Arctic Energy Alliance

A Guide for New Energy Efficient Buildings

For use by community governments and businesses that want to build new buildings in the NWT

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and the Arctic Energy Alliance

Contents

1 Introduction

1.1 Who is this guide for?

This document is intended for use by community governments and businesses that want to build new buildings in the Northwest Territories (NWT). It is meant to be a practical hands-on reference guide for people who are going to ask architects, engineers, builders, and building systems contractors to help them construct new residential and commercial buildings such as staff housing, office buildings, arenas, garages, etc. It will help you write your request for proposals document so that it spells out your requirements for energy efficiency in a clear way. It can also be used to select energy efficient systems when replacing old equipment in existing buildings.

1.2 Why ask for an efficient building?

You'll need to ask specifically for an energy efficient building because the current building code doesn't require a very high level of energy efficiency, nor does it fully recognize the significant annual energy loads required of buildings in the Canadian North. There are design techniques and technologies commonly available that can make your building use less energy, which means your building will cost a lot less to operate (for heating fuel, electricity, and water) and will produce far less greenhouse gas emissions. If you clearly state an energy efficiency target, then the designers and builders you work with will help you meet it.

Achieving a high level of energy efficiency will increase your construction budget, but if your building is well designed this will be paid back in savings on your utility bills, and you'll be protected against future increases in the price of fuel.

1.3 What's in this guide?

This guide begins with a discussion of the basic approach required when designing an energy-efficient building. This is followed by some detail on individual systems (building envelope, mechanical, electrical, and controls) to outline how this approach is applied to each of these areas.

The guide then splits in two paths, with Section 2 covering most residential buildings and Section 3 for all other building types (industrial, commercial, institutional, and large residential). Each of these sections has tables that list recommended insulation levels and equipment efficiencies, with the “Good” column representing a modest improvement over basic building code and the “Excellent” column representing an extremely high level of performance. To help illustrate the process of designing an energy efficient building, case studies will be given in this guide. They’ll show the difference between conventional construction and an energy efficient building along with the resulting savings in terms of dollars and greenhouse gas emissions.

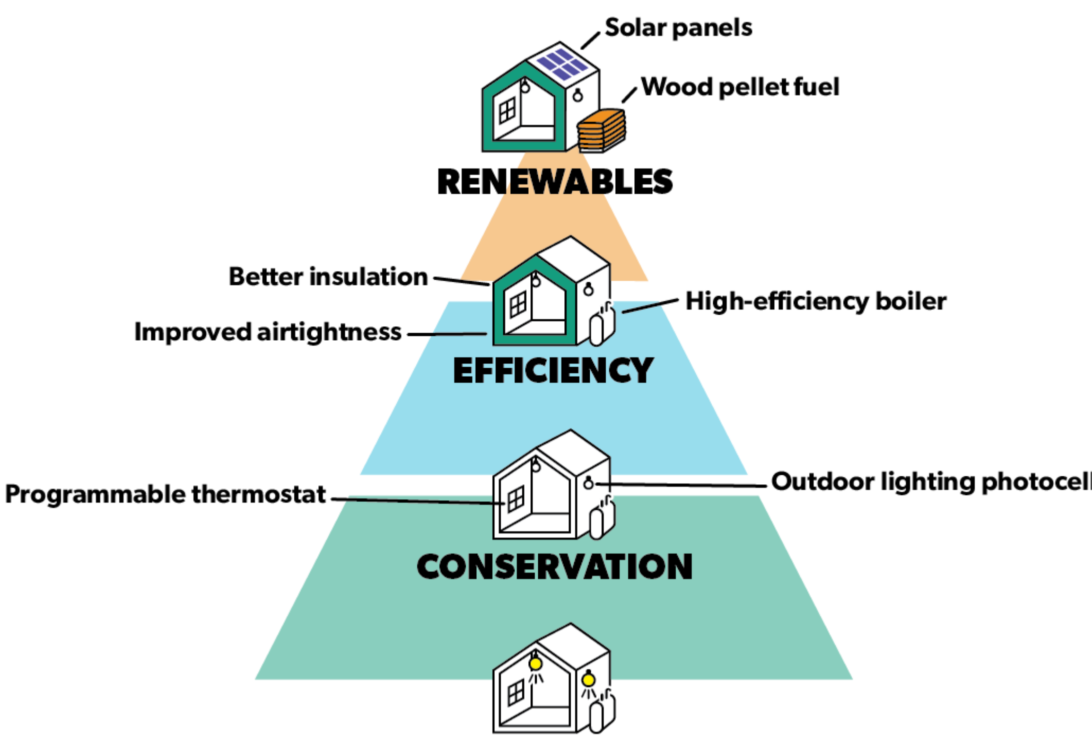
After this, there is some discussion of approaches to successfully completing an energy-efficient building project, including forming the team, contracting, construction review, and commissioning. There is sample text provided that you can include in your RFP (given in the dark blue boxes).

Lastly, some references and further reading are provided to assist the building owner and the rest of the project team.

Note that this guide is not meant to replace or indicate compliance with local building codes. Your architect and other members of the design team will be responsible for ensuring your building complies with all applicable codes and standards.

1.4 The path to an efficient building

When designing a building to be energy efficient, the recommended approach is summarized by the energy pyramid, which has conservation as the first step, followed by efficiency, and lastly renewables.



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Conservation is about reducing the use of building systems. Behavioural changes such as turning off lights and unplugging appliances are a method of energy conservation, but in this guide we'll focus on installed equipment like programmable thermostats, washroom fan timers, and lighting occupancy sensors.

Efficiency is about technology that uses less input energy to perform the same function. Examples include well-insulated walls, high-efficiency boilers, and LED lighting.

Renewables are energy sources that are replenished over a short timescale, such as solar, wind, and biomass. Compare these with non-renewable energy sources like oil that are finite, not replenished, and linked to harmful environmental effects such as climate change.

When you set out on your building project, keep this approach in mind. Focus first on conservation and efficiency, which will reduce the amount of energy used by the building as much as possible. If you reduce the building's energy use to match what can be produced using on-site renewable energy, then you've achieved net-zero energy consumption!

1.5 Approach for each building system

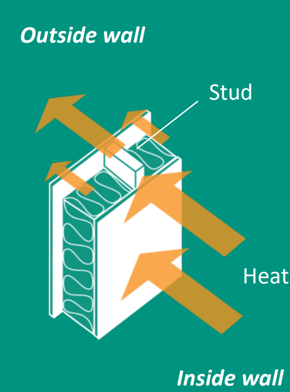
1.5.1 Building envelope

The building envelope is what separates the *inside* from the *outside*. To save energy, you want a building envelope that has a high insulating value and is airtight.

Insulation is measured in terms of thermal resistance, in RSI (metric) or R-value (imperial). Higher numbers represent better insulation. Often, window and door performance is measured in terms of thermal transmittance, in USI (metric) or U-value (imperial). U-value is the inverse of R-value, so lower numbers for thermal transmittance are better.

Be sure you refer to effective R-values or U-values. The effect of studs and other structural materials will reduce an assembly's insulating value below the insulating value that the material alone is rated for (the nominal insulation value). This effect is called thermal bridging, and it can be significant, with wood studs reducing the insulating value by 20% and metal studs reducing it by 50%!

There is a similar effect with windows and doors, where the frame tends to transmit more heat than the glass panes alone.



A blower door. Three-fan systems can be used in larger buildings, while a single-fan system would be used in a home or other smaller building.

Whereas insulation requires adding more material, achieving good airtightness is about paying attention to how material is installed. Architects and contractors experienced with energy efficient buildings will design and build the various connection points (roof to wall, wall to window, etc.) so air can't leak through. Airtightness is usually measured by a large fan that slightly pressurizes or depressurizes the building, called a blower door.

By increasing insulation and airtightness you will get a good building envelope, which is the part of the building that is the hardest to upgrade after it's completed. It will also reduce the size of heating system you need, saving money on its installation.

1.5.2 Heating

The need for heating in the NWT is obvious given our cold climate. Selecting high efficiency equipment minimizes the amount of input fuel needed to heat the building. There are also alternative heating systems that help reduce reliance on fossil fuels:

- Wood stoves use renewable wood fuel, reducing greenhouse gas emissions and supporting our local economy.
- Pellet boilers use wood pellets which are typically made from compacted waste sawdust, and many available pellet boilers can replace a conventional fossil fuel boiler. A back-up system is typically also recommended.
- Heat pumps move heat inside the building, with each unit of input energy providing three or four units of heat (under ideal conditions).

    - Air-source heat pumps require a lot of electricity, so they are not recommended in communities without hydroelectricity. A supplementary form of heating will be required in cold weather.

    - Ground-source heat pumps require drilling or excavating to install piping underground, and the recommended coefficient of performance to make this a cost-effective heating source will depend on your ground temperature and your electricity rates.

- Connect to a district heating system if one is nearby, or consider creating one if the building will be located near a convenient source of waste heat such as a diesel power plant. A district heating system can also be created using pellet boilers.

- Orient the building and the number, size, and type of windows to take advantage of passive solar heating, while not installing so many windows as to seasonally overheat the building or represent a net energy loss.

- If the building will have a large south-facing wall, install a solar air preheating system. These systems use perforated cladding with an air gap behind it to preheat air before it's drawn into the ventilation system.

1.5.3 Ventilation

Ventilation provides fresh air to occupants and removes indoor pollutants and moisture from buildings, which is especially important when designing airtight buildings. To reduce energy use while providing a safe building, you need to build tight and ventilate right.

To provide a safe amount of fresh air while minimizing energy use, specify a heat recovery ventilator (HRV) or energy recovery ventilator (ERV). These devices have a set of fans and a heat exchanger, so most of the heat energy in the air stays inside the building, rather than being lost to the outside. HRVs and ERVs do increase the electrical load of the building but

HRV vs. ERV

An HRV and an ERV are nearly identical, the main difference being the medium used to exchange heat. ERVs use a desiccant or vapour-permeable material in their heat exchangers, so they can move water vapour between the input and output air streams. This water vapour has energy, called latent heat. HRVs use a material that can't transfer humidity, so they can only move thermal energy, or sensible heat.

the alternative of not having enough fresh air in the space can cause health issues for people and mold growth in the building.

In some situations, you can also reduce the amount of fresh air being brought into the building. Usually ventilation rates are set to match minimum values published in design standards for each space use type, but you can also install sensors that measure the amount of carbon dioxide in a space. These sensors can automatically manage the amount of fresh air brought into the building so it is kept as low as possible while maintaining good indoor air quality.

Maintenance on HRVs and ERVs is relatively straightforward but as with all equipment must be conducted regularly for it to work properly.

1.5.4 Air-conditioning

In the NWT, summers are short and temperatures are rarely high, so ideally a building can be kept cool through passive design and no mechanical cooling will be needed. Provide solar shades over windows, select windows with low-emissivity coatings to reflect the sun's heat, and plant trees to shade windows during the summer. Install windows that are operable so occupants can open them to get fresh cool air from outside, and mechanical systems can be designed to use outdoor air for free cooling.

If mechanical cooling is needed because of high occupant or equipment loads, select energy efficient equipment and ensure that its controls are programmed so it won't operate at the same time as the heating system.

1.5.5 Water heating

Water heating can be a significant use of energy in some types of buildings such as homes, restaurants, healthcare facilities, and hotels. The simple fact is heating water requires a lot of energy, so the best strategies involve reducing use by specifying low-flow fixtures and equipment.

Use high efficiency water heaters. Tankless (instantaneous) water heaters tend to be more efficient than tank-style heaters because they aren't constantly keeping a large quantity of water warm.

Consider installing a drain water heat recovery system to use hot water in drain pipes to preheat cold water, or a solar hot water system that can help meet a building's hot water needs, especially through the summer.

Electricity should not be used for water heating in diesel communities. In hydro communities, using electricity will result in lower greenhouse gas emissions but may be more expensive, depending on boiler efficiency.

1.5.6 Electrical equipment

In the NWT, energy efficient electrical equipment doesn't reduce overall building energy use much during the heating season, because the "waste" heat helps heat the building. However, it can prevent overheating of a building during the non-heating season. Electricity is currently far more expensive than heating fuel and in diesel communities has higher greenhouse gas emissions associated with its production, so it's best to reduce electrical energy use as much as possible. For this reason, electricity is not to be used for space heating or water heating in diesel communities.

