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What is the Secret Formula for Making a Low-Carbon Community?

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CanmetENERGY
Leadership in ecoInnovation

Canada

AGENDA

• Introductions	10 min
• Workshop Orientation	20 min
• Workshop (incl. break)	105 min
• Feedback & Discussions	45 min

Motivation: GHG Reductions

Homes and buildings account for approximately 17% of Canada’s GHG emissions. Canada’s long term GHG reduction targets look well beyond the next 10 years:

- **National target:**
  - **30% reduction by 2030 (Paris Agreement)**
- **GoC (Greening Government Strategy):**
  - **40% reduction by 2030**
  - **80% reduction by 2050**
- **Long-term goal: Carbon Neutrality**

Emissions from natural-gas furnaces and boilers on a cold winter morning, Regina SK.

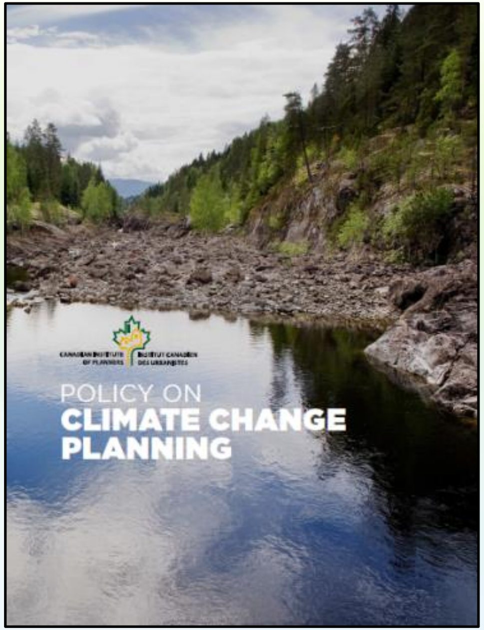
CIP Climate Change Policy

Sample Policy Objectives: Built Environment

- **"New and existing residential, commercial, and industrial developments have near- or net-zero energy and/or emissions profiles, and avoid introducing climate vulnerabilities."**
- "Communities work collaboratively with utilities to facilitate energy conservation, efficiency, and the integration of distributed energy resources, especially in remote areas. This may include renewable energy and thermal technologies and systems."

Role of Planners: Ensure Effective Decisions

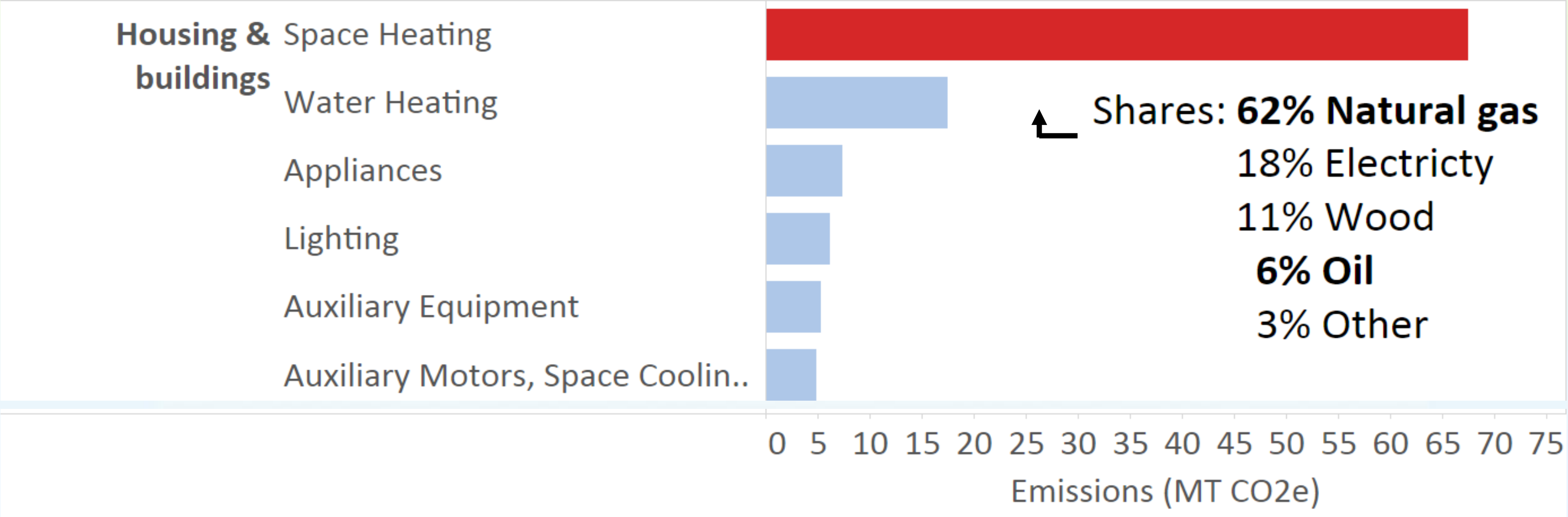
- **"Act in the public interest, incorporating measures to mitigate climate change and adapt to its impacts in all relevant planning decisions."**
- "Base planning advice on authoritative climate and energy data and projections."



http://cip-icu.ca/ClimateChange

Challenge: Space Heating

Space heating is the single biggest energy end-use for buildings in Canada, and a major contributor to GHG emissions.

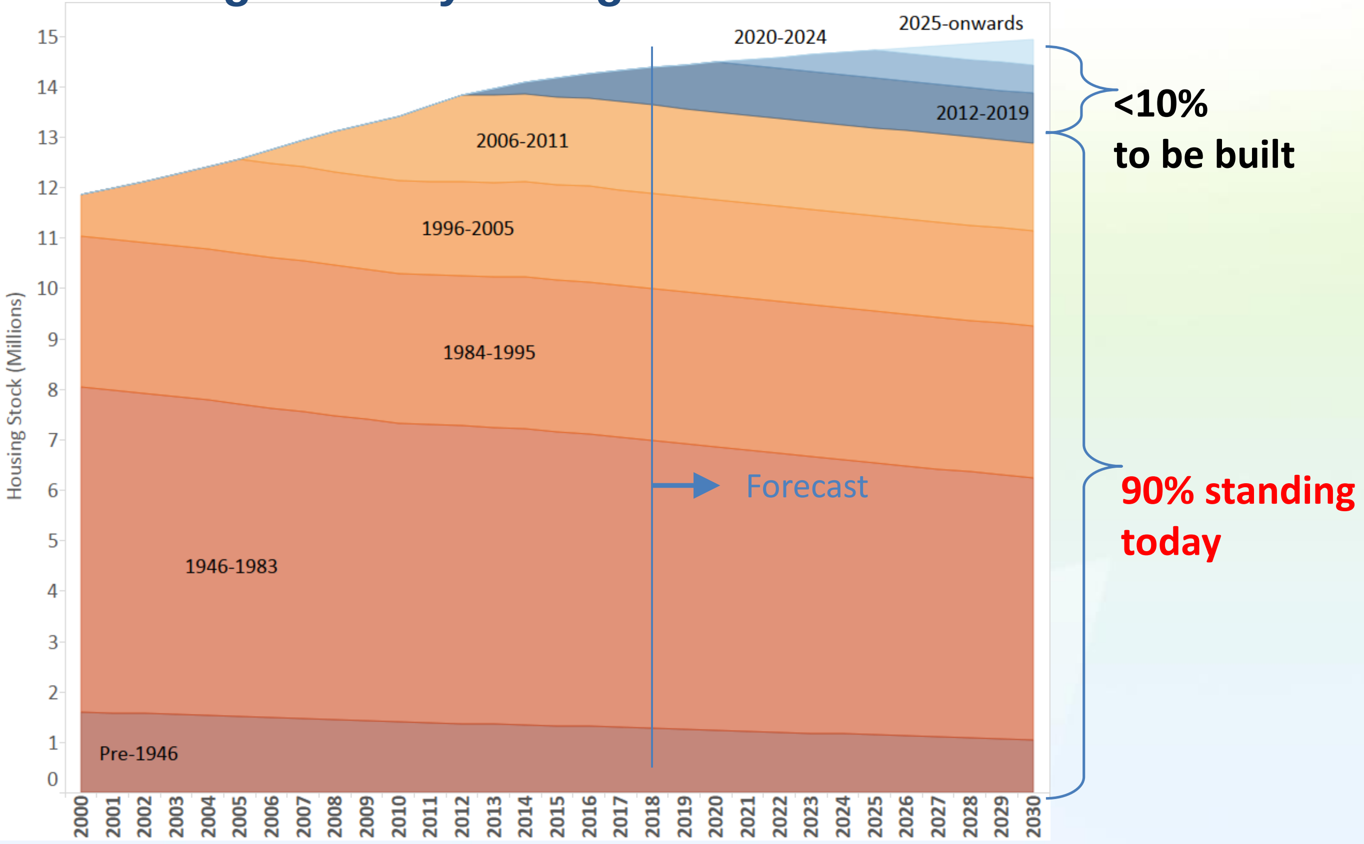


Current and Projected Housing Stock by Vintage

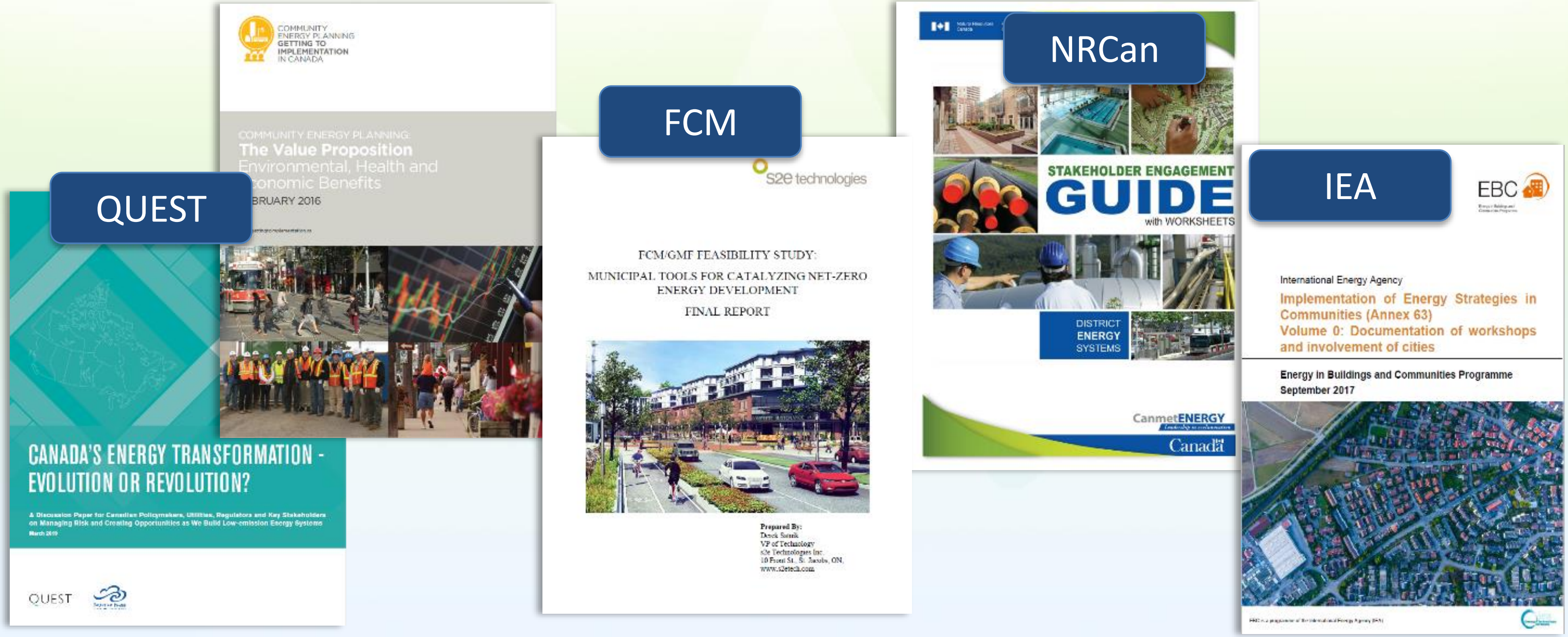
Challenge:

Most of the 2030 GHG Emissions will come from homes standing today!

