Preparing for the Impact of Climate Change:

The Importance of Improving Infrastructure Climate Resiliency - The Engineering Perspective

Submission to:
Adaptation and Resilience Working Group

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Background information

Engineers Canada is the national organization of the provincial and territorial associations that regulate the practice of engineering in Canada and license the country's 290,000 members of the engineering profession. Engineering is a self-regulated profession. Engineers Canada exists to support the provincial and territorial engineering regulatory bodies. Together, we work to advance the profession in the public interest.

Our changing climate, with its extreme weather events, is adversely impacting and threatening Canada's health and safety, and the quality of life provided to its citizens by public infrastructure. Increases in the frequency and intensity of storms and extreme temperatures across Canada are exceeding the capacities of this infrastructure, causing damage and, in some cases, failure. The result is huge repair and recovery costs as well as extended disruptions of infrastructure service to Canadian citizens and businesses. Climate change is happening, but the frequency and magnitude of these changes remain uncertain. What is clear is that engineers, other professionals, policy- and decision-makers need to consider the changing climate and its impact on Canadians' safety and quality of life as supported by public infrastructure.

Engineering is on the front line in the provision of infrastructure to society. For this reason, engineers have a significant role to play in addressing climate change issues and incorporating them into engineering practice in Canada. The profession has been engaged in this issue for over 15 years with a focus on infrastructure climate vulnerability and risk assessment, as well as proposing adaptation policies, strategies and professional practices to improve resilience.

Building infrastructure today without considering future climate impacts is incorporating vulnerabilities that will later cause service disruptions and failures, thus increasing costs to government, the private sector and the public.

While adaptation of infrastructure has a community focus, a coordinated Pan-Canadian Framework on Climate Change (the "Framework") to improving resilience is warranted to improve codes, standards, climate information, policies, procedures and professional practices.

It is Engineers Canada's view that climate resiliency is the ultimate goal, and adaptation is the key strategy to achieve it. Therefore all adaptation actions should lead to an outcome of improved resiliency for all communities be it municipalities, cities, towns or First Nations communities. All should share the goal of achieving improved resiliency to climate change through the Pan-Canadian Framework.

The focus of this submission is on public and First Nations infrastructure, which substantially contributes to the health, safety and quality of life of Canadians. Engineers' Code of Ethics demands that engineers serve this public interest first and foremost in our work. Civil infrastructure—including buildings—is one of the fundamental areas of practice for engineers and our ability to design, build, operate and maintain safe and reliable infrastructure over a long service life is threatened by our changing climate. It is integral that the engineering profession engage and provide input to this dialogue from a technical and policy perspective that will result in the Pan-Canadian Framework.

The following considers the four questions posed in the request for submissions to identify ways to adapt to climate change impacts, support affected communities—many of which are Indigenous—and build greater resilience to these impacts. These questions include:

1. What are the most important priorities for Canada in building resilience?

2. What types of science, information, Traditional Knowledge, and decision-support tools are needed to help people decide when and how to adapt? What specific policies, programs or other instruments would be most effective in supporting adaptation action? Are there specific, innovative adaptation actions that will help build resilience in Canada? How can we learn from Indigenous Peoples' Traditional Knowledge, best practices and adaptation strategies to help reduce the risks of climate change?

3. How can governments, Indigenous Peoples and stakeholders best work together to support adaptation to climate change?

4. What climate change adaptation best practices, strategies, initiatives, or information would be most beneficial to help address climate impacts faced by Indigenous Peoples living in northern and remote communities?

From the engineering perspective, climate resilience is the ability of communities to prepare, plan for, absorb, recover from, or successfully adapt to actual or potential adverse climate events occurring over the service life of the infrastructure. As such, the government's promise to include climate resilience as a key pillar in federal infrastructure programs is a proactive and positive response to this growing threat to Canada's public infrastructure. Including a complementary climate resilience objective for public infrastructure projects at provincial/territorial and municipal levels is required to complete the implementation of this strategy. It requires coordination among all levels of government and at all stages of infrastructure procurement, construction, operation and maintenance.