Consider installing a solar photovoltaic (PV) system to offset some (or all!) of your annual electrical use. Systems can be mounted on flat roofs, sloped roofs, exterior walls or ground-mounting structures. This should only be done after your building has been optimized and is using the least amount of electricity possible, as conservation and efficiency are typically cheaper than solar PV.

1.5.7 Water efficiency

Reducing water use saves energy in your building as well as minimizing energy used outside your building for treatment and delivery.

1.5.8 Controls

Achieving a high level of energy efficiency doesn't necessarily require a complicated building controls system. For residential buildings and smaller commercial buildings, simple programmable thermostats in each heating zone and a boiler controller with adjustable set points are usually sufficient.

For larger commercial buildings, central direct digital controls (DDC) or a building automation system (BAS) may be necessary to achieve the required level of system control. These systems should always be provided with a clearly written sequence of operations that describes operation in the summer mode, winter mode, and any contingency or freeze protection modes.

All controls should be equipped with battery backup so their clocks or settings are not reset after a power outage.

1.6 Spelling out your efficiency requirements

You'll need to communicate your requirements for energy efficiency to architects and contractors, and there are three ways to do this.

1.6.1 Prescriptive

You will specify the minimum insulation values and equipment efficiencies that are acceptable, much as they are listed in the next two sections of this guide. This approach is simple and inexpensive, because no energy modeling is required.

1.6.2 Performance

If you set a performance-based target, and an energy modeller will analyze your building and compare the proposed building to a hypothetical building of the same type and shape that meets the prescriptive requirements, called the reference building. As long as the calculated annual energy use of your proposed building is less than that of the reference building, it is deemed to be as good as meeting the prescriptive requirements. This allows for more flexibility in design because some aspects of the proposed building can be less than allowed in the prescriptive requirements so long as the overall performance requirement is met. To achieve a high level of efficiency, you can adjust your performance target by saying the proposed building's energy consumption must be a certain amount better than that of the reference building.

1.6.3 Certification

The final method of communicating efficiency requirements is to state a certification that must be obtained. There are many third-party certifications available that are recognized by industry. The downside of certification is there is a cost for the certification and administrative work required to apply and obtain certification, but it lays out a clear path for the building to meet a performance target and provides an objective, third-party reviewed means to ensure the target was met.

2 Residential buildings

If your building meets all of the following criteria, then the information in this section applies:

- Three storeys or less
- Building footprint up to 600 m^2 (6,458 ft^2)
- Building uses are limited to residential, which may include single family homes, duplexes, and multi-unit residential

All buildings that meet these criteria will be referred to as "residential buildings" throughout this guide. All other buildings are discussed in the "industrial, commercial and institutional buildings" section (Section 3).

2.1 Building envelope

Residential buildings tend to have a much greater exterior envelope area relative to their floor area than bigger commercial buildings, making a high-performing envelope the key to low energy consumption. The table below gives some recommended insulating and airtightness values.

All insulation values are effective insulation values taking into account the effect of thermal bridging and are in metric units, with imperial units in brackets.

Building Component		Good	Excellent
Roof	All	RSI-10.6 (R-60)	RSI-14.1 (R-80)
Wall	Above grade	RSI-7.0 (R-40)	RSI-10.6 (R-60)
	Below grade	RSI-5.3 (R-30)	RSI-7.0 (R-40)
Floor	Exposed or above unheated crawlspace	RSI-10.6 (R-60)	RSI-14.1 (R-80)
	Under floor slab[A]	RSI-7.0 (R-40)	RSI-10.6 (R-60)
Doors	Opaque entry	USI-0.91	USI-0.91
	Glazed entry	USI-1.00	USI-1.00
	Overhead (garage)	50mm (2”) thick insulation with thermal breaks Overall USI-1.10 or less Air leakage 0.50 L/s·m² (0.10 cfm/ft²) @ 75 Pa or less If glazing to be provided, use double-pane glass with argon fill	75mm (3”) thick insulation with thermal breaks Overall USI-0.95 or less Air leakage 0.50 L/s·m² (0.10 cfm/ft²) @ 75 Pa or less No glazing in door, provide daylight with through-wall windows
Windows	Conventional	Triple-pane, 2x low-e films, argon[B] fill USI-0.85 for fixed USI-1.00 for awning/casement	Quad-pane, 2x low-e films, argon fill USI-0.75 for fixed USI-0.90 for awning/casement
	Skylights	Avoid skylights, clerestory windows are preferable See thermal requirements for conventional windows	
Overall door and window area		15% of wall area or less Majority of windows on south face to increase passive solar gain	12% of wall area or less Majority of windows on south face to increase passive solar gain
Airtightness	Blower door test	1.5 ACH @ 50 Pa	0.6 ACH @ 50 Pa

2.2 Heating

Efficiencies for electric resistance heating appliances are not provided because they are generally near 100%. Use of electric resistance heating is not recommended due to high cost

[A] In areas where permafrost melting is a concern, the design should consider this risk and address it by increasing insulation further or through other means (e.g. thermosiphons, active cooling). A geotechnical engineer may need to be consulted.

[B] Krypton is an acceptable replacement for argon.

and reliance on diesel generation (either as primary power source in diesel communities or as backup power source in hydro communities).

System Type		Good	Excellent
Boiler	Wood pellet	85% overall efficiency ≤0.10 lb/MMBTU particulate limit	88% overall efficiency ≤0.10 lb/MMBTU particulate limit
	Oil	87% AFUE	
	Gas	95% AFUE	96% AFUE
		Hydronic systems must be designed for a low boiler water temperature so that high-efficiency boilers will operate in the condensing mode	
	Controls	Outdoor reset to adjust boiler water temperature based on outdoor air temperature and shut down boiler/pumps during warm weather	
	Pumps	Wet rotor circulator with built-in ECM motor	
Furnace	Wood Pellet	Same requirements as wood pellet boilers	
	Oil	96% AFUE with ECM motor	
	Gas	96% AFUE with ECM motor	98% AFUE with ECM motor
Stove	Cord wood	75% overall efficiency, and ≤2.0 g/h smoke, and EPA or CSA B415.1-M92 certified	80% overall efficiency, and ≤2.0 g/h smoke, and EPA or CSA B415.1-M92 certified
	Pellet	75% overall efficiency, and ≤2.0 g/h smoke, and ULC certified	80% overall efficiency, and ≤2.0 g/h smoke, and ULC certified
Heat pump	Air source	Not recommended in communities that burn fossil fuels to generate electricity. In a hydroelectric community, talk to the AEA for more information. A supplementary heat source will be required in cold weather.	
	Ground/water source	Talk to the AEA. The recommended COP of the system will depend on the ground temperature and your electricity rates.	
Heating controls (also see boiler controls)		Programmable thermostats to reduce heating set point outside normal occupied hours	Smart thermostats to automatically reduce heating set point when building unoccupied.

2.3 Ventilation

System Type	Good	Excellent
Bathroom fan	Do not use conventional exhaust fan; provide ventilation with whole-home HRV or ERV	
Kitchen range hood	Recirculating range hood with ventilation provided by HRV/ERV	
HRV or ERV ventilation unit	75% sensible recovery efficiency with ECM motors	90% sensible recovery efficiency with ECM motors

2.4 Air-conditioning

Air conditioners are rated in terms of their seasonal energy efficiency ratio (SEER), a ratio of the cooling output during a typical cooling season, divided by the total electric energy input during the same period. The higher the unit's SEER rating the more energy efficient it is.

Avoid or minimize the use of air conditioning by using appropriate passive design and shading strategies.

System Type	Good	Excellent
Central air conditioner	SEER 18	SEER 20
Split-unit air conditioner	SEER 20	SEER 25

2.5 Water heating

Electric water heaters are rated by their standby loss (loss of heat from the tank), measured in watts. A lower standby loss indicates a more efficient product.

All other residential water heaters are rated in terms of their Uniform Energy Factor (UEF), a measure of efficiency that replaces the old Energy Factor (EF) ratings. For both EF and UEF, higher numbers are better.

System Type		Good	Excellent
Hot water tank	Oil	UEF 0.68	Use indirect-fired tank fed by space heating boiler
	Gas	UEF 0.90	Use tankless heater
	Electric	Standby loss of 40 W	Use tankless heater
	Air-source heat pump	UEF 3.5	
Tankless			
	Gas	UEF 0.93	UEF 0.96
	Electric	Efficiency near 100% Use caution when specifying tankless electric heaters to ensure electrical panel has sufficient capacity	
Provided by boiler		Refer to heating section for recommended boiler efficiencies	
Drain water heat recovery		45% efficient (where compatible with building design)	60% efficient (where compatible with building design)
Solar hot water heating		Consult a solar hot water heating system manufacturer/designer. For backup to solar heating refer to efficiencies listed above.	

2.6 Electrical equipment

System	Good	Excellent
Interior lighting	All LED	
Interior lighting controls	Automatic controls (timer, occupancy sensor, or daylight sensor) where lights may accidentally be left on (storage rooms, garage) Install dimmers and compatible LED bulbs where appropriate	
Exterior lighting	LED in full cut-off fixtures (ideally dark sky compliant)	
Exterior lighting controls	Photocell and motion sensor	
Dishwashers Refrigerators & freezers Clothes washers Ceiling fans Dehumidifiers Computer monitors Televisions	Refer to ENERGY STAR® Most Efficient Products list for the current year	
Clothes dryers	Heat pump dryers or combo heat pump washer/dryers recommended. Refer to ENERGY STAR Most Efficient Products list for the current year	
Vehicle plug	Controlled by timer, temperature control, and/or occupant control (e.g indoor switch, "smart" plug)	

2.7 Water efficiency

System	Good	Excellent
Kitchen faucet	5.6 L/min (1.5 gpm)	5.6 L/min (1.5 gpm)
Washroom faucet	5.6 L/min (1.5 gpm)	3.8 L/min (1.0 gpm)
Toilets	4.9 L/flush (1.3 gallon/flush)	3.8 L/flush (1.0 gallon/flush) or waterless composting[C]
Showers	5.7 L/min (1.5 gpm)	4.9 L/min (1.3 gpm)
Dishwashers Clothes washers	Refer to ENERGY STAR Most Efficient Products list for the current year	

2.8 Building codes and certifications

Small residential buildings covered in this section will fall under Part 9 of the *National Building Code of Canada 2020*. The building code has energy efficiency requirements specified in Part 9.36 of the code, but these have not been adopted throughout the territory.

However, the City of Yellowknife has a building by-law (By-law No. 5058) that requires new residential buildings to meet prescriptive requirements somewhat better than those specified in Part 9.36, or the building has a thermal energy consumption 25% lower than a Part 9.36 building and total energy use of no greater that 105 kWh/m^2 of heated floor area, as proven by energy modeling.

The most common system for measuring the performance of residential buildings is the Natural Resources Canada (NRCan) EnerGuide Rating System (ERS). This rating system uses standardized calculation methods to determine an expected annual energy consumption score for each building expressed in GJ/year, with lower numbers being better and a score of 0 representing a net-zero building. ERS only applies to buildings that are at least 50% residential; if your building doesn't meet this criterion then refer to the standards for industrial, commercial, and institutional buildings in Section 3.

The Passive House standard, originally developed in Germany, has been adapted to be more appropriate to cold climates by Passive House Institute US (PHIUS). The PHIUS+ standard is dedicated to achieving very high-performance buildings by focusing on the building envelope. PHIUS also certifies high-performance building components (windows, doors,

[C] Composting toilets require small constantly running exhaust fans. These fans use electricity and remove air from the building, which can increase energy use. The effect of this should be considered by the designer when selecting which types of toilets to use.

HRVs) as meeting their requirements. Achieving Passive House certification is quite difficult in the North.

2.9 Recommended performance target

If you are building in Yellowknife, then you will need to have an ERS assessment of the building completed to meet the City by-law. If you are outside of Yellowknife, we still recommend completing an ERS evaluation on all new homes.

