June 2026

# Foundations for Net Zero Buildings

# Energy Efficient New School Development Guide


Project funded by:

Natural Resources Canada / Ressources naturelles Canada

Technical direction by:

Enerlife consulting

An applied research project of:

CLIMATE CHALLENGE NETWORK

New schools in Canada vary dramatically in energy performance. Our study of over 200 schools across five provinces found that much of the difference comes down to the process: how targets are set, how buildings are modeled and commissioned, how systems are operated, and how accountability is structured across the project lifecycle. The Energy Efficient New School Development Guide translates those findings into eight areas of practical recommendations, giving school boards and provincial governments an actionable roadmap for delivering and sustaining high energy performance in every new school they build.

**This document was prepared by Climate Challenge Network. For additional information, please contact:**

**Katia Osokine**
Program Manager
kosokine@climatechallengenetwork.org
90 Eglinton Avenue East, Suite 412
Toronto, ON, M4P 2Y3
Climate Challenge Network

# Contents

## List of figures

## List of tables

# PART A: INTRODUCTION

## Background

### About Climate Challenge Network

Climate Challenge Network is a non-profit organization that develops and manages large-scale, collaborative, data-driven sectoral programs, currently for municipalities, hospitals, school boards, and post-secondary institutions. The programs focus on accelerating reductions in building-related greenhouse gas emissions, helping owners future-proof their organizations and build resilience in their communities. Climate Challenge Network works with program members, governments, utility companies and industry experts on applied research and demonstration initiatives which develop new knowledge and best practices for energy and water efficiency in commercial buildings.

### About this project

Over the past 18 months, Climate Challenge Network has been conducting a national research project examining the energy performance of newly constructed buildings across Canada. The work spans five provinces and focuses on understanding how development processes influence energy performance outcomes in practice. The findings of this research form the basis for a set of recommendations to governments and school boards intended to inform how new buildings are planned, designed, delivered, and operated going forward.

The research is funded by Natural Resources Canada's Codes Acceleration Fund, and includes addresses four building types: hospitals, municipal community centres, K-12 schools, and commercial office buildings. All buildings included in the study were opened since 2015 and are located in British Columbia, Alberta, Manitoba, Ontario, or Nova Scotia. This timeframe was chosen to focus on buildings designed under recent codes and standards.

### About this Guide

This Energy Efficient New School Development Guide (Guide) presents findings and recommendations for new K-12 schools. We engaged extensively with school boards and provincial governments across the five provinces, conducting over two dozen meetings with boards, government agencies, and other related organizations. Basic (annual) energy performance data were collected from 67 school boards covering a total of 234 schools, providing the broader dataset against which current practice was assessed. Thirteen school boards participated in in-depth interviews, sharing data, energy modeling reports, and operational information that informed the analysis and recommendations in this Guide. The project team conducted more in-depth analysis of high performing schools, along with a number that rank lower in energy benchmarking, to help understand what differentiates high-performing buildings from those that consume more energy than expected. This comparative analysis is the foundation of the Guide, which is intended to support school boards, governments, designers, and others involved in the delivery of new schools by translating observed metrics and best practices into practical guidance. The objective is to enable every new school built in Canada to achieve a high level of energy efficiency, informed by evidence and experience from top-performing projects.

The Guide's recommendations include engaging with new school development projects currently in the planning pipeline, identifying and taking corrective action for underperforming schools through recommissioning and operational improvements, and adopting documented best practices at each stage of the development process. Interval metering of electricity and thermal energy is emphasized as foundational, underpinning the recommended integration of modeling, performance-based commissioning and ongoing operational optimization. As well, leadership by governments, utility companies and school boards plays a pivotal role in establishing policies, regulatory frameworks, and incentives that support the transition to consistently high-performance outcomes.

Throughout the Guide, we make reference to Halton Catholic District School Board (Halton Catholic DSB), a mid-sized Ontario school board whose approach to new school development and operations has consistently produced exceptional results. An in-depth case study of four recently opened Halton Catholic DSB schools is presented in Section 9. Their data, standards and management practices underpin many of the recommendations in this Guide.

In order to validate the Guide's conclusions and recommendations, we convened an advisory group meeting on March 12, 2026, comprising school board and government individuals who had taken part in the project. A public webinar was then conducted on March 26, 2026 to share the research results more widely, and to collect additional input as the Guide was finalized.

# The case for action – summary of research

## Participating boards and schools

The analysis is based on a substantial dataset drawn from five Canadian provinces. Annual energy data were collected from 67 school boards covering a total of 234 new schools listed in Table 0-1. Thirteen boards engaged in follow-up discussions, interviews, and deeper reviews of energy, building and operational data. The resulting conclusions and recommendations are considered well-grounded in a representative cross-section of jurisdictions, operating contexts and delivery models.

