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Community Technology Assessment Platform (CTAP)

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NRCan, Building and Renewables Group

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"CanmetENERGY- Ottawa leads the development of energy science and technology solutions for the environmental and economic benefit of Canadians."

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CTAP
Community Technology Assessment Platform

How to Prepare a Road Map for
The Residential Building Sector
GHG Emissions Reduction Initiative
For Small and Medium Communities

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Executive Summary

Canada has committed to reduce greenhouse gas (GHG) emissions by 40 % to 45 % by 2030, and to Net Zero by 2050 [12]. Municipalities are being asked to tackle this challenge within their jurisdictions, and to target all spheres of human activity: transportation, buildings, industry, agriculture, etc. The CTAP tool has been developed to address the GHG issues related to the residential buildings sector.

In Canada, about 70% of buildings energy requirements are met with fossil fuels. As a result, homes and buildings account for approximately 17% of Canada's GHG emissions [11]. Within the homes itself, space heating account for about 2/3 of energy consumption while domestic hot water heating accounts for about 1/6 of the energy consumption, with the rest attributed to plug loads.

Canadian municipalities must therefore develop a comprehensive program to incentivize the implementation of building level interventions to reduce GHG emissions.

Such a task can be daunting and require extensive technical expertise to complete, especially for larger municipalities with large building stocks. Smaller municipalities typically do not have internal resources, knowledge base or budgets available for the performance of the type of energy analysis, the development of alternatives, their evaluations, and selection of a pathway that would lead to a successful scenario.

CTAP was created to assist the smaller municipalities, with less that 100,000 residents - where about half of Canadians live – to do just that. This first phase of CTAP covers the residential buildings sector for small municipalities, typically mostly low-rise structures.

CTAP is easy to use, contains default parameters and data that can be edited as needed by the user and has a simple one-page dashboard and one-page output screen. When used in conjunction with the suggested program development process, CTAP can provide reasonably accurate analysis of the pathways that will achieve the desired targets.

***

This manual contains extensive narratives to explain how CTAP works, what it does, as well as the assumptions and limitations that apply. The **quick reference guide / summary is included in Section 7** will be a useful reference guide once the user understands the logic behind this tool.

More importantly, this guide describes some of the key activities that must take place outside of CTAP's simulation mechanics, that is, the scope of activities that precede input into CTAP and how the output can be utilized.

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1. Needs and Objectives:

Canada has committed to reduce greenhouse gas (GHG) emissions by 40 % to 45 % by 2030, and to Net Zero by 2050 [12]. Municipalities are being asked to tackle this challenge within their jurisdictions, and to target all spheres of human activity: transportation, buildings, industry, agriculture, etc. The CTAP tool has been developed to address the GHG issues related to the residential building sector.

In Canada, about 70% of buildings energy requirements are met with fossil fuels. As a result, homes and buildings account for approximately 17% of Canada's GHG emissions [11]. Within the homes itself, space heating account for about 2/3 of energy consumption while domestic hot water heating accounts for about 1/6 of the energy consumption, with the rest attributed to "plug loads": lights, appliances, and electronics.[11] GHG reduction efforts in existing homes focus on improvement of the building envelop (walls, windows, below ground walls and attics - also referred to as energy building alterations, or deep energy retrofits). Following optimization of the building envelope, the next step is electrification of space and water heating using low carbon energy sources – and other energy conservation measures.

Canadian municipalities must therefore develop a comprehensive program to incentivize the implementation of these various interventions in commercial, institutional, and residential buildings. The development of a realistic and comprehensive program must include the following components:

- Selection of a reference year and establishment of the current GHG emission baseline.
- Establishing milestones in time and corresponding targets for GHG reduction.
- Identification of the most appropriate technologies for the local context.
- Determination of the required level of penetration (% of implementation in the building stock) for these measures vs time to reach the 2030 and 2050 targets.
- Estimate of the required investment in building level interventions.
- Development of strategies to incentivize and finance the requirement investment which may include awareness campaign, subsidies or grants from various government levels or related entities, PACE[1] type programs, loans from private sector or energy cooperatives working in cooperation with the municipalities to fund the required interventions.

[1] The **property assessed clean energy** (PACE) model is an innovative mechanism for financing energy efficiency and renewable energy improvements on private property. PACE programs exist for: Commercial properties (commonly referred to as Commercial PACE or C-PACE). Residential properties (commonly referred to as Residential PACE or R-PACE).

- Development of “value propositions” for the stakeholders, homeowners, and landlords.

Such tasks can be daunting and require extensive technical expertise to complete, especially for larger municipalities with huge building stocks. Smaller municipalities typically do not have internal resources, knowledge base or budgets available for the performance of type of energy analysis, the development of alternatives, their evaluations, and selection of a pathway that would lead to a successful scenario. CTAP was created to assist the smaller municipalities, with less that 100,000 residents - where about half of Canadians live – to do just that. This first phase of CTAP covers the residential buildings sector for small municipalities, typically mostly low-rise structures.

CTAP is easy to use, contains default parameters and data that can be edited as needed by the user and has a simple one-page dashboard and one-page output screen. When used in conjunction with the suggested program development process, CTAP can provide reasonably accurate analysis of the pathways that will achieve the desired targets.

The main output metrics produced by CTAP include:

- Baseline GHG inventory and energy requirements for a given reference year.
- Simulated GHG inventory and energy requirements for milestone years.
- % GHG reduction compared to reference year.
- Hourly electric energy profile for the jurisdiction for a full year.
- Rough cost estimates for the implementation of the contemplated pathways.
- Rough estimate of the overall annual energy cost for the entire building stock under study for any given scenario.
- Annual energy consumption by category (electricity, fossil fuels, biomass).

2. License agreement

A copy of the licence agreement is included in the Excel based software and in Appendix E (French) and Appendix (F) English of this manual.

3. How CTAP works

CTAP is an Excel based tool with limited capacity and granularity, but which provides adequate level of accuracy. The objective is to calculate the percentage improvement in terms of GHG emissions resulting from the contemplated energy conservations measures and low carbon energy technologies conversions compared to the GHG emissions of the base case, also referred to as the “baseline scenario” when implemented throughout a community’s residential building stock.

Archetype approach: CTAP uses an “archetype approach” to generate the annual hourly energy demand for a community. The archetype approach is a method by which a large building stocks is represented by a much smaller set of “typical” buildings, or archetypes, for the purpose of energy simulation. Each archetype is the representation of an average building of average size and of a given vintage and type. Each building in the jurisdiction is matched to one of eleven archetypes. Overall, the group of buildings assigned to a given archetype may be quite different from one another. However, on average, from an energy simulation perspective for the entire building stock, the errors introduced by this simplified approach tend to cancel each other. Pilot studies in Nova Scotia and Alberta have confirmed this result.

CTAP’s main design criteria was ease of use. It is based on the concept that in these times of climate emergency, a good plan today is better than an excellent plan in 5 years. CTAP uses several simplifying assumptions to yield a reasonably accurate analysis in very little time and effort. The tool becomes a living document that can be updated as assumptions are confirmed, and parameters values are refined when better information becomes available. The archetype approach is one of those simplification method. To keep the processing time of this Excel based tool reasonably short, the software is limited to 11 archetypes.[2]

Accuracy of results: In the second pilot study, the CTAP GHG inventory results and the total energy consumption were compared to the results provided by the Municipal Energy and Emission Database (MEED) [9] and the results were within a few percentage points. Similar accuracy was confirmed when comparing results with the energy consumption data (natural gas and electricity billing information) for all buildings included in the study.

Definition of archetypes:

[2] Although the level of granularity of 11 archetypes has shown to be sufficient to produce reasonably accurate results, should more archetypes be required, two or more CTAP runs can be performed and the results matrices aggregated linearly, allowing 22 or 33 or more archetypes, should resources be available to develop custom archetypes. The software being written in Excel, this is easily done by using simple “copy/paste value” Excel functions which are within the knowledge base of most Excel users. However, the nature of energy simulations and costs estimating is such that increased level of modelling efforts quickly reaches diminishing returns in terms of accuracy of results.

Automatic Archetype definition and assignment:

To allow the user to quickly engage in scenario definition CTAP offers an automatic archetypes generation facility to represent the residential buildings stock of any given jurisdiction in Canada (city, municipality, township, etc.). This is done by leveraging the information contained in several national and provincial databases – details provided below.

51 archetypes / climate zones:

To cover the entire country and consider the local climate and residential building attributes CTAP works with 51 "archetype / climate" zones (ACZ). In addition to allow the proper climate data files to be used in energy simulations, this also allows CTAP to consider local construction characteristics and socio-economic factors reflected in the residential building stock attributes.

The user must download the CTAP version of the closest city from the following list that appears on the website:

CTAP version	Province	Area	City	Climate Zone
1	AB	C6 1	Lethbridge Area	6
2	AB	C6 2	Medicine Hat Area	6
3	AB	C7A 1	Calgary Area	7A
4	AB	C7A 2	Edmonton Area	7A
5	AB	C7A 3	Cold Lake Area	yA
6	AB	C7B 1	Fort McMurray Area	7B
7	AB	C7B 2	Peace River Area	7B
8	BC	C4 1	Vancouver Area	4
9	BC	C4 2	Victoria Area	4
10	BC	C5 1	Kamloops Area	5
11	BC	C5 2	Port Hardy Area	5
12	BC	C6 1	Prince George Area	6
13	BC	C6 2	Cranbrook Area	6
14	BC	C7A 1	Fort St John Area	7A
15	BC	C7A 2	Smithers Area	7A
16	MB	C7A 1	Winnipeg Area	7A
17	MB	C7A 2	Brandon Area	7A
18	MB	C7B 1	The Pass Area	7B
19	MB	C7B 2	Portage La Prairie Area	7B
20	MB	C8 1	Churchill Area	8
21	MB	C8 2	Thompson Area	8
22	NB	C6	Fredericton Area	6
23	NB	C7A	Charlo Area	7A
24	NF	C6	Saint Johns Area	6
25	NF	C7A	Gander Area	7A
26	NU	C8	Resolute Area	8
27	NW	C8 1	Yellowknife Area	8
28	NW	C8 2	Inuvik Area	8
29	YK	C8	Whitehorse Area	8
30	NS	C5	Yarmouth Area	5
31	NS	C6 1	Sydney Area	6
32	NS	C6 2	Truro Area	6
33	ON	C5 1	Simcoe Area	5
34	ON	C5 2	Windsor Area	5
35	ON	C6 1	Ottawa Area	6
36	ON	C6 2	Sault St. Marie Area	6
37	ON	C7A 1	North Bay Area	7A
38	ON	C7A 2	Timmins Area	7A
39	PE	C6	Charlottetown Area	6
40	QC	C6 1	Montreal Area	6
41	QC	C6 2	Sherbrooke Area	6
42	QC	C7A 1	Quebec Area	7A
43	QC	C7A 2	Ste. Agathe-des-Monts Area	7A
44	QC	C7B 1	Val D'Or Area	7B
45	QC	C7B 2	Sept-iles Area	7B
46	QC	C8	La Grande Riviere Area	8
47	SK	C7A 1	Regina Area	7A
48	SK	C7A 2	Saskatoon Area	7A
49	SK	C7B 1	Yorkton Area	7B
50	SK	C7B 2	Prince Albert Area	7B
51	SK	C8 1	Uranium City Area	8

Table 1 : List of cities for selecting the CTAP version to use.

11 archetypes per ACZ:

In most ACZ, the 11 archetypes consist or 2 or 3 archetypes per vintage range, to which all dwellings are assigned. The five vintages' ranges correspond to the years during which the applicable building codes were relatively similar from the point of view of energy conservation measures. These ranges are: (1) pre-1946, (2) 1946 to 1977, (3) 1978 to 1995, (4) 1996-2010 and (5) 2011 to 2020.

For each representative archetype, the key energy characteristics, from a simplified energy simulation point of view, considering the summation of results for a large number of structures, are:

- peak heating load
- peak cooling load
- annual energy consumption for, heating, cooling, plug load, domestic hot water.

Data sources:

The building count and types are obtained from the latest Population and dwelling counts: Canada, provinces and territories, and census subdivisions (municipalities) [10]. This provides the historical provincial statistics on building sizes and types (attached vs detached vs mobile homes, etc.).

The National Energy Usage Database (NEUD) provides detailed information on space heating systems, their energy sources, and their efficiencies. This is also available for the last few decades.

NRCan's GITHUB inventory of 6800+ archetypes [13]are based on the 1.5M + energy audits database accumulated by NRCan over the last decade or so. For each ACZ, the corresponding subsets of these audits and archetypes were consulted to select the most typical archetype to represent a group of residential buildings of a given vintage range and building types.

An example of an 11 archetypes set is shown below:

Before 1946, , , , All,
1946-1977, Single Detached, , , ,
1946-1977, Single Attached, Apart., Mob. H., ,
1978-1995, Single Detached, , , ,
1978-1995, Single Attached, Apart., , ,
1978-1995, Mob. H., , , ,
1996-2010, Single Detached, , , ,
1996-2010, Single Attached, , , ,
1996-2010, Apart., Mob. H., , ,
2011-2020, Single Detached, , , ,
2011-2020, Single Attached, Apart., Mob. H., ,

Table 2: Example of archetype for a given arch etype/climate zone.

Important note: *The methodology used to define the eleven most representative archetypes for each ACZ is quite extensive and can be obtained upon request. For the user, it is important to understand that the buildings assigned to any given archetype group will behave quite differently from one another but the energy simulation for the entire group will be reasonably accurate. CTAP can not be used for the analysis of a single building as it relies on the averaging/cancelling of the errors introduced by this simplification methodology on a large group of buildings.*

This approach allows for a much simpler simulation exercise for any given scenario. It balances the level of efforts to populate the software with the level of accuracy required for the purpose of the study.

Definition of Scenarios:

With every building assigned to an archetype, the user can start defining scenarios. For each archetype the user selects what technology and/or energy conservation measures are contemplated for a given scenario, or “pathway”. The user specifies how many buildings out of the total for each archetype will have the intervention(s) performed. The user can select from a menu of “low carbon energy systems” (LCES) and energy conservation measures (ECM) nominal “percentage” targets. The user does not specify actual interventions, such as windows upgrade or basement wall insulation, rather a target $ reduction in energy requirement for space heating/cooling, domestic hot water, lighting and plug loads. A certified energy adviser will determine what set of interventions will be required for any given archetype in the local context.

But before the user start composing “future scenarios”, there are two “universal” scenarios that are customary to define. The first 2 tables on the “Scenarios Definition” Tab are automatically populated as follows:

The “reference” or “baseline” scenario which represents the base case against which future scenario results metrics will be compared. This scenario is automatically generated by CTAP once the user selects the year for that scenario. See Section 6.2.1 of this manual for more information on how to decide which year to use as a “reference” year. The historical data contained in CTAP allow for that year to be between 2000 and current year.