Expect similar trend with the Commercial building stock



Large Body of Knowledge



Workshop Orientation

Purpose of this workshop

- Learning about low carbon energy technologies
- Providing feedback on the LCCES process
- Secret formula in making a low carbon energy community?

How we plan to run this workshop…

Limitations: time, details on technology integration, costing & business model development and implementation plan

Workshop Orientation

We are here …

Low Carbon Community Energy System (LCCES) Process

(1) Stakeholder Engagement

(2) Technology Workshop

(3) LCCES Optimization

(4) Business & Operation Model

(5) Implementation Plan

8 -10 MONTHS PROCESS DURATION

For the Purpose of This Workshop:

Completed → 60 Min → Done by "Consultants" → 30 min → Your Feedback

Technology Workshop

- Energy planning hierarchy
- Building & grid energy 101
- Review of low carbon energy technologies
- Introduction of Scenario Communities
- For your community (and your role), discuss which technology(ies) you prefer, your concerns and the potential opportunities you see ….
- Develop your best technology solutions

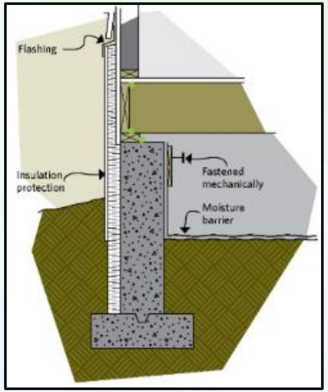
Energy Planning Hierarchy

3. Renewables

2. Reuse

1. Reduce

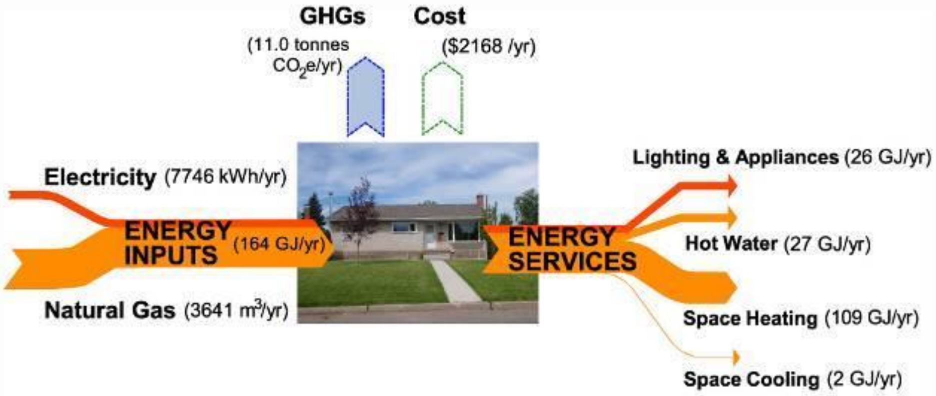
Land use & urban form



Building Science 101

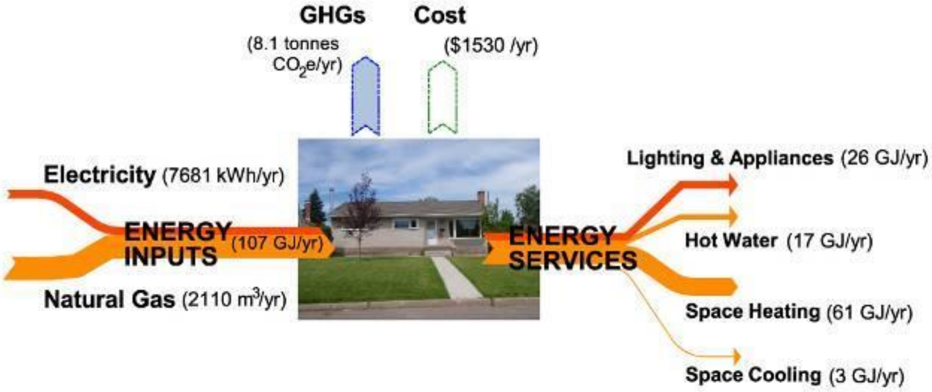
- House as a System
- Building envelope
  - Foundation and walls
  - Roof
  - Windows and doors
- Mechanical systems
  - HVAC
  - Renewables
- Equipment
  - Appliances
  - Lighting
- Occupants
- Energy use varies by building type, use and occupancy

Energy Use by Source and End-use



Single Family Dwelling 1 Base Case

Prince George, BC



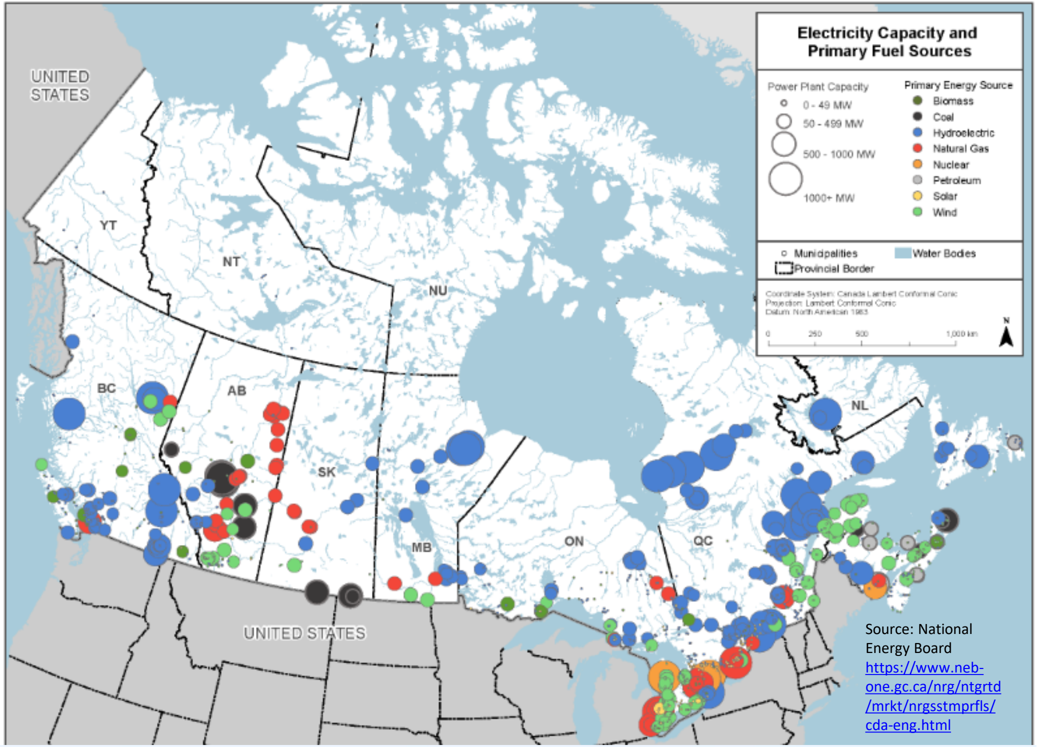
SFD1 Retrofit - Furnace, DHW & closed chimney upgrade

Prince George, BC

Grid Energy 101: electricity

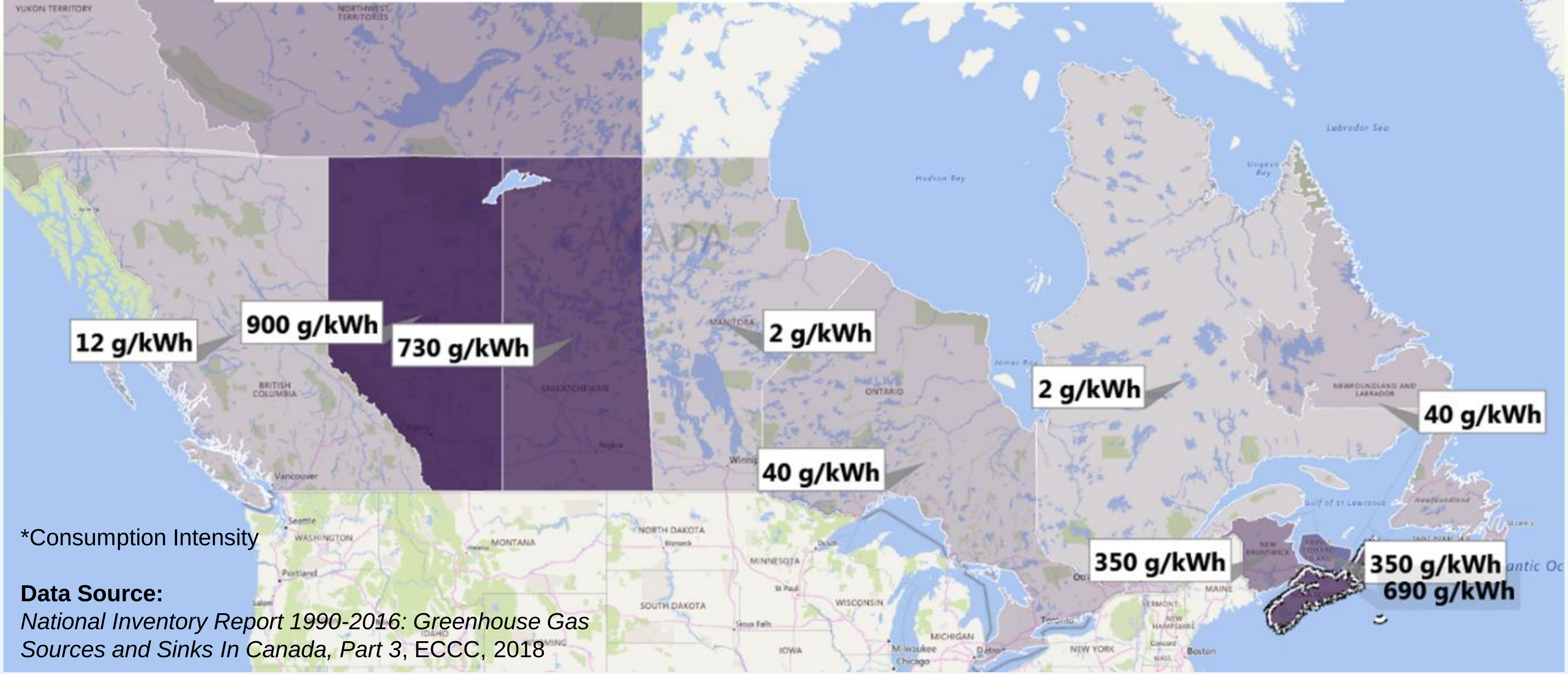
- **Generation**
  - Large
    - Hydro
    - Nuclear
    - Fossil fuel
  - Distributed
    - Solar
    - Wind
    - Biomass
  - Varies per P/T
- **Transmission**
  - High voltage over long distances
  - Losses
- **Distribution**

