Roadmap to Resilient, Ultra-Low Energy Buildings

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Centre d'études sur le bâtiment
à consommation nulle d'énergie

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Agenda for Today's Presentation

1. Roadmap introduction and case study (Andreas)
2. Vision and standards (Chris)
3. Policy principles (Andrew)
4. Metrics and empowering engineers (Rosie)
5. Closing remarks and next steps (Robert)

Roadmap and Case Study

Dr. Andreas Athienitis

What is the Roadmap?

- Guidance to achieve resilient decarbonization
- A compelling and achievable Vision for a resilient and decarbonized building stock in Canada in 2030 to 2050
- Metrics of beneficial outcomes aligned with the vision
- Case studies of buildings that align with the vision
- Principles to inform public policy and key influencers
- A call to action for the engineering profession to establish a building innovation ecosystem to catalyze transformation
- https://www.cae-acg.ca/resilient-building/

History – Canadian Academy of Engineering

- 2019 Communiqué following workshop
- 2020 Symposium and Communiqué
  - *Net-zero Ready Building Codes*
  - *Jurisdictional Responsibility for Improving the Resilience of Buildings to Climate-related Power Outages*
- 2021 Workshop – Low-carbon, Positive Energy Resilient Communities
- 2022 Panel Discussion – Bridging Silos to Catalyze Decarbonization and Resilience of Buildings

CAE Roadmap to Resilient Ultra-Low Energy Built Environment with Deep Integration of Renewables: Case Studies

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Case studies

- Summarizes examples of **three novel and high-performing community-scale or building projects** in Alberta, Ontario and Quebec.

- Each of these three case study projects accessed funding, directly from federal sources and/or through federally funded academic collaborations or federal agency research programs. They are well documented.

- Two NSERC strategic research network on smart net-zero and solar buildings were involved or followed the case studies.

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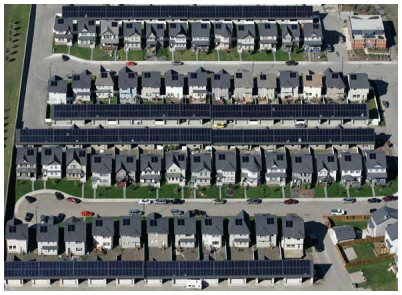
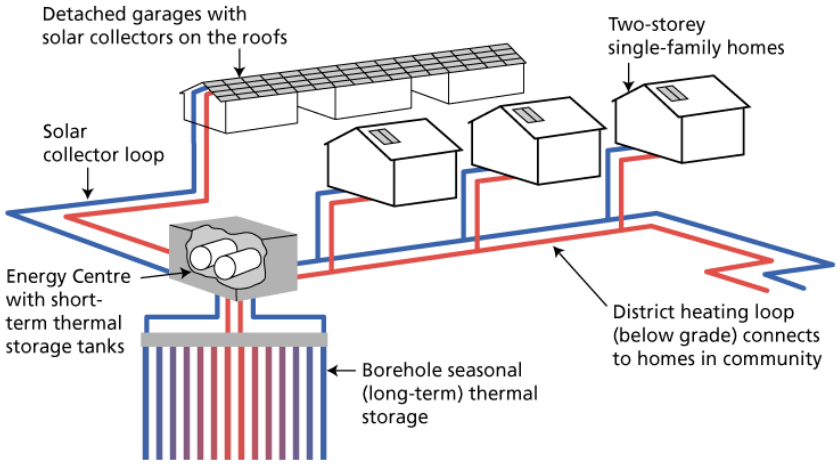
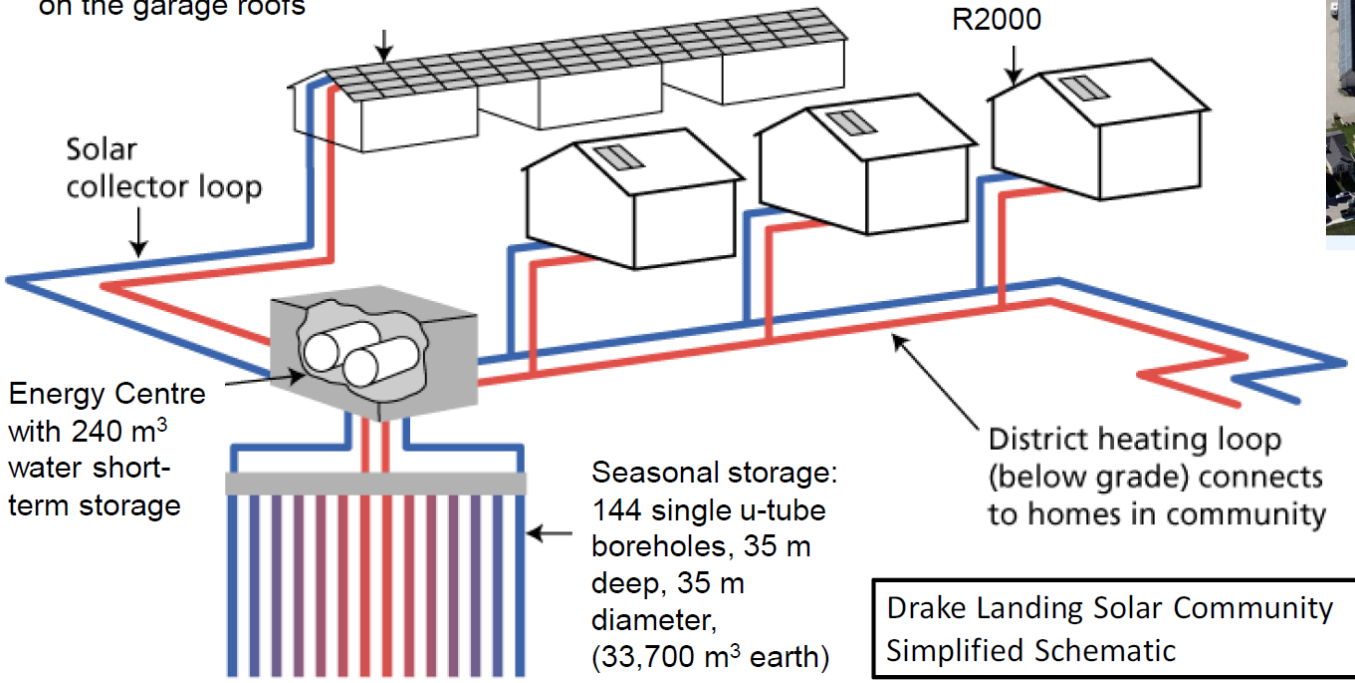
Drake Landing Solar Community (Alberta)

