Appendix - Energy and GHG Performance of New Construction

Version 1: September 13, 2024
Version 2: September 26, 2024

Building Code and Performance Tiers

Provinces have adopted since various Tiers of the National Energy Code for Buildings (NECB) 2020 based on their strategic priorities with respect to GHG reductions (see Kevin Lockhart, 2024). The Government of Alberta adopted the NECB 2020 Tier 1 which became in force in May 2024.

Table 10.1.2.1.
Energy Performance Tiers
Forming Part of Sentences 10.1.2.1.(1) and (2)

Energy Performance Tier	Percent *Building Energy Target*(1)	Percent Improvement(1)
1	≤ 100%	≥ 0%
2	≤ 75%	≥ 25%
3	≤ 50%	≥ 50%
4	≤ 40%	≥ 60%

Figure 1: NECB 2020 Tiered Energy Reduction Targets (Commercial & Institutional Buildings)

What is a Tier 2 Energy Performance Level (≥25% reduction)?

To achieve a ≥25% energy use reduction, the building design team first creates a building energy model using a specialized software and referring to the base prescriptive requirements from the NECB. The resulting model is called the Tier 1 *reference building*. The NECB requirements include thermal characteristics such as wall, ceiling and slab insulation levels, air leakage rate, fenestration and door thermal resistance, maximum lighting power levels, and the minimum performance of heating, ventilation and air conditioning (HVAC) systems. From this Tier 1 energy model, an energy use intensity (EUI) target can be derived. The design team then optimizes several components of the building envelop and systems to create a new Tier 2 model that shows a 25% reduction in energy use on an annual basis. While producing the Tier 2 model is not extremely complicated, the main challenge is doing so in the most cost-effective way. Each improvement in a building assembly or HVAC system will have a variable impact on the EUI as well as a different incremental cost. A parametric design study helps achieve the most cost-effective conceptual outcome. Other energy performance tiers such as Tier 3 and Tier 4 can be modelled though the same approach and compared with each other. The bulk of the design effort consists in creating the reference building energy model and defining the incremental cost for each energy upgrade. A cost consultant and the engineering team need to be involved in modelling higher performance tiers.

The design EUI does not represent necessarily the actual energy use. The design EUI is based on ideal operating conditions such no building tear and wear, an ideal execution of the HVAC system installation and commissioning, and control setpoints that are not modified by building users. In practice, the actual operational energy of a building is higher than the modelled one, but the increased level actually depends on building users, operators, the maintenance team, and the simplicity of the building design to a certain extent. A higher

operational EUI than design EUI is shown in Figure 2 but the increase can only be quantified once the building have been in operation for at least one year. The operational EUI has a direct impact on the building utility costs and greenhouse gas emissions.

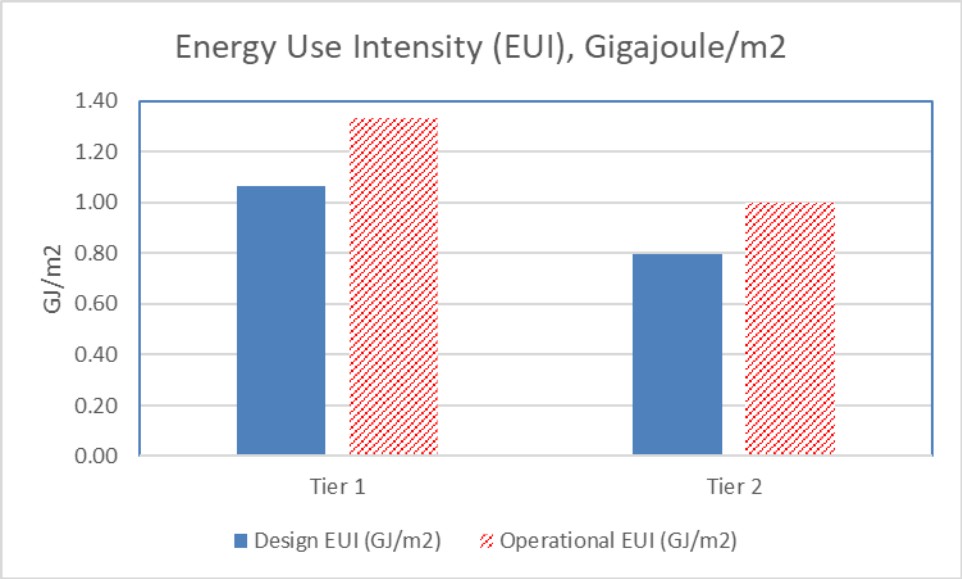

Figure 2: Design vs. Operational Energy use Intensity (EUI), NECB Tier 1 versus Tier 2