*Table 0-1 Participating boards and schools*

| School board | # of schools | School board | # of schools | School board | # of schools |
|---|---|---|---|---|---|
| Abbotsford School District | 1 | Grand Erie District School Board | 1 | Pembina Trails School Division | 1 |
| Algonquin & Lakeshore Catholic District School Board | 2 | Greater Essex County District School Board | 1 | Renfrew Country District School Board | 1 |
| Annapolis Valley Regional Centre for Education | 1 | Halifax Regional Centre for Education | 6 | Seven Oaks School Division | 3 |
| Avon Maitland District School Board | 1 | Halton Catholic District School Board | 4 | Simcoe County District School Board | 7 |
| Bluewater District School Board | 1 | Halton District School Board | 4 | Simcoe Muskoka Catholic District School Board | 1 |
| Brandon School Division | 1 | Hamilton-Wentworth Catholic District School Board | 3 | St. Clair Catholic District School Board | 1 |
| Burnaby School District | 1 | Hamilton-Wentworth District School Board | 8 | Sudbury Catholic District School Board | 2 |
| Calgary Board of Education | 30 | Hanover School Division | 1 | Surrey School District | 7 |
| Calgary Catholic School District | 14 | Hastings and Prince Edward District School Board | 3 | Thames Valley District School Board | 3 |
| CECCE - Conseil des écoles catholiques du Centre-Est | 7 | Huron-Superior Catholic District School Board | 2 | Toronto Catholic District School Board | 1 |
| Chignecto Central Regional Centre for Education | 2 | Interlake School Division | 1 | Toronto District School Board | 5 |
| Conseil des écoles publiques de l'Est de l'Ontario | 2 | Kawartha Pine Ridge District School Board | 1 | Upper Canada District School Board | 2 |
| Conseil scolaire catholique MonAvenir | 6 | Keewatin-Patricia District School Board | 1 | Upper Grand District School Board | 1 |
| Conseil scolaire de district catholique Franco-Nord | 1 | Limestone District School Board | 2 | Vancouver School Board | 3 |
| Conseil scolaire public du Nord-Est de l'Ontario | 1 | London District Catholic School Board | 1 | Waterloo Catholic District School Board | 4 |
| Conseil scolaire Viamonde | 6 | Louis Riel School Division | 1 | Waterloo Region District School Board | 7 |
| Coquitlam School District | 6 | Near North District School Board | 2 | Wellington Catholic District School Board | 1 |
| District School Board of Niagara | 4 | Niagara Catholic District School Board | 1 | Windsor - Essex Catholic District School Board | 1 |
| Division scolaire franco-manitobaine | 1 | North Vancouver School District | 2 | Winnipeg School Division | 1 |
| Dufferin-Peel Catholic District School Board | 5 | Northwest Catholic District School Board | 1 | York Catholic District School Board | 2 |

| School board | # of schools | School board | # of schools | School board | # of schools |
|---|---|---|---|---|---|
| Durham Catholic District School Board | 4 | Ottawa Catholic School Board | 3 | York Region District School Board | 8 |
| Durham District School Board | 8 | Ottawa-Carleton District School Board | 5 | **Grand Total (5 provinces, 67 school boards)** | **234** |
| Garden Valley School Division | 1 | Peel District School Board | 12 | | |

| Province | # of schools |
|---|---|
| Alberta | 44 |
| BC | 20 |
| Manitoba | 11 |
| Nova Scotia | 9 |
| Ontario | 150 |

## Benchmarking energy performance

Energy use intensities (EUIs) for the 234 schools that provided annual electricity and thermal energy consumption data are shown in Figure 0-1. Each horizontal line represents the EUI of an individual school, with electricity use shown in blue, and thermal energy in orange. All buildings are weather-normalized to Toronto conditions using a simplified but consistent methodology. Results illustrate a very wide range of performance outcomes, with the highest users having three times the energy intensity of the most efficient.