Delivers energy and decarbonization performance similar or better to that of Sweden's overall building stock based largely on solar thermal seasonal storage, achieving nearly 100% solar fraction for heating.

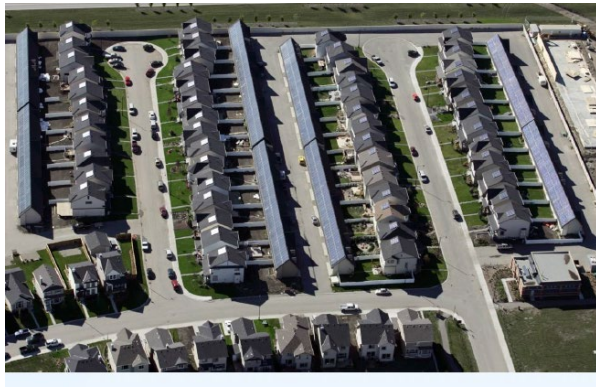




Drake Landing Solar Community (Alberta)
Seasonal solar heat storage in borefield



Drake Landing Solar Community
Simplified Schematic



Average solar fraction > 90%
In 2015/16 100%

Source: Bill Wong, NRCan

The West 5 sustainable community in London Ontario

Showed that with energy efficient buildings and extensive use of photovoltaic solar panels heat pumps and integrated electric vehicles, demonstrated that innovations in microgrid business models and adaptations to code limitations are necessary to efficiently integrate renewable energy into communities.

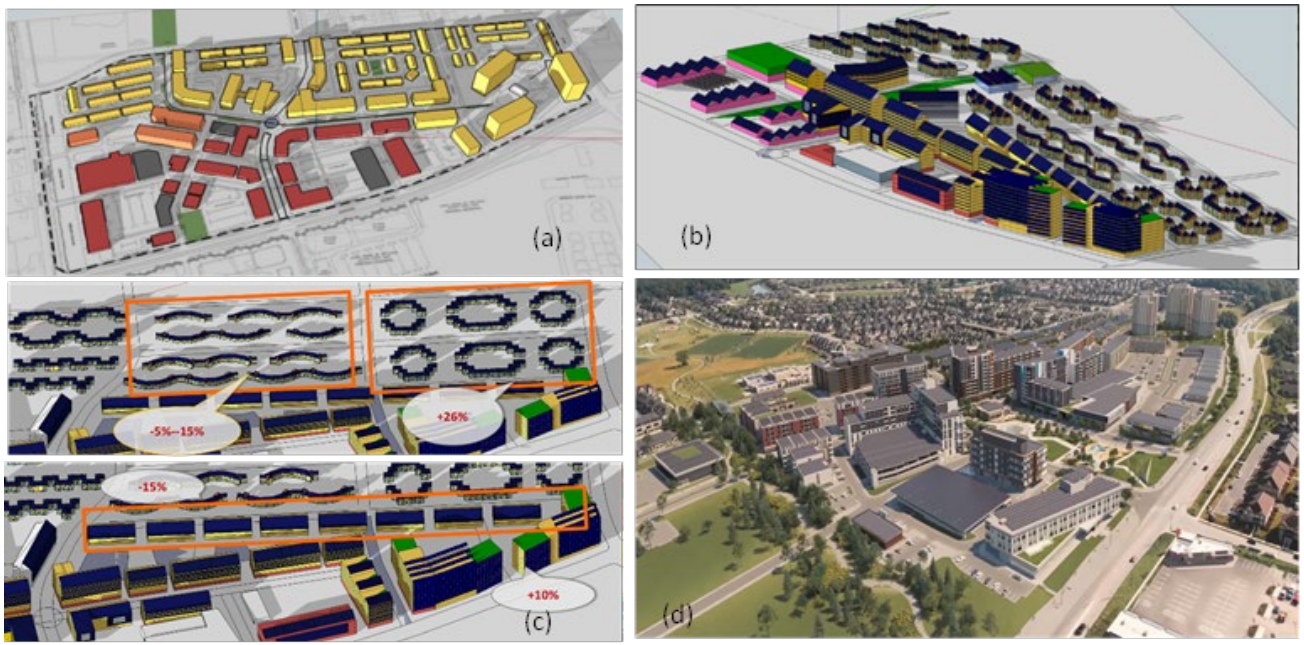
Pictures from West 5 (partly completed)