What is lifecycle costing, and who does it in Alberta and Canada?

Once the design EUI has been established by the designers, with a percentage of the building energy use coming from grid electricity and the balance from natural gas, present and future utility costs can be calculated using City-selected rates that account for inflation. Present rates with a cost escalation (typically 3% per year inflation), or future constant rates (already escalated) can be used. For the typical building, the City of Airdrie currently uses the following estimated utility rates for 2030, with no further cost escalation. The 2030 rates provide good average rate estimates for 15-year life projects.

	Electricity (FortisAlberta rate 41, small commercial)				**Natural Gas**	
	Fixed Annual Cost	**Rate (energy)**	**Equivalent Rate (demand)**	**Total Rate per kWh**	**Fixed Annual Cost**	**Rate per GJ (energy)**
2023	$500	$0.08/kWh	$0.03/kWh	$0.11/kWh	$500	$9.00/GJ
2030	$600	$0.11/kWh	$0.04/kWh	**$0.15/kWh**	$600	**$17.50/GJ**

Utility costs are then added over the life of the building (30 or 40 years), and discounted to account for the time value of money. The resulting life operating costs (including potential maintenance savings) for various designs are then compared with their upfront costs in order to find the design with the lowest total cost of ownership. A building design with a total cost of ownership lower than a Tier 1 design can deliver GHG reduction at no net cost to the City and can generate a revenue through future savings.

The City of Airdrie knows the following firms with an Alberta presence can perform parametric design studies with life cycle costing: Associated Engineering, Entuitive, Lemay, Metafor Architecture, Stantec, William Engineering, WSP. There are likely several other firms that can be identified through a request for qualifications.

What is a Net Zero Energy (NZE) Building?

For NECB energy modeling purposes, the building annual energy consumption includes lighting, water heating and space-conditioning, but no renewable energy sources. A NZE building is thus a high performance building (typically Tier 4) that is equipped with local renewable energy (RE) technologies that bring its net annual energy consumption to zero. The RE systems generate as much energy as the building uses over a year, so the net amount of energy purchased from local utilities is *approximately zero*, including heating, cooling and electricity loads. This typically implies NZE buildings are fully electrified and use no natural gas, although it is not an absolute requirement. The key element is that NZE buildings have significantly reduced heating, cooling and ventilation loads compared to Tier 1 buildings.

On one end of the performance spectrum, the 40% gap to go from Tier 4 (NZE-ready) to NZE is assumed by building code creators to be generally relatively easy, consisting in the installation of pre-designed renewable energy systems such as solar thermal or photovoltaics (PV) systems. On the other end of the spectrum, achieving a 25% (Tier 2) energy reduction is sometimes possible with simple tweaks in design and construction strategies, such as HVAC and lighting systems equipped with advanced controls, better envelope insulation with less fenestration, and heat recovery systems. Achieving 50% (Tier 3) or higher energy reductions is the most challenging step. It requires a much higher design effort (see ZEBx, 2022). This design work normally includes high-performance heating systems (i.e. 200% seasonal efficiency for air-source heat pumps and 400% efficiency for ground-source heat pumps versus 90% efficiency for fossil fuels combustion systems), building footprint, roof and wall size and orientation adjustments, enhanced building envelope details to reduce thermal bridging, advanced energy storage and recovery systems, and planning of future renewable energy systems. Thus, once Tier 3 is achieved, most of the work for achieving a NZE-ready (Tier 4) building has been completed. The extra effort to reach Tier 4 from Tier 3 is relatively small at the design stage, though it could be costly at the construction stage. However, once a Tier 3 building is constructed, it will be impossible to cost-effectively transform it into a NZE building in the future. Continued emissions from the building will be locked-in for the remaining life of the building. While the same reflection applies to all Tier 2 buildings, the initial effort to get to a 25% energy consumption reduction is much smaller, which will reduce upfront design and construction costs. Thus, targeting the NECB Tier 3 is not recommended for the City, but Tier 2 or Tier 4 are.