Strategies and Proposed Initiatives

The following proposes several strategies for the Framework as it relates to achieving public and First Nations infrastructure climate resiliency. The strategies and proposed initiatives include specific ideas and suggestions that Engineers Canada believes, when successfully implemented, would greatly improve the climate resilience of all communities across the country.

Framework Strategy #1 - Develop a more comprehensive understanding of climate vulnerabilities and risks.

Engineers Canada strongly believes that for public and First Nations infrastructure, it is fundamental to have knowledge of the risks to the physical infrastructure as well as of the consequences that a

reduction or loss of service to the infrastructure would have on the public, businesses and vulnerable populations. Engineers Canada recommends the Framework includes the following:

1. **For all levels of government, incorporate climate vulnerability assessments into proposals for infrastructure design/build requests that involve new construction or refurbishment.**

Engineers Canada has developed an assessment protocol that assesses current and future risk to infrastructure in the event of extreme weather and the impacts of a changing climate.

The Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol is a structured, formalized and documented process for engineers, planners and decision-makers to identify and recommend measures the address the vulnerabilities and risks from changes in climate design parameters and other environmental factors due to extreme climatic events. The assessment helps justify design, operations and maintenance recommendations, and provides documented results that fulfill due diligence requirements for insurance and liability purposes.

The government must support infrastructure owners, including federal departments, to develop the capacity to perform climate vulnerability assessments. The Protocol has been used over 40 times in Canada and twice internationally. The Pan-Canadian strategy should support outreach to public infrastructure owners at all levels of government, to inform them of the benefits and outcomes of climate vulnerability and risk assessments as a first step towards resilience.

Provinces, municipalities and non-governmental organizations applying for federal government funding to build or rehabilitate infrastructure should demonstrate that they have either assessed their infrastructure climate vulnerability and service risks in advance, or require this as part of their design/build procurement process. In addition, they should demonstrate that they have taken reasonable measures to address risks through adaptation measures that assure improved resilience to protect their communities.

The implementation of a climate change vulnerability assessment during the planning stages of all infrastructure projects is a well-known and recognized best practice. The federal government could assume a partnership role in working with governments at all levels to ensure that the PIEVC Protocol, a free-to-use climate change vulnerability assessment tool, becomes a part of the decision-making process for all new and existing infrastructure on northern and remote communities. The PIEVC Protocol provides vulnerability and risk information to prepare decision-makers to make the best informed and responsible decisions to cost-effectively achieve climate resilient infrastructure that protects and serves the public and their investment.

The assessment is only the first step. To truly help Canadian communities be more resilient, the government must help them build the capacity to perform the assessments and also provide sustainable funding models to execute the recommendations.

By identifying the vulnerability of new and existing infrastructure to extreme weather events and service disruptions, communities will be better able to manage the dangers to life and property that they may face in the future as a result of our changing climate.

2. **Incorporate climate vulnerability and resilience objectives into federal and provincial environmental assessment processes.**

Another place to embed climate vulnerability and risk assessment is in federal and provincial environmental assessment acts. One best practice includes that an environmental assessment consider all aspects of the environment, including, for example, emissions levels or changing climate conditions. The project proponent should be required to review the project and advise on those features that will reduce climate risk and improve resiliency. Engineers Canada recommends the Framework include climate vulnerability and resilience objectives into federal and provincial environmental assessment processes.

Consideration of climate effects in the environmental assessment of proposed projects will build resilience in the local jurisdiction or community. These considerations not only define potential risks and vulnerabilities but would also propose climate adaptation measures, and their implementation during the detailed design stage of any project. In addition, where proponents do not comply with this provision, they should be required to justify the rationale and provide evidence for such a decision. This measure reinforces due diligence on the part of government, and puts the onus of potential legal liability on the proponent unless they comply.