The current year scenario is also automatically generated by CTAP, pending vetting of defaults information by the user (detailed provide in notes on CTAP’s input screens). This scenario is really to get an appreciation of the progress made to date by conversions of fossil fuels heating systems (or improvement in their efficiencies) implemented between the reference year and current year, as estimated by provincial statistics from the NEUD database. It will also show the improvement in the GHG metrics resulting from the clean-up of the provincial power grid since the reference year. CTAP captures that quantity by cross-referencing with the Canada's Greenhouse Gas and Air Pollutant Emissions Projections dated 2020.

Future scenarios:

The next scenarios (input table 3 to 15 on the “Scenario Definition” Tab) are available to define sets of building level interventions, or pathways, and to calculates their impact on the result metrics. Each scenario can be made for a given milestone in time, for example 2027, 2030, 2035, etc.

Normally, a process of trial and error is used to achieve a given % GHG reduction target. If a set of interventions is entered in a scenario, and does not result in the target being achieved, the user simply returns to the input table, increases the numbers and types of interventions, and re-runs the software. Once a given scenario is achieving the desired target for the time milestone selected, the next table can be used to cumulatively add additional interventions for the next milestone year and % GHG reduction target, and so on.

Selecting Low Carbon Energy System (LCES) and Energy Conservation Measures (ECM) targets:

In composing scenarios, the user will need to consult with local technical advisers and trades to optimise the results. Section 6.2.3.2 elaborates on the type of issues to be addressed by a local task force. Appendix D provides some guidance as to how to gather a local task force to assist municipal staff in selecting the most appropriate technology options for the local context. A few examples of the issues that will need to be considered:

A local energy advisor and power distribution company representative can best advise as to the feasibility of photovoltaic (PV) arrays. This technology is well suited for regions with greater electricity cost and good solar radiation intensity.

Local renovators can provide input on building envelope retrofits, and the energy advisor can estimate what components need upgrade to achieve a given energy reduction target. CTAP takes as input, as a component of a scenario, the % reduction in energy requirement for any of the following: space heating, space cooling, plug loads and domestic hot water. The energy advisor can define what a given target reduction involves in terms of actual measures. CTAP comes with default unit cost estimates for such interventions, and these can be validated or adjusted with input from local trades people.

HVAC contractor and electricians can advise on the conversions of heating systems and validate default unit cost provided in CTAP.

Energy advisor can answer questions about heat pumps, limitations, hybrid heating systems, etc.

Real estate representatives can assist in the making of value proposition for the stakeholders.

Etc.

Eventually, as implementation starts, the same task force will be essential in prioritizing candidate buildings within each archetype groups to maximize early gains and results per interventions.

Some technology slides are included in Appendix B, and links to other relevant NRCan technology guides are provided in Appendix C.

Calculations:

The interventions included in any scenario instruct CTAP to modify the energy requirements for the various archetypes. To do this the software uses the standard climate data files to calculate the impacts of the technology and/or energy conservation measures on the energy demand. The software then sums up the impacts to the existing energy demand for each archetype to obtain the new annual hourly energy demand profile (in the form of an hourly data stream) for the community/jurisdiction. (365 days x 24 hours = 8760 data points).

The last step the software performs is to apply the emission factors for each energy source, including gas, oil, and the public power grid to obtain the community's buildings' GHG emissions. This result is then compared to the baseline GHG emissions. Since the baseline GHG emissions inventory is for a past reference year it must take into account the historical emissions associated to the public power grid at that time. Simulation of future emissions must consider the forecasted power grid emissions in the future. Power grid emissions are quantified in g/kWh (grams per kilowatt hour) and known as the "average emission factor" (AEF) of the electricity provided by the provincial electricity grid. AEF is one of the main components of the GHG emissions for the building sector. To incorporate this annual AEF variation into the analysis, CTAP contains the AEF history since 2005 and the most recent forecast for all provinces and territories until 2050.

4. GHG Reduction Technologies Included in CTAP:

CTAP models the impact of building level interventions on the entire building stock. The technologies that are included as options in CTAP are of two types: low carbon energy systems and energy conservation measures targets.

4.1 Low carbon energy system (LCES) for space heating:

Conversion from fossil fuel-based heating system towards electrification, and possibly biomass, is by far the most contemplated solution for reducing GHG. CTAP also offers energy storage options for managing peak demand, and some options for distributed renewable energy generation. Note that simulation of hourly profile is relatively basic, with no elaborated charge and discharge optimization algorithm for energy storage or stochastic simulation. The LCES options currently available are:

- Solar panels
- Batteries

- Electrical baseboards or furnaces
- Heat pumps, ground source, and air source
- Wood/biomass furnaces
- Solar domestic water heaters
- Thermal storage

Several technical slides with basic information are included in Appendix B. Several reference links are provided in Appendix D and in the “Useful Links” Tab of CTAP.

4.2 Energy conservation measures (ECM) nominal targets:

CTAP does not model the impact of each possible intervention separately. As it is a community modelling tool, CTAP works with targets of energy demand reduction. For example, the user will target a 50% or 60% or 70% reduction in space heating for a given subset of buildings. CTAP has default unit cost value for such interventions. The units are $/percentage reduction/square foot, and the unit costs can be different for different archetypes. The “Financial Tab” contains instruction on how to work with those unit costs. An energy advisor (EA) can, on an archetype-by-archetype basis, define what tasks are required to achieve these percentages of energy reduction targets, and local contractors can validate or adjust the average unit costs for those tasks. The interventions that reduce energy demand to be considered by the EA include, among others, building envelop upgrades, domestic hot water heating system / drain water or exhaust air heat recovery improvements, lighting systems upgrade and energy efficient appliances.

The user input therefore consists, for subsets of the building stock, of a % reduction in energy requirement for:

- Space heating
- Space cooling
- Domestic hot water
- Lighting
- Plug load.

Some useful links to LCES and ECMs technologies guides are included in the "Useful links" Tab of CTAP. The user is encouraged to add any additional links that they may find useful to that Tab.

4.3 Community Wide Renewable Energy Solutions:

The impact of community wide distributed variable renewable energy generation initiatives such as a fair size solar farm or wind farm on the edge of town, for example, is better simulated using specialized software with ample features and calibration facilities to further optimize, for example, drawn and recharge cycles, battery plant capacity, interconnection rates, etc. However, the net impact on GHG of such an initiative can be considered, on an exploratory basis, by CTAP in the following manner:

CTAP calculates the GHG emissions associated to the community's electricity usage. To do so CTAP utilises the historical and forecast AEF (average emission factors) for the provincial public grid. Introducing a renewable energy project into the electrical energy mix can be roughly (ignoring the variation of marginal emission factors per time of day) accounted for by calculating the weighted average contribution of the renewable energy project GHG to that of the public grid.

The user can specify the two key parameters (total annual renewable energy generation and full life cycle carbon content per kWh) in the "Financial" Tab. The lower carbon content power generated then brings down the effective average AEF.

For example:

Total electricity requirement for the community in a given year (future scenario): 450,000 GJ.

AEF for that given year for public grid is 400 g/kWh, as per current forecast.

Solar farm, just out of town limits, feeding into the provincial grid annual average production: 50,000 GJ.

Full life cycle analysis (LCA) of GHG emission for large solar farm: 48 g/kWh.

Effective GHG emission for the given simulation year: [(400x400) + (50x48)] / (400+50) **= 361 g/kWh.**

CTAP contains the default full life cycle carbon analysis GHG emission factors for different renewable energy generation technologies [1] for quick consideration of such alternatives. It should be noted that the production / efficiency of solar and wind is heavily impacted by local climate characteristics, so these values are likely to need adjustment by subject matter experts. Defaults are provided for exploratory analysis purposes. Table 3 presents the current average values for selected technologies as per the most recent United Nation's IPCC data [1]. Note that those values have can a wide range depending on local conditions.

Example of electricity carbon intensity	
Technology	g CO2e / kWh
Coal	820
Gas	490
Biomass	230
Large scale solar	48
Domestic solar PV	41
Hydro	24
Off-shore wind	12
Nuclear	12
On-shore wind	11

Table 3: Example of carbon intensity of electricity generation technologies

5. Limitations

CTAP is a quick and approximate simulation tool. The absolute value results are approximate, although on a relative basis, the reduction in GHG from one scenario to another should be quite accurate, more so than the absolute values of the results. The absolute values of the aggregated energy requirements results would also be subject to variations in the weather characteristics from one year to another.

The costs calculator is also a very approximate calculator. Each building is a project on its own, so on a building per building basis, the costs and benefits may vary drastically. But on average, and on the aggregate for the community, the default unit costs per technology should provide at least an idea of the magnitude of the investment required. As it will be explained later, the user can adjust those unit costs, and his encouraged to do so, as local actual data becomes available.

The simplified financial treatment within CTAP, in constant dollars, is meant to provide the user with a means to assign a rough estimate of capital requirements for a given GHG percentage reduction. This key metric is an essential part of most proposal to access subsidies or incentive programs.

CTAP also produces a hourly profiles for the community. This can be used a starting point to interface with the local utility company, to communicate possible impacts of electrification and energy saving measures on the aggregated community wide energy demand profile on an hourly basis. But it must be remembered that several other energy requirements must be considered by the utilities, including for example any process related energy demand by industry, or energy demand triggered by the electric vehicle (EV) trends. Specialty building such as sports complex, ice arenas and airports will likely need separate treatment and the result metrics aggregated to those of CTAP.

6. How to use CTAP

CTAP was designed to be a simple tool to use. There are two stages in using the software. The first one is to populate the data to be used by the software for processing. As explained earlier, most of this has been automated in the latest phase of CTAP development.

The second stage is the definition of future pathways, or scenarios by the user in the "Scenarios Definition" Tab, which is basically an iterative trial-and-error approach to gradually increase the number of interventions at the building level until the required GHG reductions are reflected in the simulations results.

6.1 Data Populating:

6.1.1 Archetypes Definition: (automatic)

As explained in Section 3, CTAP comes pre-populated with archetypes, building counts and existing heating system attributes. They are generated when the user selects the jurisdiction from a dropdown menu, and the scenario year.

The user can go ahead using those assumptions or can perform a validation exercise should better data be available, or should local circumstances suggest that the local building stock make-up is significantly different from the provincial averages. Property tax database could be a source of information to validate for example the various building counts in the vintages ranges used by CTAP.

It is understood that buildings assigned to a given archetype may differ significantly from one another in terms of size, and some characteristics, because, for example, different geometry or even renovations or additions performed through the years. However, on average and on a large base of buildings, the average energy regime of the buildings assigned to a given archetype will correspond adequately to the actual average energy regime. This important assumption and significant simplification allow for an acceptable level of accuracy for a reasonable level of effort.

6.1.2 Base Archetype Hourly Energy Demand Simulation: 8760 data streams: (automatic)

Here too the user can take advantage of the default “base case” 8760 hourly energy demand simulation results for each of the default archetypes for the given climate zone. The software customized for a given region contains those base case 8760 hourly energy demand simulation results for each of the 11 archetypes for the applicable climate zone. In this case, no action is required, the software will automatically use those data streams for the calculations.

6.1.3 Climate Data: (automatic)

The software needs the climate data to calculate the impact of interventions on the energy demand. This also comes populated in the software for the given region.

(CTAP uses the standard climate data files from Canadian Weather Year for Energy Calculation (CWEC) files. CEWC files are open-source and published by Natural Resources Canada [2].

6.1.4 Utility Rates: (default values provided)

The user must define electricity rates, for fixed or time-of-use (TOU), gas and oil unit costs, and that of wood if it to be used as well as an energy source. Financial parameters need not be adjusted for different simulation years. The financial analysis yielding approximate implementation costs and approximate annual energy cost for the community are based on a constant dollar approach. The financial analysis is very basic, and only complimentary to CTAP’s most important metric: GHG emissions reduction.

6.1.5 Power grid average emission factors (AEF) (automatic)

To calculating GHG inventory, the emissions associated to electricity usage are based on the AEF. Each province and territory has its own mix of energy generating infrastructure. This mix is constantly evolving such that the AEF will vary in time. CTAP works with available forecast of those values up to 2050. The average emission factors (AEF) for the local electricity grid are already provided using the electricity grid intensities calculated from Canada's greenhouse gas and air pollutant emissions projections [14], 2023 issue. CTAP to automatically looks-up the AEF value to be used.

Note: if scenarios are evaluating the GHG situation future years, say 2030, the results must be qualified and presented with the assumptions as to future AEF values. Future AEF forecasting is an area of considerable ongoing discussions, so stating future AEF assumptions in any conclusion is important.

"Scope 2" parameters: Scope 2 emissions refer to the emissions resulting the losses of electricity associated to the transport of electricity from the generation point to the consumption point. Similarly, for natural gas, Scope 1 emissions are associated to the GHG emissions resulting from leakage associated the transport of natural gas to the consumption point occurring within the jurisdiction limits. As per the CGP [6] convention, those must be part of the GHG inventory for municipalities.

6.1.6 Fugitive natural gas and electricity transmission losses (default provided)

For natural gas, Scope 1 emissions are associated to the GHG emissions resulting from leakage associated the transport of natural gas to the consumption point occurring within the jurisdiction limits [6]. A default value for fugitive natural gas occurring in the local distribution network and behind the meter (BTM) has been estimated to be 0.6% of NG consumption in Canada [15]. Using GWP100 of methane, this yields an additional 7.1% of CO2e kg / kWh on top and above combustion gases.

"Scope 2" parameters: Scope 2 emissions refer to the emissions resulting the losses of electricity associated to the transport of electricity from the generation point to the consumption point. As per the CGP [6] convention, those must be part of the GHG inventory for municipalities. CTAP assumes 5% for this parameter [16].

Should more accurate information be available for these parameters, these can be adjusted by the user and stated in any conclusion.

6.1.7 Fossil fuel furnaces annual fuel utilization efficiency (default provided)

One of the simplifications of CTAP is to work with only one fossil fuel type, referred to as the "dominant" fossil fuel as per the provincial statistics sourced in the latest National Energy Usage Database (NEUD) [11]. This simplification eliminates the need for the user to provide counts of each type for each archetype. Note that the fugitive natural gas component of the GHG emissions associated to natural gas furnaces is such that the overall carbon intensity of a natural gas furnace very similar in quantity as the GHG associated to an oil or propane furnaces [15].

CTAP also assumes average annual fuel utilization efficiency (AFUE) for fossil fuels-based technologies as per the provincial averages sourced in the latest National Energy Usage Database (NEUD) [11]. This represents the efficiency by which a fossil fuel, or biomass, furnace utilizes fuel to convert it into heat that is effectively used for space heating. For example, the average efficiency of a natural gas furnaces now in operation is estimated to be 78% with the more advanced models reaching 96%. The default values for the different furnace types can be edited by the user at the top of the "User Input Output" Tab. The dominant fossil fuel used in a jurisdiction is based on provincial statistic. It should be noted that improvement of the average AFUE for gas furnace can be used as a GHG reduction measure in the short and medium term. This can be selected in the Scenario Definition Tab by overwriting the default values. Should the dominant fossil fuel in a given jurisdiction be different than the dominant fossil fuel as per provincial statistics, it can be overwritten in Cell T24 of the "Financial Tab".

