and the inspection of electrical installation in residential buildings.

However, the existence of issues unique to the North may require adapting the existing *Canadian Electrical Code*.

For example, power quality and voltage fluctuations are more common in the North than in other regions due to adverse weather conditions and wildlife interfering with power lines. Likewise, electrical equipment, much of it designed and tested to operate in warmer climates, can also be affected by extreme temperatures and is more prone to variability of performance and failure. In some cases, there are also challenges with grounding electrical systems because there is nothing available to which to ground. Finally, safe distribution of electricity can be a challenge when overhead wiring is not a feasible option.

Unique cold weather electrical applications also exist that may require unique standards. One example is plumbing vent stacks that are heated electrically to prevent vent freezing.

Just as transportation and electrical infrastructure have unique needs in the North, another important topic area relates to the advancement of alternative energy in order to alleviate economic and environmental challenges resulting from the North's heavy reliance on fossil fuels. The advancement of alternative energy in the North is discussed next.

Advancing alternative energy in the North

One feature that characterizes the North is its reliance on fossil fuels (primarily propane, fuel oil and diesel) for heating, generating electricity, and transportation. The heavy reliance and use of fossil fuels has led to a number of key economic and environmental challenges. In particular, since almost all fuel is imported, fossil fuels are costly and subject to delivery disruptions, meaning that many northern communities face significant energy security issues [6]. The reliance on fossil fuels also has significant environmental effects, including contributing to climate change, local air pollution, and adversely affecting the health of local populations.

There are therefore strong benefits to advance the use of alternative energy sources, particularly low-impact renewable energy such as wind and solar photovoltaic technologies, since these offer potential solutions to energy insecurity and the other negative impacts of fossil fuels. To date, however, the uptake of renewable energy options has been limited due to:

- High installation costs
- A lack of knowledge or guidance on how to best design products for harsh Arctic environments
- A lack of energy storage options

Nonetheless, although currently the use of renewable energy is limited, research and analysis has shown that it offers great potential. In some communities, wind and solar photovoltaic technologies could provide up to 50 percent of total energy needs [49]. Renewable energy is also a viable energy option for remote mining and industrial sites.



> Protecting the northern environment as well as adapting to climate change presents a number of unique challenges. Paramount amongst these is that the northern environment is one of extreme conditions, highly sensitive to human impacts.

One factor that helps support the potential for renewable energy is that much of the electrical system in the North is decentralized and reliant on expensive, imported diesel [50, 51]. Another factor supporting renewable energy is the general lack of financial capacity among utilities and territorial governments to advance major hydro-electric projects [51]. These factors make smaller scale and less capital intensive renewable energy options more viable. Scientific research to develop smart energy systems (i.e., the integration of renewable source generation and energy storage) could also be beneficial for helping advance the uptake and application of renewable energy.

Other alternative energy sources such as bio-fuel [51] and even small modular nuclear reactors [52] are being explored to varying degrees. In recent years, for example, wood pellets have emerged as a rapidly growing alternative heating source in the Northwest Territories due in large part to government strategies to advance biomass use in the region [51].

Economic development

Canada's North has many opportunities for economic development, particularly those associated with the region's rich endowment of natural resources as well its cultural diversity, people, and history. In addition to the production of minerals and metals, for example, two sectors with significant economic growth potential are fishing and tourism. However, further to how these can be developed sustainably, there is also increasing attention being given to the local impacts of economic development activities in the North, along with the procedures and initiatives to help measure such activities [53-55].

An illustrative example of the challenges of ensuring local economic benefits from development activities are those observed with what are termed 'impact and benefit agreements' (IBAs)[9]. Even if not consistently required by legislation, these agreements have been increasingly used in recent decades by Indigenous communities and resource development companies to outline the main local economic impacts of resource development activity and to arrive at legally binding agreements [53, 55]. However, a number of key limitations are often noted, including:

- A general lack of transparency, with a limited ability to discuss these agreements.
- Limited opportunities to share in lessons learned.
- No one consistent approach to negotiating IBAs and no clear guidelines pertaining to these instruments.

Some of these limitations also reflect broader needs to improve processes and strategies to allow for effective communication and accessibility of information related to economic development.

There are also other distinct and notable challenges with specific economic development opportunities. For example, while tourism is a sector with significant growth potential, particularly related to cruise ships traversing the Arctic [56], the impacts on local communities and their environment also needs to be considered [57]. This is especially the case given that community-level infrastructure may not be adequate to handle large volumes of passengers off-loading from cruise ships.