Ref.https://west5.ca/
https://www.s2etech.com/capabilities/development/net-zero-community-design/

West 5 Net-zero Community and Smart Grid Project

- Net-zero mixed-use community in Ontario.
- 2,000 homes
- Separate micro-utility company
- Overcame regulatory barriers

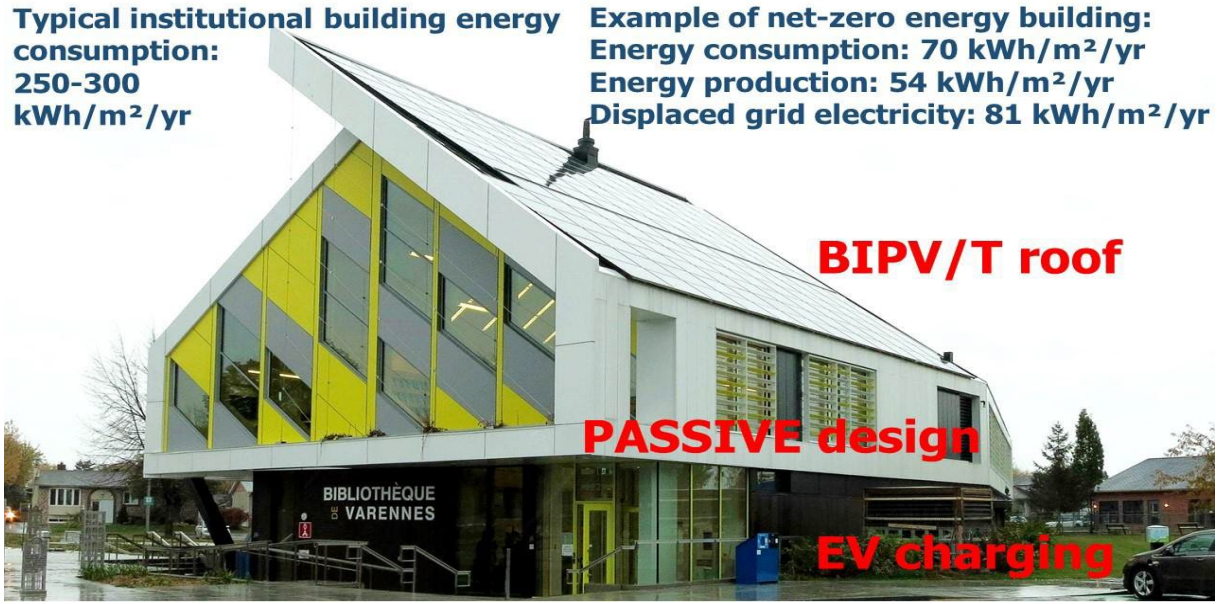
Various stages of the design process of the West 5 Community, in London Ontario



Credit: Dr. Caroline Hachem-Vermette

The Varennes library NZEB in Quebec

By exporting solar electricity from a building-integrated photovoltaic system to the grid, displaced more primary energy through photovoltaic generation than electricity imported from the grid in an average year, thereby achieving net zero energy performance.



We advised the design of Canada's first net-zero energy building.

Now its operation (model predictive control and energy flexibility) is studied under a NSERC Hydro-Québec Industrial Chair

V. Dermardiros, A. K. Athienitis and S. Bucking, "Energy performance, comfort, and lessons learned from an institutional building designed for net zero energy," ASHRAE Transactions, Vol. 125, 2019.