6.1.8 Default Implementation Unit Costs: (default values provided)

The investment estimation module was added as a result of pilot studies feedback. It is understood that the cost of implementing deep energy retrofit to achieve a given space heating energy requirement reduction (in % of reduction) will vary enormously from one building to another, so here again, a very approximate methodology is used. Default average "ballpark" estimates are provided and can be adjusted by the user. The objective is to provide an idea of the order of magnitude of the investment required. As implementation proceeds, case by case estimates must be performed involving local contractors and energy advisors, and possibly architects/engineers/building scientists for more complex structures. As the GHG reduction initiative – probably a multi-decade initiative - advances, unit costs can be adjusted to refine the overall GHG reduction program investment estimates.

As an example: one of the energy conservation measures (ECMs) is defined in any given scenario as a nominal percentage of improvement, say a 60% reduction, in space heating energy requirement for a given archetype. CTAP contains a default value of $ 0.75 / ft2 to achieve each 1% reduction in energy requirement, so in this example 60% x $0.75/%, or $ 45/ ft2, on average, for a given archetype of a given vintage (year of construction). This is a default, very crude, unit cost, and every building will have different conditions, characteristics, etc. So that unit price can not be used for any given building individually but will be applied to a subset of the building stock.

In practice, what may eventually need to be done to confirm or adjust these default unit costs, as actual cost data is obtained through the first implementation projects, is the following validation process:

A local energy advisor will be consulted to audit a sample building and he/she will determine what ECMs are required to achieve, say, 60% space heating energy savings. Reaching that figure could include some or all the following: better windows, incremental attic and basement insulation, exterior walls insulation upgrade, etc. Then, local contractors will provide costing for the required items. As data points are accumulated through early implementations, the default unit costs can be adjusted, improving the investment estimates of future CTAP analysis.

Another example: for an LCES implementation, such as the conversion from gas to a hybrid heating system, may require a different set of tasks. Electrician with local knowledge can inform what percentage of dwellings are likely to require a power service entrance upgrade, and an HVAC contractor can estimate if existing duct work will need upgrade or not, and for what percentage of the dwellings to be converted. An energy advisor may recommend simple or hybrid heating system. A hybrid heating system is a conversion to electricity while keeping fossil fuel as a back-up for peak demand. So, the average unit cost for a conversion will be a composite of these costs, plus the cost of the simple or hybrid furnace itself.

Remember, what is needed is only an idea of the order of magnitude of the investment for the community. Any specific building economic analysis must be dealt on a case-by-case basis.

6.2 Scenarios Definition:

6.2.1 Deciding on a Reference Year and Setting GHG Reduction Targets: (required)

The last steps before starting to define scenarios and run simulations in CTAP is to decide on a reference year and temporal milestones and targets. Setting targets is arguably the most important step in any endeavour, so some attention will be given to this step in this section.

Performing a simulation using the archetypes and quantities of buildings in existence as of the chosen reference year, will produce the “baseline GHG inventory” against which future improvements will be measured.

Setting the reference year and the interim targets towards 2050 will require some rationalization of the particular context of the jurisdiction where the analysis is to be performed. For example, one of the pilot studies in Alberta showed that the forecasted improvement of the electrical grid in terms of GHG emission was enough, by itself, to reduce emissions of the building stock by over 48% between 2005 and 2030. Still, it would seem inappropriate to conclude that no action is required to improve the energy performance of the building stock until 2031. The question now is, what should the adjusted (more aggressive) target for 2030 be?

The following sections provide some insight and recommended readings to address this issue. Those guides and methodologies address not only the building sector, but all spheres of humane activities, so municipalities will derive significant benefits from reviewing this material and acquiring this knowledge.

Principle and Methods for Setting Targets:

Establishing a reference year and setting temporal milestones and targets are important steps. The Federation of Canadian Municipalities (FCM) and the Local Governments for Sustainability (ECLEI) published a guide [3] in 2016 which helps municipality in setting climate targets. CTAP users are encouraged to consult these guides as they provide valuable advice on how to interact with local council on such matters.

"There are two primary methods of setting GHG targets, top-down and bottom-up, referring to the order in which the target and actions are developed. These methods are sometimes described as aspirational or pragmatic. In fact, targets should be both aspirational and pragmatic: aspirational because they reflect the need for significant action on climate change, and pragmatic because they need to be realistic and achievable. These aspects of a target can co-exist, regardless of whether the target-setting methodology is top-down or bottom-up." [3]

Example of targets setting in Canadian municipalities are shown in the Table 4 [3] below. Note the targets adjustment history as context changed:

Examples of Canadian Municipal Targets (and how they evolved in time)			
Corporate		**Community**	
Bridgewater, NS	15% below 2007 by 2017	Edmonton, AB	35% below 2005 by 2035 ***
Halton Hills, ON	20% below 2011 by 2031	Kelowna, BC	33% below 2007 by 2020
Quebec City, QC	10% below 1990 by 2020 *	Sackville, NB	10% below 2011 by 2021
Richot, MB	15% below 2011 by 2025	Thunder Bay, ON	10% below 2005 by 2017
Saskatoon, SK	30% below 2006 by 2020 **	Whitehorse, YT	6% below 2014 by 2030 ****
* Revised target. Previous target was 22.3% below 2002 by 2010.		*** Revised target. Previous target was 6% below 1990 by 2010.	
** Revised target. Previous target was 10% below 1990 by 2013.		**** Revised target. Previous target was 6% below 2001 by 2013.	

Table 4: Examples of Canadian Municipal Targets [3]

Examples of Global and National Guidelines:

As overall guidance the latest IPCC (International Panel on Climate Change) report entitled "Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6)" [4] dated March 20, 2023, sets the targets for GHG reduction to be achieved with respect to a 2019 baseline as 43% by 2030, 60% by 2035 and 69% by 2040.

These global targets encompassing all sectors have been raised several times in the last few official IPCC reports. The 2050 Net Zero target remains, but with a recommendation for*" … wealthy nations to achieve Net Zero as close as possible to 2040".* [5]

There is also the Canadian Government global commitment of reaching 40% to 45% reduction by 2030, and Net Zero by 2050, for all sectors of humane activities. [6]

The Canadian Government document entitled "2030 Emission Reduction Plan – Sector-by-Sector overview" states: "The 2030 Emissions Reduction Plan is an ambitious and achievable roadmap that outlines a sector-by-sector path for Canada to reach its emissions reduction target of 40 percent below 2005 levels by 2030 and net-zero emissions by 2050." [7]

The building sector, specifically, has the following targets [7]:

Science-Based Targets (SBT):

Another source of information is contained in the "Science-Based Climate Targets: A Guide for Cities" issued in 2020 by the United Nations Framework Convention on Climate Change's (UNFCCC) [8]. In this guide, another perspective is given to the task of setting GHG reduction targets.

"Science-based climate targets should be bound by the following principles: they must be science-driven, equitable and complete. Science-driven means led by the latest climate science. Equitable means they take into account the different historical contributions to levels of carbon dioxide in the atmosphere and take into account socio-economic development. Complete means that these targets are robust and comprehensive, taking into account city-wide emissions from a variety of sources (at least scopes 1 and 2) and multiple GHGs." [8]

"Cities worldwide have varying historic responsibility for and current capacity to respond to the climate challenge. Using a science-based methodology to set a target ensures that these factors are considered, so the target will represent a 'fair share' of emission reduction. This means that, while the global target

is to reduce greenhouse gas emissions by 48% by 2030, the level of reduction required by each city may be higher or lower, dependent on these equity considerations." [8]

The SBT approach was adopted by the C40 initiatives which regrouped the 40 largest cities of the world accounting for approximately 20% of the global economy. Table 5 [8] illustrates sample conclusions from that process which was completed in 2020:

GHG/capita	City GDP/capita (USD)	Indicative city target reduction fo 2030 per capita missions (% changes from 2015 levels)*	City 2050 target (from baseline year 2015)	Example cities that match this profile
High (>5.1 tCO2e/capita)	High (>15k/capita)	-70% to -75%	Net zero emissions	Toronto Melbourne New York City Yokohama Heidelberg Wroclaw
	Low (<15k/capita)	-10% to -15%	Net zero emissions	Cape Town eThekwini Tshwete Rio Grande Sao Jose dos Campos
Low (<5.1 tCO2e/capita)	High (>15k/capita)	-55% to -60%	Net zero emissions	Stockholm Seoul London Chula Vista Helsinki Barcelona
	Low (<15k/capita)	0% to -5%	Net zero emissions	Quito Nairobi Amman Buenos Aires Johannesburg Passing City

* These ranges are based on an estimation using existing targets of C40 cities.

Table 5: Examples of GHG reduction targets set by cities of different context [8].

After considering those different perspectives, a tentative reference year and interim milestones / targets can be defined. The next step is to run a CTAP simulation to obtain the GHG inventory for the reference year, also referred to as the "baseline GHG inventory".

6.2.2 Obtaining the "Baseline" (or "Reference Year") and "Current Year" GHG Inventories:

Once the reference year is selected the baseline GHG inventory can be determined using CTAP. CTAP dedicated the "Scenario 1" input screen in the "Scenarios Definition" Tab to the reference year. First, the number of buildings in each archetype must be adjusted downwards to exclude buildings that were built after the selected reference year. This is easily done by consulting most property tax database which usually contain vintage and type of buildings (see Section 6.1.1).

CTAP automatically populates most of that "Scenario 1" Table in terms of archetypes and existing attributes as of the selected reference year. If required and if that information is available, the user can validate that data. The ECMs and LCES can be adjusted as per the existing conditions as of the end of the reference year. For example, if it is estimated that 3% of the dwellings had PV arrays on their roofs, then that number can be included in the base case. For an archetype with 200 buildings assigned to it, the user would enter 6 in that LCES, and the average installed capacity next to it.

		Select space heating method								Additional low carbon energy technology options Enter number of buildings to be upgraded							Energy conservation measures (ECMs) (energy retrofit and appliances ugrades)				
		Electricity	Combustion		Heat Pumps			Hybrid													
Archetype	Total number of buildings (ea.)	Beseboard or electric furnace (ea.)	Select here Gas (ea.)	Efficiency (default provided, can be edited below) (%)	Wood (ea.)	Air source heat pump for heating and cooling (ASHP) (ea.)	Ground source heat pump for heating & cooling (GSHP) (ea.)	Capacity of heap pump (HP) (kW)	Heat Pump with auxiliary (select below)	Solar domestic water heater (SDHW) (ea.)	Photo-voltaic array (PV) (ea.)	Capacity of PV array per building (kWp)	Battery electricity storage (BES) (ea.)	Battery electricity storage capacity (kWhr)	Thermal energy storage (ea.)	Thermal energy storage (kWh)	Heating Load Reduction (%)	Cooling Load Reduction (%)	Domestic Hot Water Reduction (%)	% buildings retrofited	Plug + Lighting Load Reduction (%)
Scenario number:	**1**	Baseline scenario 2005																			
Pre-45-1St-wtBsm	25		25	80%				11.3	Fossil fuel					14		240					
Pre-45-1St-noBsm	25		25	80%				9.2	Fossil fuel					14		180				0%	
46-70-1St-wtBsmt1	80		80	80%				9.5	Fossil fuel					14		180				0%	
46-70-1St-wtBsmt2	81		81	80%				11.3	Fossil fuel					14		240				0%	
71-90-1St-noBsm	57		57	80%				10.3	Fossil fuel					14		240				0%	
71-90-1St-wtBsm1	65		65	80%				12.7	Fossil fuel					14		240				0%	
71-90-1St-wtBsm2	66		66	80%				11.6	Fossil fuel					14		240				0%	
91-10-1st-wtBSm	25		25	80%				18.3	Fossil fuel					14		240				0%	
91-10-1st-split	10		10	80%				10.6	Fossil fuel					14		240				0%	
11-20-1st-wtBsm				80%				15.1	Fossil fuel					14		240				0%	
11-20-2st-wtBsm				80%				12.3	Fossil fuel					14		240				0%	
Total	434																				

This baseline scenario is then defined in the “Scenario 1” input table. Going to the “User Input Output” Tab, CTAP is then run, and the results matrix can be saved in the first column of the comparison table. It will be the basis for comparing results of future runs.

Table 6: Example of a baseline scenario:

This scenario is generated automatically when the user, having selected the jurisdiction in Cell K18 of the Input Output Tab, and the reference year in Cell C17 of the Scenario definition Tab. The software extrapolates backward in time using the growth rate between 2016 and 2021, the two census data points for building count, to obtain an approximate number of buildings in the reference year. The user should make the appropriate adjustment as detailed in the note of Cell J34. These adjustments should be reflected in the next scenario, the one dedicated to the “current” year scenario.

Current Year Scenario uses the Scenario 2 input Table in the “Scenarios Definition” Tab and the process is the same. Input is automatically generated, and the user simply validates the data and modify it as required. Explanatory notes are included in the input screen should that be required. Going to the “User Input Output” Tab, the user runs CTAP, and results are stored in the second column of the comparison table.

Here is an example of a “Current Year” Scenario: it has 20 more buildings than the reference year, and 4 heat pumps have been installed since.