Likewise, the Arctic fishing industry also has been growing and could have important benefits for the North and northerners in the future [58, 59]. Nonetheless, one key barrier to the growth of Arctic fisheries, and particularly local fisheries and local economic development, is a deficit in marine infrastructure such as ports and small craft harbours [59]. There are also needs and opportunities to develop skills sets through the training of northerners who want to pursue a career in the fishing industry[10], as well as ensuring the sustainability of northern fisheries more broadly [58, 59].

The final thematic area considered is environmental protection and adapting to climate change.

Environmental protection and adapting to climate change

Protecting the northern environment as well as adapting to climate change presents a number of unique challenges. Paramount amongst these is that the northern environment is one of extreme conditions, highly sensitive to human impacts, with often limitations in the availability of weather and environmental data.

[9] Miningfactors.org offer further details on impact benefit agreements, including their history, their use, their contents and limitations, and areas for further research and development.

[10] There are a range of organizations providing skills development to Northerners, particularly to the Indigenous population. One that focuses specifically on the fisheries sector is that of the Nunavut Fisheries Training Consortium (NFTC).

Many implications of climate change have been discussed throughout this paper for specific thematic areas, and in this section, attention is drawn to remaining issues and challenges or elements that connect these. Here, one overarching challenge is how future climate change is accounted for with respect to climate-sensitive topics – i.e., from the planning, design and construction of infrastructure, to issues pursuant to food security. In particular, feedback from many experts and practitioners have identified that there is a need to arrive at agreement on what are the best processes and procedures to factor future climate change into related decision making, as well as the use of climate modelling and other tools used to project or account for environmental and climatic change.

A complicating challenge is that there are not as many stations that collect weather and environmental data in the North as in southern Canada. A lack of data could pose a challenge for numerous areas of public policy, regulations and related decision making. For example, this data might be necessary to help set requirements for buildings with respect to snow load, for the design of drainage systems, accounting for the effects of changes in permafrost for various infrastructure types, and many other issues [2].

Similarly, climate change adaptation has been discussed in various parts of this paper, and a few additional items are highlighted. In the mining sector, there are opportunities to advance procedures for adapting the design of tailings containment facilities to climate change and other unique environmental conditions [60]. Shoreline erosion due to less ice coverage causing more waves in conjunction with increases in extreme weather is also a concern that needs to be managed.

There are other key challenges related to environmental protection as well as environmental management. Waste management is an ongoing concern in northern communities [61]. The geographical range of plant and animal species are also changing, in turn impacting on both local ecosystems and the populations that depend on hunting and fishing for food and their livelihood.

With all of the gaps identified related to inclusion of northerners and northern perspectives, ensuring basic human needs and sustenance, supporting societal systems, and physical infrastructure and sustainable economic development requirements, standards have a clear role to play in addressing these challenges.

HOW CAN STANDARDS CONTRIBUTE TO SAFETY, SUSTAINABILITY & ECONOMIC GROWTH?

Historical role and application

Standards are instruments with a long history of use, by some accounts dating back to the beginning of recorded history [62], with often far reaching societal benefits. Standards generally comprise several different types of documents – ranging from the more formal standard that sets forth requirements on a given topic, to guidance documents that provide higher level instructions.

Numerous studies have demonstrated the economic and societal contributions of standards to labour productivity, innovation, new product development and public credibility, amongst other benefits [63-66]. Over time, their use has broadened greatly and now can be tied to nearly every sphere of society and the economy. Also contributing to the value of standards is the general approach used in their development, as this often involves multiple stakeholder groups working to agree on the technical and procedural requirements or guidance on a given topic, often for opportunities that are complex and involve a diverse range of stakeholder groups.

Standards can either be referenced directly in regulation or used voluntarily. They also are often used as the basis for training, skills development, and the certification of people and products. In this way, standards usually work in a complementary way with other instruments.

Opportunities to help address key northern challenges

Given the broader application of standards, what opportunities might exist for standards to help address key societal issues and challenges facing Canada's North? Although standards might not address all the challenges identified or be the *only* solution, standards are important tools that could be used in conjunction with other instruments, regulation, and policy and programs to affect positive change.

The topics considered and listed in the second column of table 1 (all 12) were then ranked according to the three criteria defined in Section 2 – namely, the societal benefit resulting from addressing these, their urgency, and the feasibility for standards. Three possible rankings were considered: high, medium, or low. The results are summarized in Table 2, and are colour-coded to illustrate the various rankings of each thematic area ***(red*** – where the thematic area was ranked high for all criteria, ***orange*** – where one or more criteria were ranked as medium, and ***blue*** – where one or more criteria was ranked as low).