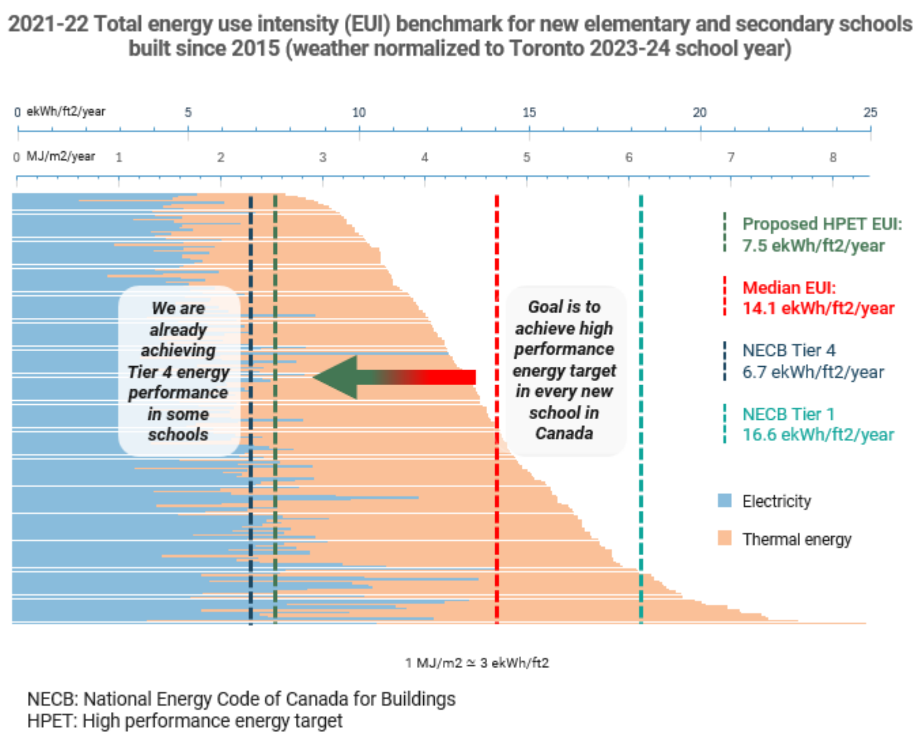



*Figure 0-1 Total energy use intensity benchmark for recently-built schools*

The red dotted line on the chart represents the median energy performance of all schools in the dataset, reflecting the current state of practice over the past decade and indicative of what is being delivered today in new school construction across Canada. The large majority of schools in this dataset have conventional heating systems, primarily gas-fired boilers, with a small number employing geothermal or other heat pump systems.

The green dotted line to the left represents the proposed high performance energy target (HPET) that is being advanced through this work, relating to the school archetype defined in Section 2 of the Guide. The target is intended to represent an achievable level of performance for all new schools, based on current codes and standards and observed best operational practices. It is comparable to Tier 4 of the National Energy Code for Buildings, indicating that this national high performance standard is within reach.

Importantly, the research indicates that schools with the highest energy performance did not incur any material capital cost premium. Our recommendations do include some upfront investment in enhanced energy modeling, metering and more rigorous commissioning processes than are typically practiced today, considered necessary to reach the high performance energy target. The analysis examined the life cycle cost implications of this investment. Using Ontario utility rates, the difference between median and high performance energy intensity yields lifetime discounted utility cost savings between $1.7 million (50,000 sf elementary school) and $6.8 million (200,000 sf secondary school), repaying many times over the recommended additional upfront costs. With Ontario electricity grid carbon forecasts, those same schools will avoid between 1,500 and 3,000 tonnes of lifetime greenhouse gas emissions.

Provincial governments are uniquely exposed to the cost of underperformance because they bear responsibility for both ends of the equation – capital funding and ongoing operating costs. A school that misses its energy performance potential represents a compounding loss of inflated utility expenditures paid year after year, for the full operational life of the building which may span fifty years or more. Such schools also place unnecessary demands on energy supply grids, adding to costs incurred for the energy transition. Provinces are encouraged to consider the Guide's recommendations in order to save energy and money, and to help meet emission targets without cost to taxpayers.

## Understanding performance gaps: what goes wrong?

The project team held many discussions with project participants about their higher-performing and underperforming schools. Six recurring factors emerged, summarized in Table 0-2, that contribute to energy performance outcomes falling short of expectations. Gaps in commissioning, handover and operations were considered particularly important and are addressed in Sections 6, 7 and 8 of the Guide.

*Table 0-2 Summary of feedback from 13 school boards in 5 provinces, Apr 2024–Nov 2025*

| # | Contributing factor | Details |
|---|---|---|
| 1 | **Lack of standardization in design and specifications** | • Outdated or inconsistent design standards or master specifications lead to inconsistent outcomes and inefficiencies. Better if the same team works on a number of projects |
| 2 | **Operational input needs to be formalized in design** | • Operators report insufficient influence during design stages, leading to systems that don't match day-to-day operational needs |
| 3 | **Commissioning (Cx) gaps** | • Inadequate scope and oversight to verify performance<br>• Missed issues, especially with controls<br>• Rigorous commissioning process (1-year + monitoring period) for newly built schools "incredibly valuable" |
| 4 | **Limited metering and data access** | • Boards lack sub- or interval metering, or data are not readily accessible |

| # | Contributing factor | Details |
|---|---|---|
| 5 | **Procurement constraints** | • P3 (public-private partnership) models can limit operational flexibility<br>• Changes in responsibility affect processes and limit board control<br>• Prequalified firms limit ability to select based on board-specific needs |
| 6 | **Training and staffing limitations** | • Insufficient performance monitoring and remedial action<br>• Limited operator knowledge and training<br>• Insufficient O&M resources<br>• System complexity exceeds capability of O&M staff |

## Project development process

With the background of Halton Catholic DSB's schools, the project team mapped out the school development process presented in Figure 0-2, from pre-planning through to ongoing operations. This process mapping helped with discussions to highlight how decisions made at different stages influence final energy performance. Calls with school boards explored where opportunities for improvement exist within this process, and where common failure points occurred leading to schools not performing as expected.

We include this diagram at the beginning of each of the Guide's sections, highlighting the project development stage that individual recommendations relate to.