		Select space heating method								Additional low carbon energy technology options							Energy conservation measures (ECMs)				
		Electricity	Combustion		Heat Pumps			Hybrid		Enter number of buildings to be upgraded							(energy retrofit and appliances ugrades)				
Archetype	Total number of buildings (ea.)	Beseboard or electric furnace (ea.)	**Select here** Gas (ea.)	Efficiency (default provided, can be edited below) (%)	Wood (ea.)	Air source heat pump for heating and cooling (ASHP) (ea.)	Ground source heat pump for heating & cooling (GSHP) (ea.)	Capacity of heap pump (HP) (kW)	Heat Pump with auxiliary (select below)	Solar domestic water heater (SDHW) (ea.)	Photo-voltaic array (PV) (ea.)	Capacity of PV array per building (kWp)	Battery electricity storage (BES) (ea.)	Battery electricity storage capacity (kWhr)	Thermal energy storage (ea.)	Thermal energy storage (kWh)	Heating Load Reduction (%)	Cooling Load Reduction (%)	Domestic Hot Water Reduction (%)	% buildings retrofited	Plug + Lighting Load Reduction (%)
Scenario number:	**2**	Status at 2023																			
Pre-45-1St-wtBsm	25		25	80%				11.3	Fossil fuel					14		240					
Pre-45-1St-noBsm	25		25	80%				9.2	Fossil fuel					14		180					
46-70-1St-wtBsmt1	80		80	80%				9.5	Fossil fuel					14		180				0%	
46-70-1St-wtBsmt2	81		81	80%				11.3	Fossil fuel					14		240				0%	
71-90-1St-noBsm	57		53	80%		4		10.3	Fossil fuel					14		240				0%	
71-90-1St-wtBsm1	65		65	80%				12.7	Fossil fuel					14		240				0%	
71-90-1St-wtBsm2	66		66	80%				11.6	Fossil fuel					14		240				0%	
91-10-1st-wtBSm	32		32	80%				18.3	Fossil fuel					14		240				0%	
91-10-1st-split	16		16	80%				10.6	Fossil fuel					14		240				0%	
11-20-1st-wtBsm	3		3	80%				15.1	Fossil fuel					14		240				0%	
11-20-2st-wtBsm	4		4	80%				12.3	Fossil fuel					14		240				0%	
	454																				

Table 7: example of “Current Year” Scenario

Column #	1	2
Scenario Title:	Baseline scenario 2005	Status at 2023
Peak Elec. (kW)	1,324	1,388
PV Production (kWh)	-	-
Total Electricity Consumed (kWh)	5,212,495	5,492,643
Total fossil fuel (kWh)	11,022,770	11,583,370
Total Wood (kWh)	-	-
Annual Total Energy Purchased (minus PV) (kWh)	16,235,266	17,076,013
Elec. GHG (kg/CO2e)	5,156,227	1,440,665
Fossil fuel GHG (kg/CO2e)	2,299,783	2,416,746
Wood GHG (kg/CO2e)	-	-
Total GHG (kg/CO2e)	7,456,010	3,857,412
Rough imlementation cost ($000)	-	38
Electricity Cost ($)	722,430	760,722
Fossil fuel ($)	301,162	316,479
Total Cost ($/yr)	1,023,592	1,077,200
Elec GHG Intensity (kgCO2e/kWh)	0.989	0.262
Fossil fuel GHG Intensity (kgCO2e/kWh)	0.209	0.209
Wood GHG Intensity (kgCO2e/kWh)	0.000	0.000
Electricl Rate (Time of use or fixed)	TOU	TOU
Fixed Elec. Rate, if applicable. ($/kWh)	0.120	0.120
Heating Fossil fuel ($/kWh)	$ 0.03	$ 0.03
		1
GHG Reduction as % of baseline scenario:		**48.3%**
Tons of CO2 avoided per year		3599

Table 8: example of result matrix

The corresponding result matrix for the current year, shown beside the baseline and the current year is as follow. The user must save the result of any scenario run into this table by clicking the button on the "User Input Output" Tab (See Quick Reference Guide in Section 7). This is an example from central Alberta, and the reduction in GHG is attributable to the cleaning of the power grid is obvious:

6.2.3 Developing Scenarios (or Pathways) to Achieve Target GHG Reduction:

This step is likely to be an iterative, trial-and-error process by which different types of interventions (LCES and ECMs) are contemplated for the different archetypes and at different levels of penetration.

As more and more interventions are included in subsequent CTAP runs, the results will show improved GHG reduction. Several trials will likely be required to reach the target GHG reduction for a given timeframe.

When this step is completed, the user will have a relatively good idea of the amount and nature of the work required, and a rough idea of the investment needed to get the work done.

Establishing Timeframe and Interim Targets:

With the overall targets defined earlier (see Section 6.2.1) for 2030 and 2050 it is now recommended to define interim milestones and targets. For example, a 50% GHG reduction target by 2030 could be complemented by a 20% reduction target by year end 2025, and/or a 40% reduction target by year end 2028.

Evaluating LCES and ECMs with Respect to Local Context:

To achieve GHG reduction the user must select from the LCES and ECMs options available in CTAP (see Section 4). This task is best performed following consultations with a task force of local knowledgeable resources. See Appendix D for the full task force make-up suggestion.

For example, a certified energy advisor will be able to advise on technologies that are most appropriate for the local context. Some examples of considerations are given below:

Higher cost of electricity (incl. distribution charge) will favor solar panels.

Exterior temperature annual profile will impact the type of heat pump to be used.

Type and vintage of dwellings will have different building envelope upgrade priorities.

Energy advisor will be able to estimate what interventions are required for a given archetype to reach the targeting reduction in space heating.

Etc.

Representatives of the local power distribution company will be consulted to address issues such as:

Impact on the hourly power demand profile as electrification of the heating systems progress through time.

Interconnection conditions of distributed solar power generation with the public grid.

Demand Side Management (DMS) issues (how to shave the peak).

Note: (CTAP offers two energy storage options: thermal and electrical)

Etc.

Local renovators, builders, electricians, and HVAC contractors will be able to provide informed estimates of:

Retrofit unit cost for windows, insulation upgrade, for any given archetype etc. as informed by the recommendation of the energy advisor.

In the case that a conversion from gas to heat pump, or hybrid heat pump with gas back-up, how likely it is for the power service entrance will need to be upgrade or not, and how likely it is for the air distribution ductwork needing to be modified.

Etc.

Note that those estimates are to be "order of magnitudes" estimates, understanding that each building is different. For example, local contractors will have a good idea of what percentage of older vintage homes have a limited power entrance capacity that will need upgraded to accommodate a heat pump and what percentage is likely not to need this. The use of hybrid heating system (natural gas back-up to a heat pump) would lower the peak power demand and may avoid the need for power and / or ductwork upgrades, etc. The input of knowledgeable local contractors will be valuable in confirming or refining default unit costs provided and in identifying opportunities for cost efficiency.

Links to useful technology guides produced by NRCan are included in Appendix C. This initiative will spread over decades, so the development of local expertise will be a worthwhile investment within the township office's staff and within the community.

Defining Scenarios in CTAP:

Having established the baseline, temporal milestones and targets, the user must now define future scenarios. The user selects, for each archetype, the different interventions, LCESs and/or ECMs and run the simulation to see the reduction in GHG that would be achieved. The user will likely need to proceed on a trial-and-error basis until enough interventions are included to achieve the target percentage in GHG reduction by the target milestone year.

With an understanding of which of the LCES and ECMs are most appropriate the user can start selecting options to define scenarios. Some basic considerations:

There is a consensus that before space heating systems are replaced or converted to LCES technology, the space heating requirement must be optimized. This means ECMs: building envelope upgrades: insulation levels, air tightness, windows, and doors, etc. are to precede or coincide with LCES implementation.

It is also intuitive that older vintage buildings will likely present more improvement potential than more recent, more energy performant ones (lowest, biggest hanging fruits concept).

The economic feasibility of an intervention always benefits from coordinating the replacement of a building system/component with the end of service life of the existing one (example: furnace, exterior cladding, etc.).

The selected “interventions” are then entered in the “Scenarios Definition” Tab, starting with Table 3 for the first trial.

Calculations

Data input done! Now simply trigger the calculations as per instructions on the spreadsheet. If will take a few seconds for the software to calculate all the incremental hourly energy consumption values for each technology options, for each archetype and aggregate all of these to the base case 8760 data stream for all archetypes.

(Inside CTAP’s “black box”: depending on the technology options selected and the number of archetypes in which these will be implemented, CTAP will modify the hourly energy demand for the given “upgraded” archetype. This is done automatically, locally in the software, using the local climate data, also provided by default. For example, switching from electric baseboard heating to an air source heat pump, CTAP will modify the energy demand associated to space heating by using the coefficient of performance of the heat pump corresponding to the outdoor temperature for each of the 8760 hours of the year. This process happens automatically with no need for the user to intervene.)

After the calculations are done, the user is asked if he/she want to save the results of that run for future reference and comparison. Follow explanatory notes in CTAP.

Fine-Tunning Scenarios: Trial-and-Error Process:

The first trial scenario is likely not to produce the necessary GHG reduction estimates. The user must then revisit the Scenarios Input Screen and modify the selection of ECMs and LCESs applied to the building stock. The user then run CTAP again and analyses the result matrix.

When a run is useful, with promising results, the user can save the results to the Scenario Comparison Table. He/she can either overwrite the last scenario or use a new column in the input table and keep the previous scenario(s) for reference.

When naming a scenario, the user can develop a “shorthand convention” to be as descriptive as possible with a limited number of characters. It should always contain the simulation year corresponding to the milestone. See examples below.

The user can safeguard every trial, or only save the successful scenario for the first target and move on to the next time milestone year and target and keep adding to the ECMs and LCESs.

IMPORTANT: When initiating a new scenario for a new time milestone, remember that all LCESs and EMCs interventions are cumulative, so future year scenario must include all previous year scenarios interventions. To avoid having to re-enter the previous scenario’s data, a button is provided on the right of the table to copy/paste the previous scenario’s data into the new one. Another button is provided to re-initialize to the “current Year” data should the user want to initiate a new direction in the trial-and-error process.

Examples of LCES and ECMs selections and scenarios in the “Scenarios Definition” Tab are shown on the next page:

Town of Smoky Lake Date: April 11, 2023

Legend: input default calculated

Press "F9" after entering data.
Scroll down to define additional scenarios

Archetype	Total number of buildings (ea.)	Beseboard or electric furnace (ea.)	Select here Gas (ea.)	Efficiency (default provided, can be edited below) (%)	Wood (ea.)	Air source heat pump for heating and cooling (ASHP) (ea.)	Ground source heat pump for heating & cooling (GSHP) (ea.)	Capacity of heap pump (HP) (kW)	Heat Pump with auxiliary (select below)	Solar domestic water heater (SDHW) (ea.)	Photo-voltaic array (PV) (ea.)	Capacity of PV array per building (kWp)	Battery electricity storage (BES) (ea.)	Battery electricity storage capacity (kWhr)	Thermal energy storage (ea.)	Thermal energy storage (kWh)	Heating Load Reduction (%)	Cooling Load Reduction (%)	Domestic Hot Water Reduction (%)	spare	Plug + Lighting Load Reduction (%)
		Select space heating method: Electricity	Combustion			Heat Pumps			Hybrid	Additional low carbon energy technology options – Enter number of buildings to be upgraded							Energy conservation measures (ECMs) (energy retrofit and appliances ugrades)				
Scenario number 3		2030 1rst trial: pre-45 70% DER and 3/5 ASHP + 2/5 96% NG																			
Pre-45-1St-wtBsm	25		10	96%		15		11.3	Fossil fuel					14		240	70%		40%		
Pre-45-1St-noBsm	25		10	96%		15		9.2	Fossil fuel					14		180	70%		40%		
46-70-1St-wtBsmt1	80		80	80%				9.5	Fossil fuel					14		180					
46-70-1St-wtBsmt2	81		81	80%				11.3	Fossil fuel					14		240					
71-90-1St-noBsm	57		53	80%		4		10.3	Fossil fuel					14		240					
71-90-1St-wtBsm1	65		65	80%				12.7	Fossil fuel					14		240					
71-90-1St-wtBsm2	66		66	80%				11.6	Fossil fuel					14		240					
91-10-1st-wtBSm	32		32	80%				18.3	Fossil fuel					14		240					
91-10-1st-split	16		16	80%				10.6	Fossil fuel					14		240					
11-20-1st-wtBsm	13		13	96%				15.1	Fossil fuel					14		240					
11-20-2st-wtBsm	24		24	96%				12.3	Fossil fuel					14		240					
	484																				
Scenario number 4		2030 2nd trial = 1rst + Pre-70 50% DER + 1/2 ASHP + all ES appliances																			
Pre-45-1St-wtBsm	25		10	96%		15		11.3	Fossil fuel					14		240	70%	70%	40%		25%
Pre-45-1St-noBsm	25		10	96%		15		9.2	Fossil fuel					14		180	70%	70%	40%		25%
46-70-1St-wtBsmt1	80		40	96%		40		9.5	Fossil fuel					14		180	50%	50%	40%		25%
46-70-1St-wtBsmt2	81		41	96%		40		11.3	Fossil fuel					14		240	50%	50%	40%		25%
71-90-1St-noBsm	57		53	80%		4		10.3	Fossil fuel					14		240					
71-90-1St-wtBsm1	65		65	80%				12.7	Fossil fuel					14		240					
71-90-1St-wtBsm2	66		66	80%				11.6	Fossil fuel					14		240					
91-10-1st-wtBSm	32		32	80%				18.3	Fossil fuel					14		240					
91-10-1st-split	16		16	80%				10.6	Fossil fuel					14		240					
11-20-1st-wtBsm	13		13	80%				15.1	Fossil fuel					14		240					
11-20-2st-wtBsm	24		24	80%				12.3	Fossil fuel					14		240					
	484																				
Scenario number 5		2030 3rd = 2nd + 25% SDWHP and V on 50% of entire blg stock																			
Pre-45-1St-wtBsm	25		10	96%		15		11.3	Fossil fuel	6	12	3		14		240	70%	70%	40%		25%
Pre-45-1St-noBsm	25		10	96%		15		9.2	Fossil fuel	6	12	3		14		180	70%	70%	40%		25%
46-70-1St-wtBsmt1	80		40	96%		40		9.5	Fossil fuel	20	40	3		14		180	50%	50%	40%		25%
46-70-1St-wtBsmt2	81		41	96%		40		11.3	Fossil fuel	20	40	4		14		240	50%	50%	40%		25%
71-90-1St-noBsm	57		53	80%		4		10.3	Fossil fuel	14	28	4		14		240					
71-90-1St-wtBsm1	65		65	80%				12.7	Fossil fuel	16	32	4		14		240					
71-90-1St-wtBsm2	66		66	80%				11.6	Fossil fuel	16	33	4		14		240					
91-10-1st-wtBSm	32		32	80%				18.3	Fossil fuel	8	16	4		14		240					
91-10-1st-split	16		16	80%				10.6	Fossil fuel	4	8	4		14		240					
11-20-1st-wtBsm	13		13	96%				15.1	Fossil fuel	3	6	5		14		240					25%
11-20-2st-wtBsm	24		24	96%				12.3	Fossil fuel	6	12	5		14		240					25%
	484																				
Scenario number 6		2030 4ht = 3 rd + 15% Biomass and 80% ASHP														Building number does not					
Pre-45-1St-wtBsm	25		0	80%	5	20		11.3	Fossil fuel	6	12	3		14		240	70%	70%	40%		25%
Pre-45-1St-noBsm	25		0	80%	5	20		9.2	Fossil fuel	6	12	3		14		180	70%	70%	40%		25%
46-70-1St-wtBsmt1	80		2	80%	14	64		9.5	Fossil fuel	20	40	3		14		180	50%	50%	40%		25%
46-70-1St-wtBsmt2	81		3	80%	14	64		11.3	Fossil fuel	20	40	4		14		240	50%	50%	40%		25%
71-90-1St-noBsm	57		2	80%	10	45		10.3	Fossil fuel	14	28	4		14		240					
71-90-1St-wtBsm1	65		2	80%	11	52		12.7	Fossil fuel	16	32	4		14		240					
71-90-1St-wtBsm2	66		2	80%	12	52		11.6	Fossil fuel	16	33	4		14		240					
91-10-1st-wtBSm	32		1	80%	6	25		18.3	Fossil fuel	8	16	4		14		240					
91-10-1st-split	16		1	80%	3	12		10.6	Fossil fuel	4	8	4		14		240					
11-20-1st-wtBsm	13		0	80%	3	10		15.1	Fossil fuel	3	6	5		14		240					25%
11-20-2st-wtBsm	24		0	80%	5	19		12.3	Fossil fuel	6	12	5		14		240					25%
	484																				