For all homes in the territory, we recommend meeting, at a minimum, a thermal energy consumption target of 25% below Part 9.36 requirements, total energy use of no greater 105 kWh/m^2 of heated floor area, or the prescriptive requirements stated in the "Good" column of this document.

If you want to obtain a very high level of energy efficiency, we recommend meeting the prescriptive requirements in the "Excellent" column of this document, a performance target of 50% below Part 9.36 requirements, or obtaining Passive House certification.

Example of a performance target statement for your RFP:

Final payment is contingent on the building being supplied with an ERS label and a report showing thermal energy consumption of 25% below Part 9.36 requirements, and a total energy use of no greater than 105 kWh/m^2 of heated floor area.

2.10 Residential building example

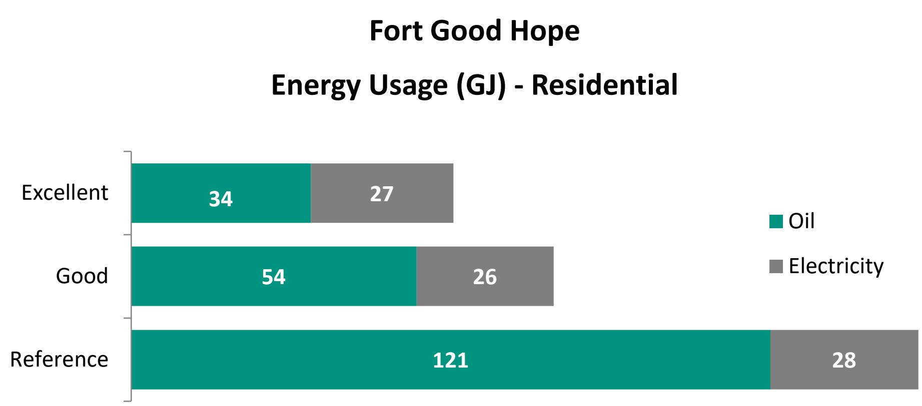
To help illustrate the benefits of energy efficient design, we'll look at an example of a typical new home in the Northwest Territories (built to minimum National Building Code of Canada energy requirements—the "reference house"), and compare its annual energy consumption, costs and greenhouse gas emissions to the insulation values and efficiencies listed in the "Good" column, and those in the "Excellent" column of the tables above.

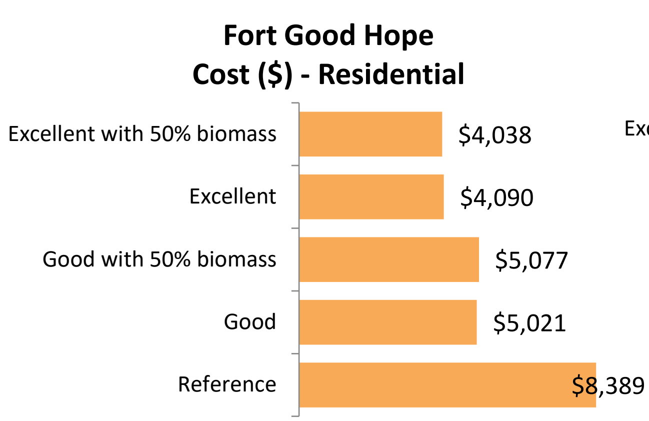
The homes were modelled in HOT2000 and are based on the 1,200 ft^2 "access house," a typical NWT Housing Corporation design that has been used throughout the territory. The house is on a basement foundation (Yellowknife, Fort Smith) or on piles (Fort Good Hope, Paulatuk).

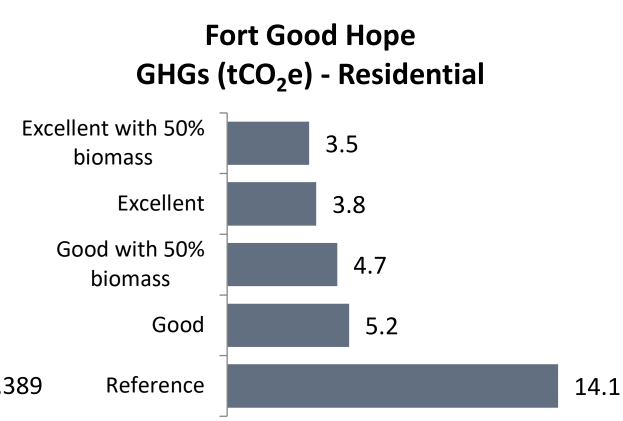
We have also demonstrated the savings possible by combining both energy efficiency and renewable energy with the use of a wood stove providing 50% of the building's energy load.

Examples of access houses, designed by the NWT Housing Corporation.

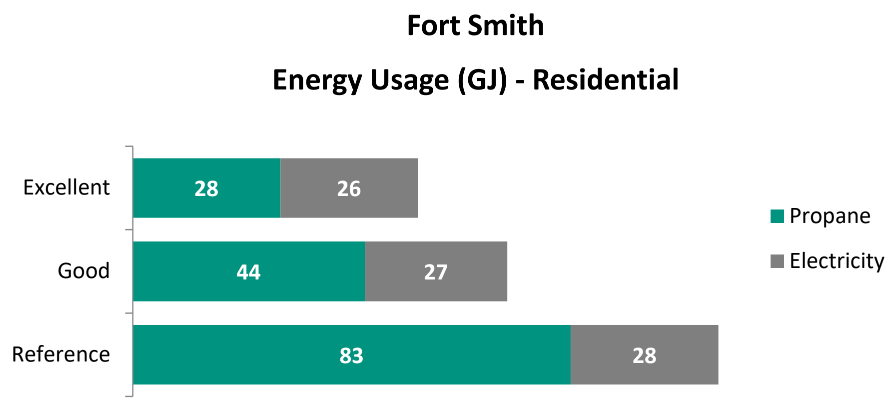
2.10.1 Fort Good Hope

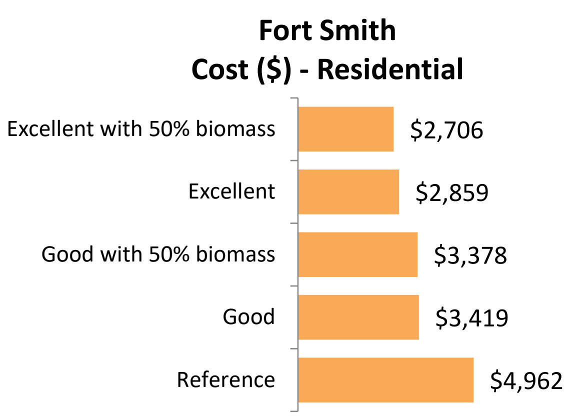


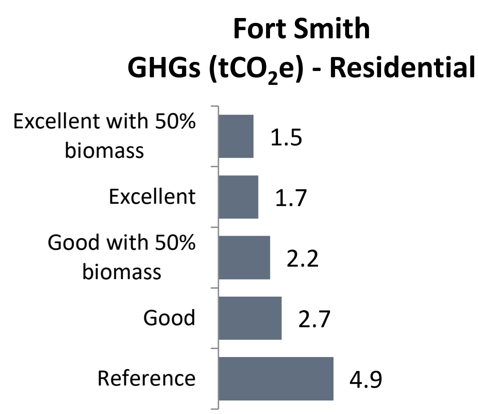




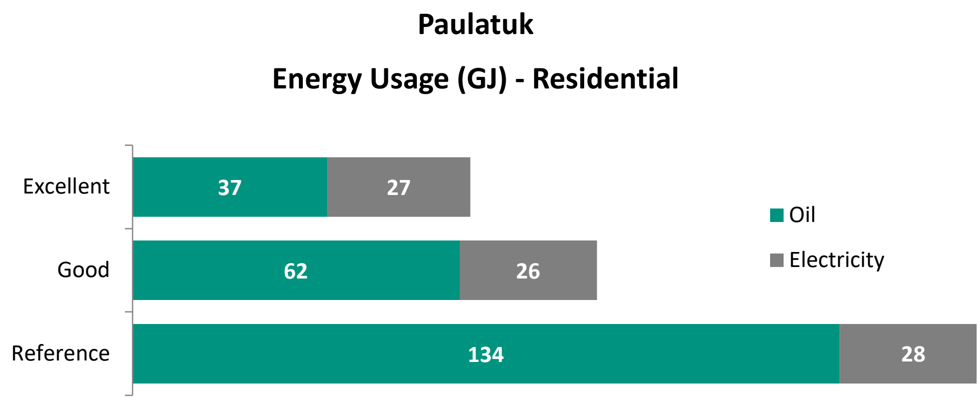
2.10.2 Fort Smith

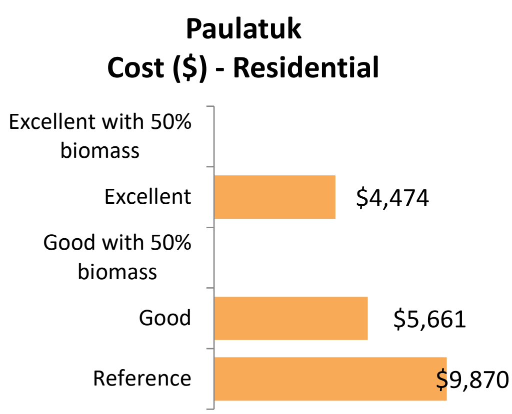


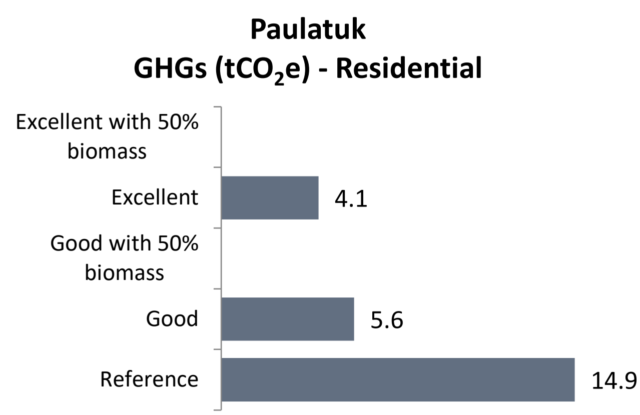




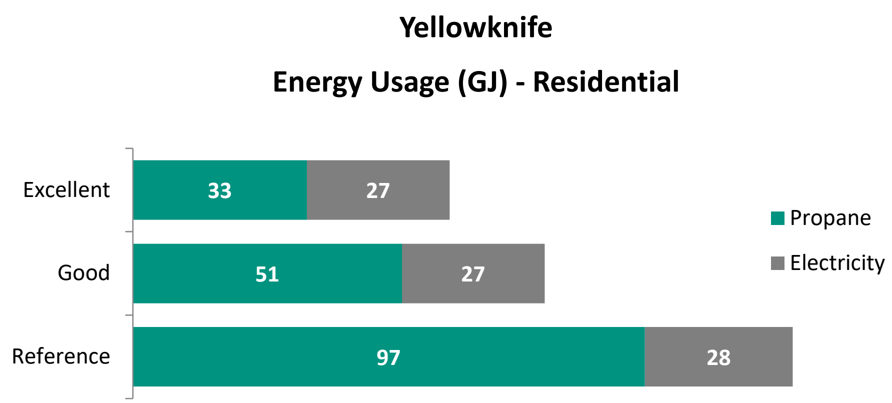
2.10.3 Paulatuk

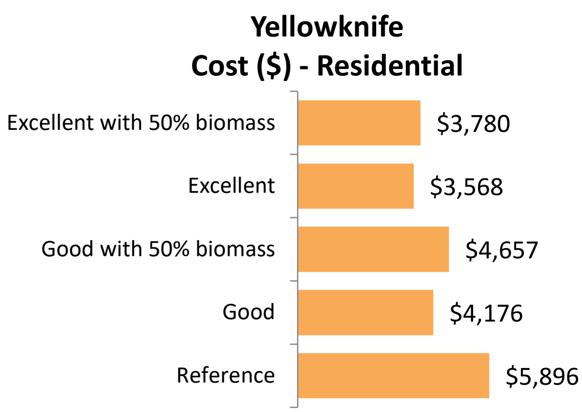


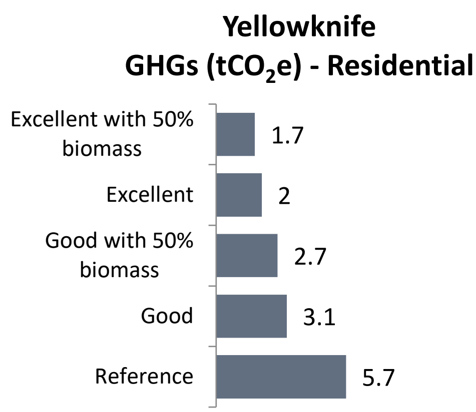




2.10.4 Yellowknife







3 Industrial, commercial and institutional buildings

If your building does not meet the requirements described under the "residential buildings" section, then the information in this section applies. This could include office buildings, garages, fire halls, recreation centers, arenas, and large residential buildings.