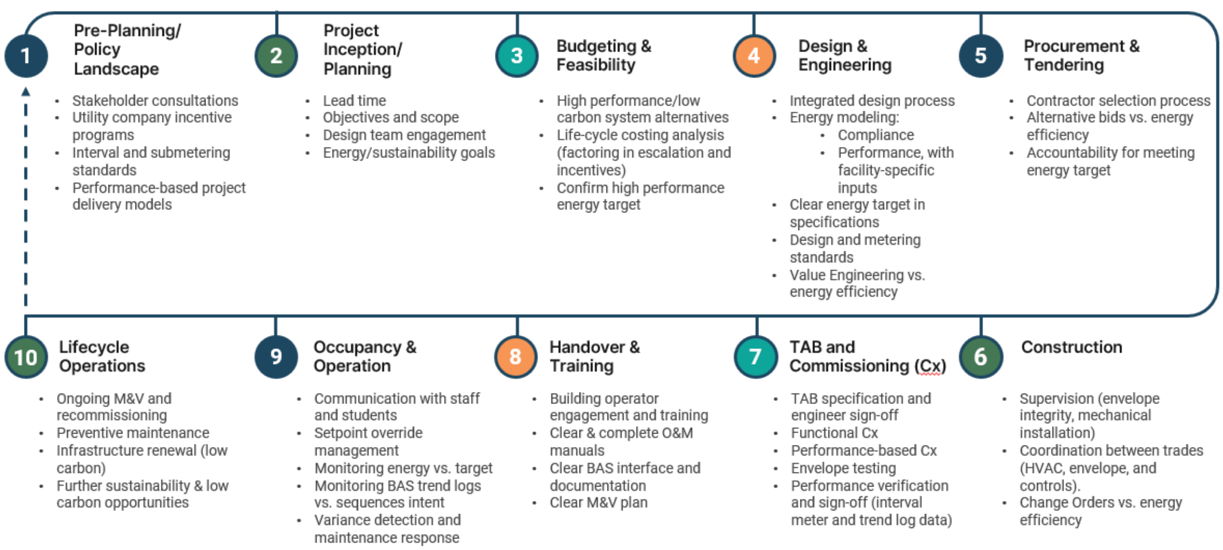



*Figure 0-2 Project development process*

## Primary conclusions and recommendations

The following evidence-based conclusions and recommendations apply to school boards, governments, project teams and utility companies across Canada. Recommendations are further expanded upon in the body of the Guide.

### Conclusions

1. We know how to build and operate highly energy-efficient new schools. The top performing schools achieve close to NECB Tier 4 without significant capital cost premium. While some advisory group participants questioned the attainability of Tier 4 in typical delivery contexts, the evidence from this research indicates that this level of performance is achievable.
2. With dozens of new schools opening each year across Canada, there is considerable potential for utility cost savings and emissions reductions.
3. Provincial governments have a strong financial interest in achieving high standards of energy efficiency:
    a. Millions of dollars in lifetime utility cost savings for the median school, with little or no incremental upfront cost.
    b. 20-30% percent reduction in peak electrical demand, avoiding unnecessary investment on the grid.
    c. Thousands of tonnes of avoided lifetime greenhouse gas emissions reductions.
4. Excessive energy use found in a majority of new schools is attributed to correctable failures at one or more stages of the development, commissioning and facility operations process.
5. The Guide presents a call to action, prompting substantial change in roles, responsibilities and development processes which can avoid missteps and deliver consistent high-energy performance for all new schools.

### Recommendations

1. Governments and school boards adopt policy, process and design standard improvements which can enable consistent high-performance outcomes in future.
2. Intervene now with new schools under development to implement and road test process improvements which can lead to better performance outcomes. Consider integrated design charettes, bringing together project, policy and operational groups to update standards and practices.
3. Take targeted remedial action now to improve existing underperforming new schools, focused on recommissioning and facility operations. Section 10 of the Guide presents an analytical process using interval meter data to identify, quantify and correct specific inefficiencies in individual schools. These projects can save energy, emissions and utility costs while helping reinforce process improvements.
4. Embed interval electric and gas/fuel metering and submetering in specifications, modelling, commissioning and ongoing facility operations as an essential foundation for achieving and sustaining high energy performance over time.

# PART B: THE GUIDE

## 1 Government policy and regulations

Figure 1-1 shows that the recommendations of this section relate to the Pre-Planning/Policy Landscape project development stage.

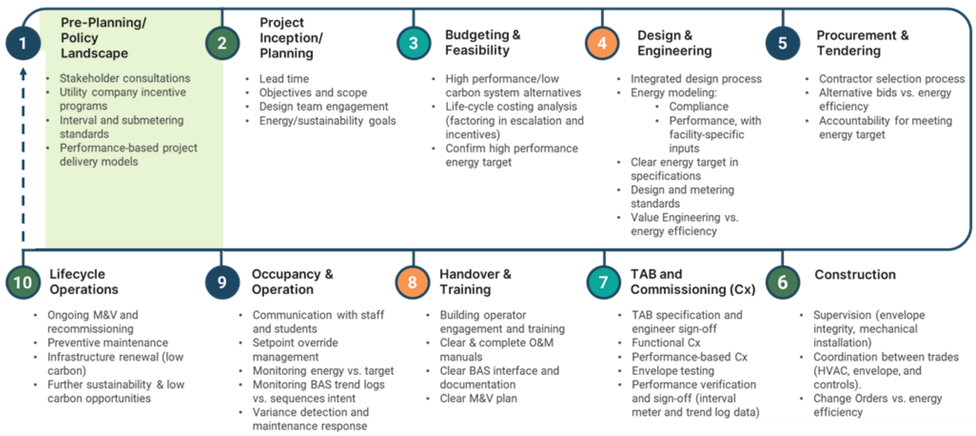



*Figure 1-1 Project development process: Pre-Planning/Policy Landscape stage*

The range of recommended policy and regulatory levers available to governments to facilitate the transition to energy efficient new schools is summarized in Table 1-1.