Overview of energy flows in a NZEB like Varennes Library

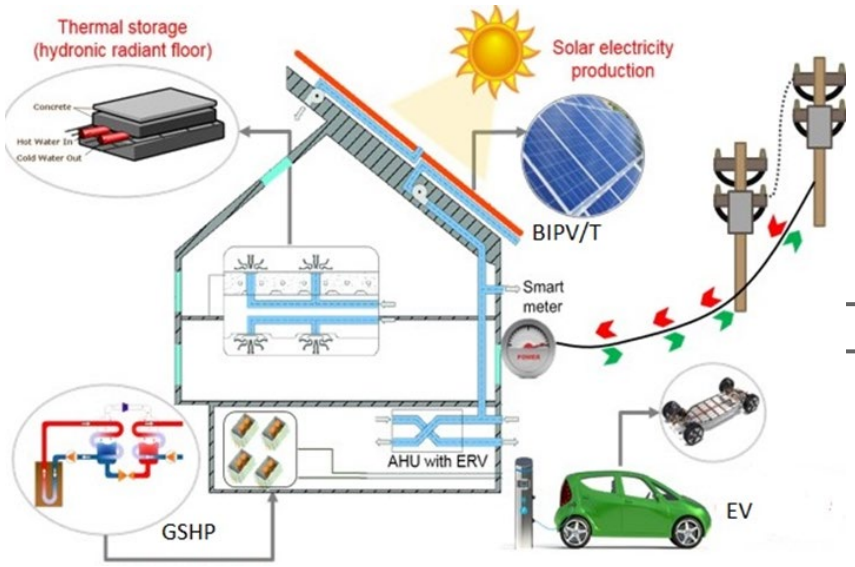
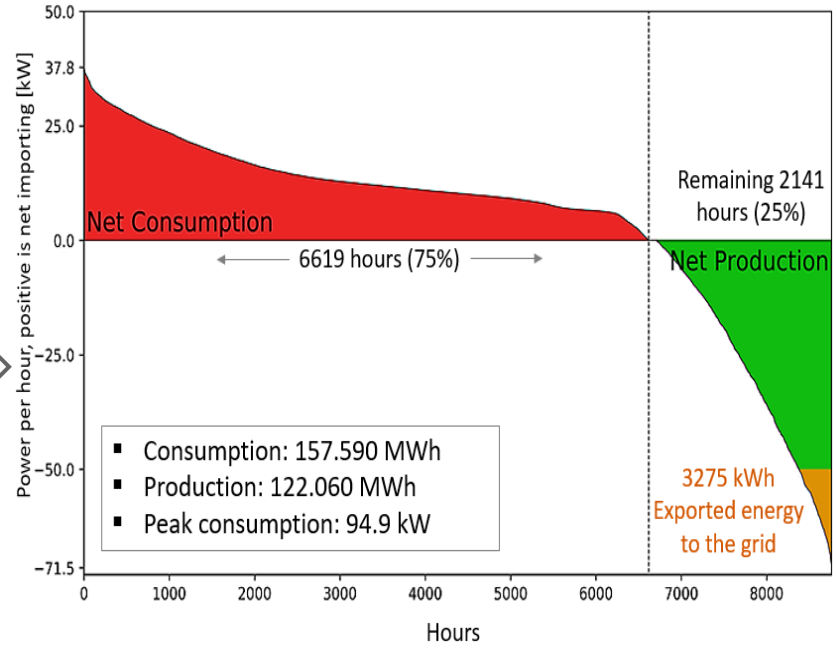


Illustration of different energy technologies that can be used to enhance flexibility in the operation of the Varennes library



Load duration curve: electricity flow from and to the grid

Note: grid will buy up to a max. of 50 kW from building

A NZEB like the Varennes Library can provide flexibility to the grid in response to grid signals through predictive control