3. **Embed quality based selection criteria that include criteria to evaluate improvements to climate resilience into all phases of procurement for services in the infrastructure life cycle (i.e. design, construction, operations and maintenance contracts).**

Services for infrastructure that are procured solely on the lowest bid can lead to cost savings initially. However, this process can also lead to higher construction, operation and maintenance costs over the lifespan of the infrastructure by encouraging the replication of older, cheaper technologies that will not be resilient to the inevitable future changes in climate. A selection method that attaches an overriding significance to infrastructure costs, such as the cost of engineering fees, can result in a situation where design-time limitations restrict the engineer's professional autonomy to find the best solutions to improve infrastructure climate resilience and protect public safety.

Qualifications-based selection is a transparent procurement process used for the selection of architectural and engineering services for public infrastructure construction projects. Under this system, the infrastructure owner considers a variety of competing engineering firms and selects a qualified firm, and then negotiates the project scope of work, schedule, budget, and fees. Adopting a qualifications-based selection process significantly enhances the prospects for innovative approaches that include climate adaptation. This will benefit taxpayers through improved reliability, climate resiliency, safety and long-term savings.

Qualifications-based selection maximizes the value of the engineer's contribution to a project while reducing the project's life cycle costs. Design engineering typically accounts for only about 2 per cent of the life cycle cost of infrastructure, but dramatically impacts the cost, climate resilience and quality of the remaining 98 per cent.

The Framework should include implementing policies requiring that qualifications-based selection be used for the procurement of all infrastructure services (e.g. engineering design) and include climate resilience as a requirement.

Framework Strategy #2 – Properly operate and maintain public infrastructure to absorb and withstand climate impacts over the life cycle

Public and First Nations infrastructure is a huge taxpayer investment and as a result it must provide reliable and cost-effective service over long periods—anywhere from 25 to 100 years. It requires applying the principles of asset management for the life or service cycle of the asset to achieve a sustainable and resilient infrastructure at lowest long-term cost and with least disruption of service. The scope includes not only a climate resilient design, but also cost-effective operations, maintenance and emergency response measures for low probability, high impact extreme events.

It is physically and economically impossible to design and construct "climate-proof" infrastructure that is resilient to every conceivable extreme event. Therefore, regular and sustained maintenance is necessary to maintain the performance of the climate resilient design. Low-probability but extremely damaging events such as tornadoes or hurricanes that exceed design or maintenance capacities will require response measures to deal with the consequences.

Engineers Canada recommends the following additional measures in the Framework to further build public and First Nations infrastructure resilience:

4. **Incorporate asset management principles, including climate resilience, into planning infrastructure projects and operating the assets over their life cycle.**

It is particularly important to ensure that new infrastructure investments incorporate measures to enhance the resiliency of infrastructure through its life cycle. Increasingly, municipalities and private infrastructure owners are using asset management principles to plan, build, operate and replace infrastructure so that it provides cost-effective service to the public.

Asset management is the coordinated activities of an organization to realize value from its assets in the achievement of its organizational objectives. From a practical perspective,
asset management is based on a set of four fundamental pillars:

- Value: Assets exist to provide value to the organization and its stakeholders
- Alignment: Asset management aligns the organizational objectives with technical and financial decisions, plans and activities
- Leadership: Leadership and workplace culture are crucial to realize value
- Assurance: Asset management gives assurance that assets will fulfill their required purpose

An important addition to asset management that has yet to be realized is due consideration of our changing climate, which continually impacts the asset. To incorporate this principle into the pillars listed above, there needs to be a concerted effort to define and instill this additional element into the practice of asset management. This includes the capacity-building of professionals who are directly or indirectly engaged in applying asset management to their assets.