*Table 1-1 Policy and regulatory levers*

| # | 1. Recommendations: Government policy and regulations | |
|---|---|---|
| 1.1 | Review, adopt, update and align codes and design standards with the high performance energy target | Provincial education ministries |
| 1.2 | Require interval central and submetering | |
| 1.3 | Replicate, evaluate and continuously improve standard designs | |
| 1.4 | Develop project delivery models that reward project team integration throughout the project lifecycle and are linked to achieving the HPET | |
| 1.5 | Require the modeled energy target for every new school to meet or exceed the HPET standard in Section 2 of the Guide, with post occupancy verification | |
| 1.6 | Develop and implement performance-based modeling and commissioning standards | |
| 1.7 | Update operational directives to school boards and districts in line with the HPET | |
| 1.8 | Ensure local authorities and utility companies have the necessary resources to inspect and verify that codes and standards are met | |
| 1.9 | Introduce public reporting of building energy use data for all schools | Provincial energy ministries |
| 1.10 | Implement DSM programs for new commercial construction | |

| # | 1. Recommendations: Government policy and regulations | |
|---|---|---|
| 1.11 | Explicitly reference new commercial construction in integrated resource planning requirements | |
| 1.12 | Implement advanced metering infrastructure (AMI) for both electricity and natural gas | |
| 1.13 | Support demonstration projects and application guides to derisk transition to low energy and emissions technologies | |
| 1.14 | Further develop the NECB to incorporate empirical data with additional energy targets and archetypes | Federal government |
| 1.15 | Develop, test and promulgate performance-based modeling, energy targets and commissioning standards and specifications | |
| 1.16 | Support workforce training in high energy performance design, construction and operations | |
| 1.17 | Establish an intergovernmental advisory group to share best practices through the transition | |
| 1.18 | Establish/maintain/support municipal green standards and carbon targets | Municipal government |

## 1.1 Recommendations for provincial education ministries

Provincial governments have the most to gain from high energy performance in schools.

The provinces pay directly for new school construction, and indirectly for ongoing utility costs. The median school today is costing its province millions of dollars in unnecessary lifetime utility costs. High energy performance for every new school can be achieved without additional capital expenditure, only consistent application of proven project development processes which have been identified through this project and presented in this Guide. Thousands of tonnes of lifetime greenhouse gas emissions reductions can be delivered without cost to taxpayers.

The provinces also have the greatest influence on energy efficiency outcomes for new schools. They set the rules. Provincial policies, regulations funding models and directives to school boards play a central role in shaping financial and energy performance outcomes. Recommendations for provincial education ministries are:

- Design standards – review, adopt, update and align codes and standards with the high performance energy target. We heard from one province of a legacy design mandate from a bygone period requiring excessive outside air volumes, which is no longer relevant and needs to be removed.
- Energy metering – require interval central and submetering as described in Section 3 of the Guide.
- Proven designs – adopt Halton Catholic DSB's practice of replicating, evaluating and continuously improving proven designs.
- Project funding and delivery – develop models that reward project team integration throughout the project lifecycle and are linked to achieved performance.
- High performance energy targets (HPETs) – require the modeled HPET for every new school to meet or exceed the standard in Section 2 of the Guide, and to be verified through commissioning, handover and ongoing facility operations.
- Performance based modeling and commissioning – develop and implement standards as described in Sections 4 and 6 of the Guide.
- Operational directives – consistent with current ASHRAE guidance, avoid excessive HVAC run times and local controls overrides which were regularly found to drive unnecessarily high energy consumption.
- Compliance – ensure local authorities and utility companies have the necessary resources to inspect and verify that codes and standards are met.

## 1.2 Recommendations for provincial energy ministries

Energy ministries can also support, and benefit from, energy efficient new school construction. All provinces face enormous investments in energy supply infrastructure to meet the demands of population growth, decarbonization and electrification. The energy efficient schools profiled in Section 9 of the Guide have lower peak heating, cooling and electrical loads, placing corresponding reduced demands on the grid. More energy efficient schools can mitigate new energy infrastructure costs and related increases in consumer utility prices. Recommendations for provincial energy ministries are:

- Introduce public reporting of building energy use data to enable tracking of operational energy performance of all new schools. Ontario's Broader Public Sector (BPS) reporting and Calgary's Energy Star Portfolio Manager reporting helped greatly with this research.
- Implement DSM programs for new commercial construction to incentivize enhanced modeling and commissioning, and reward achievement of high energy performance standards. Appendix 1 provides an overview of current programs, with the Fortis BC Commercial New Construction program coming closest to meeting this recommendation. We consider this type of programming to be a necessary bridge for building owners and industry transitioning to the new processes recommended in the Guide.
- Explicitly reference new commercial construction in integrated resource planning requirements, enabling investment in load reduction which can avoid energy supply infrastructure costs.
- Implement advanced metering infrastructure (AMI) for both electricity and natural gas, to enable province-wide adoption of the interval data analytics for all new and existing commercial buildings profiled in Section 9 of the Guide. Most provinces have interval metering for electricity. Only Fortis BC is known to be implementing AMI for natural gas.
- Support demonstration projects and application guides to derisk transition to low energy and emissions technologies including heat pumps, thermal energy networks and energy storage.

Provinces should also lead the industry training, demonstration and support necessary to implement the recommendations of the Guide. The recommendations represent a substantial shift in how new schools come into being, involving new practices, tools, roles and responsibilities. While these changes are common across the country, applications, regulatory environments and economics vary between provinces. New methods will take practice, and will be refined over time. School board/industry hands on training charettes are recommended, bringing all parties together to address remedial action for the many underperforming new schools, and introduction of process changes for new schools currently under development.

## 1.3 Recommendations for the federal government

The federal government also has a major role to play in bridging the pathway from current practice to the consistently energy efficient new school future. This Codes Acceleration Fund (CAF) funded research, for schools and the other building types being studied, demonstrates that current processes are generally failing to deliver energy efficient buildings. Failures are identified, not in technologies or capital costs, but in a fragmented development and delivery process using outdated practices and focused on first cost reductions rather than fietime costs and performance. The transition to an integrated performance based process is akin to the introduction of Leadership in Energy and Environmental Design (LEED) rating system in the early 2000s, which gave rise to integrated design principles and fundamental changes to the new commercial construction delivery process. We recommend the following actions for the federal government to help enable this transition:

- Further develop the NECB to incorporate empirical data with additional absolute energy targets and archetypes.
- Develop, test and promulgate performance based modeling, energy targets and commissioning standards and specifications.
- Support workforce training in the knowledge, skills and outcomes arising from this research.

- Establish an intergovernmental advisory group, similar to the informal group which guided this research, to share best practices through the transition.

## 1.4 Recommendations for municipalities

Municipal leadership can also contribute to energy efficient schools, and to replicating best practices across communities. A large number of Canadian regions, cities and towns have committed to emissions reduction targets and are working to improve energy efficiency of their own buildings. Where permitted by their provincial legislation, municipal green standards (with target EUIs) and carbon targets are serving to raise awareness, promote best practices and unite communities around a shared concern for climate action.

# 2 High performance energy target (HPET)

Figure 2-1 shows that the recommendations of this section relate to the Project Inception/Planning and Budgeting & Feasibility project development stages.

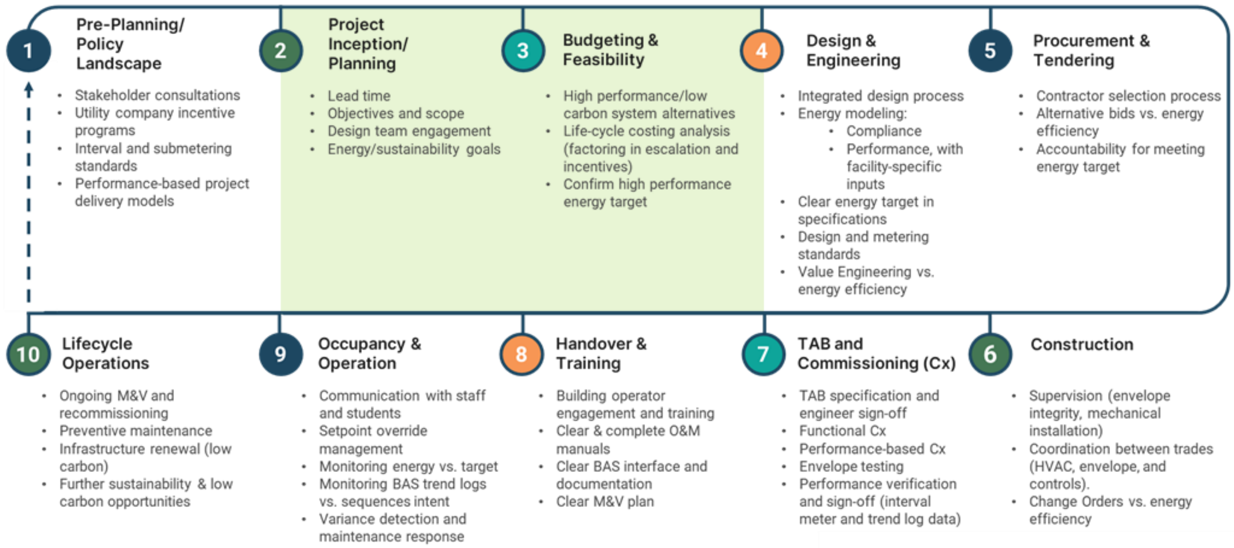



*Figure 2-1 Project development process: Project Inception/Planning and Budgeting & Feasibility stages*

High energy performance new construction begins with the energy target. Using empirical data to set the target provides confidence to all parties that it is achievable, helps identify best design, implementation and operational practices, and supports continuous improvement over time. Table 2-1 summarizes recommendations related to the high performance energy target (HPET).