Discussion
Scope of Roadmap and Case Studies

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Vision

Dr. Chris Kennedy

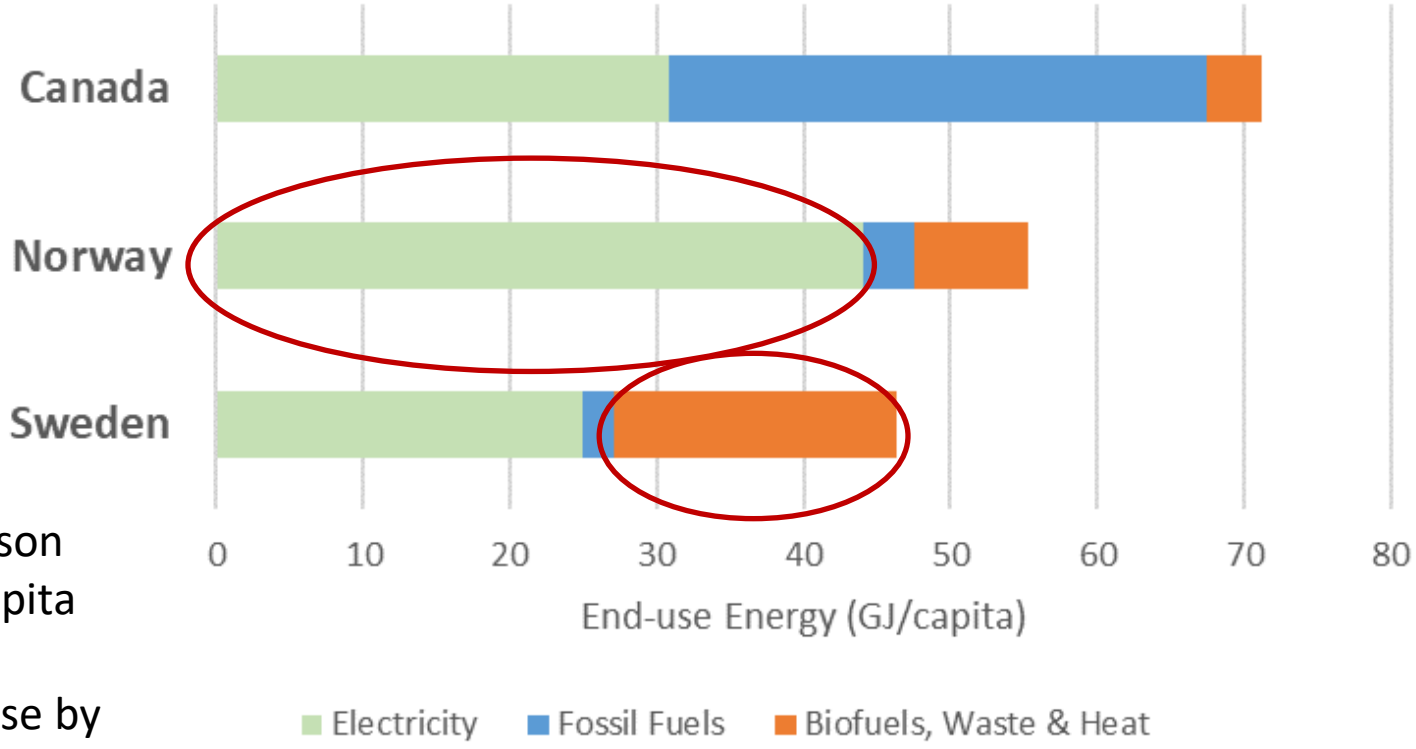
Vision

Climate change adaptation and mitigation necessitates a transformation of Canadian energy systems.

The design of buildings, transportation systems and industry must change, with an additional emphasis on:

- Eliminating fossil fuels
- Increasing energy efficiency
- Bolstering resilience

Strategies for Decarbonization



Comparison of per capita building energy use by source

The Resilience Imperative

Requirement: a diversity of carbon-free energy sources; including building & community scale power systems.

Market Update on Green Building Standards

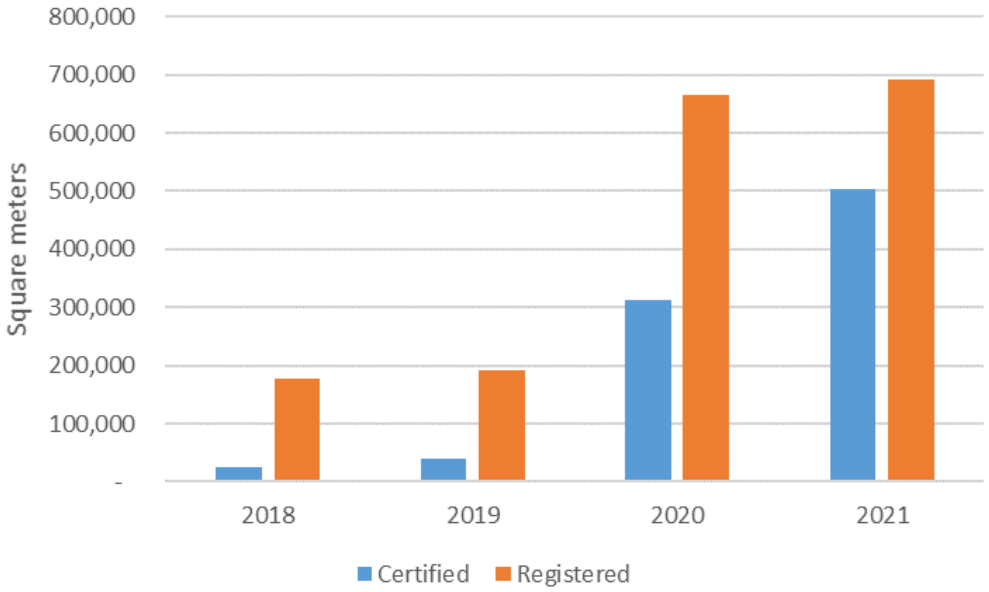


Figure 1. Building space registered for or certified as zero carbon by the Canadian Green Building Council.

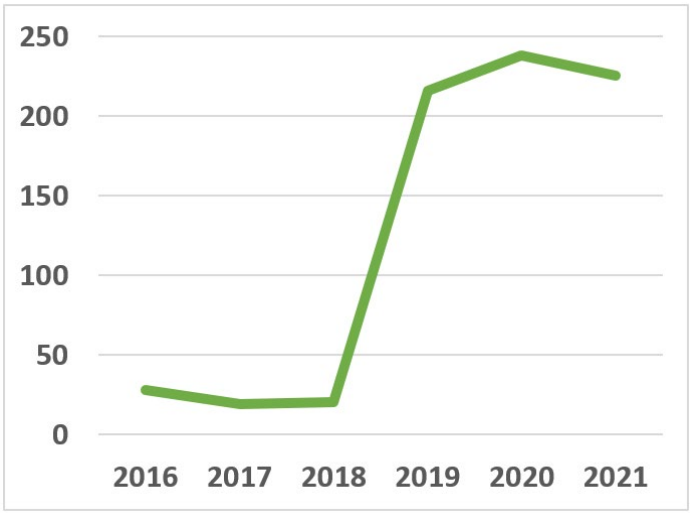


Figure 2. Number of units recorded by the Canadian Home Builders Association as net-zero-energy or net zero energy-ready