Table 9: examples of scenarios showing cumulative selection of interventions

And the result metrics matrix for each of those runs is displayed in the following Scenarios Summary table:

Saved Scenarios Summary								
Column #	1	2	3	4	5	6	7	8
Scenario Title:	Baseline scenario 2005	Status at 2023	2030 1rst trial: pre-45 70% DER and 3/5 ASHP + 2/5 96% NG	2030 2nd trial = 1rst + Pre-70 50% DER + 1/2 ASHP + all ES appliances	2030 3rd = 2nd + 25% SDWHP and V on 50% of entire blg stock	2030 4ht = 3 rd + 15% Biomass and 80% ASHP		
Peak Elec. (kW)	1,324	1,388	1,468	1,516	1,285	3,855		
PV Production (kWh)	-	-	-	-	1,102,082	1,102,082		
Total Electricity Consumed (kWh)	5,212,495	5,492,643	5,858,537	5,520,017	5,226,445	7,960,645		
Total fossil fuel (kWh)	11,022,770	11,583,370	11,474,102	8,719,227	8,719,227	284,960		
Total Wood (kWh)	-	-	-	-	-	2,078,883		
Annual Total Energy Purchased (minus PV) (kWh)	16,235,266	17,076,013	17,332,639	14,239,244	12,843,591	9,222,407		
Community level renewable energy project credit (kg/CO2)			-	-	-	-		
Elec. GHG (kg/CO2e)	5,156,227	1,440,665	1,272,738	1,199,196	895,997	1,489,989		
Fossil fuel GHG (kg/CO2e)	2,299,783	2,416,746	2,393,949	1,819,173	1,819,173	59,454		
Wood GHG (kg/CO2e)	-	-	-	-	-	-		
Total GHG (kg/CO2e)	7,456,010	3,857,412	3,666,687	3,018,370	2,715,171	1,549,443		
Rough imlementation cost ($000)	-	38	3,454	11,608	14,588	17,235		
Electricity Cost ($)	722,430	760,722	810,604	757,057	591,856	926,937		
Fossil fuel ($)	301,162	316,479	313,493	238,225	238,225	7,786		
Total Cost ($/yr)	1,023,592	1,077,200	1,124,097	995,282	830,081	934,723		
Elec GHG Intensity (kgCO2e/kWh)	0.989	0.262	0.217	0.217	0.217	0.217		
Fossil fuel GHG Intensity (kgCO2e/kWh)	0.209	0.209	0.209	0.209	0.209	0.209		
Wood GHG Intensity (kgCO2e/kWh)	0.000	0.000	0.000	0.000	0.000	0.000		
Electricl Rate (Time of use or fixed)	TOU	TOU	TOU	TOU	TOU	TOU		
Fixed Elec. Rate, if applicable. ($/kWh)	0.120	0.120	0.120	0.120	0.120	0.120		
Heating Fossil fuel ($/kWh)	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03		
	1	1	1	1	1	1	1	1
GHG Reduction as % of baseline scenario:		48.3%	50.8%	59.5%	63.6%	79.2%	0.0%	0.0%
Tons of CO2 avoided per year		3599	3789	4438	4741	5907	0	0

Table 10: example of table of comparison of scenarios' result matrices

Composite Scenario: Using Several Runs to Make a Composite Scenario:

CTAP was written in Excel to keep it accessible and simple to use for most users. The limitation is that only 11 archetypes can be processed at a time. This has proven to provide appropriate granularity for acceptable results accuracy. However, there are a few cases when an extra step may be required to accommodate a given scenario.

<u>Case 1:</u> When only a subset of building of a given archetype will be subjected to building energy retrofit. Example: If only half of pre-1970 buildings are to have, say, a 70% reduction in space heating and the other half, nothing. If there are 3 out of the 11 archetypes that are pre-1970, this means that from a point of view of energy simulation we now have 11 base archetypes plus 3 modified archetypes (with a better building envelope), so a total of 14.

The way to handle this with CTAP is to break the scenario in 2 parts. Part one scenario input table will contain the 11 archetypes but with only half the building count for the 3 pre-1970 archetypes. The second scenario part will contain only the 3 pre-1970 archetypes also with only half the building count for those archetypes, with the 70% reduction in space heating requirements. Both runs are performed, and the results added up for the complete scenario.

		Select space heating method								Additional low carbon energy technology options							Energy conservation measures (ECMs) (energy retrofit and appliances ugrades)				
		Electricity	Combustion			Heat Pumps		Hybrid		Enter number of buildings to be upgraded											
Archetype	Total number of buildings (ea.)	Beseboard or electric furnace (ea.)	Select here Gas (ea.)	Efficiency (default provided, can be edited below) (%)	Wood (ea.)	Air source heat pump for heating and cooling (ASHP) (ea.)	Ground source heat pump for heating & cooling (GSHP) (ea.)	Capacity of heap pump (HP) (kW)	Heat Pump with auxiliary (select below)	Solar domestic water heater (SDHW) (ea.)	Photo-voltaic array (PV) (ea.)	Capacity of PV array per building (kWp)	Battery electricity storage (BES) (ea.)	Battery electricity storage capacity (kWhr)	Thermal energy storage (ea.)	Thermal energy storage (kWh)	Heating Load Reduction (%)	Cooling Load Reduction (%)	Domestic Hot Water Reduction (%)	% buildings retrofited	Plug + Lighting Load Reduction (%)
Scenario number	3	2030 Part 1 of 2 - half homes untouched																			
Pre-45-1St-wtBsm	12		12	80%				11.3	Fossil fuel					14		240					
Pre-45-1St-noBsm	12		12	80%				9.2	Fossil fuel					14		180					
46-70-1St-wtBsmt1	40		40	80%				9.5	Fossil fuel					14		180				0%	
46-70-1St-wtBsmt2	41		41	80%				11.3	Fossil fuel					14		240				0%	
71-90-1St-noBsm	29		25	80%		4		10.3	Fossil fuel					14		240				0%	
71-90-1St-wtBsm1	32		32	80%				12.7	Fossil fuel					14		240				0%	
71-90-1St-wtBsm2	33		33	80%				11.6	Fossil fuel					14		240				0%	
91-10-1st-wtBSm	16		16	80%				18.3	Fossil fuel					14		240				0%	
91-10-1st-split	8		8	80%				10.6	Fossil fuel					14		240				0%	
11-20-1st-wtBsm	2		2	80%				15.1	Fossil fuel					14		240				0%	
11-20-2st-wtBsm	2		2	80%				12.3	Fossil fuel					14		240				0%	
	227																				
Scenario number	4	2030 Part 2 of 2 - half existing 50% better + 20 new homes 50% better than 2020 code and 50% heatpumps																			
Pre-45-1St-wtBsm	13		0	80%		13		5.0	Fossil fuel					14		240	50%	50%			
Pre-45-1St-noBsm	13		0	80%		13		5.0	Fossil fuel					14		180	50%	50%			
46-70-1St-wtBsmt1	40		0	80%		40		5.0	Fossil fuel					14		180	50%	50%		0%	
46-70-1St-wtBsmt2	41		0	80%		41		5.0	Fossil fuel					14		240	50%	50%		0%	
71-90-1St-noBsm	28		0	80%		28		5.0	Fossil fuel					14		240	50%	50%		0%	
71-90-1St-wtBsm1	32		0	80%		32		5.0	Fossil fuel					14		240	50%	50%		0%	
71-90-1St-wtBsm2	33		0	80%		33		5.0	Fossil fuel					14		240	50%	50%		0%	
91-10-1st-wtBSm	16		0	80%		16		5.0	Fossil fuel					14		240	50%	50%		0%	
91-10-1st-split	8		0	80%		8		5.0	Fossil fuel					14		240	50%	50%		0%	
11-20-1st-wtBsm	11		0	80%		11		5.0	Fossil fuel					14		240	50%	50%		0%	
11-20-2st-wtBsm	12		0	80%		12		5.0	Fossil fuel					14		240	50%	50%		0%	
	247																				

Table 11: example of a composite scenario

Illustrated example: when approximately half the jurisdiction buildings are to be retrofitted to reduce heating / cooling energy requirements by 50% and converted to a hybrid heating system air source heat pump capped at 5 kW capacity. To analyse this scenario the user needs to use two input screens, one with half the building stock with no LCES or ECM, and the second screen with the second half of the building, plus the anticipated increase in buildings, with the contemplated LCES and ECMs intervention.

Table to combine up to three scenario parts	Part 1	Part 2	Part 3	Total
Select scenario parts to be added =>	2030 Part 1 of 2 - half homes untouched	2030 Part 2 of 2 - half existing 50% better + 20 new homes 50% better than 2020 code and 50% heatpumps		2030 Part 1 of 2 - half homes untouched + 2030 Part 2 of 2 - half existing 50% better + 20 new homes 50% better than 2020 code and 50% heatpumps +
Peak Elec. (kW)	695	1,750	0	2,445
PV Production (kWh)	-	-	0	-
Total Electricity Consumed (kWh)	2,765,912	4,241,851	0	7,007,763
Total fossil fuel (kWh)	5,748,775	171,687	0	5,920,462
Total Wood (kWh)	-	-	0	-
Annual Total Energy Purchased (minus PV) (kWh)	8,514,688	4,413,538	0	12,928,226
Elec. GHG (kg/CO2e)	600,881	921,521	0	1,522,402
Fossil fuel GHG (kg/CO2e)	1,199,420	35,821	0	1,235,241
Wood GHG (kg/CO2e)	-	-	0	-
Total GHG (kg/CO2e)	**1,800,301**	**957,342**	0	**2,757,643**
Rough imlementation cost ($000)	38	14,336	0	14,374
Electricity Cost ($)	382,792	566,269	0	949,060
Fossil fuel ($)	157,067	4,691	0	161,758
Total Cost ($/yr)	539,859	570,959	0	1,110,818
Cost compared to Baseline (%)	0	0	0	-
Elec GHG Intensity (kgCO2e/kWh)	0.2172	0.2172	0.0000	0.4345
Fossil fuel GHG Intensity (kgCO2e/kWh)	0.2086	0.2086	0.0000	0.4173
Wood GHG Intensity (kgCO2e/kWh)	0.0000	0.0000	0.0000	0.0000
Electricl Rate (Time of use or fixed)	0.0000	0.0000	0.0000	0.0000
Fixed Elec. Rate, if applicable. ($/kWh)	0.1200	0.1200	0.0000	0.1200
Heating Fossil fuel ($/kWh)	0.0273	0.0273	0.0000	0.0273

Table 12: example of Composite Scenario Table

Saved Scenarios Summary							
Column #	1	2	3	4	5	6	7
Scenario Title:	Baseline scenario 2005	Status at 2023	2030 Part 1 of 2 - half homes untouched	2030 Part 2 of 2 - half existing 50% better + 20 new homes 50% better than 2020 code and 50% heatpumps	2030 Part 1 of 2 - half homes untouched + 2030 Part 2 of 2 - half existing 50% better + 20 new homes 50% better than 2020		
Peak Elec. (kW)	1,324	1,388	695	1,750	2,445		
PV Production (kWh)	-	-	-	-	-		
Total Electricity Consumed (kWh)	5,212,495	5,492,643	2,765,912	4,241,851	7,007,763		
Total fossil fuel (kWh)	11,022,770	11,583,370	5,748,775	171,687	5,920,462		
Total Wood (kWh)	-	-	-	-	-		
Annual Total Energy Purchased (minus PV) (kWh)	16,235,266	17,076,013	8,514,688	4,413,538	12,928,226		
Elec. GHG (kg/CO2e)	5,156,227	1,440,665	600,881	921,521	1,522,402		
Fossil fuel GHG (kg/CO2e)	2,299,783	2,416,746	1,199,420	35,821	1,235,241		
Wood GHG (kg/CO2e)	-	-	-	-	-		
Total GHG (kg/CO2e)	7,456,010	3,857,412	1,800,301	957,342	2,757,643		
Rough imlementation cost ($000)	-	38	38	14,336	14,374		
Electricity Cost ($)	722,430	760,722	382,792	566,269	949,060		
Fossil fuel ($)	301,162	316,479	157,067	4,691	161,758		
Total Cost ($/yr)	1,023,592	1,077,200	539,859	570,959	1,110,818		
					0%		
Elec GHG Intensity (kgCO2e/kWh)	0.989	0.262	0.217	0.217	0.434		
Fossil fuel GHG Intensity (kgCO2e/kWh)	0.209	0.209	0.209	0.209	0.417		
Wood GHG Intensity (kgCO2e/kWh)	0.000	0.000	0.000	0.000	0.000		
Electricl Rate (Time of use or fixed)	TOU	TOU	TOU	TOU	0		
Fixed Elec. Rate, if applicable. ($/kWh)	0.120	0.120	0.120	0.120	0.120		
Heating Fossil fuel ($/kWh)	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03		
	1	1	0	0	1	1	1
GHG Reduction as % of baseline scenario:		48.3%	0.0%	0.0%	63.0%	0.0%	0.0%
Tons of CO2 avoided per year		3599	0	0	4698	0	0

Table 13: example of a composite scenario being added into the Scenario Comparison table

In the example table above (Table 13), Column 5 is the sum of the two parts of the 2030 scenario calculated separately and safeguarded in Columns 3 and 4, added up using the Composite Scenario Table on the User Input Output Tab shown in Table 12.

Case 2: If a future simulation year must include the anticipated growth in the community with say 200 more homes by 2030, and if those homes can be included as archetypes of 2011/2022 vintage but with improved energy performance by, say, 50% - if that is the standard to which they will be built -, then a second scenario part would contain those 200 homes in the appropriate archetypes and with the appropriate LCES/ECMS attributes.

6.3 Outputs:

6.3.1 Primary Output Metrics:

The output table is self-explanatory, a sample is provided in the previous section. This tool is a community level planning tool. The key primary annual metrics provided are:

- Energy consumption by type (electricity, fossil fuels, wood) in kWh.
- GHG associated to these energy consumptions in kg.
- Rough investment requirement in constant $.
- Rough energy cost in constant $.
- Full annual hourly electricity power demand in kW.
- Peak power demand in kW.