TABLE 1. POSSIBLE STANDARDS-BASED CONTRIBUTIONS

	THEMATIC AREA	PURPOSE AND INTENDED OUTCOME
INCLUSION OF NORTHERNERS & NORTHERN PERSPECTIVES	CROSS CUTTING ACROSS ALL THEMATIC AREAS	The mainstreaming of best practices for the engagement of Indigenous and non-Indigenous northerners in standards development initiatives.
		The engagement of communities and other stakeholders on the application/use of standards.
		The inclusion of Indigenous people and traditional knowledge in the development of northern data and information, including the use of community-based monitoring.
BASIC NEEDS AND HUMAN SUSTENANCE	WATER	The assessment of water treatment facilities and the design/improvements of such facilities.
		The design, construction, operation and maintenance of wastewater treatment lagoons, wetlands and lagoon/wetland hybrid systems.
		The design, construction, operation and maintenance of solid waste disposal sites, including the use of engineered liners.
	FOOD	The design and construction of greenhouses for cold-climate regions, including the design and use of heat recovery ventilation (HRV) systems.
		The composting of municipal waste in cold-climate conditions.
	LIVING ENVIRONMENT	The enhancement of building foundations for cold-climate conditions (i.e. beyond the requirements of the *National Building Code of Canada*).
		The update/expansion of existing northern-based building standards for other applications and users (e.g., CSA S500, *Thermosyphon foundations for buildings*).
		The design and construction of modular structures for housing and municipal buildings to better reflect the culture of Canada's North.
		The adaptation of standards referenced in the *National Building Code of Canada* and data used within to incorporate changing climate conditions.

TABLE 1. POSSIBLE STANDARDS-BASED CONTRIBUTIONS *CONTINUED*

	THEMATIC AREA	PURPOSE AND INTENDED OUTCOME
SOCIETAL SYSTEMS	HEALTH CARE	Adapting existing health care standards to the needs of the North (e.g., CSA Z8000, *Canadian Health Care Facilities – Planning, Design and Construction*).
	EDUCATION	The benchmarking of educational and skills attainment, as well as development of the necessary data and information to do so.
		The design and delivery of culturally appropriate material, particularly for the Indigenous perspective.
		The development and delivery of distance education programs, particularly for the Indigenous perspective.
		The partnering of educational institutions to deliver shared/remote educational programs.
	EMERGENCY RESPONSE	The capacity of first responders and the availability and use of technologies and equipment for emergency response (including requirements for on board vessels).
		The performance of the personal protection equipment (PPE) used in cold-climate conditions.
		The detection, response, mitigation and monitoring of Arctic oil/chemical spills, including the use of technologies, equipment and materials.
PHYSICAL INFRASTRUCTURE & SUSTAINABLE ECONOMIC DEVELOPMENT	TRANSPORTATION	The adaption of existing transportation standards (i.e., those that are southern-based) to reflect cold-climate conditions.
		The incorporation of climate change adaption into the design, construction and maintenance of transportation infrastructures.
	ELECTRICAL SYSTEMS	The adaption of the *Canadian Electrical Code, Part I*, as well as electrical product and system standards, for safety, performance and durability in cold-climate conditions.
		The development of additional electrical product or system standards for unique northern electrical applications, such as heating plumbing vents.
	ALTERNATIVE ENERGY	The design, construction and operation of stand-alone photovoltaic systems.
		The design, construction and operation of wind towers/turbines.
		The adaption/adoption of existing alternative energy standards for cold-climate conditions.
	ECONOMIC DEVELOPMENT	Best practices with respect to impacts on the local people and environment from northern tourism, including that of cruise ships.
		The development of best practices for ensuring the sustainability of northern fisheries.
		The development of best practices to facilitate local participation in project design/bidding.
		The measurement and reporting of the local economic benefit/societal impact of economic development activities.
	ENVIRONMENTAL PROTECTION[11]	The disposal of municipal solid waste in northern communities.
		The adaption of existing standards or the development of new ones for the design of northern tailings containment facilities.
		Best practices with respect to factoring future climate change into relevant decision making, as well as the use of climate modelling.
		The minimization/mitigation of the effects of shoreline erosion.

[11] The thematic area of environmental protection is one that intersects with many others. As such, topics that relate to environmental protection are captured in other thematic areas as well.