You should check with your architect to confirm if you are unsure what type of occupancy your building is classified as. All buildings that meet these criteria will be referred to as "commercial buildings" throughout this guide, and this section applies. All other buildings are discussed in the "residential buildings" section (Section 2).

3.1 Building envelope

All insulation values are effective insulation values unless otherwise stated and are in metric units, with imperial units in brackets.

Building Component		Good	Excellent
Roof	All	RSI-10.6 (R-60)	RSI-14.1 (R-80)
Wall	Above grade	RSI-7.0 (R-40)	RSI-10.6 (R-60)
	Below grade	RSI-6.2 (R-35)	RSI-8.8 (R-50)
Floor	Exposed or above unheated crawlspace	RSI-10.6 (R-60)	RSI-14.1 (R-80)
	Under floor slab[D]	RSI-7.0 (R-40)	RSI-10.6 (R-60)
Doors	Opaque entry	USI- 2.10 or less	USI-1.65 or less
	Storefront or curtain wall w/glazing	Double-pane[E], 1x low-e film, argon fill in thermally broken aluminum curtain wall frame USI-2.80 or less	Double-pane[E], 1x low-e film, argon fill, aluminum/fiberglass hybrid curtain wall frame USI-1.40 or less
		Public entrances should include vestibule to minimize intrusion of cold air in the winter	
	Doors, fully glazed balcony	Triple-pane, 2x low-e film, argon fill in fiberglass frame USI-1.25 or less	

[D] In areas where permafrost melting is a concern, the design should consider this risk and address it by increasing insulation further or through other means (e.g. thermosiphons, active cooling). A geotechnical engineer may need to be consulted.

[E] Double-pane glazing is often preferred to keep the weight of the door low, but use triple-pane glazing for even better energy performance.

	Overhead	50mm (2”) thick insulation with thermal breaks Overall USI-1.10 or less Air leakage 0.50 L/s·m² (0.10 cfm/ft²) @ 75 Pa or less If glazing to be provided, use double-pane glass with argon fill	75mm (3”) thick insulation with thermal breaks Overall USI-0.95 or less Air leakage 0.50 L/s·m² (0.10 cfm/ft²) @ 75 Pa or less No glazing in door, provide daylight with through-wall windows Provide high-velocity down-flow air curtains
Windows	Conventional	Triple-pane, 2x low-e films, argon[F] fill in vinyl or fiberglass frame USI-0.85 for fixed USI-1.00 for awning/casement	Quad-pane, 2x low-e films, argon fill in vinyl or fiberglass frame USI-0.75 for fixed USI-0.90 for awning/casement
	Storefront or curtain wall	Triple-pane, 2x low-e films, argon fill in thermally broken aluminum curtain wall frame USI-1.40 for fixed USI-1.80 for awning/casement	Triple-pane, 2x low-e films, argon fill, aluminum/fiberglass hybrid curtain wall frame USI-0.80 for fixed USI-1.00 for awning/casement
	Opaque spandrel panels	Insulate to same level as rest of wall if possible	
	Skylights	Avoid skylights, clerestory windows are preferable See thermal requirements for conventional windows	
Overall door and window area		20% of wall area or less Majority of windows on south face to increase passive solar gain	15% of wall area or less Majority of windows on south face to increase passive solar gain
Airtightness	Blower door test	1.3 L/s·m² of envelope area @ 75 Pa	0.41 L/s·m² of envelope area @ 75 Pa

Example of how to specify an airtightness target in your RFP:

The building’s air leakage shall not exceed 0.41 L/s per square meter of envelope area when measured by blower door testing at a pressure of 75 Pa in both pressurization and depressurization.

[F] Krypton is an acceptable replacement for argon.

3.2 Heating

Efficiencies for electric resistance heating appliances are not provided because they are generally near 100%. Use of electric resistance heating is not recommended due to high cost and reliance on diesel generation (either as primary power source in diesel communities or as backup power source in hydro communities).

System Type		Good	Excellent
Boiler	Wood pellet	85% overall efficiency ≤0.10 lb/MMBTU particulate limit	88% overall efficiency ≤0.10 lb/MMBTU particulate limit
	Oil	87% AFUE	90% AFUE Hydronic systems must be designed for a low boiler water temperature so that high-efficiency boilers will operate in the condensing mode
	Gas	95% AFUE	96% AFUE
		Hydronic systems must be designed for a low boiler water temperature so that high-efficiency boilers will operate in the condensing mode	
	Pumps	Wet rotor circulator with built-in ECM motor Total combined power of all pumps not to exceed 4.5W per kW of peak boiler plant output	
	Controls	Outdoor reset to adjust boiler water temperature based on outdoor air temperature and shut down boiler/pumps during warm weather	
Furnace	Oil	95% AFUE with ECM motor	95% AFUE with ECM motor
	Gas	96% AFUE with ECM motor	98% AFUE with ECM motor

Unit heater	Oil	Not recommended, use oil boiler and hydronic unit heaters	
	Gas	91% efficient	95% efficient
	Hydronic	Refer to boiler efficiencies	Refer to boiler efficiencies
Infrared tube heater	Gas	Not recommended, use high efficiency unit heaters	
Stove	Cord wood	75% overall efficiency, and ≤2.0 g/h smoke, and EPA or CSA B415.1-M92 certified	80% overall efficiency, and ≤2.0 g/h smoke, and EPA or CSA B415.1-M92 certified
	Pellet	75% overall efficiency, and ≤2.0 g/h smoke, and ULC certified	80% overall efficiency, and ≤2.0 g/h smoke, and ULC certified
Heat pump	Air source	Not recommended in communities that burn fossil fuels to generate electricity. In a hydroelectric community, talk to the AEA for more information. A supplementary heat source will be required in cold weather.	
	Ground source	Talk to the AEA. The recommended COP of the system will depend on the ground temperature and your electricity rates.	
Heating controls (also see boiler controls)		For regular use schedules: Programmable thermostats or building automation system to reduce heating setpoint outside normal occupied hours For irregular use schedules: Smart thermostats or building automation system with motion sensors to reduce heating setpoint when not occupied	

3.3 Ventilation

System Type		Good	Excellent
Air handling unit		70% sensible recovery efficiency on exhaust	85% sensible recovery efficiency on exhaust
		Include all of the following: Dedicated outdoor air system (DOAS) Heat recovery core bypass to allow for economizer cooling ECM or VFD motor on fans Total combined power of supply and return fans not to exceed 1.6 W per L/s of air supplied to the building's spaces.	
Make-up air furnace	Indirect-fired oil	Not recommended, use hydronic heating coil supplied by boiler	
	Indirect-fired gas	91% efficient Should only be used for occasionally operating ventilation systems where heat recovery isn't appropriate such as vehicle garages or kitchen make-up air; for constantly operating systems use an ERV with heat provided by a hydronic heating coil	
	Hydronic heating coil	Refer to boiler efficiency table	Refer to boiler efficiency table
Packaged rooftop units (RTUs)		Avoid use of RTUs, use boiler/furnace for heating and HRV/ERV for ventilation	
Commercial kitchen range hood		Variable speed controlled by fume/heat sensors on hood	
Vehicle storage and vehicle maintenance buildings exhaust		DOAS air handler for low-rate ventilation Separate exhaust fan controlled by exhaust gas sensor for high-rate ventilation	Variable speed DOAS air handler controlled by exhaust sensor to handle all ventilation requirements
Solar air preheating		Orient building to allow use of solar air preheating and locate mechanical systems adjacent to the potential solar air preheating wall.	
Ventilation controls		Central ventilation system controlled by programmable schedule. Provide manual timer or occupancy sensor to engage system after usual hours.	Central ventilation system controlled by programmable schedule. Provide manual timer or occupancy sensor to engage system after usual hours. For spaces with variable occupancy, install CO_2 sensors or occupancy sensors to allow demand-control ventilation

3.4 Air conditioning

Packaged air conditioning systems are rated in terms of their seasonal energy efficiency ratio (SEER), a ratio of the cooling output during a typical cooling season, divided by the total electric energy input during the same period. The higher the unit's SEER rating the more energy efficient it is.

Avoid or minimize air conditioning by using appropriate passive design and shading.

System Type	Good	Excellent
Central air conditioner	SEER 18	SEER 20
Split-unit air conditioner	SEER 20	SEER 25

For large central cooling systems such as chillers, the mechanical engineer and energy modeler should perform a life-cycle cost analysis of high efficiency equipment compared to conventional equipment.

3.5 Water heating

Smaller commercial buildings may use residential-sized water heaters and thus the efficiencies are the same as in the residential section, specified in terms of uniform energy factor (UEF), energy factor (EF), or standby losses. Commercial buildings with higher hot water loads will have commercial water heaters in which case their efficiencies will be stated in thermal efficiency (TE).

The table below states the efficiencies for residential water heaters first and then for commercial water heaters in brackets (% thermal efficiency). These two ratings are not directly comparable, and usually only one or the other will be listed for a given product.

System Type		Good	Excellent
Hot water tank	Oil	UEF 0.68 (82% TE)	Use indirect-fired tank fed by space heating boiler
	Gas	UEF 0.90 (95% TE)	Use tankless heater
	Electric	Standby loss of 40 W (Near 100% TE)	Use tankless heater
	Air-source heat pump	UEF 3.5	
Tankless	Gas	UEF 0..93 (95% TE)	UEF 0.96 (98% TE)
	Electric	EF 0.99 (Near 100% TE) Caution must be used when specifying tankless electric heaters because they have a very high peak power draw, which can increase electrical demand charges significantly	
Provided by boiler		Refer to heating section for recommended boiler efficiencies When boiler is connected to a storage tank, connecting pipes should be insulated and tank standby loss should be less than 40 W	
Drain water heat recovery		45% efficient (where compatible with building design)	60% efficient (where compatible with building design)
Solar water heating		Consult a solar water heating system manufacturer/designer For backup to solar heating refer to efficiencies listed above	
Water heating pump		Wet-rotor circulator with built-in ECM motor Install timer to turn off pump outside normal occupied hours	

3.6 Electrical equipment

System	Good	Excellent
Interior lighting	All LED	
Exit signs	3 watt LED	0 watt photoluminescent[G]
Interior lighting controls	Occupancy sensors for on/off control	Occupancy sensors for on/off or dim/full control, and daylight-responsive automatic controls
Exterior lighting	LED in full cutoff fixtures (ideally dark sky compliant)	
Exterior lighting controls	Photocell and motion sensor	
Three-phase motors	NEMA Premium Efficiency or ECM/VFD	
Dishwashers Refrigerators & freezers Clothes washers Ceiling fans Dehumidifiers Computer monitors Televisions	Refer to ENERGY STAR Most Efficient Products list for the current year	
Clothes dryers	Heat pump dryers or combo heat pump washer/dryers recommended. Refer to ENERGY STAR Most Efficient Products list for the current year	
Vehicle plug	Controlled by timer, temperature control, and/or occupant control (e.g indoor switch, “smart” plug)	

[G] Photoluminescent exit signs require illumination of their faces at a minimum light level meeting the manufacturer’s requirements, which may reduce some of the power savings associated with their use.