Organization	Region	Program	Total floor area (sqr.-m) All years
Canadian Green Building Council	Canada	Zero-carbon certified	1,111,000
Canadian Home Builders Association	Canada	Net Zero energy or net-zero ready	230,000
International Living Future Institute	International	Zero Carbon certified	46,000
Passive House	International	Passive house certified	over 3,000,000

Floor area of net-zero carbon, net-zero energy, net zero-energy ready, and Passive house certified buildings (as of May 2022).

This 100% solar community endured Hurricane Ian with no loss of power and minimal damage

By Rachel Ramirez, CNN
Updated 11:53 AM EDT, Sun October 2, 2022

Babcock Ranch is a solar-powered town with 2,000-homes

- 700,000 panels
- buried power & internet cables
- designed for floods

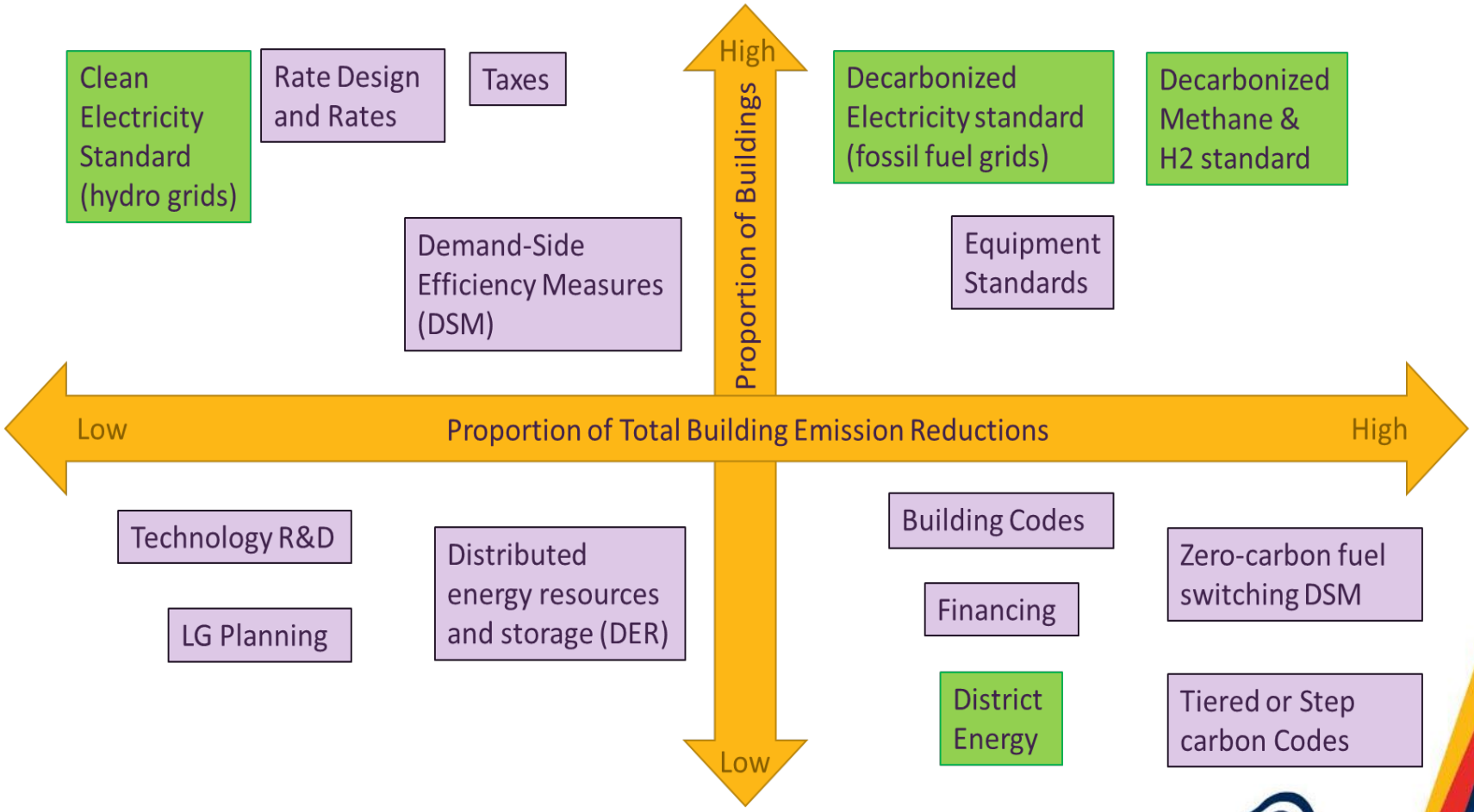
Discussion
Vision and Standards

Policy Principles

Andrew Pape-Salmon

Measures to Decarbonize Buildings

Demand-side Measures (purple)
Supply-side Measures (green)