It should be noted the NECB sets a relative scale of GHG reductions in percentage while other approaches such as the Passive House standard (see Passive House Canada 2024) and the Canadian Green Building Council (CaGBC) Zero Carbon standard use an absolute scale, i.e. they set maximum levels of energy consumption per m^2 based on the climate zone. Also NECB modeling reduction targets do not necessarily in actual energy use since operational factors such as system setpoint override by operators, user behavior, changes in occupancy and scheduling are not accounted for by energy models.

Tiers and NZE Cost-Effectiveness

As of today, no comprehensive study has been conducted to quantify the lifecycle cost-effectiveness of NZE or high performance buildings due to the difficulty in comparing building archetypes and project/site specific parameters, given the relative novelty of NZE buildings. However some are not underway, including by the City of Edmonton. Previous older studies have looked into the economic, environmental and social value of green building rating systems such as LEED (see HRD Corporation, 2013), or high performance building design strategies, before the introduction of *Canada Green Buildings Strategy* and the carbon tax (see Integral Group, 2020). More recently the City of Edmonton and City of Calgary have been updating their cost-benefit analysis of implementing or mandating building performance requirement higher than the NECB at the community level. Results will become available in the coming months.

Several smaller high-performance buildings have achieved net zero energy performance at no additional upfront costs using innovative design methods, such as integrated project delivery (see Reimagine Architects (2024)). Net zero energy or carbon facilities do not necessarily come at higher life-cycle costs for owners, with the future low operating costs offsetting sometimes fully the higher upfront costs, or even more if low-carbon grant funding can be secured. To reduce future building retrofit costs, early energy and GHG modeling should become part of the City standard site master planning process (see ZEBx, 2022).

Other Alberta Municipalities

The following Alberta municipalities are considering or have adopted the following sustainable building policies and implementation guidance documents.

	Document	**Application**	**Adoption Date**	**Summary and Status**
Banff	*C7006 Municipal Sustainable Building Policy*	All new municipal buildings and building expansions	2021-04-26	Buildings require certification through one or more green building rating systems
Calgary	*CP2021-02 Sustainable Building Policy* *Sustainable Building Guidance Document Version 2.0 - January 2024*	All new City-owned and City-financed facilities	2004-09-13 2021-07-05 (last amended)	The City of Calgary plans, delivers, and maintains infrastructure that shows smart investment beyond initial construction costs by addressing the **lifecycle** impacts on buildings through: • operating costs, • effects of climate change, • the environment, and • the people who use the infrastructure. The *Sustainable Building Guidance Document* details specific sustainability targets, requirements, and deliverables.

Lethbridge	-	-	-	In development
Edmonton	*C532 Sustainable Building Policy Procedure – Climate Resilient Design and Construction of City Buildings*	All City-owned and occupied facilities; new constructions or additions with floor area of >500 m^2	2017-05-09 2018-03 (last amended)	New City-Owned buildings will be designed and constructed in a manner that mitigates the risks and impacts of future energy and carbon pricing and provides flexibility to incorporate emerging technologies that become cost effective in the future.
Okotoks	*Sustainable Building Standard*	All new municipal buildings > 500 m2	(in development)	• Guidance on Standard proposal currently being internally reviewed, possibly targeting NECB Tier 3 energy performance
St. Albert	*Sustainable Building Policy*	Planning, construction, renovation, and operations of all municipal buildings	2017-04-3 (in revision)	• Industry recognized standard third-party verified green rating certification • New policy currently under revision: possibly targeting NECB Tier 2 energy performance, a Thermal Energy Demand Intensity (TEDI) minimum target, and a life cycle cost analysis to inform investment decisions on renewable energy systems

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