3.7 Water efficiency

System	Good	Excellent
Public washroom faucet	1.9 L/min (0.5 gpm) with proximity sensor	1.3 L/min (0.35 gpm) with proximity sensor
Private washroom faucet	5.6 L/min (1.5 gpm)	3.8 L/min (1.0 gpm)
Toilets	4.9 L/flush (1.3 gallon/flush)	3.8 L/flush (1.0 gallon/flush) or waterless composting[H]
Urinals	0.5 L/flush (0.125 gallon/flush)	Waterless urinal
Showers	5.7 L/min (1.5 gpm)	4.9 L/min (1.3 gpm)
Dishwashers Clothes washers	Refer to ENERGY STAR Most Efficient Products list for the current year	

3.8 Building codes

Some small non-residential buildings (for example offices, garages, retail stores) fall under Part 9 of the *National Building Code of Canada 2020*. The remainder of buildings described in this section (large residential and all other industrial, commercial and institutional, such as large offices, arenas, community halls, etc.) fall under Part 3 of the building code. Your architect can help you determine which part of the code is applicable to your specific building.

The *National Energy Code of Canada for Buildings* (NECB) is the most commonly used energy standard in Canada and has been legally adopted in many of the provinces. NECB has not been adopted in the NWT, but we recommend that all new industrial, commercial, institutional and large residential buildings should meet its requirements or better as noted below.

The City of Yellowknife has adopted NECB 2020 for non-residential buildings, and has additional prescriptive, performance, and airtightness testing requirements for large residential buildings. Refer to By-law 5058.

[H] Composting toilets require small constantly running exhaust fans. These fans use electricity and remove air from the building, which can increase energy use. The effect of this should be considered by the designer when selecting which types of toilets to use.

3.9 Recommended performance target

For all commercial buildings in the territory, we recommend meeting the prescriptive requirements stated in the “Good” column or Energy Performance Tier 2 as stated in Part 10 of NECB 2020.

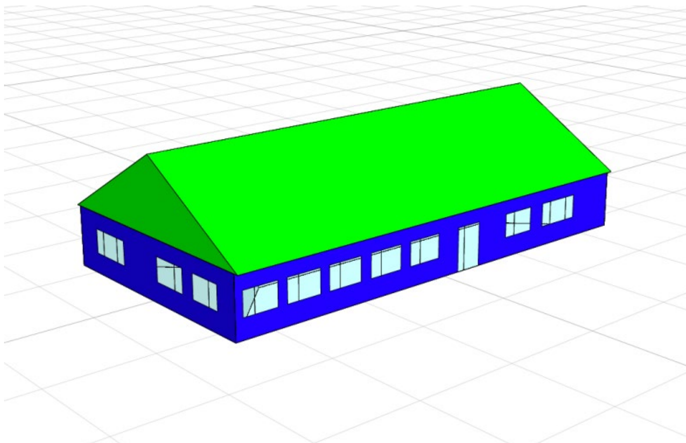
If you want to obtain a very high level of energy efficiency, we recommend meeting the prescriptive requirements in the “Excellent” column, or Energy Performance Tier 3 as stated in Part 10 of NECB 2020.

We highly recommend energy modelling on all commercial buildings. However, on very small buildings, the cost of energy modelling may not be warranted.

Example of a performance target statement for your RFP:

The building shall meet Energy Performance Tier 3 as described in Part 10 of NECB 2020.

3.10 Commercial building example

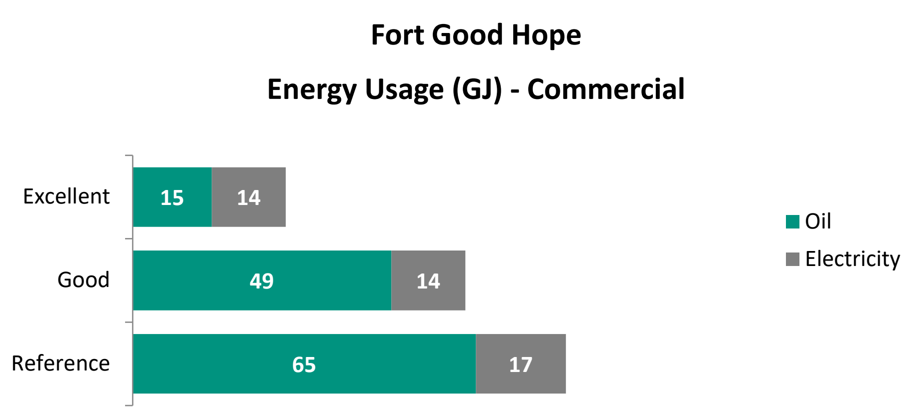


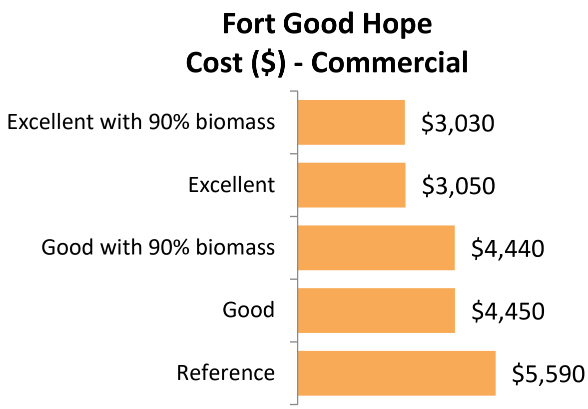
To help illustrate the benefits of energy efficient design, we'll look at an example of a typical one-storey office building in the Northwest Territories (built to the National Energy Code of Canada for Buildings energy requirements—the "reference building") and compare its annual energy consumption, costs and greenhouse gas emissions to the insulation values and efficiencies listed in the "Good" column and those in the "Excellent" column of the tables above.

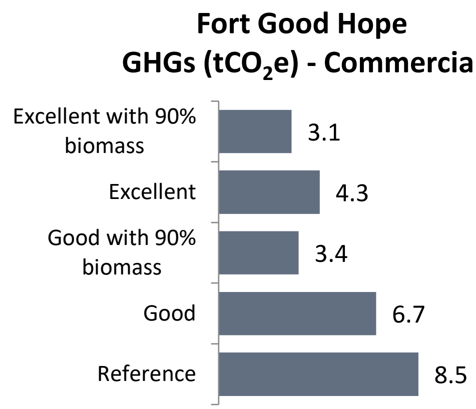
The office buildings were modelled in IES and are based on a 350m^2 typical one-storey office building.

We have also demonstrated the savings possible by combining both energy efficiency and renewable energy with the use of a biomass heating system providing 90% of the building's heating load.