The taxpayer expects their community to withstand not only the rigours of daily use, but also unforeseen events including extreme weather or other service failures. Asset management is a growing area of standardized practice for many municipalities and, together with an expanded scope to include

climate resilience, a wider uptake should be encouraged and even regulated if necessary. The same principles, adjusted for First Nations use, should also be encouraged.

5. **Develop (or build on) emergency response measures at the community level to respond to low likelihood, extreme weather events that would cause serious infrastructure damage or loss of asset.**

The most cost-effective strategy to improving the resilience of infrastructure and communities for severe but rare events such as tornadoes are emergency response plans. These plans are vital for the purpose of reducing the vulnerabilities of critical infrastructure in the face of extreme events and focus on decreasing the duration and scope of disruptions and facilitate response and recovery. Emergency response plans should include measures that provide sufficient resilience to ensure the health and safety of workers that operate and maintain the infrastructure, as well as the public.

6. **Amend national and provincial master contract specifications to include due consideration of climate resiliency and sustainable infrastructure.**

Master contract specifications are useful tools for small and medium communities to procure infrastructure that serves their needs. The federal government, and provincial governments with the support of the federal government, should amend, enhance and expand existing documents to other types of infrastructure not covered to date and include clauses that speak to the requirement for climate resilience.

Framework Strategy #3 – Undertake an initial five-year dedicated program on infrastructure codes, standards and other instruments (CSRI) to incorporate climate resiliency

National and provincial codes, standards and policies are key foundations that support integration of climate change adaptation into standard practices to improve resiliency. Engineers Canada is aware that efforts are underway to incorporate climate change considerations into the National Building Code of Canada (NBCC). We fully endorse these efforts and suggest the Framework acknowledge and confirm its support for this important work.

Our strategy is aimed at expanding and accelerating this effort to the extent that financial and human resources can be allocated. Moreover, this should be an ongoing effort on many fronts in a cycle that is similar to the NBCC.

Engineers Canada suggests that the scope of CSRI be extended to include maintenance standards that are infrastructure-specific. Aside from public use, our changing climate and extreme weather events present a huge load that diminishes the design capacity over the life cycle of infrastructure unless proper maintenance is continuous. Insufficient maintenance has led to the “infrastructure deficit” that exists today and increases our vulnerability to extreme weather events in the shorter term.

Providing an infrastructure maintenance schedule as part of the delivered infrastructure design/build would provide an important tool for communities to maintain operations and maintenance budgets. But

that maintenance schedule should adhere to national or provincial/territorial standards that must be developed to reflect current and anticipated climate extremes. This will require dedicated resources that could be applied to existing processes or create a dedicated project/program.

Based on this Engineers Canada recommends:

7. **By 2020, amend national, provincial/territorial and municipal level infrastructure design standards, by-laws and other mechanisms to incorporate climate resiliency and provide guidance.**

8. **By 2020, develop the first generation of national and provincial/territorial infrastructure maintenance standards that recognize climate resiliency as a prime objective. These should complement the climate resiliency provisions in building and infrastructure construction design codes and standards.**

Framework Strategy #4 – Improve climate science, climate-related information, climate services and improve utilization of climate tools

There are many types of science, information and decision-support tools governments must invest in and better use to help all communities improve resilience to adapt to climate change.

For example, certain areas of Canada are vulnerable to floods and in some cases new developments are being built, unknowingly, on flood plains. Building in or near a flood plain can be disastrous on various levels, especially if major flooding is not taken into account during the design phase of infrastructure. Flood plain mapping is an important tool in the assessment and management of flood risks. These maps constitute a basis for land use and planning, infrastructure maintenance and development and emergency planning. It is therefore vital information to planning a more resilient community. To better equip planners, engineers and communities as a whole, flood plain maps should be updated regularly, especially following a flood, to communicate accurate and reliable information to those who manage the development and continue to live within the area.