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Principles for Policy Makers

1. Facilitate Integrated Demand- and Supply-side Resource Planning
2. Focus on Performance Outcomes that Foster Competition and Enable Innovation
3. Allocate Jurisdictional and Institutional Responsibility
4. Leverage Building Lifecycle Investment Triggers
5. Facilitate Data-driven, Outcome-based Policymaking

1. Facilitate Integrated Resource Planning

Current Institutional Planning Frameworks

Regulatory Frameworks for Buildings	Residential	Commercial	Institutional	Rental & Social Housing
Land Use Planning	Local / Regional / Indigenous Government Planning			[P/T Emerging]
New Construction	Building codes, Advanced energy efficiency standards, Government energy efficiency policy, incentives and programs			
Equipment	Federal and provincial Energy Efficiency Act, Energy efficiency programs			
Asset Management	Mandatory Depreciation Report	N/A	Capital Asset Management Framework	
Building Renewal	Building codes, Energy efficiency, Tax exemptions and credits			+ Design guidelines, Rent control, Government funds
Real Estate	Real estate labelling	Benchmarking	Greening government buildings	Tenant protection
Electricity Supply	Public Utility Commission (PUC) oversight (resource planning, project approval, supply, rates), clean electricity policies, utility demand side management (DSM) programs			
Fossil fuel and other methane and H2	PUC oversight, emerging carbon policies, DSM programs			
Distributed and district energy	Public Utility Commission oversight, net metering, government ownership, mandatory local DE connection bylaws.			

Stages of Building Life-Cycle

Energy Supply

Proposed Planning Framework – across institutions for entire building sub-sectors

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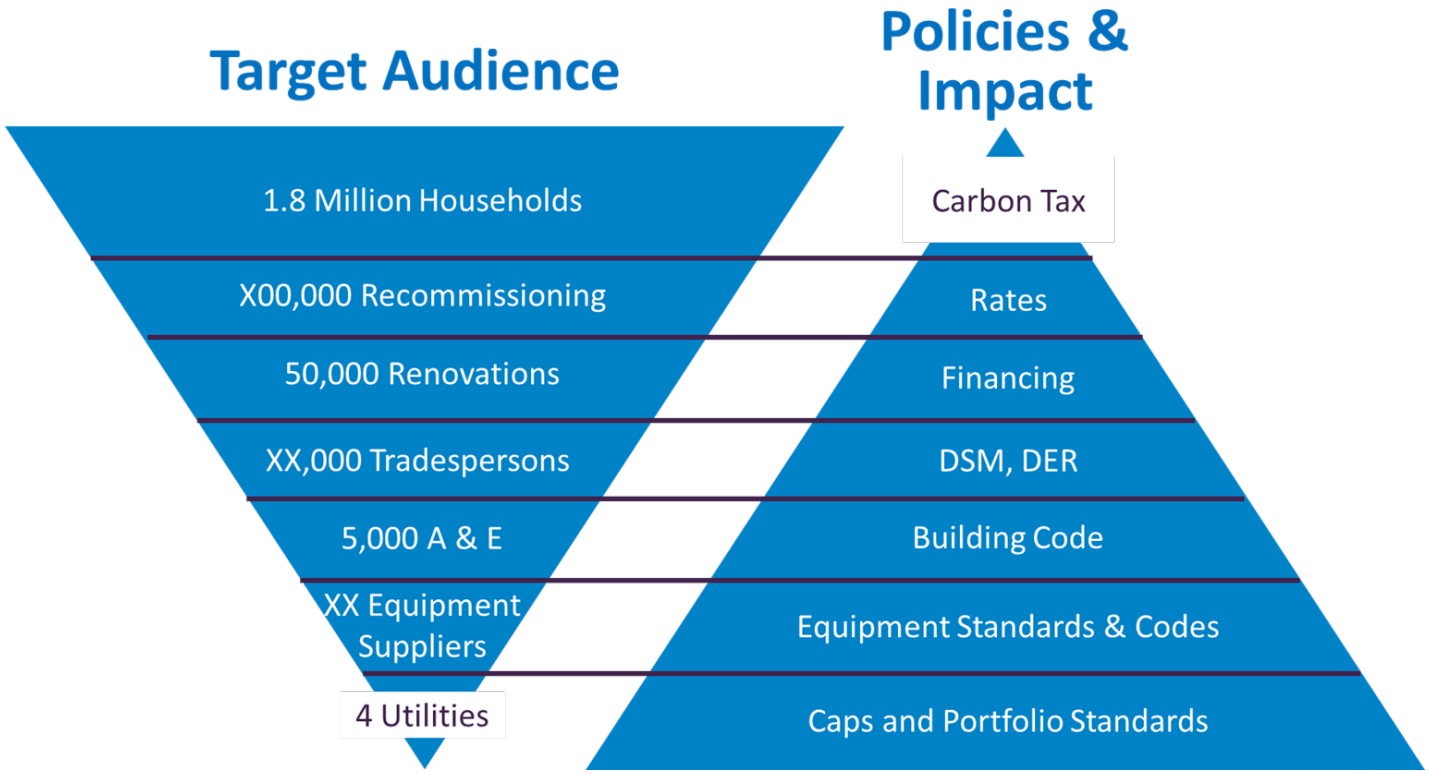
2. Focus on Performance Outcomes that Foster Competition and Enable Innovation