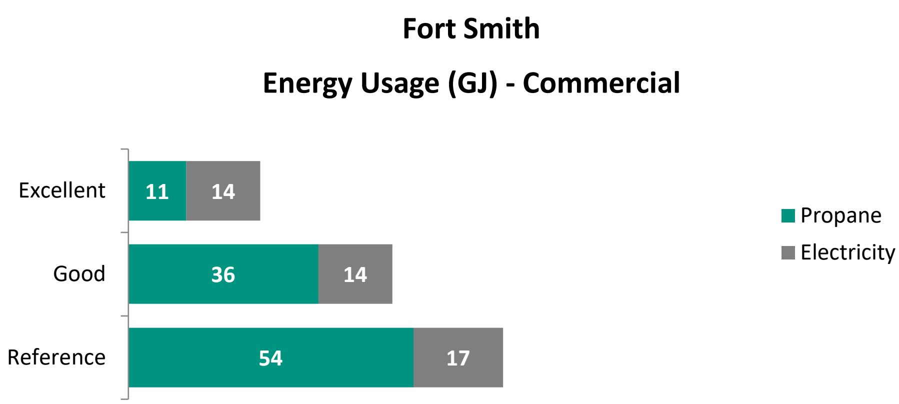
3.10.1 Fort Good Hope

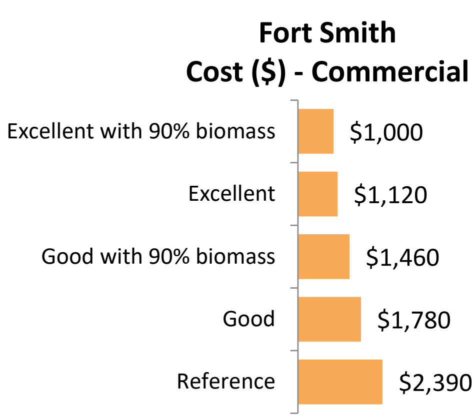


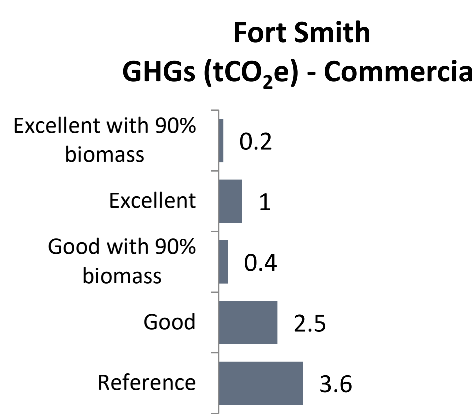




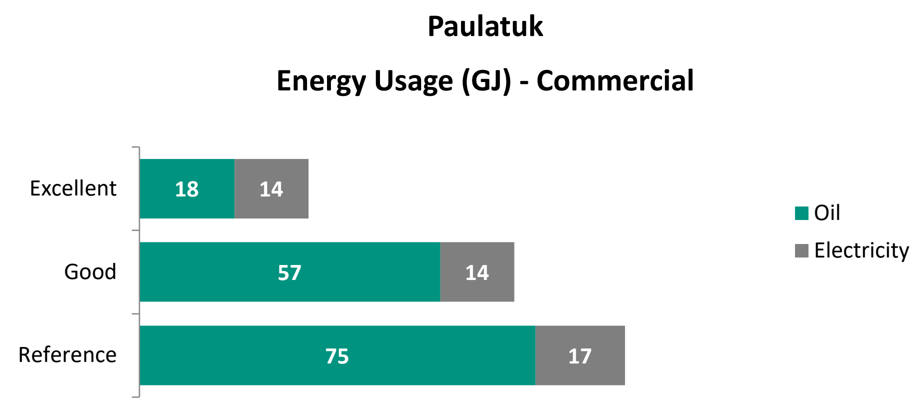
3.10.2 Fort Smith

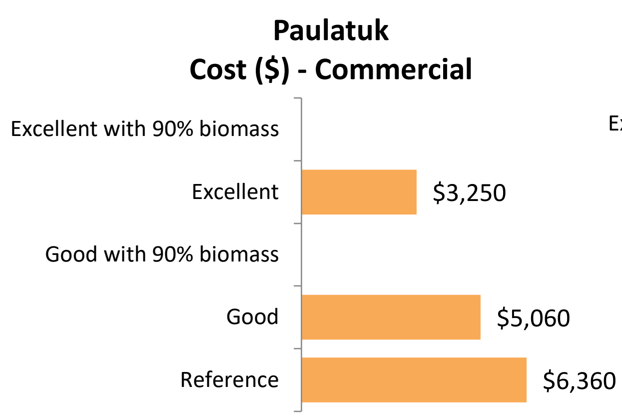


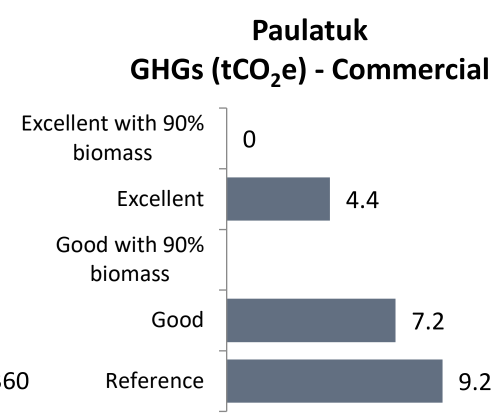




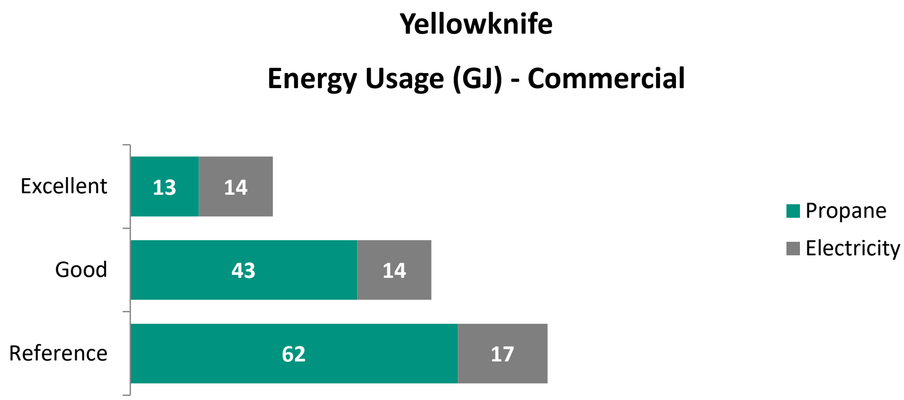
3.10.3 Paulatuk

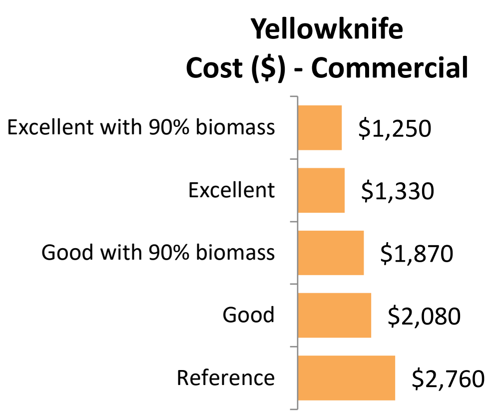


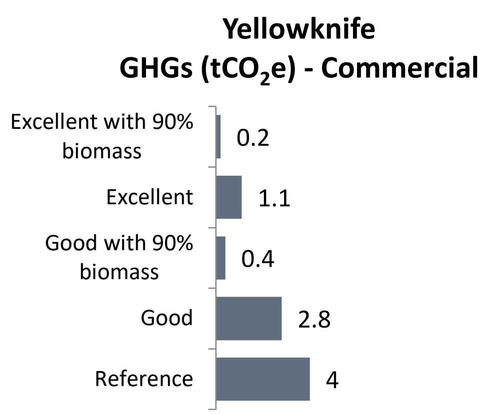




3.10.4 Yellowknife







4 Successful project completion

4.1 Building the team

To successfully complete your building, you'll need to take great care when assembling the team that will work together through the design, construction, commissioning and handover stages of the project. Choose people and firms that have proven experience in northern and energy-efficient building construction projects. You'll also want to make sure that all members of the team communicate well together—if the team isn't getting along before design starts, there will definitely be problems when the shovels hit the ground.

Integrated design process (IDP)

A highly successful process to use in building design is an integrated design process (IDP). As stated by the Canada Mortgage and Housing Corporation (CMHC) in their article "The Northern Sustainable House: An Innovative Design Process" (2009), IDP is:

> *…a holistic approach to building design. Led by a facilitator, it brings together all of the building's stakeholders including designers, property managers, builders, technical experts, municipal representatives and, for residential buildings, prospective residents to discuss their interests and ideas.*
>
> *In a series of sessions, an IDP team considers technical issues such as site, climate, building form and space planning, building envelope, energy efficiency, renewable energy potential, mechanical and electrical systems, as well as user preferences. In the Far North, this includes a strong focus on addressing the unique social and cultural issues of northern communities. Developing consensus is an essential part of the process.*
>
> *[Multidisciplinary design planning meetings] are a key ingredient in the IDP, serving as effective forums in which participants are encouraged to think in positive and innovative ways about sustainable building design and construction. They also provide a creative environment where diverse skills, expertise and personal interests can be brought together to contribute new perspectives on issues in order to develop new solutions.*

Through this process, "the IDP can contribute to an improved sense of community ownership and connection with the project being considered, and ultimately to reduced building and operating costs."

4.1.1 Building owner

The first member of the team is you, the building owner. Make sure you have enough members of your organization on your side of the table to ensure none of your requirements are missed.

4.1.2 Maintainer and operator

A member of your staff or a property management company will take care of your building. Be sure to include them on the design team because they can give feedback to improve the long-term maintainability of your building.

4.1.3 Energy efficiency advisor

An energy efficiency advisor will bring together all details of the design to give you a big-picture look at the building's expected performance, and can suggest improvements to each of the design team members. An energy efficiency advisor should have a certification such as Certified Energy Manager (CEM) from the Association of Energy Engineers or Building Energy Modeling Professional (BEMP) from ASHRAE.

4.1.4 Architect

An architect usually takes the lead on design and is responsible for the coordination of the design team. In addition to leading the design process and providing a set of drawings and specifications for construction, the architect will perform inspections and field reviews during construction to confirm that the design is meeting their requirements. This is especially critical when aiming to achieve a high level of airtightness because the building's air barrier is contained within the wall and can't be inspected or repaired once construction is complete.

Look for a firm that has experience designing efficient buildings in a style that you find aesthetically pleasing. Don't focus your evaluation of the architect (and rest of the design team) primarily on price. The complete design team's fees are around 10% of the overall construction budget, and they have a very big impact on the final result.

All architects working in the NWT must be registered with the NWT Association of Architects (nwtaa.ca).

4.1.5 Engineers and other consultants

The architect will generally subcontract the various engineers (civil, structural, mechanical, and electrical) as well as any specialty designers (commercial kitchen designer, landscape designer). You'll want to get information on these other members of the design team as well, especially the mechanical engineer, to make sure they have experience designing efficient building systems.

All engineers working in the NWT must be registered with NAPEG (napeg.nt.ca).

4.1.6 General contractor

The building contractor takes primary responsibility for construction of the building. They will coordinate their own workers as well as those of specialty subcontractors. Select a contractor with experience in northern construction. If aiming for a very high level of energy efficiency, it will be important to select a contractor that has experience with high-performance buildings.

The Northwest Territories and Nunavut Construction Association (nnca.ca) maintains a list of general contractors and sub-contractors working in the NWT.

4.1.7 Sub-contractors

The general contractor will hire a number of specialty sub-contractors to handle aspects of the construction their own forces aren't skilled or trained in. These usually include HVAC equipment installation, electricians and plumbers. Make sure you know who these sub-contractors will be, and that they have experience working with any high-efficiency equipment that is selected. If a sub-contractor isn't completely familiar with a new technology, make sure they have a manufacturer's representative come to site to oversee the installation and commissioning.

4.1.8 Commissioning agent

The commissioning agent is responsible for coordinating and carrying out the commissioning process. Building commissioning is the professional practice that ensures that buildings are delivered to achieve the building owner's project requirements as intended by the building owner and as designed by the building architects and engineers. Commissioning is the ongoing process of tuning and calibrating the building's systems to make sure buildings are performing as efficiently as possible.

Commissioning begins at the design stage and continues through construction and occupancy. A commissioning agent monitors building plans, tests and documents all systems, and arranges training for building occupants on proper operation and maintenance. They are focused on quality and keeping an eye to future maintenance and operation of the building. They verify all of the building components throughout the building process, typically with reviews at 50%, 75% and 100% of the project completion.

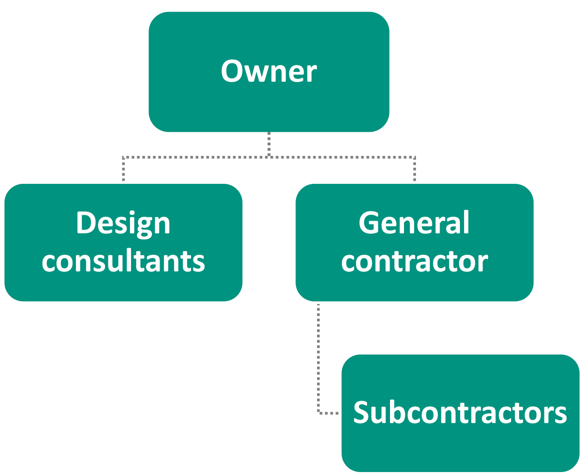
4.2 Procurement and contracting methods

Now that you know who you'll need on your team, you need to decide how to organize the team, which will decide the way the contracts are written between all parties. There are two main ways of building contracting: design-bid-build and design-build.

4.2.1 Design-bid-build

Design-Bid-Build (D-B-B) is the more traditional method of completing a project. With design-bid-build you have more control over your project and are more likely to meet your energy efficiency desires.

You will directly hire an architect to complete fully detailed design drawings and specifications. You'll need to issue a Request for Proposals (RFP) document that spells out the type of building you want to complete, the qualifications you require, your schedule, and your budget. It should include the scoring criteria that will be used for evaluating proposals. The architect who scores highest on your criteria would be successful, and you'd form a design contract with them. An industry-standard contract for this owner-architect relationship is the *Canadian Standard Form of Contract for Architectural Services – Document Six*, published by the Royal Architectural Institute of Canada (RAIC). The architect will then subcontract the engineers and other designers. If you have a commissioning agent, they should be working on your design team to ensure they represent your interests, not those of the contractor.



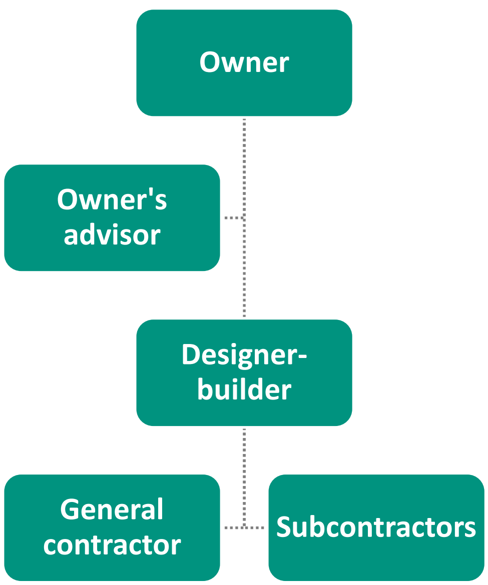
You'll then take these completed drawings and specifications and put them out to tender for general contractors to bid on. You can make the evaluation based on price only, or have some component of the evaluation based on past experience and/or references with northern and energy-efficient construction. An industry-standard contract used for the owner–contractor relationship is *CCDC 2 Stipulated Price Contract*, published by the Canadian Construction Documents Committee.

The advantage of D-B-B is that you know exactly what building you'll get because you work with the architect to produce fully detailed drawings, and contractors have certainty about what they are being asked to build. The disadvantage is that if there is any disagreement about interpretation of the construction documents it can become a finger-pointing game between the design team and contractor, and this can result in increased costs for redesign and/or construction.

4.2.2 Design-build

Design-Build (D-B) is a newer contracting method where you will hire a combined designer-builder team that is made up of architects, engineers and contractors who all work together to complete your building. It streamlines the process but you lose a lot of control of your project and may miss out on energy conservation opportunities that are not stated in your up-front design requirements.

Before you can hire a designer–builder, you'll need to make sure your requirements are well defined. If it's a simple building, you may be able to do this yourself. In most cases, you'll want to hire your own architect who will define your needs and represent your interests during the design and construction process (called an owner's advisor or bridging consultant). They will work with you to get the design to the conceptual or schematic design phase and will produce a set of documents (statement of requirements) that can be put out as part of an RFP to designer-builders. Hiring an owner's advisor is similar to hiring your own design team: you'll want to put out an RFP that defines your expectations and scoring criteria.



When you've got the documents from your owner's advisor you then put those out as another RFP to designer-builders. Your scoring criteria should examine the experience and qualifications of the builder and the builder's design team, as well as the quality of their proposed design, their proposed price and their ability to meet your schedule.

The advantage of D-B is that it can eliminate your risk of miscommunication between the designers and the builder, since they are on the same side contractually. It can also speed up construction because the builder can get started on some parts of the building (like the foundation) before the detailed design of mechanical and electrical systems are complete. The disadvantage is that it removes much of the control over the final design of the building that you'll get, so you need to be very clear in your statement of requirements what you expect. It also can make it harder to take advantage of energy efficiency opportunities because the designer-builder has little incentive to further improve efficiency once they've met your specified target.

