2nd Communiqué: *Canadian Roadmap for Resilient Buildings*

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On October 16, 2020 the Canadian Academy of Engineering (CAE) hosted a virtual symposium in support of a national "Roadmap to Resilient, Ultra-Low Energy Built Environment with Deep Integration of Renewables" to be released in 2023. Many of the participating thought leaders authored 18 peer-reviewed papers to inform discussions at the symposium [1]. Key influencers from professional associations, building technology, housing, real estate and construction industries, academia and three levels of government participated in the symposium. The CAE is committed to convening discussions with Indigenous organizations and communities for the next stage of this initiative.
The symposium, organized by Concordia's Centre for Zero Energy Building Studies (CZEBS), was a catalyst for the transformation of the building stock in support the Canadian Net-Zero Emissions Accountability Act, introduced in Parliament in November 2020, that will formalize Canada's target to achieve net-zero emissions by the year 2050, and establish a series of interim emissions reduction targets at 5-year milestones toward that goal. Governments are developing a new model energy efficiency "retrofit" code for existing buildings, with the goal of having this code in provincial and territorial (P/T) regulations by 2025. Furthermore, collaboration is underway to develop and adopt increasingly stringent model building codes for new construction, with the ultimate goal of a net-zero energy ready (i.e., ultra-low energy) construction by 2030.

From a technical standpoint, the Roadmap will provide guidance to co-optimize carbon reduction, energy efficiency and building resilience in new and existing buildings, while ensuring continued compliance with other National Building Code (NBC) objectives. The Roadmap will highlight energy supply reliability enhancements via community-based renewable energy, energy storage and micro-grids, thereby maximizing resilience against energy outages during natural disasters such as extreme weather events and earthquakes.

The following table highlights major topics of papers and presentations at the symposium [1]

Themes	**Papers (lead authors):**	**Evidence for Roadmap**
Net-zero design	Meli Stylianou	Pathways for net-zero buildings and communities
Renewable energy	Costa Kapsis Ian Beausoleil-Morrison	Building integrated photovoltaics Solar energy and thermal storage
Smart grid integration	Miguel Anjos	Interface of smart buildings with grids
Building codes and standards	Andrew Pape-Salmon Remi Charron Iain MacDonald	Optimizing energy efficiency in codes Options for performance standards Supporting development of net-zero codes
Institutions	Chris Kennedy	Institutional oversight for electrification
Building Operations	Rosamund Hyde Louis Gosselin	Occupant behaviour and operations Monitoring performance of high-performance social housing
Ventilation systems	Chang-Seo Lee	Air filtration systems
Resilient buildings	Andreas Athienitis Theodore Stathopoulos Ted Kesik Liam O'Brien Marianne Touchie	Resilient and flexible buildings, resistance to pandemics Wind resilience Thermal resilience strategies Codifying thermal resilience Passive strategies for multi-family housing
Resilient communities	Caroline Hachem-Vermette Ursula Eicker	Resilience neighborhood design strategies Planning for carbon-neutral communities

The work completed for the symposium, along with over a decade of technical research and practice will support robust technical solutions and design methods that have a high level of acceptance across sectors, regions and professional disciplines, all necessary components for incorporation in national codes.

As highlighted in the final panel discussion on "Designing a Resilient Ultra-Low Energy Built Environment with Deep Integration of Renewables", additional work is required with respect to:

- Policy and regulatory strategies, particularly for resilience, as highlighted by Marianne Armstrong;
- Utility management and evolution of the building-grid interface, by Christian Bélanger;
- Local government leadership to address market barriers, by Bryan Purcell; and,
- Technology leaps for heat-pumps, storage and control, by Sophie Hosatte-Ducassy.

The following conclusions are drawn by the co-Chairs based on distillation of the information provided:

- The vision is for a resilient built environment that is economically optimized in design, operation, durability, renewal and energy supply over a long-term horizon (at least 50 years).
- To accelerate the innovation cycle, we will look to reframe the problem statements, continue to learn from existing building operations, and enable "double-loop" learning.
- Energy efficiency and on-site renewable energy generation are required for broader resilience of the building stock and associated community infrastructure.
- Canada has a suitable climate for widespread replication of buildings such as the Varennes Library in Québec, producing approximately as much energy as it uses in an average year through a building-integrated photovoltaic system, as the solar energy potential across most of the populated areas of Canada is significantly higher than most of northern Europe.
- Peak utility demand can be reduced through smart grids, with smart buildings being active participants to provide load flexibility and services to the grid, including short-term curtailment of loads, thermal and electrical storage, including electrical vehicles.
- Energy utility planning and the development of building codes and standards will benefit from access to measured data from building operations.
- The COVID19 pandemic has revealed the need for buildings and their ventilation systems to be designed to limit the spread of viruses such as COVID19, which has been shown to be significantly spread as aerosols. This can be done by reducing recirculation of HVAC air and bringing in more fresh air to dilute pathogen concentration, thus limiting the spread of infections, in addition to use of special filters and UV disinfection measures.
- We will aim to integrate "silos" in the professional community and institutions, but heavily influenced by government legislation.

The Roadmap will provide at least three "pathways" to achieve the desired outcomes, with one or more pathways suitable for each of the regions across the country with varying degrees of market capacity and readiness, differing economic, social and political drivers, and diverse climate conditions:

1. An incremental pathway that implements performance improvements one step at a time and transforms the market as capacity grows (i.e., the "bike path")
2. An accelerated pathway that front-loads leadership to drive change through leadership by prominent institutions and businesses (i.e., the "Trans-Canada highway")
3. A rapid transformation that adopts ultimate performance outcomes in advance of the mass market that drives innovation and positions the region to export its technology and know-how to other parts of Canada and the world (i.e., the "bullet-train")

These and other themes are topics that will be discussed at the 2022 CAE Symposium in Victoria, BC (face-to-face), along with presentation of three invited white papers on: (1) government policy and legislation, (2) economic-social-equity and (3) institutions and professional integration. An additional in-depth discussion will identify opportunities for reconciliation with Indigenous Peoples via partnerships to provide the labour force for one of the largest works in Canadian history to renew the building stock to be more resilient. A major upcoming activity of the Roadmap is a webinar on low carbon resilient communities on October 12, 2021, organized by CAE and Concordia's CZEBS.

[1] Athienitis, A.K., ed. (2020). Roadmap to Resilient Ultra-Low Energy Built Environment with Deep Integration of Renewables in 2050: Proceedings, Montreal Symposium. Centre for Zero Energy Building Studies, Concordia University, and Canadian Academy of Engineering, Montréal, Canada. ISBN 978-0-9690101-1-1.
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