Electricity source by % of nat'l generation (2014)	
Large Hydro	59.3 %
Nuclear	16 %
Coal	9.5 %
Natural gas	8.5 %
Non-hydro renewable	5.2 %
Oil	1.5 %
Total	**100%**



Source: National Energy Board https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/cda-eng.html

Electricity Carbon Intensity*, 2016 (CO_2eq)

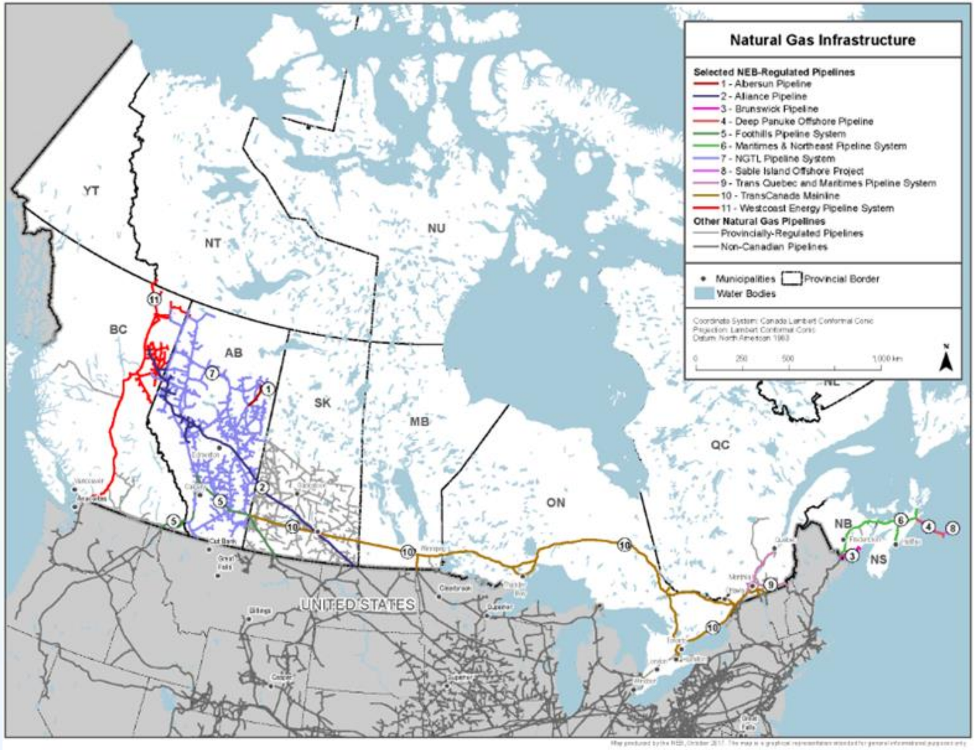


*Consumption Intensity

Data Source:
National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks In Canada, Part 3, ECCC, 2018

Grid Energy 101: Natural Gas

- **Generation**
  - Gas extraction
- **Transmission & Distribution**
  - Pipelines
- **Predominant uses**
  - Space heating
  - Water heating



Source: National Energy Board https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/cda-eng.html

Partial Low Carbon Energy Technologies Inventory

- Photovoltaics (PV)
- Solar thermal collectors
- Solar PV-Thermal collectors
- Solar cooling
- Concentrating solar power generation
- Ground source heat pumps
- Air source heat pump
- Lake/river coupled heat pump
- Earth tubes
- Sewer waste heat recovery
- Biomass (pellets/chips) for heat
- Biomass for heat & power
- Biogas (anaerobic digestion) heat & power
- Biomass gasification for heat & power
- Small-scale wind
- Large-scale wind
- Thermal energy storage (short term)
- Thermal energy storage (seasonal)
- Electrical energy storage
- Hydrogen generation and storage
- Waste to energy (multiple technologies)
- Waste heat recovery (Organic Rankine Cycle)
- Cold storage (short term and long term)
- Fuel cell (multiple technologies)
- District Energy systems (heating & cooling)
- Smart grid (for energy management)

Low Carbon Technologies: Photovoltaics (PV)

Overview:
Converts sunlight into electricity;
Large international suppliers;
Few Canadian manufacturers;
Becoming popular and more common.

Typical Install:
Residential and commercial building rooftop;
Requires electrician to install;
Could be small (less than 10 panels on a roof of a home) to very large systems (30,000+ panels – ground mount systems).

Opportunities / Benefits:
Clean & local electricity;
Displaces high carbon grid electricity in some provinces;
Widely available.

Costs and Concerns:
Relatively low cost;
Very low maintenance cost;
Easy to install;
Connection acceptance by local utilities?

Low Carbon Technologies: Solar Thermal

Overview:

Converts sunlight into heat (thermal energy);
Higher temperature vs. low temperature;
Popular with government subsidies;
Competing against fossil fuels;
Few Canadian suppliers.

Typical Install:

Residential and commercial building rooftop;
Require plumber to install for hot water;
Typically small systems in Canada (2 – 4 collectors on homes, up to 30 collectors on commercial buildings).

Opportunities / Benefits:

Clean energy for space heating and hot water;
Good in areas with high heating oil price.

Costs and Concerns:

More expensive to install and operate;
Limited market technical support capacity.

Low Carbon Technologies: Heat Pumps

Overview:

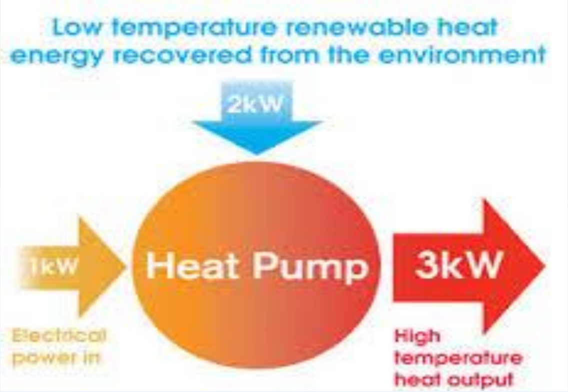
Use refrigerant fluid properties to "upgrade" heat from low temperature sources to higher temperature use;
Typically use electricity to run (compressor);
Well established market (fridge and A/C).

Typical Install:

Configuration depending on low temperature heat source (air, river, ground, etc.);
Can be for individual home/building or a group of buildings;
Common in modern day high-rise condos.

Opportunities / Benefits:

Extract renewable heat from the environment for space heating or hot water;
Low carbon technology when electricity is clean.



Costs and Concerns:

More expensive than conventional fossil-based heating;
Requiring knowledgeable system designer;
Limit on output temperature.

Low Carbon Technologies: Biomass Heat

Overview:

Converts chemical energy in biomass into thermal energy (heat);
Combustion of wood chips or pellets;
Require feed stock processing and transport;
Small quantity of waste needs disposal.

Typical Install:

Household size to commercial/industrial scale;
Large systems requiring emissions controls and monitoring;
Compatible with hydronic or forced air system;
Established technology.

Opportunities / Benefits:

Use of waste woody products or by-products;
New market for Canada (export feed stock to Europe).

Costs and Concerns:

Slightly higher cost than fossil fuels;
Some controversy on GHG implications;
Requiring emissions controls.

Low Carbon Technologies: Electrical Energy Storage

Overview:

Range of electrical energy storage battery technologies;
Simple to implement;
Store energy during low demand periods and retrieve the energy during peak.

Typical Install:

Could be on a building scale or utility scale;
Coupled with PV or other renewable electricity generation;

Opportunities / Benefits:

When PV generation is available but demand is low;
Reduced demand from grid during peak periods may reduce emission from high carbon "peakers".

Costs and Concerns:

Relatively expensive;
Require clever controls;
Some savings on electricity bills by avoiding peak time grid power usage.

Low Carbon Technologies: Thermal Energy Storage

Overview:

Store heat (could be from solar or other renewable sources) when available for later use or increase capacity;

From hot water tanks to more advanced technologies of storage.

Typical Install:

Hot water tanks in homes;

Large tanks (for heat or cold) in commercial buildings;

Seasonal thermal energy storage for large communities.

Opportunities / Benefits:

Reduce demand during peak heating;

Reduce heating equipment size;

Reduce GHG emissions in certain applications.

Costs and Concerns:

More expensive than conventional heating;

Wide cost range for different technologies;

Heat loss during thermal storage.

Low Carbon Technologies: District Heating & Cooling

Overview:

Delivering heat (or cold) to a group of buildings connected to the district system;

Less popular in Canada compared to European cities;

Found in older institutions and downtown.

Typical Install:

High density neighbourhoods;

One central energy plant with connecting pipe network;

Each building has an energy transfer station with heat meter to measure consumption.

Opportunities / Benefits:

Enable fuel switching;

Some operating efficiency gains;

GHG emissions reduction comes from the type of fuel or energy source.

Costs and Concerns:

High capital cost;

Require high density in loads;

Requiring a utility partner to operate the system to provide heating and cooling in a community.

Low Carbon Technologies: Energy Efficiency Measures

Overview:

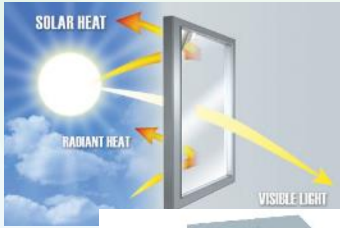
Measures to reduce energy service requirements through better designs;
Means to conserve energy usage by better controls;
Recover waste heat.