4.3 The design process

This section is written assuming that you're procuring your building as a design-bid-build project. If you opt for design-build, the process is similar, except responsibility for design is passed from the owner's advisor to the designer-builder's consultants at the conceptual or schematic design stage. If you choose the design-build process, you must be very clear up front about what you want in your design and have some steps along the way to ensure that you are getting the design you have intended.

Before you start the design process you'll want to be sure you have a good idea of what your needs are, what spaces you'll want in the building to meet those needs, the overall look of the building, and the level of energy performance you'd like to aim for. Be sure to clearly communicate this to your architect through the RFP process and throughout the design process.

Early stages in the design process can include the functional program (which defines the spaces that are needed in the building, their sizes and their relationship to each other), the conceptual design (which gives a rough sketch of the proposed form and layout of the building), and schematic design (a more detailed design of the building that includes details on proposed mechanical and electrical systems). Be sure to take the time to review these design submissions and provide plenty of feedback, because it's much easier (and less expensive) to make changes at early stages than when the design is nearly done.

Once the schematic design is completed and approved the design team will move into design development, where the drawings and specifications are written. Request multiple reviews of these documents, usually at the 50%, 75%, and 100% design stages. Be sure that everyone with your organization that needs to review these documents is able to, especially maintenance and operations personnel. You don't want to get to completion of design (or worse, construction) before someone notices something was missed!

If you are aiming for a high level of energy performance and have an energy modeler on the project team, they should be providing reports at each of these stages so you know the design is on track to meet your performance target. They can also review the design at each stage to identify improvements that can be made to the design along with the cost and greenhouse gas savings of each.

The drawings and specifications not only spell out what the builder is to construct, but can define how they are to construct it, and when the architect will perform field reviews to ensure what is being built matches the design intent.

When the design documents are completed, you'll be ready to hire a general contractor and move into the construction phase.

4.4 Construction

The general contractor will take the completed construction documents and begin construction of the building. Your architect and engineers should perform regular reviews of the construction process, especially the details of the air barrier if you are aiming for a high level of airtightness. You should also perform regular reviews of the construction site yourself to ensure the project is progressing on schedule and material is being delivered to site, because this determines appropriate payments for the contractor to receive as construction progresses (payments are usually monthly).

4.5 Commissioning and handover

Prior to the building being turned over from the contractor to you, a number of key things need to happen—known as commissioning. For any of these items not completed, the architect will determine an amount of payment to withhold from the contractor (holdback) until it is completed.

You should include the following statement in your RFP:

Prior to final payment and payment of deficiency holdbacks, the contractor must provide the following:

- ***Submittal documents required in the specification, such as as-built drawings, operating and maintenance manuals, equipment specification sheets, etc.***
- ***A clear language sequence of operations that describes how the building and its equipment will operate in the summer mode, winter mode, and any unusual operating modes (e.g. freeze protection). One copy is to be provided to the project manager and one copy is to be placed or posted in a conspicuous location in the mechanical room.***
- ***Completion of all commissioning, with commissioning reports provided. The operation of the controls system must match the intended sequence of operations.***
- ***A training session with building staff to explain and review the intended operation of the building and regular maintenance requirements.***
- ***Correction of all deficiency items identified by the project manager, architect, engineers, and other designers.***

Building commissioning is the professional practice that ensures that buildings are delivered to achieve the building owner's project requirements as intended by the building owner and as designed by the building architects and engineers. Commissioning is the ongoing process of tuning and calibrating the building's systems to make sure buildings are performing as efficiently as possible.

Commissioning assists in the delivery of a project that provides an efficient, safe and healthy facility; optimizes energy use; reduces operating costs; ensures adequate orientation and training for operations and maintenance staff; and improves documentation for installed building systems. The commissioning should be handled by a third party.

4.6 Warranty review and ongoing commissioning

The warranty period is typically one year. Shortly before the end of this warranty period, the architect will perform another review to identify any issues to be corrected by the contractor under warranty.

Even though commissioning was performed at the end of construction, for maximum energy efficiency it is recommended you perform ongoing commissioning. Equipment fails, goes out of calibration or is adjusted by building occupants, all of which can reduce energy efficiency. Every three years, the operation of building systems should be reviewed to ensure they are still working as described in the sequence of operations. Ongoing commissioning provides annual energy savings of 10 to 15 percent on average. Other benefits include longer equipment life, lower maintenance costs, and a safer and more comfortable indoor working environment.

You should also track your building's energy use and regularly review it. The simplest way to do this is input utility bills into a spreadsheet or energy tracking database such as ENERGY STAR Portfolio Manager. If you see energy use increasing over time, you know further investigation (an energy audit or recommissioning) is needed.

The Arctic Energy Alliance provides a service to NWT businesses in which they review energy and water consumption data and compare with data for similar buildings (where available). This is called a yardstick energy audit. See www.aea.nt.ca for more information.

5 Additional resources

5.1 Further AEA resources

Arctic Energy Alliance YouTube page (https://www.youtube.com/user/ArcticEnergyAllianc1)

Best Energy Practices for Remote Facilities (http://aea.nt.ca/files/download/99)

Fuel Cost Library (updated frequently, refer to the AEA website for the latest version)

Residential Wood Pellet Heating – A Practical Guide for Homeowners (http://aea.nt.ca/files/download/562)

5.2 Other resources

ASHRAE *Cold-Climate Buildings Design Guide*

BC Housing *Building Commissioning Guidelines*

BC Housing *Guide to Building Handover*

Government of Northwest Territories *Good Building Practice for Northern Facilities, Fourth Edition*

NAIMA *Canada Guide to Near Net Zero Residential Buildings*

Yukon Government *Design Requirements & Building Standards Manual*

5.3 Glossary

ACH	Air changes per hour, a measurement of air movement that is the volume of air moved in an hour divided by the volume of the space or building. Commonly used when performing blower door tests to measure a building envelope's airtightness.
AFUE	Annual fuel utilization efficiency, a measure of the average efficiency of a furnace or boiler taking into account inefficiencies associated with on/off operation, part load operation, and pilot lights (if applicable).
Air-source	When discussing heat pumps, this refers to heat pumps that obtain their heat from the atmosphere directly.
Airtightness	A measure of how well a building resists air movement from inside to outside, or vice versa. The wind, difference in air temperature between inside and outside, and appliances or fans can all cause air movement in or out of a building, which is undesirable because it lets cold air in or hot air out. Commonly measured using a blower door test.
Blower door test	A test used to measure a home's airtightness: a powerful fan is mounted in an exterior door opening and used to pressurize or depressurize the house. By measuring the force needed to maintain a certain pressure difference, the home's airtightness can be determined. Operating the blower door also exaggerates air leakage and makes it easier to find and seal leakage areas.
Btu	British thermal unit, the amount of heat required to raise one pound of water (about a pint) one degree Fahrenheit in temperature—about the heat content of one wooden kitchen match. One Btu is equivalent to 0.293 watt-hours or 1,055 joules. Capacity of heating equipment is typically measured in Btu/h.
Catalytic	Catalytic stoves use a special element coated in exotic metals to trigger additional combustion of the smoke produced by wood burning. This increases the heat output and reduces the amount of smoke produced.
CFL	Compact fluorescent lamp. They are typically three to four times as efficient as incandescent light bulbs, and last eight to ten times as long. Most contain a small amount of mercury, and they have been largely replaced by even more efficient LEDs.
Clerestory	Windows that are oriented vertically but high up so there is no direct sightline to the outdoors. Often used in place of skylights.
COP	Coefficient of performance, a measure of the efficiency of heat pumps and air-conditioners. For heat pumps, the COP indicates the number of units of heat delivered to the space per unit of electricity used. For air conditioners, COP indicates the number of units of heat removed from the space per unit of electricity used. Higher numbers are better.
Daylighting	Use of sunlight for interior lighting needs. Daylighting strategies include solar orientation of windows as well as the use of skylights, clerestory windows, solar tubes, reflective surfaces, and interior glazing to allow light to move through a structure.

District heating system	A heating system in which a shared loop of water or steam is used to move heat energy between buildings. Typically the heat energy is provided by a central boiler building, or the waste heat from a diesel generating station may be used.
ECM	Electronically commutated motor. A brushless motor that is electronically controlled, and more efficient than a conventional motor.
EF	Energy factor, an efficiency measure for rating the energy performance of dishwashers, clothes washers, water heaters, and certain other appliances that heat water. The higher the energy factor, the greater the efficiency. Has been replaced by the newer Uniform Energy Factor (UEF).
Efficiency	The fraction of energy input into a device that can perform useful work, with the rest being rejected as waste heat. The term is also used in a general sense to describe the performance level of buildings.
ENERGY STAR	A labeling system sponsored by the Environmental Protection Agency and the US Department of Energy for labeling the most energy-efficient products on the market; applies to a wide range of products, from computers and office equipment to refrigerators and air conditioners. In Canada, it is administered by Natural Resources Canada.
EPA	Environmental Protection Agency, an agency of the federal government of the United States charged with protecting human health and the environment, by writing and enforcing regulations based on laws passed by Congress. The agency conducts environmental assessment, research, and education. It has the responsibility of maintaining and enforcing national standards under a variety of environmental laws, in consultation with state, tribal, and local governments.
Glazing	Windows or skylights.
Greenhouse gases (GHGs)	Gas emissions that have been linked to causing climate change and global warming. Carbon dioxide (CO_2) is the most commonly discussed GHG, but there are others that are more potent such as methane (CH_4) and some refrigerants. To simplify measurement of different GHGs, they are commonly converted to tonnes of carbon dioxide equivalent (tCO_2e).
Ground-source	When discussing heat pumps, this refers to heat pumps that obtain heat from the ground using water circulated in drilled wells or loops of pipe buried below the ground.
Heat pump	A device that has a compressor and fluid (called refrigerant) pumped between two points to move heat from one location to another. Refrigerators, freezers, and air conditioners all have heat pumps within them, and the term is also used to refer to units that can move heat from the outside into a building.
HSPF	Heating seasonal performance factor, a measure of heat pump efficiency expressed in Btu of heat output per watt-hour of electricity used.
Hydronic	A system that uses hot water to circulate heat energy.
Insulation	A material that will transfer heat slowly compared to other materials. Fiberglass batts, mineral wool and rigid foams are common insulation in buildings.
Joule (J)	A metric unit of energy.
Kilowatt-hour (kWh)	A unit of energy commonly used for measurement and billing of electricity.

LED	Light emitting diode, a type of light bulb that produces light by running electrical current through a semiconductor diode. LED lamps are much longer lasting and much more energy efficient than incandescent lamps; unlike fluorescent lamps, LED lamps do not contain mercury and can be dimmed.
Low-e	Low emissivity. These are coatings on windows that reflect heat energy. This helps keep heat inside of buildings during the winter, and reduce heating caused by the sun during the summer months.
NBC	National Building Code of Canada, a document published by the National research council which sets out technical provisions for the design and construction of new buildings. It can be adopted by jurisdictions (municipal, provincial, or territorial) in its entirety, with modifications, or not at all.
NECB	National Energy Code of Canada for Buildings, a document published by the National Research Council which sets out technical requirements for the energy efficient design and construction of new buildings. It can be adopted by jurisdictions (municipal, provincial, or territorial) in its entirety, with modifications, or not at all.
NEMA	National Electrical Manufacturers Association, an American body that sets performance standards for electrical equipment.
Pa	Pascal, the metric unit of pressure commonly used when discussing blower door tests or ventilation systems.
Passive solar heating	Heating that does not require the use of fuel or electricity. The most common type of passive solar heating is using windows, which let the sun's energy into the building. Special attention is needed to maximize passive solar heating during the winter months and to reduce it during the summer months. Common strategies to manage solar heating in the summer include providing shade with canopies or deciduous trees, carefully selecting window coatings, and using high thermal mass building assemblies.
SEER	Seasonal energy-efficiency ratio, the operating efficiency of a room air conditioner on an annual basis measured in Btus of cooling output divided by the power consumption in watt-hours. The higher the SEER, the greater the efficiency.
Thermal break	A design feature that aims to reduce thermal bridging.
Thermal bridging	The effect where structural materials tend to have a poor insulating value, so they reduce the overall insulating value of a wall or window frame. This can also cause problems with condensation inside the wall assembly.
Thermal mass	Thermal mass is the ability of a material to absorb and store heat energy. Heavy materials like concrete have a high thermal mass, and light materials like wood have low thermal mass.
UEF	Uniform energy factor, an efficiency measure for rating the energy performance of dishwashers, clothes washers, water heaters, and certain other appliances that heat water. The higher the energy factor, the greater the efficiency. Replaces the older energy factor (EF).
Watt (W)	The metric unit of power, defined as one joule of energy per second. Commonly used to describe the energy consumption of electrical equipment. One thousand

	watts equals one kilowatt (kW), which is used to describe larger power demands such as boilers or a whole building's electrical use.
Wet rotor	A pump design in which the motor is directly connected to the pump and the fluid being pumped acts to cool the motor.