*Table 2-1 HPET recommendations*

| # | 2. Recommendations: High performance energy target (HPET) |
|---|---|
| 2.1 | Adopt the empirically derived archetypal high performance energy target (HPET) proposed in the Guide |
| 2.2 | Use the energy model to adjust for project-specific weather, heating system and other variances from archetype for the individual school design, operations and weather year |
| 2.3 | Embed the HPET in project procurement, contracts and design briefs as an explicit, measurable deliverable, with assigned accountabilities |
| 2.4 | Apply climate zone adjustments (Table 2-4) and adjust for archetype variances (including portable classrooms, process loads, heating system type, solar PV) as listed in Table 2-5 |
| 2.5 | Track and report actual post-occupancy EUI against the adjusted HPET for every new school, and use variances to inform continuous improvement in design standards and operational practices |

The proposed HPET, adjusted for local weather and building-specific variances from the archetype detailed in Table 2-3, should be achievable by every new school. The HPET will be lower in milder climates, and if a school design goes beyond the archetype, for example using heat pump technology or rooftop solar.

The total energy use intensity (EUI) target of 7.5 equivalent kilowatt-hours per square foot[1] (0.29 GJ/m2), based on Toronto 2023-2024 school year weather, is broken down by subsystem in Table 2-2. The HPET is derived empirically, based on the Halton Catholic DSB schools documented in Section 9 of the Guide.

*Table 2-2 Proposed high-performance energy target (HPET) breakdown by system*

| School | Total EUI (excluding portables) | Electricity use intensities (2023-2024) - ekWh/sf | | | | | Gas use intensities (2023-2024) - ekWh/sf | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Electricity EUI (excluding portables) | Lighting | Cooling | Plug load | Pumps and fans | Gas EUI | Heating | DHW |
| **Any Zone 5 school** | **7.5** | **3.5** | 0.7 | 0.3 | 0.2 | 2.3 | **4.0** | 3.8 | 0.2 |

The HPET target relates to an archetype school with parameters described in Table 2-3. Energy modeling described in Section 4 is used to verify attainment and adjust for local weather and school-specific variances from the archetype.

*Table 2-3 HPET archetype school parameters*

| | |
|---|---|
| **Climate zone** | 5 |
| **Building area** | 74,401 sf |
| **Standard school day operating hours** | 6:00 AM to 6:00 PM |
| **Permitting hours per year** | 6% (percent additional school day operating hours based on actual permit hours multiplied by percent of school in use) |
| **Heating system** | Hydronic, gas-fired condensing boilers |
| **Air distribution** | Variable air volume air handling units (AHUs) (x2)<br>Rooftop units (RTUs) (x4) serving library, stage, and gymnasium |
| **Terminal equipment** | Series fan-powered VAV boxes with hydronic heating, standard VAV boxes for internal spaces, hydronic cabinet heaters at entrances and stairwells |
| **Cooling system** | Air-cooled chiller (scroll) – whole school air conditioned |
| **Heat recovery** | Enthalpy wheels on both AHUs |
| **Building automation system** | In place. Real-time utility monitoring (electricity, gas, water), All equipment including unit heaters controlled by BAS |
| **Lighting** | LED throughout, advanced lighting control system |
| **Domestic water heaters** | Gas-fired condensing |
| **Energy metering** | Hourly interval data for both electricity and gas, including submetering for electricity |

[1] We use equivalent kilowatt-hours per square foot (ekWh/sf) throughout the analysis as the primary EUI metric.

Table 2-4 adjusts the archetypal school HPET for different Canadian climate zones. Adjustments use a heating degree day (HDD) balance temperature of 15 degrees Celsius, determined by regression analysis of the Halton Catholic DSB's schools.

*Table 2-4 High-performance energy target for different ASHRAE/NECB climate zones and provinces, normalizing weather-sensitive components (HDD 15°C BT, CDD 10°C)*

| ASHRAE zone | NECB HDD (Base 18°C) | NECB zone | Typical Canadian cities | Total EUI (ekWh/sf) | Electricity EUI (kWh/sf) | Gas EUI (ekWh/sf) |
|---|---|---|---|---|---|---|
| 4C | < 3,000 | Zone 4 | Vancouver | 6.5 | 3.3 | 3.1 |
| 5A / 5B | 3,000 – 4,000 | Zone 5 | Toronto | 7.5 | 3.5 | 4.0 |
| 6A | 4,000 – 5,000 | Zone 6 | Halifax | 8.3 | 3.4 | 4.9 |
| 6B | 5,000 – 6,000 | Zone 6 | Calgary | 9.3 | 3.3 | 6.0 |
| 7 | 6,000 – 8,000 | Zone 7A / 7B | Winnipeg | 9.9 | 3.3 | 6.5 |
| 8 | > 8,000 | Zone 8 | Whitehorse | 11.3 | 3.2 | 8.1 |

Table 2-5 lists additional adjustments to be incorporated as needed during modeling.