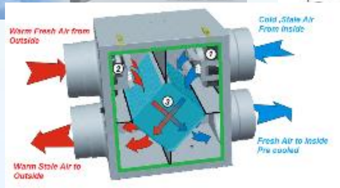
Typical Install:

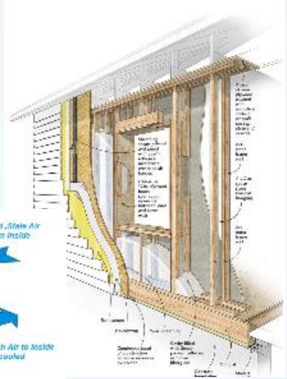
Commonly found in improved wall assemblies, better windows and air exchange;
Applicable to whole building or community;

Opportunities / Benefits:

Reducing consumption translates into lower emissions;
Better envelope: quieter indoor environment;
Saves operating cost.







Costs and Concerns:

Generally lower cost than implementing renewable energy;
Difficult and more costly in retrofit situations.

Technology Workshop Breakout Group Community Scenarios

Workshop Orientation

We are here …

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Technology Workshop

For each community:

Community GHG emissions Baseline

Facilitated discussion on technology preferences and technology mix options / opportunities.

Share pre-determined outcome decision on technology mix for each community.

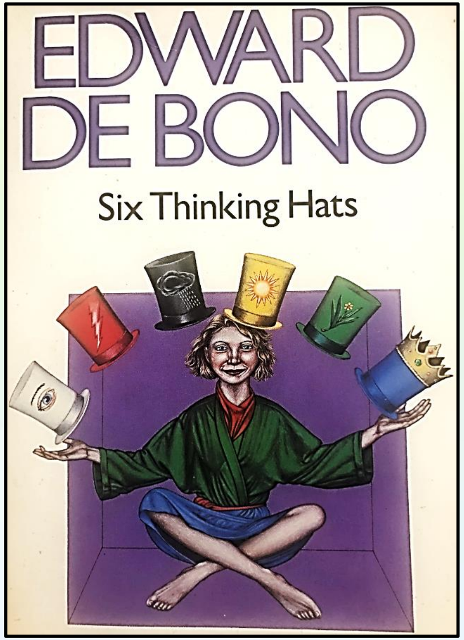
Stakeholders

You have been assigned one of the following roles:

- Developer
- Consulting Engineer, Architect or Planner
- Real Estate Agent
- Resident
- Commercial Tennant or Building Owner
- Utility Representative
- Mayor
- Municipal Elected Official
- Municipal Planner
- University Energy Manager
- Equipment Installer

wear one…or maybe two…hats

- White – factual, info known or needed
- Red – emotional, focus on feelings and intuition
- Yellow – optimistic, focusing on benefits
- Green – creative, generating a wealth of ideas
- Black – critical, focusing on problems
- Blue – process, focus on control and next steps

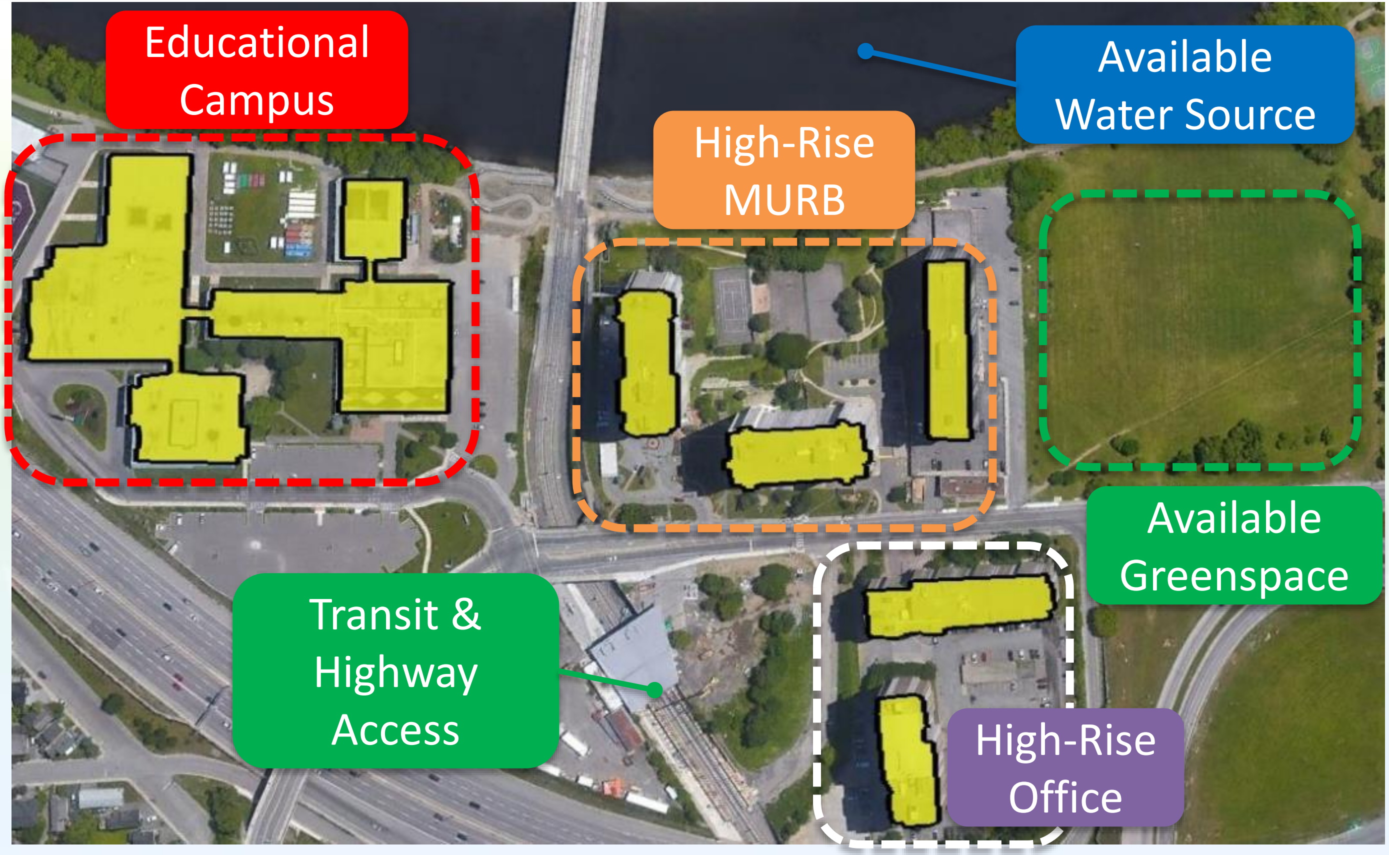


Bellarmine University

Scenario Role Play

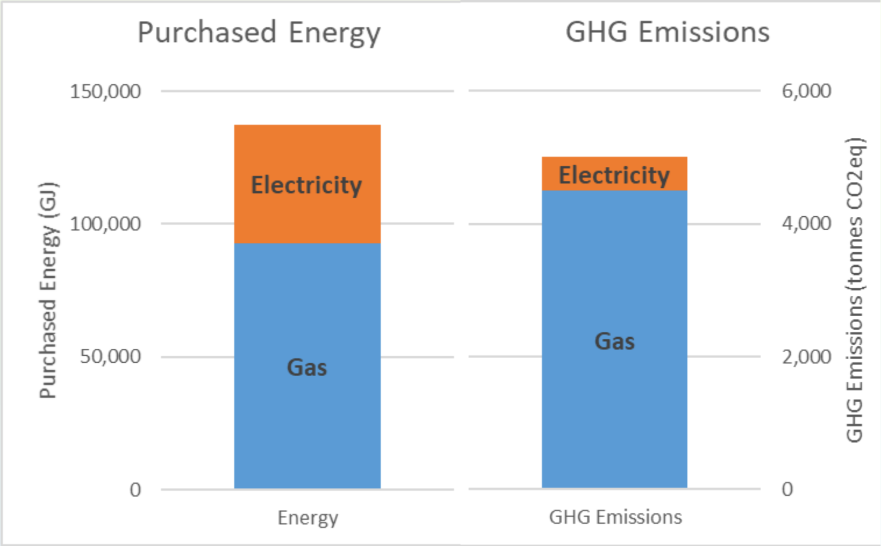
Please take a few minutes to read over your handouts for your location and your assigned role ….

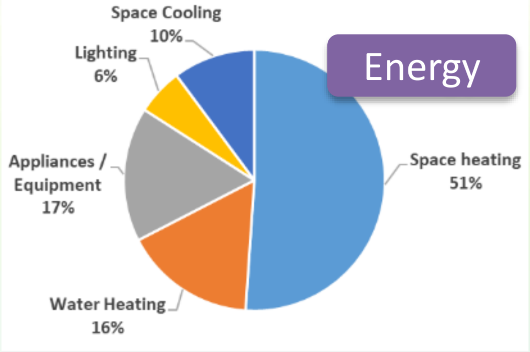
COMMUNITY PROFILE: OTTAWA, ONTARIO

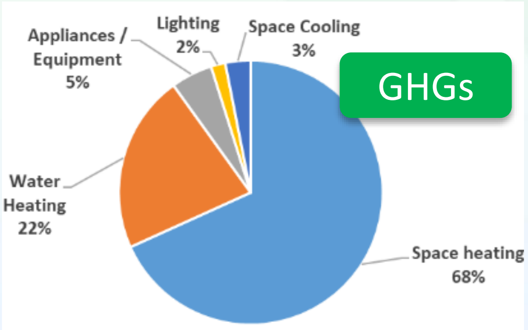


Note: The described scenario including building information, energy consumption, GHG emissions, and energy costs represents a fictitious community and is intended to be used only for the purpose of this workshop.