Appendix: Fuel Cost Library: 5-Year Average with Carbon Tax – 2019-2023

Updated December 2023	Residential									
5 Yr Average, 2019-2023				Oil$/Litres	Propane$/L	ropane$/m	Nat Gas$/GJ	Pellets$/Pallet	Pellets$/Tonne	Wood$/Cord
Prices do not include GST.	Electricity Data (Not Averaged) $/kwh			Oil $/Litres	Propane $/L	Propane $/m³	Nat Gas $/GJ	Pellets $/Pallet	Pellets $/Tonne	Wood $/Cord
	Basic $	up to subsidy limit	over subsidy limit		Delivered	Metered		(1Bag)	Bulk Delivered	
Aklavik	$18.00	$0.32	$0.74	$2.08	$1.91			$900.00		$500.00
Behchoko	$18.00	$0.32	$0.38	$1.72	$0.91			$487.00	$350.00	$455.00
Colville Lake	$18.00	$0.32	$0.74	$2.02						$648.00
Deline	$18.00	$0.32	$0.74	$1.68						$660.00
Dettah	$18.00	$0.32	$0.38	$1.56	$0.90			$410.20	$368.20	$450.00
Enterprise	$19.28	$0.34	$0.40	$1.49	$0.82			$312.15	$247.95	$355.00
Fort Good Hope	$18.00	$0.32	$0.74	$1.90				$484.61		$710.00
Fort Liard	$18.00	$0.32	$0.74	$1.65						$410.00
Fort McPherson	$18.00	$0.32	$0.74	$2.19	$1.91				$780.00	$483.33
Fort Providence	$18.00	$0.32	$0.74	$1.58	$0.85			$312.15	$286.04	$350.00
Fort Resolution	$18.00	$0.25	$0.27	$1.57	$0.89			$312.15	$280.92	$410.00
Fort Simpson	$18.00	$0.32	$0.74	$1.48	$0.89			$413.28		$420.00
Fort Smith	$18.00	$0.25	$0.27	$1.53	$0.92			$385.20	$293.45	$340.00
Gameti	$18.00	$0.32	$0.74	$1.89						$490.00
Hay River	$19.28	$0.34	$0.40	$1.45	$0.82	$3.21		$307.92	$262.15	$355.00
Hay River Reserve	$19.28	$0.34	$0.40	$1.44	$0.82			$307.92	$260.13	$350.00
Inuvik	$18.00	$0.32	$0.74	$2.02	$1.87		$40.07	$774.00	$685.00	$500.00
Jean Marie River	$18.00	$0.32	$0.74	$1.79	$0.89					$400.00
Kakisa	$18.00	$0.32	$0.74	$1.57	$0.80			$351.60	$281.04	$373.00
Lutsel Ke	$18.00	$0.32	$0.74	$1.85						$640.00
Nahanni Butte	$18.00	$0.32	$0.74	$1.70						$460.00
Norman Wells	$18.00	$0.32	$0.60	$1.90				$538.52	$618.00	$660.00
Paulatuk	$18.00	$0.32	$0.74	$2.14						
Sachs Harbour	$18.00	$0.32	$0.74	$2.14						
Sambaa K'e	$18.00	$0.32	$0.74	$1.86						$433.33
Tsiigehtchic	$18.00	$0.32	$0.74	$1.84	$1.91					$570.00
Tuktoyaktuk	$18.00	$0.32	$0.74	$1.96	$1.91					$600.00
Tulita	$18.00	$0.32	$0.74	$1.83				$484.62		$700.00
Ulukhaktok	$18.00	$0.32	$0.74	$2.13						
Wekweeti	$18.00	$0.32	$0.74	$2.07						$500.00
Wha Ti	$18.00	$0.32	$0.74	$1.70				$600.00		$500.00
Wrigley	$18.00	$0.32	$0.74	$1.68	$1.56					$458.00
Yellowknife	$18.13	$0.33	$0.33	$1.53	$0.87			$374.00	$368.20	$450.00

Updated December 2023	Commercial								
5 Yr Average, 2019-2023					CommercialOil$/Litres	Propane$/L	Propane$/m³	Nat Gas$/GJ	Pellets$/Tonne
Prices do not include GST.	Electricity Data (Not Averaged)				Oil $/Litres	Propane $/L	Propane $/m³	Nat Gas $/GJ	Pellets $/Tonne
	$/kVa or kW	$/kWh	$/kWh (>200 kWh/kW)	minimum charge		Delivered	Metered		
Aklavik	$8.00	$0.64		$40.00	$2.08	$2.00			
Behchoko	$8.00	$0.37		$40.00	$1.72	$0.91			
Colville Lake	$8.00	$0.64		$40.00	$2.02				
Deline	$8.00	$0.64		$40.00	$1.68				
Dettah	$8.00	$0.37		$40.00	$1.56	$0.90			$322.25
Enterprise	$10.40	$0.28	$0.23	$52.00	$1.49	$0.78			$247.95
Fort Good Hope	$8.00	$0.64		$40.00	$1.90				
Fort Liard	$8.00	$0.64		$40.00	$1.65				
Fort McPherson	$8.00	$0.64		$40.00	$2.19	$2.00			$750.00
Fort Providence	$8.00	$0.64	$0.65	$40.00	$1.58	$0.85			$274.78
Fort Resolution	$8.00	$0.22		$40.00	$1.57	$0.89			$267.96
Fort Simpson	$8.00	$0.64		$40.00	$1.48	$0.89			
Fort Smith	$8.00	$0.22		$40.00	$1.53	$0.92			$281.88
Gameti	$8.00	$0.64		$40.00	$1.89				
Hay River	$10.40	$0.28	$0.23	$52.00	$1.45	$0.77	$3.06		$251.65
Hay River Reserve	$10.40	$0.28	$0.23	$52.00	$1.44	$0.78			$247.95
Inuvik	$8.00	$0.64		$40.00	$2.02	$2.00		$40.07	$616.67
Jean Marie River	$8.00	$0.64		$40.00	$1.79	$0.89			
Kakisa	$8.00	$0.64	$0.65	$40.00	$1.57	$0.80			$268.11
Lutsel Ke	$8.00	$0.64		$40.00	$1.85				
Nahanni Butte	$8.00	$0.64		$40.00	$1.70				
Norman Wells	$8.00	$0.54		$40.00	$1.90				$573.33
Paulatuk	$8.00	$0.64		$40.00	$2.14				
Sachs Harbour	$8.00	$0.64		$40.00	$2.14				
Sambaa K'e	$8.00	$0.64	$0.65	$40.00	$1.86				
Tsiigehtchic	$8.00	$0.64		$40.00	$1.84	$2.00			
Tuktoyaktuk	$8.00	$0.64		$40.00	$1.96	$2.00			
Tulita	$8.00	$0.64		$40.00	$1.83				
Ulukhaktok	$8.00	$0.64		$40.00	$2.13				
Wekweeti	$8.00	$0.64	$0.65	$40.00	$2.07				
Wha Ti	$8.00	$0.64		$40.00	$1.70				
Wrigley	$8.00	$0.64		$40.00	$1.68	$1.67			
Yellowknife	$14.79	$0.25		$73.94	$1.53	$0.87			$322.25

Updated December 2023	Government							Transportation	
5 Yr Average, 2019-2023								Transportation	
Prices do not include GST.	Residential Electricity(Not Averaged)			Commercial Electricity(Not Averaged)				Gasoline (Not Averaged)	Diesel (Not Averaged)
		$/kwh						$/L	$/l
	Basic $	up to 700 kWh	all kWh	$/kVa or kW	$/kWh	$/kWh (>200 kWh/kW)	minimum charge		
Aklavik	$18.00	N/A	$0.98	$8.00	$0.95		$40.00	$2.07	$2.55
Behchoko	$18.00	N/A	$0.41	$8.00	$0.47		$40.00	$1.79	$2.00
Colville Lake	$18.00	N/A	$3.44	$8.00	$3.04		$40.00	$2.39	$2.62
Deline	$18.00	N/A	$1.25	$8.00	$1.20		$40.00	$2.07	$2.21
Dettah	$18.00	N/A	$0.46	$8.00	$0.53		$40.00	$1.62	$1.80
Enterprise	$19.28	N/A	$0.40	$16.64	$0.27	$0.18	$332.80	$1.75	$2.10
Fort Good Hope	$18.00	N/A	$1.09	$8.00	$0.97		$40.00	$2.25	$2.43
Fort Liard	$18.00	N/A	$1.18	$8.00	$1.08		$40.00	$1.74	$2.09
Fort McPherson	$18.00	N/A	$1.23	$8.00	$1.14		$40.00	$2.16	$2.31
Fort Providence	$19.04	N/A	$0.93	$14.81	$0.76	$0.65	$74.06	$1.96	$2.33
Fort Resolution	$18.00	N/A	$0.37	$8.00	$0.33		$40.00	$1.60	$1.73
Fort Simpson	$18.00	N/A	$1.11	$8.00	$0.99		$40.00	$1.72	$1.79
Fort Smith	$18.00	N/A	$0.30	$8.00	$0.24		$40.00	$1.85	$2.05
Gameti	$18.00	N/A	$1.95	$8.00	$2.27		$40.00	$2.15	$2.24
Hay River	$19.28	N/A	$0.40	$16.64	$0.27	$0.18	$332.80	$1.75	$2.10
Hay River Reserve	$19.28	N/A	$0.40	$16.64	$0.27	$0.18	$332.80	$1.75	$2.09
Inuvik	$18.00	N/A	$0.91	$8.00	$0.83		$40.00	$2.25	$2.65
Jean Marie River	$18.00	N/A	$2.23	$8.00	$3.04		$40.00	$2.02	$2.24
Kakisa	$19.04	N/A	$0.93	$14.81	$0.76	$0.65	$74.06	$1.96	$2.33
Lutsel Ke	$18.00	N/A	$1.19	$8.00	$1.12		$40.00	$2.49	$2.29
Nahanni Butte	$18.00	N/A	$2.49	$8.00	$3.25		$40.00	$2.02	$2.12
Norman Wells	$18.00	N/A	$0.72	$8.00	$0.66		$40.00	$2.09	$2.39
Paulatuk	$18.00	N/A	$1.85	$8.00	$1.77		$40.00	$2.64	$2.76
Sachs Harbour	$18.00	N/A	$2.28	$8.00	$2.17		$40.00	$2.12	$2.82
Sambaa K'e	$19.04	N/A	$0.93	$14.81	$0.76	$0.65	$74.06	$1.98	$2.15
Tsiigehtchic	$18.00	N/A	$1.69	$8.00	$1.52		$40.00	$2.13	$2.22
Tuktoyaktuk	$18.00	N/A	$1.07	$8.00	$0.96		$40.00	$2.45	$2.60
Tulita	$18.00	N/A	$1.35	$8.00	$1.32		$40.00	$2.07	$2.36
Ulukhaktok	$18.00	N/A	$1.35	$8.00	$1.32		$40.00	$2.44	$2.78
Wekweeti	$19.04	N/A	$0.93	$14.81	$0.76	$0.65	$74.06	$2.43	$2.66
Wha Ti	$18.00	N/A	$1.28	$8.00	$1.20		$40.00	$2.00	$2.08
Wrigley	$18.00	N/A	$2.07	$8.00	$2.24		$40.00	$1.94	$2.09
Yellowknife	$18.13	N/A	$0.33	$14.79	$0.25		$73.94	$1.62	$1.80