6.3.2 Secondary Output Metrics:

From these primary metrics other secondary metrics can be derived: for example, divide investment by GHG emission reduction in tons to get $/ton GHG emission reduction over a given study duration. I the example of Section 6.2.3.6, an investment of $ 14.3M achieved a reduction of 4700 tons GHG per year. But this included reduction associated to public grid improvement. The user can run the 2005 scenario with 2030 AEF to isolate the contribution of GHG reduction achieved by the public power grid improvement. In this case the 2005 scenario with 2030 AEF results in a GHG inventory in 2005 with 2030 AEF of 3,432,172 kg. The difference between this and the 2030 scenario, with 2030 AEF is:

3,432 tons CO2 (2005 simulated with 2030 AEF) less 2,758 (2030 scenario with 2030 AEF) = 674 tons/yr.

Over a 50-year study, the GHG reduction would be 50 x 674 tons at a cost of $14.3M

or 33,700 tons/$14.3M = **424 $/ton CO2 (50-year study)**

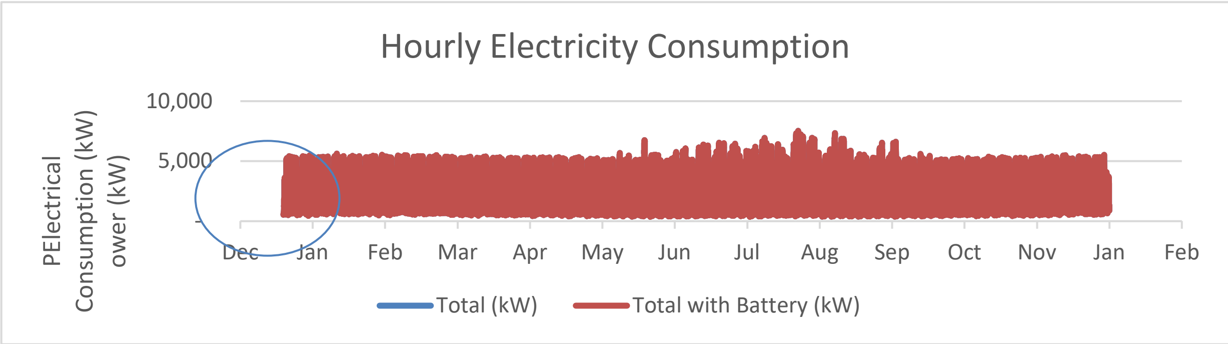
Another interesting metric would be the increase or decrease in energy costs – again community wide –. This would allow a very, very approximate “straight payback” calculation. This ratio would be obtained by dividing the investment amount by the annual savings in energy costs. Note that all calculations are in constant dollars, with no visibility of future energy costs increases factored in. So not a solid indicator, but still, food for thought.

From our example, between 2023 and 2030, with an investment of 14.3M and a marginal (beyond significant digits of the calculations) increase in energy costs, there is no “straight payback” from a financial point of view. This result is not surprising with the current cost structure between fossil fuel and electricity in this part of the country.

6.3.3 Output graphics:

Several output graphics are provided and are self-explanatory. One worthy of mention here is as follows:

The output also includes a graph showing the electricity demand for the entire building stock on an hourly basis for the entire year. This output (also available in a table format) would be most useful when coordinating with the local utility company: here is a sample.



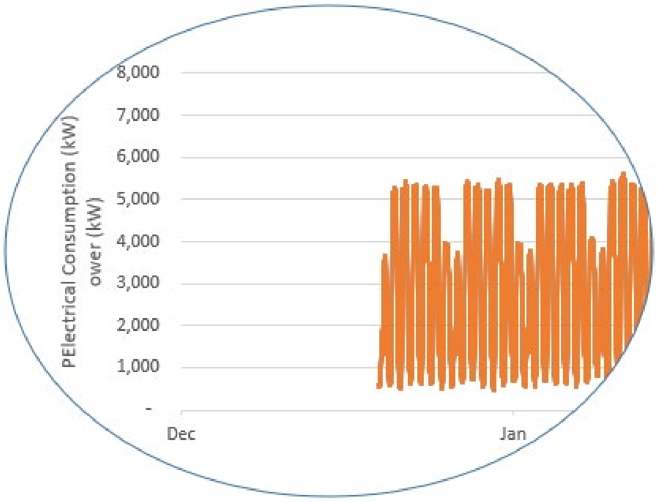


Table 14: example of electric power demand graphic

7. Quick User reference Guide: (also included in the CTAP file in the "Instruction" Tab)

Instruction on how to use CTAP:

Introduction:

CTAP was designed to provide a good estimate of a community's residential building sector greenhouse gas (GHG) inventory with as simple as possible data entry requirements.

Its target user base is made up of small and medium communities administrators who want to engage into the national GHG reduction initiative and who want to gain an understanding of the magnitude challenge in a timely and cost effective manner, and develop a road map for setting targets and achieving them.

CTAP allows the user to quickly obtain a general idea of where their community stands in terms of GHG inventory:

* for any given reference year (e.g. 2005, 2017, etc.) and
* for the current year (e.g. 2024) and
* and for any future scenario.

A scenario is defined as a series of building interventions in the community's residential buildings stock.
Building level interventions include: conversions of heating system (example: electrification), introduction of renewable energy

The main objective of CTAP is to assist the local GHG reduction task force to quantify the type and level of penetration of building level interventions required to achieve a given percentage GHG reduction target. The percentage reduction of GHG is relative to that of the chosen reference year. An important section of the User Manual discusses the selection of the reference year and targets. CTAP also provides a very broad cost estimate for implementing any given scenario. Although the financial analysis is not applicable to any specific building, the overall order of magnitude of the investment required can be used in sourcing funds by associating a capital budget estimate to a given program its targeted results when applying for subsidies, incentives or other financing vehicles.

First Phase of the Study: Select the CTAP version for your locality, and obtaining the GHG inventory for the reference year and for the current year:

Customized CTAP version:

From the 51 customized CTAP versions, the user selects the one for the city closest to his/her locality. This version of CTAP will be pre-populated with the data for the user's community.

In Cell O14 of the "User Input Output" Tab, select Francais or English. Save a virgin copy and work on a duplicate.

CTAP comes customized for a given region with the appropriate climate file, 11 default archetypes and their baseline annual hourly energy demand profiles (the 24 hours for 365 days, also called the "8760s" data points). The archetypes counts and existing heating systems in use are also pre-defined based on provincial averages contained in the latest census for dwelling counts and types, and the National Energy Usage Database. This is done for the current year, and for any past reference (or baseline) year, adjusting the data accordingly. *** Note that the data used is for a provincial average, applied to your city. Should better information be available that would be significantly different from the provincial average, the user can adjust the data as per the explanatory notes on the input screen.

Reference year GHG inventory:

1) In Cell K18 on "User Input Output" Tab, select your City

2) After selecting the reference year (see section of the User Manual on this topic), enter it in Cell C17 of the "Scenarios Definition" Tab. In cell C18, the estimated number of buildings appears. If better data is available (example tax roll database), validate and correct that number by overriding the default in that same cell. Then, adjust the number of buildings in each of the 11 default archetypes presented in the first table in Cells B23 to B33. See explanatory notes in Cells A34, A35 and J34 as required.

3) The reference year run can now be executed. In the "User Input Output" Tab, select Scenario 1 in Cell L15. Then click on the macro button (beside "Step 2"). The macro beside "Step 3" will save the result matrix into the scenario comparison table. The macro beside "Step 4" saves you work up to that point.

Current year GHG inventory:

1) In Cell T15 on "User Input Output" Tab, enter current year (example: 2024).

2) After entering the current year CTAP extrapolates from the latest census to get an estimated number of buildings which appears in Cell W15. If data is available (example tax roll database), validate and correct that number by overriding the formula in Cell W15. CTAP adjusts the number of buildings in the most recent archetype of the second table, in Cell B53. Adjust data as required, see explanatory note in Cell J54 as required.

3) CTAP also performs a very simple constant dollar estimation of the annual energy costs for the community's residential building stock, as a reference for the impact of future scenarios, excluding any inflationary impact. To obtain that value, the user can enter the energy unit costs in the "Financial" Tab in Rows 18 to 45. It includes electricity costs (fixed and time of Use (TOU)), natural gas, propane, oil, and wood.

4) The current year run can now be executed. In the "User Input Output" Tab, select Scenario 2 in Cell L15. Then click on the macro button (beside "Step 2"). The macro beside "Step 3" will save the result matrix into the scenario comparison table in the second column where it can be readily compared to the results for the reference year. The macro beside "Step 4" saves you work up to that point.

<u>Second Phase of the Study: develop and evaluate Scenarios for different milestones, until GHG reduction target reached</u>

1) Prior to proceeding with this phase, the community's administrator should:

* Identify a task force leader
* Establish targets and millstones, between now and 2050 in terms of GHG reduction for any and as many interim years along the path to Net-Zero.
* Identify and solicit the assistance of local stakeholders, technical resources and subject matter experts to build a local task force (See relevant section in the User Manual)
* After several workshops and consultations, identify the best technologies for the local context, and even validate the default unit costs provided in the upper section of the "Financial" Tab

2) Defining the first future scenario:

* Starting in the third table in the "Scenarios Definition" Tab, in Cell B62 and C62, enter the scenario's year and name. The name should start with the year, and contain a short form of the main components on the scenario in abbreviated form to keep it somewhat short, but still capturing the main attributes of the scenario.

* The user must also estimate the number of dwellings that will be added between the current year and the year of the future scenario. This is done by increasing the number of dwellings in the most recent archetype(s) vintage. (2011-2020). Unless those new dwellings are demonstratively going to be built to NET-ZERO standard.

* enter the number of dwellings converting to different heating system technologies. It is assumed that the conversion will be on dwelling currently using fossil fuels, and CTAP will reduce the count of fossil fuel heating systems automatically as conversions are entered. The user can of course overwrite that assumption if, for example, a heat pump is introduced into a dwelling heated by baseboard.

* Enter the number of new technologies (solar arrays, solar domestic hot water, thermal or electrical storage and their average capacities, etc..) in Cells K63 to Q73.

* Enter the targets energy conservation measures (ECMs) in Cells S63 to W73. Note that these are target reductions. Consultation with a local energy adviser will be needed to define what actual conponents of a deep energy retrofit or other measures are required to achieve those targets for any given archetype.

Once those choices are made, just like selecting items from a menu, the first "future scenario" run can be executed. In the "User Input Output" Tab, the user selects Scenario "3" ("Step 1"). then clicks the macro " Step 2" to calculate, and "Step 3" to save the result matrix in tje third column of the comparison table. At the bottom, the GHG % reduction from the reference year is shown. Shoudl the result not match the target for that year, the user can go back to the "Scenarios definition" Tab and add more interventions/items in Cells "B63 to W73" and run the scenario again, until the target is achieved.

3) Defining additional future scenarios:

* Any additional scenario would normally be cummulative to the previous ones, that is it includes all of the interventions done previously, and then adds some more to achieve more GHG % reduction. Don't forget to adjust forecasted number of new dwellings to be added.

* To save the user the tedious task of re-entering all of the interventions selected in previous scenarios, a macro button is provided to the right of the entry tables. The blue one copies the data from the previous table, and the orange one re-initializes the table to the setting of the current year (second table).

* The next future scenario runs are executed in the same fashion in the "User Input Output" Tab.

Composite Building Stocks approach

When only a subset of buildings within an archetype is ear-tagged for ECMs (energy conservation measures) the group must be broken up in what becomes 2 archetypes; the original archetype and a second one with different properties as per the ECMs. Since the capacity of the software is 11 archetypes, we can create a second scenario for the additional modified archetype. If an archetype A with 10 buildings assigned to it will have only 3 of its buildings retrofitted, that scenario would included in "part 1" the 7 buildings of archetype A with no retrofit, and the other 10 archetypes counts remain the same. A "Part two scenario" would contain the 12th archetype - which is archetype A + retrofit identified - with a count of 3, All other counts are 0. The sum of the results matrices is for both parts, and can be copied into the next column of the comparison table ("Step 5" on the "User Input Output" Tab). See additional instructions at Cell G102 of the same tab.

7.1 One page Summary of instructions

Before starting using CTAP the stakeholder must decide on a reference year and interim targets to 2050 NetZero. Alternatively, the analysis can proceed with preliminary vision in that regard and adjust the reference year, targets and scenarios later.

<u>On “Financial” Tab:</u>

Enter energy costs (power, gas, oil, wood, propane) as applicable.

Confirm global parameters (Transmission losses, heating system efficiencies, etc.) (default values provided).

Confirm or adjust unit costs for interventions as per task force input (default values provided)

<u>On “Scenarios Definition” Tab:</u>

Select city and reference year,

Validates and modifies building counts and existing attributes (default provided) if applicable and practical, as per notes on input screen, for both reference and current year scenarios definition.

<u>On “User Input Output” Tab</u>:

Run reference year simulation and save results to 1rst column of “Scenario Summary” table.

Run current year simulation and save results to 2nd column of “Scenario Summary” table.

-Save your work! – ***

<u>On “Scenarios Definition” Tab</u>: (following task force consultations)

Starting in Table 3, define first future scenario to achieve first milestone target.

Use button to copy data from previous scenario to add interventions cumulatively.

Don’t forget to adjust building count upwards for future years.

Run simulation and analyse results.

Edit type and number of interventions upwards if target not reached.

Repeat steps 10 and 11 until target achieved for this milestone and save results to “Scenario Comparison” table.

Save your work! -

Repeat steps 9 to 12 for each future milestone/target using table 4, table 5, etc., on “Scenarios Definition” Tab.

Note: If ECMs are to apply to a subset of buildings included in a given archetype, see “composite scenario” approach in Section 6.2.3.6 (optional). See “composite scenario approach”. Also see instructions in Cell G102 of the “User Input Output” Tab in CTAP.

8. The Building Sector GHG Planning Process Using CTAP

Initiating a GHG reduction program development project for a municipality is a complex task. CTAP only addresses the most common type of residential buildings. This represents on average only 13% of Canada GHG emissions, and yet, it is a complex task, and requires new knowledge transfer to the front-line actors, and the municipalities play a key role in this initiative.

CTAP was created to facilitate the development and analysis of scenarios with the key metric of GHG reduction in focus. However, several resources and assistance sources are available to help along this process. The CTAP development team have developed a suggested process for knowledge transfer, provides ideas and points to external resources that can be drawn upon by the municipality's task forces. The following 5 step process is suggested:

Table 15: Low carbon Community Energy System (LCCES) Process

A suggested tasks list that covers this process is provided in Appendix D. Some useful links for LCES and ECM technologies are included in Appendix C.

9. References:

[1] "The World Needs to Spend $73 TRILLION to Get Off Carbon-Based Power. Only One Industry is Ready to Deliver", M/T Market Tactic, Editorial Feature, Mar 17, 2023, Industry

https://markettactic.com/world-needs-to-spend-73-trillion-to-get-off-carbon-based-power/5543312/?utm_source=Yahoo&utm_medium=CPC&utm_campaign=TI

[2] Standard climate data files from Canadian Weather Year for Energy Calculation (CWEC) files. CEWC files are open-source and published by Natural Resources Canada

https://open.canada.ca/data/en/dataset/55438acb-aa67-407a-9fdb-1cb21eb24e28)

[3] "Reaching Milestone 2: How to set emissions reduction targets", ©2016 Federation of Canadian Municipalities.