Baseline Energy & Emissions: Ottawa, Ontario







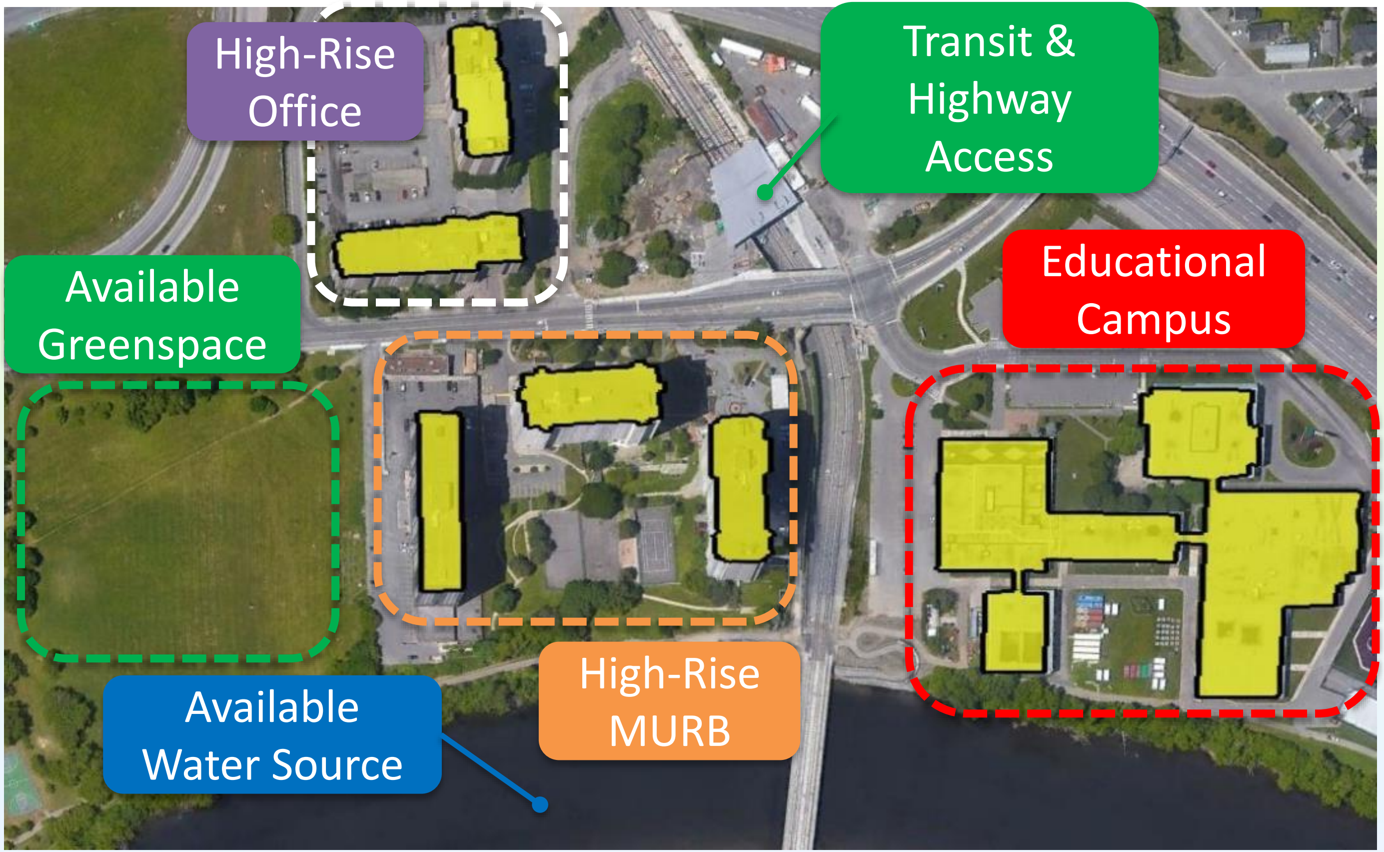
Energy Use:
137,435 GJ
0.88 GJ/m^2

Energy Cost:
$2,092,349
$13/m^2

GHG Emissions:
5,005 tCO_2eq
32 kg CO_2/m^2

Note: The described scenario including building information, energy consumption, GHG emissions, and energy costs represents a fictitious community and is intended to be used only for the purpose of this workshop.

COMMUNITY PROFILE: EDMONTON, ALBERTA



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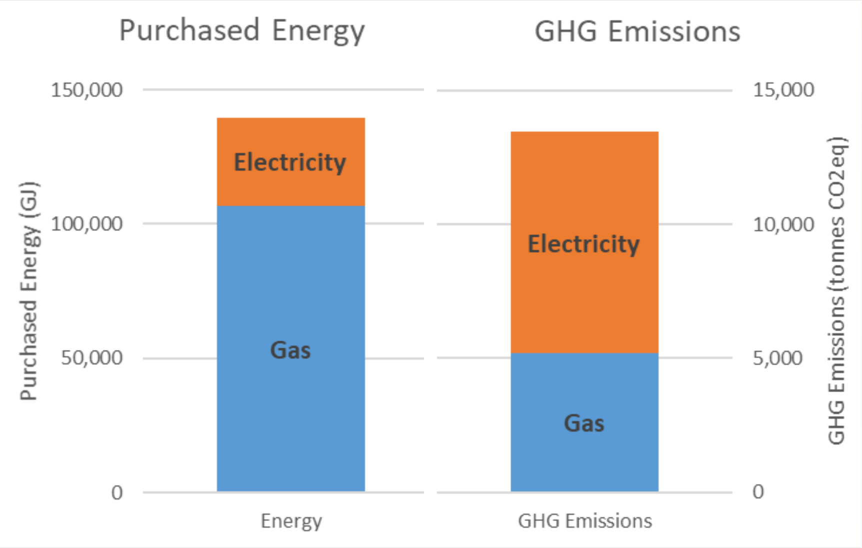
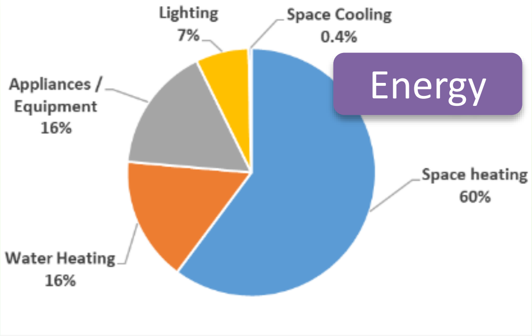
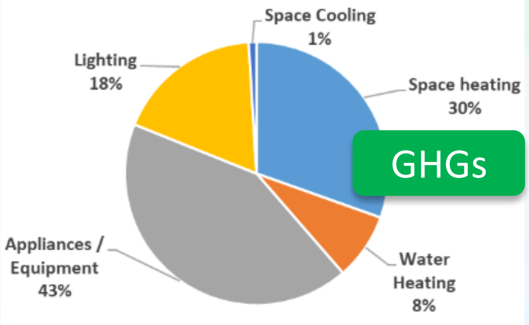
Baseline Energy & Emissions: Edmonton, Alberta







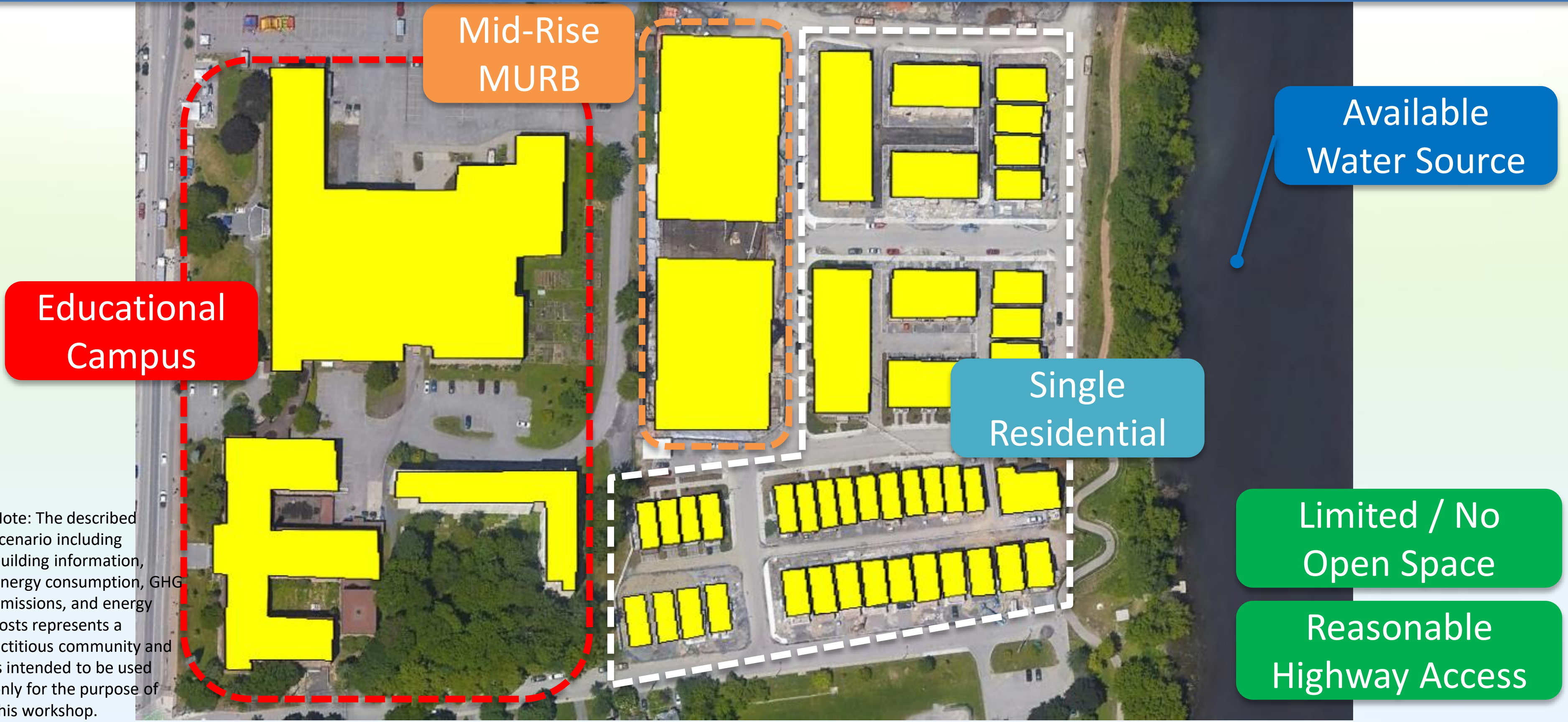
Energy Use:
139,620 GJ
0.90 GJ/m^2

Energy Cost:
$1,243,537
$8/m^2

GHG Emissions:
13,433 tCO_2eq
86 kg CO_2/m^2

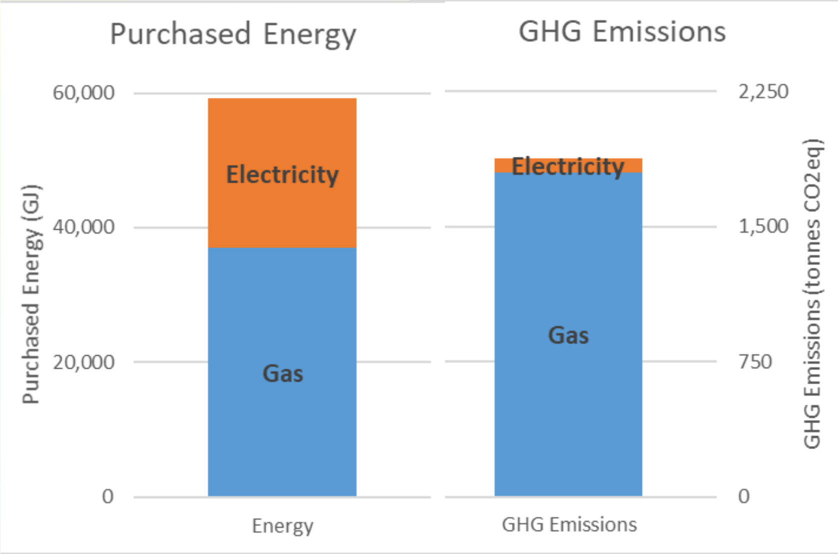
Note: The described scenario including building information, energy consumption, GHG emissions, and energy costs represents a fictitious community and is intended to be used only for the purpose of this workshop.