- Establish common performance standards across objectives and regulatory frameworks
- Empower professionals to design to those goals and co-optimize design across objectives and across regulatory frameworks
- Harmonize all regulatory frameworks to avoid conflicts preventing co-optimization.
- Maximize flexibility on pathways to achieve goals for those objectives, thereby enhancing innovation, competition and cost-minimization.
- Establish an “innovation ecosystem” within key professional and institutional communities
- Develop adaptative design solutions and avoid prescriptions with dead ends, despite known changing conditions.
- Focus on risk identification, vulnerability assessment and mitigation versus exposure to recovery and damage costs.
- Communicate extensively with governments on potential adjustments to policy frameworks to enhance performance, innovation and resilience, as opposed to a “compliance mindset”.

3. Allocate Jurisdictional and Institutional Responsibility



Principles for Policy Makers

4. Leverage Building Lifecycle Investment Triggers
5. Facilitate Data-driven, Outcome-based Policymaking

Discussion – Policy Principles

Question for audience:

- *What is the appropriate role for municipalities?*
- *Is it important to empower municipalities to lead, followed by Province- and Territory-wide building code standards?*
- *British Columbia empowers individual municipalities to set differing progressive standards for energy efficiency, along with carbon pollution standards*

Metrics and Empowering Engineers

Dr. Rosamund Hyde

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Measuring progress

- Goal of buildings-related emissions net zero by 2050
- Are we making progress?
- Metrics – what characteristics are needed?
- Collection of data on performance is a high priority
  - verify Building Sector's transition toward vision
  - inform future government policy

Metrics groups

- Net-Zero emissions
- Increase energy-related resilience
- Change the design process
- Improve building energy codes

Approach net-zero emissions

Toward high-performance, efficient buildings with integrated energy storage, renewable energy use and electric vehicle charging capacity - **fraction of** :

- new buildings and major retrofits using the full potential of energy efficiency, energy storage, renewable energy and providing adequate EV charging capacity
- operating energy for buildings in Canada under normal conditions supplied by site or regional renewable energy
- smart buildings that are connected interactively to smart grids

Toward coordinated grid and built environment decarbonization strategies - **fraction of:**

- grid energy delivered to Canada's consumers through utilities with confirmed decarbonization commitment

Increase energy- related resilience

Toward buildings designed for predictable resilience at site and community scale – **fraction of**:

- new buildings designed to be resilient (initially to generate their power and heat for a certain period)
- new buildings with predictable response to disruption
- Canada's urban population living in communities with reliable verified urban modelling

Change design process

Toward building design and evaluation process that supports accountability and continuous improvement in changing environment **- fraction of**:

- advertised positions for credentialled subdisciplines (like building energy modelling, energy manager, airtightness, envelope, comfort) filled within one month
- new buildings designed using modelling and simulation software as a design tool
- 3-year-old buildings with BIM-based calibrated model
- new buildings with a technical continuity strategy in place.
- new buildings with integrated budget strategy in place

Improve building energy codes

Towards building code strategies that support near and long-term goals

- Level of acceptance of net-zero definition by construction and utility community
- Fraction of new floorspace governed by building codes that use an ultimate goal as a reference
- Fraction of new buildings receiving performance-based code approval
- Code policy is reviewed and updated throughout levels of government and jurisdictions

Empowering engineers

Expanded role needed for engineers because the profession:

- Serves multiple Buildings sector stakeholders
- Bridges across government, institutional and sectoral silos
- Aligns with codes of ethics including “ hold paramount the safety, health, and welfare of the public, including the protection of the environment…

Engineers are in a unique position to catalyze meaningful action on policy goals while highlighting limitations of design solutions in the context of management practices, local context and a changing climate.

Call to action for engineers

Establish a vision for future-proofing buildings

Individually evaluate risk factors and mitigation measures

If involved in building operation: measure building performance and use data to optimize operation

Contribute to policy development including codes

Collaborate with academe on demonstration projects

Collaborate with CAE on innovation ecosystem

Broader scope for building design engineers

- Serve clients better and strengthen competition
- Move toward more harmonized system of codes
- Elevate building design and focus on stewardship
- Address gap between practice and research
- Attract recruits motivated to improve buildings
- Engage with design professionals and engineers in other fields
- Participate strategically in climate action

Discussion
Metrics and Empowering Engineers

Closing Remarks

Dr. Robert Crawhall

Roadmap Next Steps

- First draft of Roadmap: Completed November 2022
- Advisory Committee input: December-March
- Final Roadmap: June 2023
- Presentation at CAE National Conference, Victoria: June 2023
- Dissemination to F/P/T Ministers of Energy and Building Code: Fall 2023