[4] "10 Big Findings from the 2023 IPCC Report on Climate Change", Sophie Boehm and Clara Shumer, World Resources Institute, March 20, 2023

www.wri.org/insights/2023-ipcc-ar6-synthesis-report-climate-change-findings#:~:text=The%20IPCC%20finds%20that%20there,sooner%20—%20between%202018%20and%202037.

[5] UN Chief: Rich Nations Must Achieve Net Zero Carbon Quicker, By 2040, Agence France Presse, March 20, 2023

www.barrons.com/news/un-chief-rich-nations-must-achieve-net-zero-carbon-quicker-by-2040-f7c1d39

[6] 2030 Emissions Reduction Plan: Clean Air, Strong Economy, Government of Canada, July 12, 2022

2030 Emissions Reduction Plan: Clean Air, Strong Economy - Canada.ca

[7] 2030 Emissions Reduction Plan: Sector by Sector Review, July 12, 2022

www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030/sector-overview.html#sector2

2030 Emissions Reduction Plan – Sector-by-sector overview - Canada.ca

[8] Science-based Climate Targets: A Guide For Cities, FCM and ECLEI, November 2020

Science-Based Targets for Cities - CDP, www.cdp.net/en/cities/science-based-targets-for-cities

[9] Municipal Energy and Emissions Database Municipal Energy and Emissions Database - Home (meed.info)

[10] Population and dwelling counts: Canada, provinces and territories, and census subdivisions (municipalities)1

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810000202&pickMembers%5B0%5D=1.488

[11] National Energy Uses Databases, NRCan, National Energy Use Database | Natural Resources Canada (nrcan.gc.ca)

[12] Government of Canada confirms ambitious new greenhouse gas emissions reduction target, 2021, Environment and Climate Change Canada, Government of Canada confirms ambitious new greenhouse gas emissions reduction target - Canada.ca

[13] NRCan Housing Archetypes for Energy Analysis, NRCan, CANMET Energy, GitHub - canmet-energy/housing-archetypes: Library of Canadian housing archetypes for use in energy modelling

[14] Canada’s greenhouse gas and air pollutant emissions projections, 2023, https://publications.gc.ca/site/fra/9.866115/publication.htm

[15] Fugitive Methane New guidelines determine need to curb natural gas emissions in Ontario, The Atmospheric Fund, Juan Sotes, Carbon and Co-Benefits Analyst., 2021.

[16] US Energy Information Administration: Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA)

Appendix A: CTAP Summary of Features

NRCan's Community Technology Assessment Platform (CTAP)

An Excel based tool to assist municipalities with their building sector GHG reduction program development.

Approach:

Archetype based hourly energy simulation for the building stock (residential Part 9).

Pre-populated, customized for 51 regions in Canada, with default data developed using CEUD (Comprehensive Energy Use Database), NEUD (National Energy Use Database (NEUD), the national census data on building counts and attributes, and the GITHUB inventory of 6800+ archetypes developed by NRCan and the 1.5M + energy audits database.

Designed to be easy to use. Users select the City name and CTAP is pre-populated with archetypes and all data required to perform scenario analysis in seconds.

Offers a series of options for low carbon energy systems (LCES) for space and water heating technology:

Air source and ground source heat pumps

Domestic solar hot water

Hybrid heating systems

Thermal storage

Battery storage

Offers a series of energy conservations measures (ECMs) targets options for:

Space heating and cooling (achieved through retrofit of building envelope)

Plug loads (achieved through appliances upgrades, LED, etc.)

Hot water heating (aerators, drain heat water recovery, appliances upgrade)

Handles, fossil fuels heating systems (oil, gas, propane), biomass (pellet or wood stove), baseboards and the low carbon technologies mentioned above.

Allows taking into consideration community based renewable energy project analysis (e.g., solar farm)

Operational parameters:

Public grid's average emission factor (AEF) history and most recent forecast for the 2000 to 2050 period for all provinces and territories – already included –.

Unit costs for building level interventions (ECMs and LCESs) - defaults provided -.

Fugitive natural gas (Scope 1) parameters and transmission losses of energy supply to jurisdiction) – default provided -

Fossil fuel furnaces efficiency – default provided -

Time of use (TOU) for electricity – locally defined -

Energy costs (fossil fuels, biomass, power) and emission factors – default provided -

Output: Chose any baseline (reference year), any interim time milestone, trial any scenario defined as a set of building level interventions, and obtain a set of standard metrics, including:

Reduction of GHG as % from baseline year, including impact of AEF improvements

Rough implementation cost for entire building stock program

Hourly profile, including peak, consumption, and energy cost (constant dollar) for energy by category: biomass, electricity, and fossil fuel, for the entire building stock. Interface with local power Co. effectively.

In seconds, update your plan as assumptions get refined (e.g., unit costs) and context changes (building stock growth, AEF forecast refinement, energy costs, TOU). Monitor plan against progress just as easily.

An easy-to-use tool providing defendable GHG reduction analysis for a given program / scenario cost.

Appendix B: Technologies slides

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?

Natural Resources Canada | Ressources naturelles Canada

Canada

UNCLASSIFIED - NON CLASSIFIÉ

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.

Natural Resources Canada | Ressources naturelles Canada

Canada

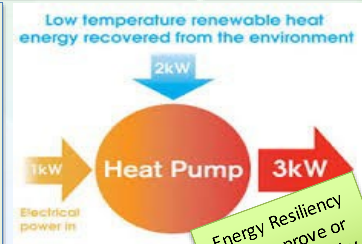
UNCLASSIFIED - NON CLASSIFIÉ

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.



Energy Resiliency may improve or degrade, case by case

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

Natural Resources Canada Ressources naturelles Canada

Canada

UNCLASSIFIED - NON CLASSIFIÉ

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).

Greatly Improved Energy Resiliency

Costs and Concerns:
Slightly higher cost than fossil fuels;
Some contr... ersy on GHG impl...
...sions controls.

Biomass must be sustainably harvested

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Canada

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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.

UNCLASSIFIED - NON CLASSIFIÉ

Low Carbon Technologies: Hybrid Heating Systems

Overview:
Use gas when it’s coldest outside
Use the heat pump when it’s more moderate outside
Allows homeowners to switch between fuels depending on when one system is more cost-effective to operate

Typical Install:
Install heat pump outdoor unit (or replace existing A/C condenser) of appropriate capacity;
Install heat pump indoor coil (or replaced A/C evaporator) or capacity matching outdoor unit;
Replaced existing t-stat with new t-stat (that has smart switching control capability

Opportunities / Benefits:
Can easily be retrofitted in existin HVAC system;
Possible to implement without increasing service entrance capacity;
Takes advantage of time of day rates is applicable at location

Costs and Concerns:
Still significant GHG emissions;
Cost recovery is long term only;
Additional maintenance;
Not functional in very low temperature

Low Carbon Technologies: Energy Conservation 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.

Building Sciences 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

Appendix C: Useful links

AFUE for gas furnace:

AFUE Rating For Furnaces: How To Calculate AFUE Savings? (80 vs 94 AFUE Example) (learnmetrics.com)

Ground source heat pumps cost:

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjvus3i8o3-AhUQk4kEHfVjBjsQFnoECAsQAQ&url=https%3A%2F%2Fclimatebiz.com%2Fcost-of-a-ground-source-heat-pump%2F&usg=AOvVaw0eegTNor9dWQ247a_dEp_c

Air source heat pumps info:

Heat Pumps - Walker Climate Care

What Is The Cost Of A Ground Source Heat Pump? (climatebiz.com)

Useful links regarding biomass:

- Biomass / Rural community programs/ small scale district biomass

https://www.nrcan.gc.ca/reducingdiesel

- See attached pdf on small scale biomass energy system. From the UK, but still very informative

- Here are NRCan publication: https://publications.gc.ca/site/fra/9.647721/publication.html https://d1ied5g1xfgpx8.cloudfront.net/pdfs/9511.pdf

Small scale biomass district heating system: https://www.sciencedirect.com/science/article/abs/pii/S0306261915013422

A Real Estate valuation study was performed a few years back in Edmonton aiming at determining the added valuation to a property following energy savings measures investment. It would be interesting to discuss the findings and any gaps with local RE professionals. A copy of the study can be found at this link:

https://homes.changeforclimate.ca/wp-content/uploads/2019/08/City-of-Edmonton-Hedonic-Price-Analysis-Energy-Efficiency-Final.pdf?5f4561&5f4561

Additional helpful links:

- NRCan DER guides and others:

Energy efficiency for homes (nrcan.gc.ca)

- NRCan research on exterior wall panels for insulation value upgrade:

https://www.nrcan.gc.ca/energy-efficiency/data-research-insights-energy-efficiency/housing-innovation/peer-prefabricated-exterior-energy-retrofit/19406

- Looking ahead of the curve… for our next LCCES CTAP process workshop in the fall: link to financial incentives:

https://oee.nrcan.gc.ca/residential/programs/programs.cfm?attr=24

https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm

https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-grant/start-your-energy-efficient-retrofits/plan-document-and-complete-your-home-retrofits/eligible-grants-for-my-home-retrofit/23504

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https://oee.nrcan.gc.ca/residential/programs/programs.cfm?attr=24

https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm

https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-grant/start-your-energy-efficient-retrofits/plan-document-and-complete-your-home-retrofits/eligible-grants-for-my-home-retrofit/23504

More guides

All via this link: https://www.nrcan.gc.ca/energy-efficiency/homes/local-energy-efficiency-partnerships-leep/leep-technology-guides/17346

CER – Provincial and Territorial Energy Profiles – Alberta (cer-rec.gc.ca)

https://www.canada.ca/en/environment-climate-change/news/2021/07/government-of-canada-confirms-ambitious-new-greenhouse-gas-emissions-reduction-target.html

https://data.ec.gc.ca/data/substances/monitor/canada-s-greenhouse-gas-emissions-projections/Current-Projections-Actuelles/Energy-Energie/Grid-O%26G-Intensities-Intensites-Reseau-Delectricite-P%26G/Electricity-grid-intensities-intensites-reseau-delectricite-1.csv

Appendix D: Suggested Process for Developing a Plan for GHG Reduction Targets

The steps required for a small or medium size community will include:

1) Establishing a team within the town's administration staff that will be responsible for this initiative.

2) Research and decisions on selecting reference year, and establishing interim temporal milestones and targets to Net Zero by 2050

3) Identifying local technical resources to become part of a multi-discipline task force. Such resources should include the following disciplines:

- Constructor and renovators
- Certified energy consultant
- Solar consultant
- Mechanical and electrical contractors
- Real estate professionals
- Possibly, local material suppliers
- Utility company representatives
- Representative from community housing organization
- Representative from the local landlord association (residential rental)
- Business – board of trade – association representative(s)
- Someone from the town's building permit / construction department
- Representatives from the public, homeowners' association, community leaders.

4) Get familiar with the various technology solutions available for:

- Energy conservation measures (ECMs)
- Low carbon energy systems technologies (LCESs)

5) Through consultations with the technical task force, become familiar with their attributes such as cost, how applicable these are to local climatic and economic conditions, how feasible and practical these would be in the local setting.

6) Through consultations with the technical task force, select the most promising technologies.

7) Using CTAP, analyse and test various scenarios to define the quantities and speed of implementation of the various interventions to meet specific GHG reduction targets milestones in time. A scenario is defined by a set of ECMs and LCESs per archetype.

Note: CTAP results are very approximate based on an archetype approach, and the analysis is valid for a set including many buildings, but not for any individual building. For a cost / benefit analysis on a building-by-building basis, the services of a certified energy advisor will be required.

CTAP will provide the following two important assessments:

A) A realization of the quantity of interventions required – the magnitude of the challenge – and the rate, timeline of implementation needed.

B) A rough idea of the magnitude of investment required.

C) CTAP will become a “living” document that can be easily adjusted as more reliable data comes in and as context changes.

D) CTAP can be used to track progress vs plan.

With the scenario that will meet the given GHG reduction target for the milestone selected (as an example: 10% reduction between January 1, 2023, and December 31, 2024 – or 5% per year compatible with a 40% to 45% reduction by 2030), the focus can now shift to developing strategies to:

- Involve the public and raise awareness.
- Social media
- Town hall meetings, public consultations
- Seminars, presentation by local technical resources
- Testimonial of early adopters
- …

8) At the same time, research and apply for available funding or incentive programs.

- Federal
- FCM / GMF
- Others

9) Encourage, incentivize, and research funding alternatives to enable the series of interventions (ECMs and LCESs) within the community's building stock.

- Federal incentives program: grants, loans for individual homeowners and business
- Federal grants for municipalities to fund local programs such as low or no interest loans,
- P.A.C.E. type initiatives
- Third party private capital funded programs.
- Some other initiatives: equipment manufacturers rebates, utilities' incentives, etc.

10) Develop and present a full scope value proposition for your constituents:

- Lower energy costs
- Take advantage of building components replacement at end of service life
- Comfort

- Improved real estate value: lower operations costs, improved appearance, etc.
- Reduced maintenance costs.
- Energy resiliency
- Bragging rights – recognition of early adopters –
- Grants and subsidies
- Etc.

11) Identify specific projects that will approximately match the scenario's quantities and qualities.

12) Create a project implementation schedule.

Appendix E: License agreement (French)

LE PRÉSENT CONTRAT DE LICENCE D'UTILISATEUR FINAL (CLUF) EST UN ACCORD JURIDIQUE ENTRE VOUS, L'UTILISATEUR FINAL, EN VOTRE QUALITÉ DE PERSONNE PHYSIQUE ET/OU D'AGENT DE VOTRE ENTREPRISE, INSTITUTION OU AUTRE ENTITÉ (ci-après dénommé le « **Licencié** »), ET SA MAJESTÉ LE ROI DU CHEF DU CANADA, REPRÉSENTÉE PAR LE MINISTRE DES RESSOURCES NATURELLES (ci -après dénommé « **RNCan** »)

ATTENDU QUE **RNCAN** AFFIRME QU'IL A TOUS LES POUVOIRS NÉCESSAIRES POUR OCTROYER UNE LICENCE POUR LA PLATEFORME COMMUNAUTAIRES D'ÉVALUATION DES TECHNOLOGIES (PCET), UN OUTIL BASÉ SUR EXCEL QUI EST UTILISÉ POUR EFFECTUER UNE ANALYSE « ET SI » AFIN DE MESURER L'IMPACT DE LA MISE EN ŒUVRE DE NOUVELLES TECHNOLOGIES ÉNERGÉTIQUES À BASE DE COMBUSTIBLES NON FOSSILES DANS LES COMMUNAUTÉS (ci-après appelé le « Logiciel »)

EN TÉLÉCHARGEANT, INSTALLANT, UTILISANT OU COPIANT LE LOGICIEL LE **LICENCIÉ** CONVIENT PAR LES PRÉSENTES D'ADHÉRER AUX CONDITIONS GÉNÉRALES CI-DESSOUS :

EN CONSÉQUENCE, les parties conviennent de ce qui suit :

1 OCTROI DE LA LICENCE

1.1 Aux termes des conditions générales énoncées ci-après, **RNCan** accorde par les présentes, à vous le **Licencié**, une licence non exclusive, libre de redevances d'utilisation du Logiciel.