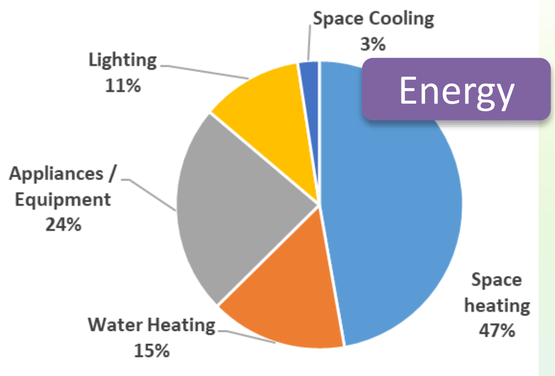
Community Profile: COQUITLAM, BRITISH COLUMBIA

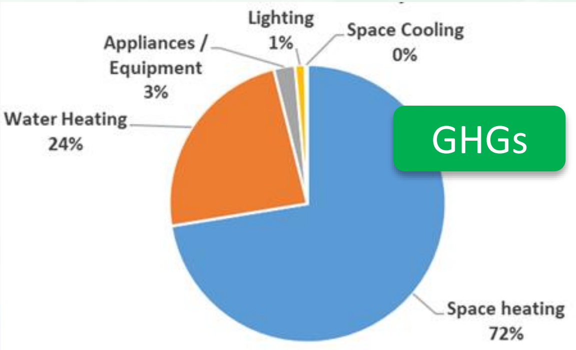


Note: The described scenario including building information, energy consumption, GHG emissions, and energy costs represents a fictitious community and is intended to be used only for the purpose of this workshop.

Baseline Energy & Emissions: Coquitlam, British Columbia







Energy Use:
59,152 GJ
0.70 GJ/m²

Energy Cost:
$823,876
$10/m²

GHG Emissions:
1,876 tCO_2eq
22 kg CO_2/m^2

Note: The described scenario including building information, energy consumption, GHG emissions, and energy costs represents a fictitious community and is intended to be used only for the purpose of this workshop.

Considerations

Significant regional variances exist with respect to cost and GHG intensities of primary energy supplies:

		Ottawa	Edmonton	Coquitlam
Energy Cost* ($/GJ)	Electricity	$33.36	$26.39	$26.25
	Natural Gas	$6.46	$3.50	$7.36
GHGs (kg/GJ)	Electricity	11	250	3
	Natural Gas	49	49	49

*Values shown for reference only and may not fully represent total site utility costs due to variances across different rate code structures

Assumptions

- Aiming for a reduction in GHG emissions by 50% or more
- Focus is on building energy & GHGs only (transportation is excluded)
- Each site is well established, with buildings at mid-life or younger
- Space and water heating currently provided by natural gas-fired systems for each building
- Some building-level energy conservation measures will be implemented to improve efficiency and reduce energy demand, with an average reduction of 15% for each end use (heating, cooling, etc)
- Reasonable / Good access and availability of alternative solid fuels (eg. biomass pellets, wood chips, etc) within 100km of each site

Breakout Group Discussions

Challenge: Reach consensus on an implementable solution that will achieve a 50%+ reduction in GHG emissions for your site

From your defined stakeholder position:

- What are your initial thoughts, ideas, and concerns regarding this challenge?
- Based upon energy end-use, where should the focus be placed in regards to reducing GHG emissions?
- What low carbon technologies should be pursued? Avoided?
- What physical site features would best support those technologies?
- What non-technical elements do you consider important and what potential barriers need to be addressed to help implement a solution?
- What information and data is needed to better support the analysis and decision process?

15-Minute Break

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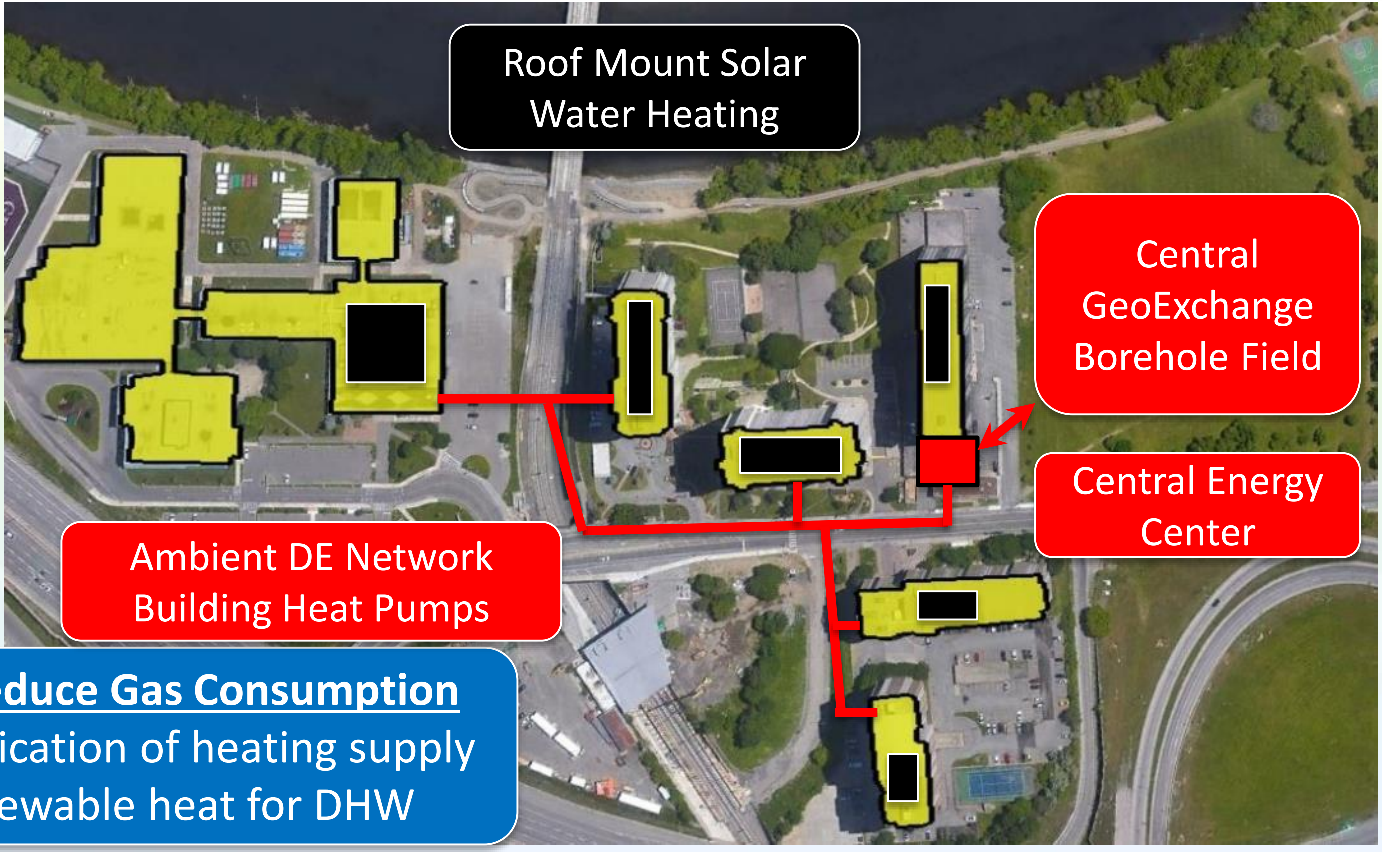
Consultant Proposed Low Carbon Technology Solution Sets and Impacts

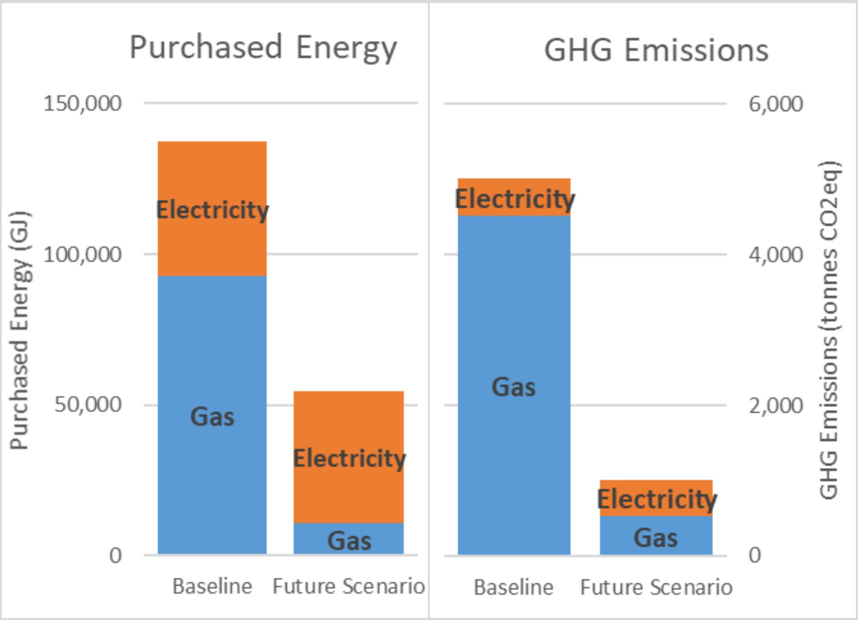
Consultant Proposed Solution: Ottawa, Ontario