Environment and Climate Change Canada should restore its leadership role in collecting, analysing, standardizing and freely sharing climate data with public and private agencies, particularly at the provincial level. This should include, but not be limited to, a significant expansion and coordination of the network of climate and weather stations operated by Environment and Climate Change Canada and by others across the country. Engineers Canada also recommends improved support for the development of provincial and territorial climate data sets and scientifically defensible climate projections for use by many sectors of the economy.

Engineers Canada therefore strongly recommends that:

9. **The Framework include improvements to climate science, climate related information and climate services including:**
    - **Continued development of ensemble approaches to climate projections that reduce or better define uncertainties**

- **Consulting with climate data users to recommend and implement an initial research program for future projections of climate parameters other than, but in addition to, temperature and precipitation**
- **Updated flood mapping prioritized to flood-prone or flood risk communities and areas that includes improved digital elevation models**
- **Enhanced and easily accessible historical weather and climate data**
- **A program to update outdated Intensity, Duration and Frequency curves to present time coupled with an ongoing program to update them every 5-10 years**
- **Implement an enhanced and cooperative climate and watershed data collection program among all levels of government and the private sector that meets national standards.**
- **Development of provincial and territorial future climate data sets at a community level of resolution based on projections that focus on extreme values and percentiles, using scientifically defensible methodologies.**

Improving the utilization of climate tools at the community level requires not only financial resources, but also human resources. This is particularly required for small and First Nations communities that often do not have the professional expertise on staff.

Outreach, capacity-building and training are fundamental strategies that must be embraced by the Framework to achieve climate resiliency. It will take people to fully embrace and implement adaptation actions to improve climate resiliency. Proactive outreach and consultation on infrastructure climate vulnerabilities and risks, as well as understanding needs and priorities with a focus on smaller and First Nations communities is a first step. This would be followed by capacity-building that includes training of individuals engaged in planning and operating infrastructure for their communities through a learn-by-doing approach.

Engineers Canada thus recommends that:

10. **The Framework include provision for capacity-building for smaller and First Nations communities to define climate risk and vulnerabilities to their infrastructure followed by the development of community-based adaptation plans to improve the climate resilience of their infrastructure.**

It is suggested that funding of pilot projects and demonstration projects in a few communities be completed as a first phase. The learning outcomes would be developed into a replicable process that could be applied jointly or separately to small and First Nations communities.

The outcomes could also serve as a very compelling source of information to support public infrastructure decision makers as well as First Nations decision-makers. These projects would provide great hands-on learning opportunities for the participants, but more importantly can provide powerful evidence to prove the application and improve the transferability of climate resilient solutions across the country.

Framework Strategy #5 – Partner with First Nations communities to enhance local climate information and infrastructure resilience

The deficit for on-reserve and remote community infrastructure is estimated at several billions of dollars by the First Nations Financial Management Board. Ageing, inadequate and poor infrastructure can have significant negative effects on the social and economic outcomes of communities. In this respect, infrastructure is about meeting the most basic needs of individuals, families and communities—putting a safe, resilient roof over a family's head and making sure that they have access to clean drinking water.

First Nations communities offer an additional source of Traditional Knowledge that can be translated into more informed decisions. Elder knowledge of historical climate and climate trends on their land should inform and become part of infrastructure planning, design, operations and maintenance. Knowledge of local impacts such as invasive species, changes to the eco-system should be documented and included in climate risk and vulnerability assessments of First Nations communities.

11. **The government must provide sufficient, predictable and sustained funding of core public infrastructure on First Nation reserves and in remote communities to the same level as the rest of Canada.**

Funding must focus largely on resilient and sustainable public infrastructure. Essential infrastructure on First Nations reserves and in remote communities, such as safe drinking water, access to stable sources of electricity, wastewater treatment, waste management, information technology, schools and housing, must be properly funded, built to industry standards and resilient. This will greatly help the state of infrastructure on First Nation reserves and northern communities, as well as help the government deliver on their promise to have clean drinking water on reserves within five years of forming government. Cultural practices must be incorporated into the design of this infrastructure and the subsequent training to maintain infrastructure. This will require engineers and Indigenous and Northern Affairs Canada employees to undergo training in cultural awareness.