TABLE 2. RANKING OF POSSIBLE STANDARDS-BASED CONTRIBUTIONS

MACRO AREA	THEMATIC AREA	SOCIETAL BENEFIT	URGENCY	FEASIBILITY
Inclusion of northerners and northern perspectives	Cross cutting	High	High	High
Basic needs and human sustenance	Water	High	High	High
	Food	High	High	High
	Living environment	High	High	High
Societal systems	Health care	High	High	Medium
	Education	High	Medium	Medium
	Emergency response	High	High	High
Physical infrastructure and sustainable economic development	Transportation	High	Medium	Medium
	Electrical systems	Medium	Low	Low
	Alternative energy	High	Medium	Low
	Natural resources	High	Medium	Medium
	Environmental protection	High	High	Medium

In general, all but one of the thematic areas ranked high in terms of societal benefit. The only area that did not rank high was electrical systems – largely because this is already well covered by the *Canadian Electrical Code*. The high ranking of nearly all thematic areas reflects the expectation that standards have an important role to play in Canada's North and that there are many distinct opportunities where it could contribute alongside or in conjunction with other complementary instruments, government regulations, or a combination thereof.

Thematic areas with potential implications for basic human sustenance, human health and safety, as well as environmental protection generally were deemed to have both the greatest societal benefit as well as being the most urgent due to the close relationship between these topics and the well-being of those living in, working in, or visiting the North. This interpretation also corresponds with the basic premise that the physiological needs of food, water, warmth and rest, as well as the need for safety and security are the building blocks of a healthy society and form the first elements in the hierarchy of needs [23].

Thematic areas were generally rated the highest with respect to feasibility where there were already preexisting procedures or guidance documents, as well as where relevant stakeholders were readily available.

Additional commentary is provided below in regards to the assessment of each thematic area.

Inclusion of northerners and northern perspectives

One factor that crosses nearly all thematic areas is the need to include northerners in the development of data, standards and related documents, as well as the need to ensure that there are adequate processes and procedures in place to allow this to happen. The inclusion of northern perspectives and data should be considered a high priority with respect to opportunities for standards as it has high societal benefit and is a feasible initiative to pursue.

Basic needs and human sustenance

Water: Three specific items were identified - water treatment, the management of waste water, and the management of solid waste. All of these items are important, although efforts tied to water treatment might have the most immediate results and may be the most feasible to achieve.

Food: An important opportunity relates the growing body of knowledge and experience with growing food in greenhouses situated in cold-climate regions. This could provide an invaluable source of information that could be tapped to develop standards in this area.

Living environment: A number of opportunities were presented for potential standards involving the adaptation of already existing standards or updating and expanding these documents. Some of these are readily feasible to undertake where existing knowledge or documents can be leveraged (e.g., updating existing building-related standards).

Societal systems

Health care: Although there was only one opportunity presented with respect to health care, as discussed later in this paper, a number of health-related topics have also been identified for which there could be more opportunities for standards pending more direction from stakeholders or the evolution of related government policy.

Education: Four different opportunities were presented. Central to these is the opportunity for standards to help in the development of culturally appropriate educational programs that reflect the unique cultural considerations of the northern people as well as the geographical realities of the North.

Emergency response: Several of the more significant stakeholders and initiatives involved with Arctic emergency response have been highlighted in this paper. Their efforts should be leveraged and tapped into, in turn, increasing the opportunity for advancing standards in this area.

Physical infrastructure and sustainable economic development

Transportation: Standards that can help adapt transportation infrastructure to climate change or make the infrastructure more climate resilient are needed. In addition, there is an opportunity to adapt already existing transportation standards or updating and expanding these documents for the North.

Electrical systems and alternative energy: The unique environment of the North may require the development of new technical standards, particularly related to energy and alternative energy. Note that adapting the Canadian Electrical Code could involve a significant amount of effort given the scope of the code and the lack of data.

Economic development: Standards can help ensure that economic development initiatives benefit all northerners, in turn helping to increase the self-sufficiency and economic well-being of its people.

Environmental protection and adapting to climate change: A number of distinct opportunities were presented where standards could contribute to environmental protection and adapting to climate change, including the procedures and processes to incorporate climate change into relevant decision making.

Areas requiring additional research

Finally, there were several topic areas that were identified that will require additional research and investigation in terms of the potential role of standards or the development of required data and information. In some cases there is a need to further advance technologies and in other cases the opportunities identified and discussed hinge more on the evolution of government policy and programs (e.g., the provision of northern health care, education, etc.).