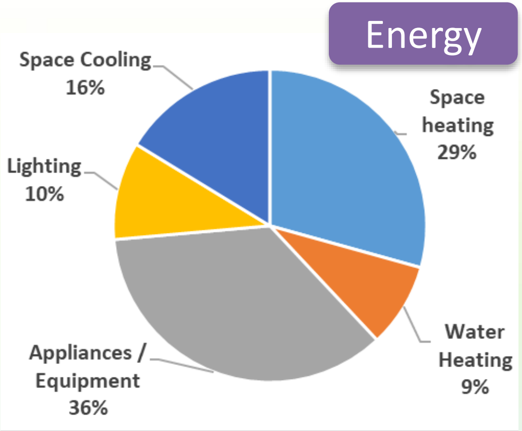


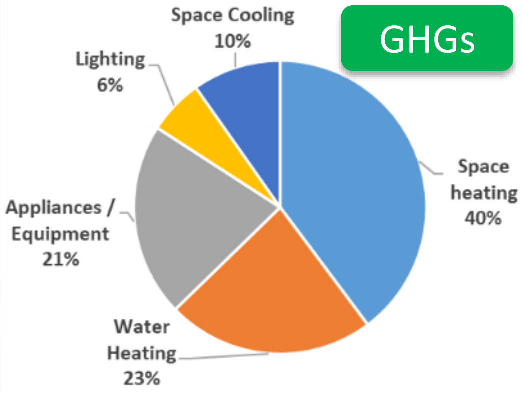
Focus: Reduce Gas Consumption

- Electrification of heating supply
  - Renewable heat for DHW

Proposed Solution Energy & Emissions: Ottawa, Ontario







Energy Use:
56,955 GJ
0.37 GJ/m^2
-59%

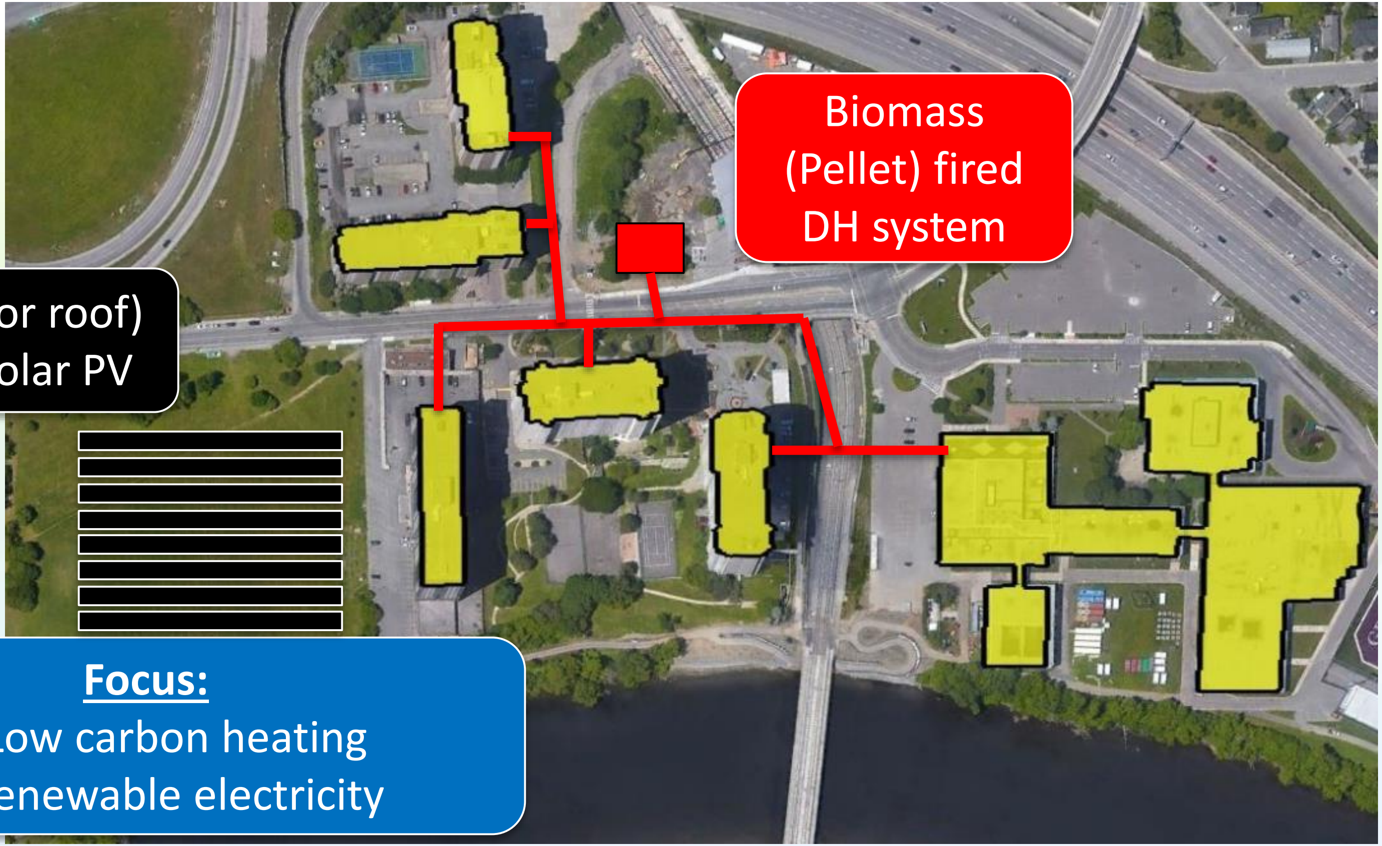
Energy Cost:
$1,611,142
$10/$m^2$
-23%

GHG Emissions:
1,036 tCO_2eq
7 kg CO_2/m^2
-79%

Detailed Costing??

Breakout Group Solution: Ottawa Scenario

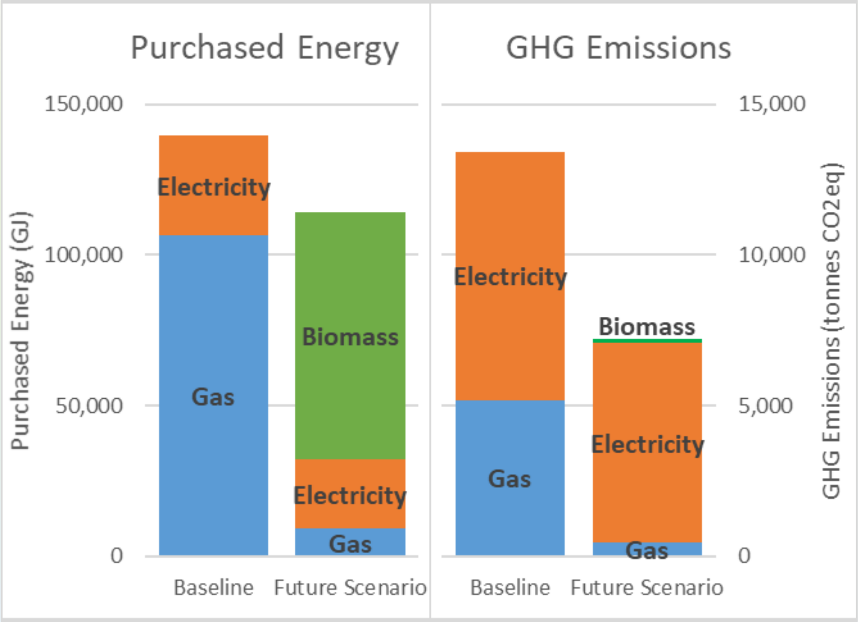
Consultant Proposed Solution: Edmonton, Alberta

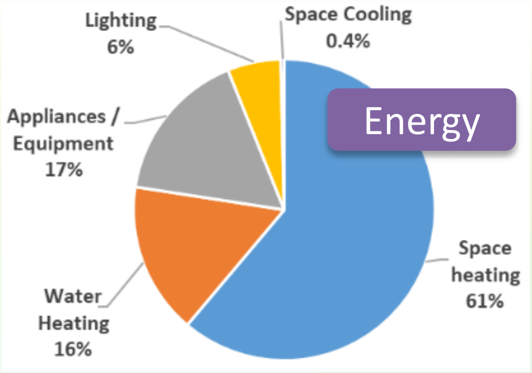


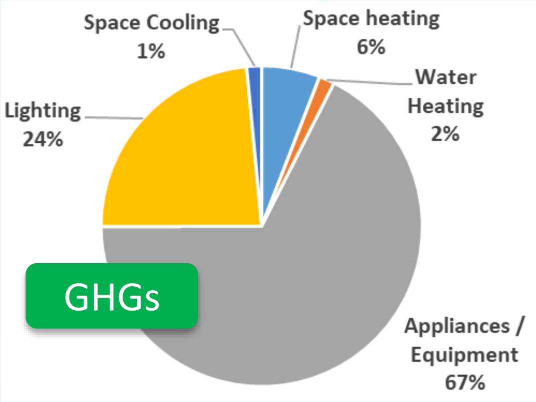
Focus:

- Low carbon heating
- Renewable electricity

Proposed Solution Energy & Emissions: Edmonton, Alberta







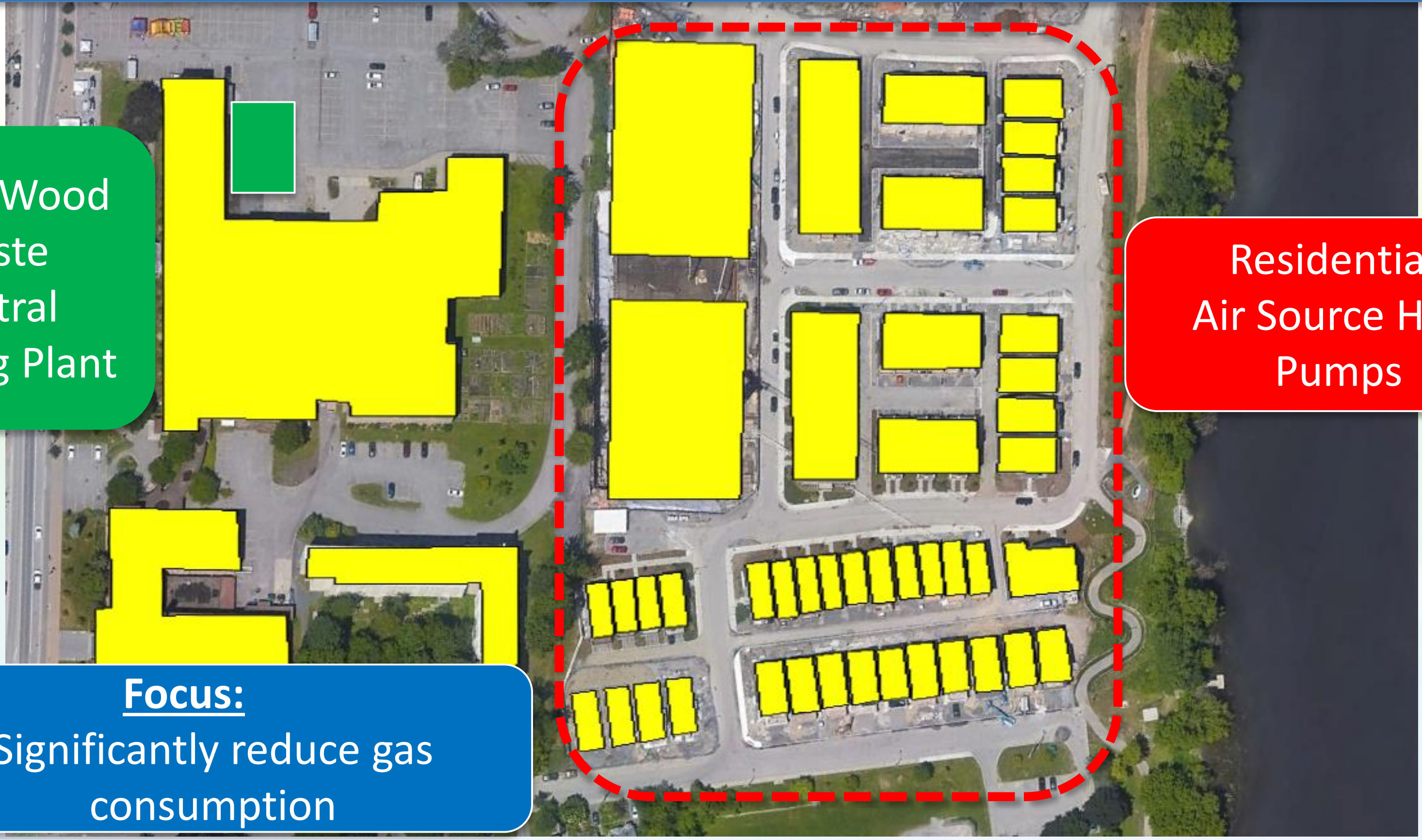
Energy Use:
114,147 GJ
0.73 GJ/m^2
-18%

Energy Cost:
$1,411,142
$9/m^2
+15%

GHG Emissions:
6,300 tCO_2eq
40 kg CO_2/m^2
-53%

Breakout Group Solution: Edmonton Scenario

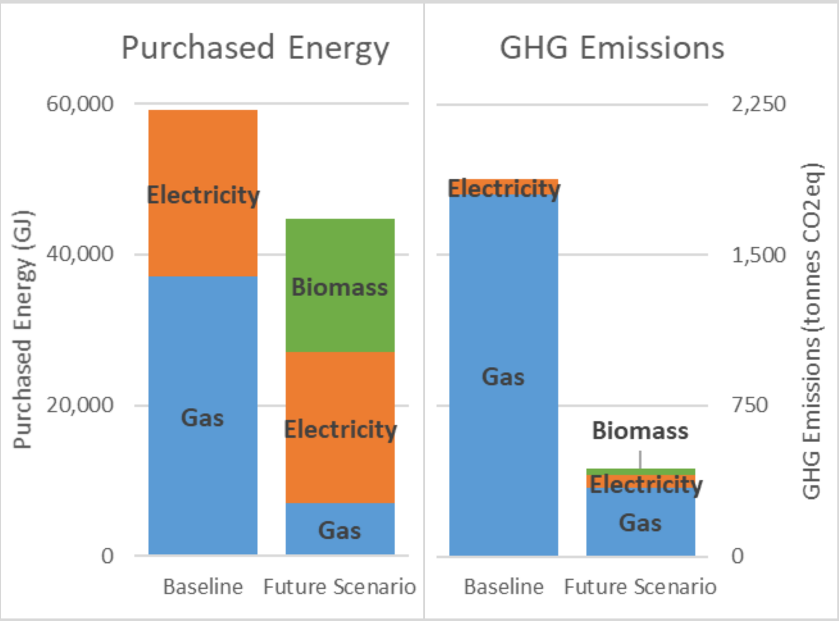
Consultant Proposed Solution: Coquitlam, British Columbia

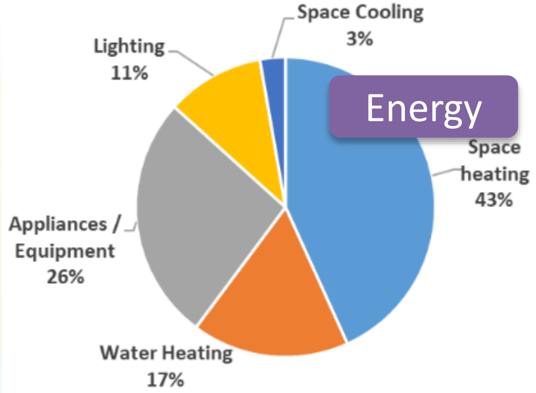


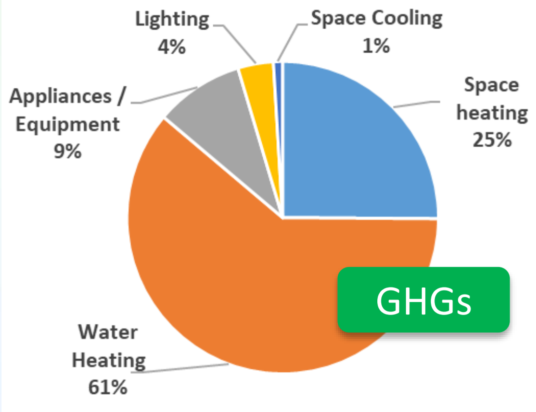
Focus:

- Significantly reduce gas consumption

Proposed Solution Energy & Emissions: Coquitlam, British Columbia







Energy Use:
44,678 GJ
0.53 GJ/m^2
-24%

Energy Cost:
$688,628
$8/$m^2$
-16%

GHG Emissions:
434 tCO_2eq
5 kg CO_2/m^2
-77%

Breakout Group Solution: Coquitlam Scenario

Key Takeaways

- Significant variances exist across the country with respect to how energy is used, how much energy is needed, and in terms of the GHG intensity of energy supplies.
- Important to assess how energy is being used, and the associated GHG implications of that energy use, to help identify appropriate low carbon technology solutions that fit the local situation.
- Significant coordination between stakeholders is required: Focus on solutions that fall within the control of the local stakeholders, in terms of energy supply and demand.

Key Takeaways

- Achieving a total community GHG reduction target of 50% does not necessarily mean it is practical and cost effective for each and every building to achieve a reduction of at least 50%.

- With the exception of energy conservation, no singular technology solution can be implemented in every community across the country to achieve the best local low-carbon solution.

Workshop Orientation

We are here ..

Low Carbon Community Energy System (LCCES) Process

(1) Stakeholder Engagement

(2) Technology Workshop

(3) LCCES Optimization

(4) Business & Operation Model

(5) Implementation Plan

8 -10 MONTHS PROCESS DURATION

For the Purpose of This Workshop:

Completed → 60 Min → Done by "Consultants" → 30 min → Your Feedback

Business and Operation Model

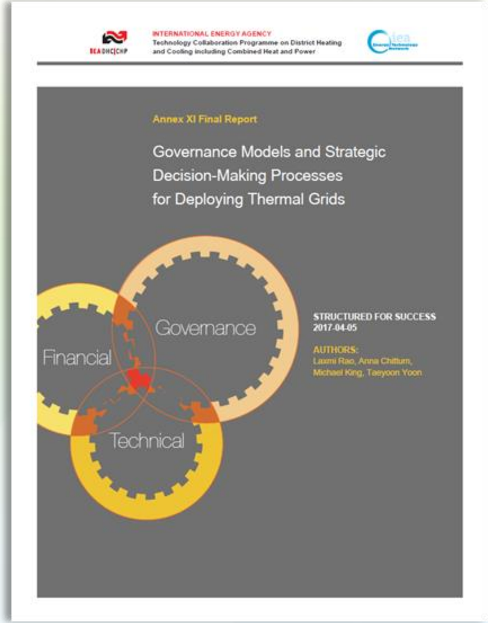
Review and understand the optimized technology mix and environmental impact for each community

Review implementation cost (capital, operation, maintenance and life cycle)

Possible business models for implementation (examples only)

- Utility
- Special purpose utility (private)
- Non-profit

Feasible model for implementation and financing



Reference:
Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids, IEA-DHC, 2017

Business and Operation Model – Cost Estimation

- Get an independent cost estimate done for your region;
- Be cautious on project costs. It will cost more! Build in sufficient contingency;
- Unforeseen weather events could cause delays and increase in costs.

Business and Operation Model - Partnerships

- If it is easy, it would have already been done!
- When you think it is not going to work, try to take another angle and explore another approach.
- Make sure you have a good exit strategy.
- Need a strong local champion!

Business and Operation Model - Operation

- Technology maturity in your region?
- Available market support (technology sustainability);
- User and operator knowledge.

Workshop Orientation

Low Carbon Community Energy System (LCCES) Process

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8 -10 MONTHS PROCESS DURATION

For the Purpose of This Workshop:

Completed → 60 Min → Done by "Consultants" → 30 min → Your Feedback

LCCES Process Feedback Discussion

Low Carbon Community Energy System (LCCES) Process

(1) Stakeholder Engagement

(2) Technology Workshop

(3) LCCES Optimization

(4) Business & Operation Model

(5) Implementation Plan

8 -10 MONTHS PROCESS DURATION

- Do you think the LCCES process (or something like it) will assist and encourage the implementation of more low carbon communities?
- What are the most challenging or difficult tasks for the stakeholder group?
- Suggestion for improvement and general comments?
- Who should champion the LCCES process?

Wrapping Up

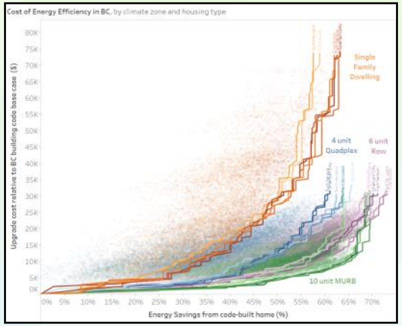
Key Takeaways

1. Regional / market / stakeholder dependent;
2. Consensus for implementation;
3. The best solution is an implementable solution;
4. Energy and environmental impact should be a key element in the planning process;
5. Energy usage data is important;
6. Need a strong process champion (planners?)

CanmetENERGY Housing and Building Data Initiatives

HTAP – Housing Technology Assessment Platform

- HOT2000 + cloud computing
- 240 new housing archetypes for eight major markets for model Net-Zero Energy Ready codes
  - https://github.com/NRCan-IETS-CE-O-HBC/HTAP-archetypes/tree/master/NRCan-EGH-NewHousing
- Existing housing archetypes available in 2020

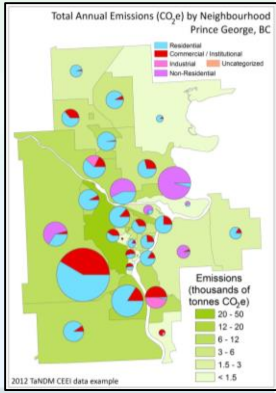


BTAP – Building Technology Assessment Platform

- EnergyPlus + Open Studio + cloud computing
- 16 new commercial building archetypes for 60+ Canadian cities
  - https://github.com/canmet-energy/necb_2011_reference_buildings
- Updates will include files for the 2015 and 2017 codes

CEE Map – Canadian Energy End-use Mapping Project

- An energy efficiency opportunities map with available national data layers least one municipal prototype.



THANK YOU

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