12. **The government must collaborate and provide funding to help First Nation reserves and remote communities build the capacity to assess, plan and manage their infrastructure.**

It is very important for Indigenous peoples living in northern and remote communities to build the capacity to assess, plan and manage their infrastructure. The government can help Indigenous communities build capacity by supporting the training and education of Indigenous peoples to foster and maintain expertise. This will better equip communities to build capacity, increase infrastructure resilience and improve sustainability.

13. **The government must encourage and support partnerships between municipalities and nearby First Nation reserves and remote communities to share infrastructure maintenance services.**

The sharing of services is a great opportunity for municipalities and Indigenous peoples to work together where these communities are near enough that shared services could be feasibly implemented. A large part of resilience is the ability to properly maintain the infrastructure and have a sustainable maintenance schedule. Not all First Nations reserves and Indigenous communities have the capacity to

do so. Federal government funding and subsidies to support and encourage these partnerships would have a strong return on the investment.

14. **The government must act swiftly on its promise to assist northern and remote First Nation communities to reduce reliance on diesel and other fossil fuels to generate heat and power and implement the use of more renewable energy.**

A particular issue of concern for remote and northern First Nations community resiliency is the availability and reliability of electric power. Diesel generators remain the most cost-effective means to deliver power and often the only energy alternative. These generators are high GHG emitters as well as vulnerable to climate impacts. Reduced reliance on diesel generators could become a project or program under the Framework. First Nations reserves could serve as the testing grounds for sustainable energy alternatives to increase resiliency and reduce the carbon footprint. Moreover, this is a problem not limited to First Nations communities and solving it there could bring learnings that could be transferred to other remote and northern communities.

Concluding Remarks

Engineers Canada has worked on assessing the impacts, vulnerabilities and risk of our extreme weather and future climate on public infrastructure for many years. We have developed considerable expertise and perspective on climate change adaptation and resilience. This work informed the development of our National Guideline on Principles of Climate Change Adaptation for Engineers. It provides professional practice guidance to engineers to consider climate change in their everyday work and enables engineers to turn “words into action.” But the words of policy must work with the actions of implementation. The engineering profession is well-placed to actively participate on both fronts knowing the vulnerabilities and risks that must be addressed.

Engineers have an obligation to serve the public and protect health, safety and the environment. In the face of a changing climate, the increasing frequency and severity of extreme weather events, and the large infrastructure investments being made by the federal government, it is vital that engineers be prepared to ensure that what we build today can withstand the climate of tomorrow.

Engineers Canada has developed the Infrastructure Resilience Professional (IRP) certification to provide engineers with the additional knowledge and competencies they need to plan, design and manage resilient infrastructure in the face of a changing climate. The IRP certification provides increased confidence to infrastructure owners and operators, to governments, and to the public that the recommendations or approvals being made by these engineers are supported by advanced training and experience in climate vulnerability assessment, risk management and climate adaptation on top of the robust set of requirements they must meet to be a licensed engineer.

The IRP certification program will create a cohort of engineers with the additional knowledge and competencies required to improve the resiliency of the built environment in communities across Canada. Six engineers achieved the certification in June 2016, with more to follow once these individuals have completed the course requirements. All levels of government who own and operate public infrastructure will improve its climate resiliency by accessing the specialized expertise of these certified engineers

Engineers Canada appreciates the opportunity to provide input to the Pan-Canadian Climate Change Strategy – Adaptation and Resilience Working Group. Canada's engineers are in a position to offer unbiased, objective evidence-based advice on climate change adaptation that serves the public interest. The profession is committed to collaborating with all levels of governments and other professionals to contribute to the implementation of the Pan-Canadian Climate Change Strategy.