1.2 Le **Licencié** ne doit pas accorder de sous-licence, vendre, prêter, transférer, distribuer, divulguer, procéder à une ingénierie inverse du Logiciel ou autrement céder tout droit en vertu du présent CLUF à un tiers.

1.3 Sous réserve de l'article 8.2, le **Licencié** ne peut faire plus d'une (1) copie de sauvegarde du Logiciel. La copie de sauvegarde doit être tenue confidentielle et ne doit être utilisée qu'à des fins de sauvegarde.

2 DURÉE

2.1 Le présent CLUF entre en vigueur dès la première utilisation du Logiciel par le **Licencié** ou dès que le **Licencié** en prend possession.

2.2 Le présent CLUF demeure en vigueur jusqu'à ce qu'il soit résilié par a) **RNCan** à la suite d'une violation du présent CLUF par le **Licencié**, ou b) par le **Licencié** à la suite de la destruction par celui-ci de toutes les copies du Logiciel.

2.3 Nonobstant toute autre disposition du présent contrat, les articles 3.1 et 3.2 restent en vigueur après la fin du présent CLUF.

3 OBLIGATIONS DU LICENCIÉ

3.1 Le **Licencié** ne doit faire aucune déclaration ni représentation indiquant que **RNCan** ou le Gouvernement du Canada appuie ou approuve une recommandation, une étude, un rapport, un produit, un service ou une ligne de conduite à la suite de l'utilisation du Logiciel par le **Licencié**.

3.2 Les publications du **Licencié** faisant référence au Logiciel doivent indiquer l'origine du Logiciel en

Page **1** of **3** **LIC-1091** CLUF le 31 octobre 2022 utilisant le texte suivant : « La plateforme communautaire d'évaluation des technologies (PCET) de **RNCan** est la propriété de Sa Majesté le Roi du Chef du Canada, représentée par le ministre des Ressources naturelles © 2022 ». Le **Licencié** doit obtenir l'approbation écrite préalable pour toute autre déclaration concernant **RNCan** qui va au-delà de l'origine du Logiciel.

4 MAINTENANCE ET SOUTIEN

4.1 Les parties comprennent et conviennent que, bien que le **Licencié** puisse signaler à **RNCan** tout bogue ou toute défectuosité technique du Logiciel à l'Autorité pour l'octroi des licences tel qu'énoncé à l'article 11 - Avis, **RNCan** n'est pas tenu de fournir un soutien technique, des services de maintenance, des services de mise à jour, des avis de vices cachés ni d'assurer la correction de défauts pour le Logiciel.

5 TITRE

5.1 Le **Licencié** convient que le Logiciel est, et demeurera en tout temps, la propriété de **RNCan**. Le **Licencié** n'a aucun droit, titre ni intérêt à son égard et s'y afférant, sauf dans la mesure expressément prévue dans le présent CLUF.

5.2 Le **Licencié** reconnaît que le Logiciel est protégé par la *Loi sur le droit d'auteur*.

6 GARANTIE ET INDEMNISATION

6.1 Une licence est octroyée pour le Logiciel « tel quel ». **RNCan** ne fait à l'égard du Logiciel aucune représentation ou garantie, expresse ou tacite, découlant de la loi ou d'autres sources, y compris, mais sans toutefois s'y limiter son efficacité, son intégralité, son exactitude ou son utilité à des fins particulières.

6.2 **RNCan** ne peut être tenu responsable en cas de réclamations, de revendications ou d'actions en justice, quelle qu'en soit la nature de la cause, alléguant des pertes, des préjudices ou des dommages, directs ou indirects, pouvant résulter de la possession ou de l 'utilisation du Logiciel par le **Licencié**. **RNCan** ne peut aucunement être tenu responsable de la perte de revenus ou de contrats, ou de toute autre perte conséquente de quelque nature que ce soit, découlant de la possession ou de l 'utilisation du Logiciel par le **Licencié**.

6.3 Le **Licencié** indemnisera et défendra **RNCan**, ses employés, ses contractants, ses mandataires et ses fournisseurs en cas de réclamations, demandes, pertes, dommages, coûts (y compris les frais juridiques et les coûts sur une base d'indemnité substantielle), actions, poursuites ou procédures intentées par un tiers, étant de quelque manière que ce soit fondés sur, attribuables à ou issus de la possession, l'utilisation ou de la performance du Logiciel par le **Licencié**, ses employés ou ses mandataires.

7 RÉSILIATION

7.1 Sous réserve de l'article 8.2, si le **Licencié** manque à une obligation en vertu du présent CLUF et n'y remédie pas dans un délai de trente (30) jours civils, le présent CLUF est réputé avoir été résilié immédiatement sans préavis.

7.2 Nonobstant toute autre disposition du présent contrat, les articles 3.1 et 3.2 restent en vigueur après la fin du présent CLUF.

8 DESTRUCTION

8.1 Avant de céder, de vendre ou d'aliéner autrement un médium (électronique ou autre), le **Licencié** doit effacer ou autrement détruire toute version du Logiciel contenue sur ce médium.

8.2 À la résiliation ou à l'expiration du CLUF, le **Licencié** convient de ce qui suit :

(1) retourner immédiatement à **RNCan** toutes les copies du Logiciel et toute documentation connexe, et effacer complètement ou détruire de toute autre manière la copie de sauvegarde du Logiciel prévue à l'article 1.3 sur le médium du **Licencié**, ou

(2) effacer complètement ou détruire de toute autre manière toutes les copies du Logiciel, y compris, sans toutefois s'y limiter, la copie de sauvegarde prévue à l'article 1.3, ainsi que toute documentation connexe sur le médium du **Licencié**.

9 DROIT APPLICABLE

9.1 Le présent CLUF est interprété conformément aux lois en vigueur dans la province de l'Ontario.

10 CONFLIT D'INTÉRÊTS

10.1 Une modalité précise de ce contrat est que tout fonctionnaire public actuel ou passé qui est assujetti au *Code de valeurs et d'éthique du secteur public* fédéral, à la *Politique sur les conflits d'intérêts et l'après-mandat* fédérale ou le *Code de valeurs et d'éthique de* ***RNCan*** doit respecter les *Codes* ou la *Politique* qui s'appliquent.

11 AVIS

11.1 Les avis, les demandes de renseignements et les autres communications mentionnées aux présentes doivent se faire par écrit et sont réputés avoir été dûment donnés une fois que **RNCan** en a confirmé réception :

1. Autorité pour l'octroi des licences
Ressources naturelles Canada
Division de la propriété intellectuelle
Courriel : ipd-dpi@nrcan-rncan.gc.ca

2. Autorité technique
Charles Mougeot
Ressources naturelles Canada, CanmetÉNERGIE – Ottawa
Courriel : charles.mougeot@NRCan-RNCan.gc.ca

Page **3** of **3** **LIC-1091** CLUF le 31 octobre 2022

Appendix F: Licensee Agreement (English)

THIS END-USER LICENCE AGREEMENT (EULA) IS A LEGAL AGREEMENT BETWEEN YOU, THE END-USER, IN YOUR CAPACITY AS AN INDIVIDUAL AND/OR AS AN AGENT FOR YOUR COMPANY, INSTITUTION OR OTHER ENTITY (hereinafter referred to as the "**Licensee**"), AND HIS MAJESTY THE KING IN RIGHT OF CANADA, AS REPRESENTED BY THE MINISTER OF NATURAL RESOURCES (hereinafter referred to as "**NRCan**")

WHEREAS **NRCAN** HAS THE RIGHT TO GRANT A LICENSE FOR THE COMMUNITY TECHNOLOGY ASSESSMENT PLATFORM (CTAP), AN EXCEL BASED TOOL THAT'S USED TO PERFORM "WHAT IF" ANALYSIS TO MEASURE IMPACT OF IMPLEMENTING NEW NON-FOSSIL FUEL BASED ENERGY TECHNOLOGIES IN COMMUNITIES (hereinafter referred to as the "Software")

BY DOWNLOADING, INSTALLING, USING OR COPYING THE SOFTWARE THE **LICENSEE** AGREES TO BE BOUND BY THE TERMS AND CONDITIONS BELOW:

NOW THEREFORE, the Parties agree as follows:

1.0 GRANT OF LICENSE

1.1 Upon the following terms and conditions **NRCan** hereby grants to you, the **Licensee**, a non-exclusive, royalty free license to use the Software.

1.2 The **Licensee** shall not sublicense, sell, loan, transfer, distribute, disclose, reverse-engineer the Software or otherwise assign any rights under this EULA to any third party.

1.3 Subject to Article 8.2, the **Licensee** shall not make more than one (1) backup copy of the Software. The backup copy shall be held confidential and shall be used only for the purpose of backup.

2.0 TERM

2.1 This EULA shall come into force upon the first instance that the Software is used by the **Licensee** or comes into the possession of the **Licensee**.

2.2 This EULA shall remain in force until terminated by a) **NRCan** as a result of the **Licensee**'s breach of this EULA, or b) the **Licensee** destroys all copies of the Software.

2.3 Notwithstanding any other provisions in this agreement, Articles 3.1 and 3.2 shall survive termination of this EULA

3.0 OBLIGATIONS OF THE LICENSEE

3.1 The **Licensee** shall not make any statement or representation indicating that **NRCan** or the Government of Canada endorses or approves any recommendation, study, report, product, service or course of action as a result of the **Licensee**'s use of the Software.

3.2 The **Licensee**'s publications referring to the Software must state the origin of the Software using the following text: "NRCan's Community Technology Assessment Platform (CTAP) is owned by His Majesty the King in Right of Canada, as represented by the Minister Natural Resources © 2022". The **Licensee** shall seek prior written approval for any other statements concerning **NRCan** beyond the origin of the Software.

4.0 MAINTENANCE AND SUPPORT

4.1 The parties understand and agree that while the **Licensee** may report any bugs or technical malfunctions in the Software to **NRCan**'s Technical Authority as set out in Article 11 - Notices, **NRCan** is under no obligation to provide technical support, maintenance services, update services, notices of latent defects, or correction of defects for the Software.

5.0 TITLE

5.1 The **Licensee** agrees that the Software is and shall at all times remain the property of **NRCan**. The **Licensee** shall have no right, title and interest therein or thereto, except as expressly set forth in this EULA.

5.2 The **Licensee** acknowledges that the Software is protected under the *Copyright Act*

6.0 WARRANTY AND INDEMNITY

6.1 The Software is licensed on an "AS IS" basis. **NRCan** makes no guarantees, representations, or warranties respecting the Software, either express or implied, arising by law or otherwise, including but not limited to effectiveness, completeness, accuracy, or fitness for a particular purpose.

6.2 **NRCan** shall not be liable in respect of any claim, demand or action, irrespective of the nature of the cause of the claim, demand or action alleging any loss, injury or damages, direct or indirect, which may result from the **Licensee**'s use or possession of the Software. **NRCan** shall not be liable in any way for loss of revenue or contracts, or any other consequential loss of any kind resulting from the **Licensee**'s use or possession of the Software.

6.3 The **Licensee** shall indemnify and defend **NRCan**, its employees, contractors, agents and suppliers, from and against all claims, demands, losses, damages, costs (including legal fees and costs on a substantial indemnity basis), actions, suits or proceedings brought by any third party, that are in any manner based upon, arising out of, or attributable to the use, possession, or performance of the Software by the **Licensee,** or its employees or agents.

7.0 TERMINATION

7.1 Subject to Article 8.2, if the **Licensee** breaches any obligation under this EULA and fails to remedy the breach within thirty (30) calendar days, the present EULA is deemed to be terminated immediately without any notice.

7.2 Notwithstanding any other provisions in this agreement, Articles 3.1 and 3.2 shall survive termination of this EULA.

8.0 DESTRUCTION

8.1 Prior to assigning, selling or otherwise disposing of any media, the **Licensee** shall completely erase or otherwise destroy any Software contained on such media.

8.2 Upon termination of the Agreement, the **Licensee** agrees to either:

(1) Return to **NRCan** immediately all copies of the Software and any related documentation and completely erase or otherwise destroy the backup copy of the Software provided for under Article 1.3 on the **Licensee**'s media, or

(2) Completely erase or otherwise destroy all copies of the Software, including but not limited to the backup copy provided for under Article 1.3, as well as any related documentation on the **Licensee**'s media.

9.0 APPLICABLE LAW

9.1 This EULA shall be interpreted in accordance with the laws in force in the Province of Ontario, Canada.

10.0 CONFLICT OF INTEREST

10.1 It is a term of this Agreement that all current or former public servants to whom the federal *Values and Ethics Code for the Public Sector,* federal *Policy on Conflict of Interest and Post-Employment*, or *NRCan Values and Ethics Code* applies shall comply with the *Codes* or *Policy*, as applicable.

11.0 NOTICES

11.1 All notices and communications required under this Agreement shall be sent in writing, and shall be deemed to have been duly given once confirmation is received after sending to **NRCan:**

1. Licensing Authority
Natural Resources Canada
Intellectual Property Division
Email: ipd-dpi@nrcan-rncan.gc.ca

2. Technical Authority
Charles Mougeot
Natural Resources Canada, CanmetENERGY – Ottawa
Email: charles.mougeot@NRCan-RNCan.gc.ca

Contact:
Charles Mougeot
Senior Project Leader
Director's Office (DO)
Natural Resources Canada, CanmetENERGY
Charles.mougeot@nrcan-rncan.gc.ca

About CanmetENERGY

Natural Resources Canada's CanmetENERGY is the Canadian leader in clean energy research and technology development. Our experts work in the fields of clean energy supply from fossil fuel and renewable sources, energy management and distribution systems, and advanced end-use technologies and processes. Ensuring that Canada is at the leading edge of clean energy technologies, we are improving the quality of life of Canadians by creating a sustainable resource advantage.

Head Office	Devon, Alberta	Ottawa, Ontario	Varennes, Quebec
580 Booth Street	1 Oil Patch Drive	1 Haanel Drive	1615 Lionel-Boulet Boulevard
Ottawa, ON	Devon, AB	Ottawa, ON	Varennes, QC
Canada	Canada	Canada	Canada
K1A 0E4	T9G 1A8	K1A 1M1	J3X 1S6