These areas for further research have been outlined in the following list:

Health care

- Understanding the experience of northern paraprofessionals to improve the delivery of related health and well-being services.
- Investigating how traditional healing methods can be integrated with the biomedical model of health service delivery, including research on Indigenous attitudes towards medicine.
- Investigating the use of technology applications (e.g., telemedicine, drones providing community paramedicine) to improve access to services and quality of life in Canada's North.

Renewable energy

- Evaluation of the renewable standards landscape and performing a gap analysis with respect to technologies suitable for northern applications.
- Evaluating the use of distributed renewable energy systems as part of broader renewable energy plan for northern communities. This would be part of a larger, comprehensive effort to look at the broader picture including the impact of such systems the *Canadian Electrical Code* and *National Building Code*, etc.

Buildings

- Determining how northern buildings can be economically designed, with less complex mechanical systems and maintenance requirements, to function successfully in areas without easy access to replacement parts or specialized maintenance professionals.

Transportation

- Investigating the use of airships and airship ports and the potential role of standards in their safe and effective operation.

Electrical systems

- Assessing and evaluating the performance of electrical components, such as breakers, in extreme temperatures.

Overall, many feasible opportunities exist to address urgent northern-specific challenges with standards-related solutions resulting in significant societal benefit.

SUMMARY

This paper has touched on some of the key challenges facing Canada's North. One of the most far reaching is that of climate change, as it impacts the sustainability of northern infrastructure and has broader socio-economic implications. Other challenges were also identified related to the provision of safe and sufficient water, the adequacy of health care services and housing, low levels of educational attainment and skills development, as well as issues related to both food and energy security. Ensuring that northerners and northern communities benefit more strongly from economic and resource development in the North is also a key opportunity.

Standards has a crucial role to play as part of the larger toolbox for helping to address challenges in the North. Through consultation with a wide range of stakeholders and an extensive literature review, 35 different opportunities for standards development have been identified. Of these, the greatest priorities have immediate ties to human health and safety and ensuring basic human sustenance. Northerners need to be part of any process for addressing these issues and the process of standards offers a valuable opportunity to help make this happen in a collaborative and consensus-based way.

Effectively addressing the challenges facing Canada's North, including those for which standards can contribute, will require building upon successes and lessons learnt, as well as engaging both the affected stakeholders and the relevant knowledge base for given challenges or opportunities. Partnering and collaborating with other stakeholders will be crucial as the issues are complex and interlinked. Overall, these elements, namely, the engagement of stakeholders and northerners themselves, the partnership, cooperation and coordination between stakeholders, and the leveraging of existing knowledge and successes, will all be essential to support and foster the development of solutions that lead to the sustainability of Canada's North.



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ANNEX A: KEY STAKEHOLDER GROUPS CONSULTED

Aboriginal organizations:

- Council of Yukon First Nations
- Women of Métis Nation

Territorial governments:

- Department of Public Works and Services, Government of Northwest Territories
- Department of Municipal and Community Affairs (MACA), Government of Northwest Territories
- Department of Community Services, Government of Yukon
- Highways and Public Works, Government of Yukon
- Health and Social Services, Government of Yukon
- Infrastructure and Development, Government of Yukon
- Occupational Health and Safety Department, Government of Nunavut
- Department of Community and Government Services, Government of Nunavut
- Department of Health, Government of Nunavut
- Mackenzie Valley Land and Water Board

Federal government:

- Member of Parliament for Yukon (Federal)
- Marine Safety, Ocean, Coastal and River Engineering, National Research Council
- Cold Region Technologies, Ocean, Coastal and River Engineering, National Research Council
- Defence Research and Development Canada (DRDC)

Universities and colleges:

- Northern Research Institute, Laval University
- Indigenous Environmental Studies program, Trent University
- School of Epidemiology, Public Health and Preventive Medicine, University of Ottawa
- Fisheries and Marine Institute, Memorial University
- Cold Climate Innovation, Yukon Research Centre, Yukon College
- Fleming College
- Aurora Research Institute, Aurora College

Organizations:

- Canadian Manufactured Housing Institute (CMHI)
- Risk Sciences International
- Remote Energy Security Technologies Collaborative (RESTCo)
- Council of Canadian Academies
- Inukshuk Planning & Development Ltd

CSA Group program area staff:

- Construction and Infrastructure program area
- Natural Resources program area
- Environment and Climate Change program area
- Occupational Health and Safety program area
- Electrical program area
- Fuels & Appliances program area

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