*Table 2-5 Additional adjustments*

| Adjustment | Details |
|---|---|
| **Performance year weather** | Electrical distribution panels or variable frequency drive outputs |
| **Portable classrooms** | Electric or fuel heated |
| **Process loads** | Swimming pools, kitchen/canteen, sports dome, greenhouse |
| **Heating system type** | GSHPs, ASHPs |
| **Electric heat** | Based on % of school |
| **Air conditioning** | Based on % of school |
| **Solar PV** | Metered kWh |
| **School day schedule** | Operating hours |

# 3 Energy metering

Figure 3-1 shows that the recommendations of this section relate to the Design & Engineering project development stage.

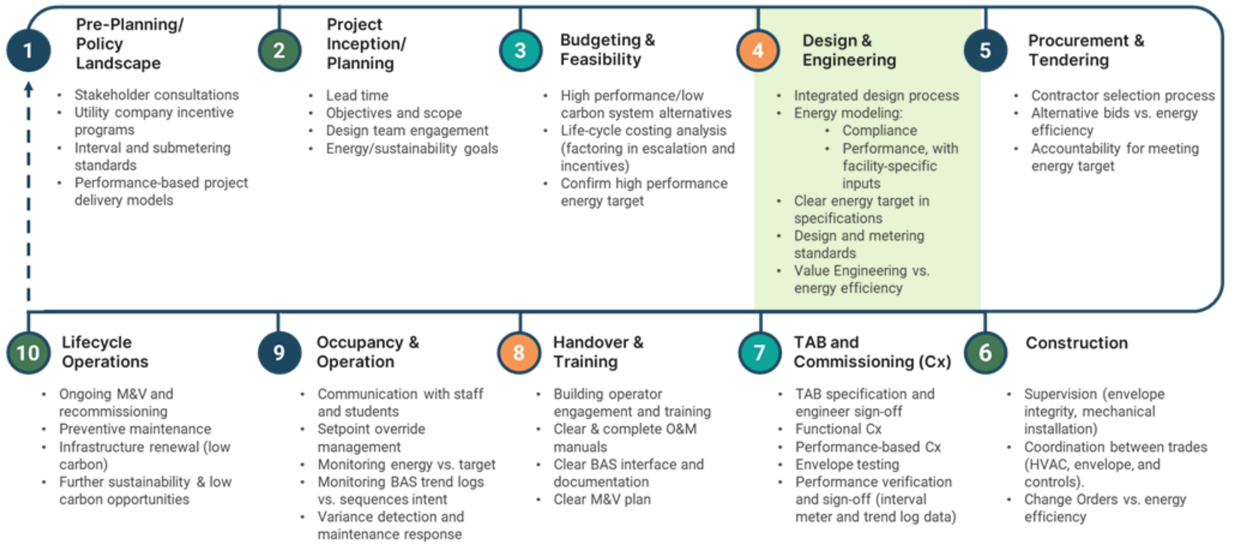



*Figure 3-1 Project development process: Design & Engineering stage*

Interval metering of electricity, natural gas and other heating fuels is a foundation of the recommendations in the Guide, considered essential to validate modeling, conduct effective commissioning and manage ongoing efficient facility operations. Metering recommendations are summarized in Table 3-1.

*Table 3-1 Metering recommendations*

| # | 3. Recommendations: Metering |
|---|---|
| 3.1 | Require central interval metering of electricity, natural gas and other heating fuels |
| 3.2 | Require submetering of main systems, including lighting and portables |
| 3.3 | Data access: ensure readily accessible and timely reporting |

## 3.1 Central electricity and natural gas/fuel metering

Central interval metering should be specified in the school design and protected from being trimmed by value engineering. Data should be readily accessible in real time and recorded in historical trend logs for use by the design team, the commissioning agent and the facility manager as soon as the school begins operations. Where available, utility company meters should be used, which may be connected to the board's data network, a third party service provider or the building automation system. Figure 3-2 shows a typical gas meter process flow to connect to BAS/EMS. For fuel oil and propane, and where utility company meters are not accessible, separate metering should be installed.

**Gas meter**
↓
**Pulse output / encoder**
↓
**Intrinsic safety barrier (Zener)**
↓
**Data logger / volume corrector**
↓
**Communication module**
↓
**EMS / BAS / utility server**

*Figure 3-2 Typical gas meter process flow to generate interval data*

As described in Sections 6 and 7, central meter interval data and resulting metrics and charts are used extensively to verify intended energy performance during commissioning, and to identify/quantify negative variances for remedial action. The graphic in Figure 3-3 illustrates how interval metering can serve as a practical diagnostic tool, providing insight into operational inefficiencies and opportunities to optimize energy use across different seasons, days of the week, and times of day. For example, evidence of higher electricity use in the middle of weekday nights than on weekends, is an area for further investigation and potential savings.

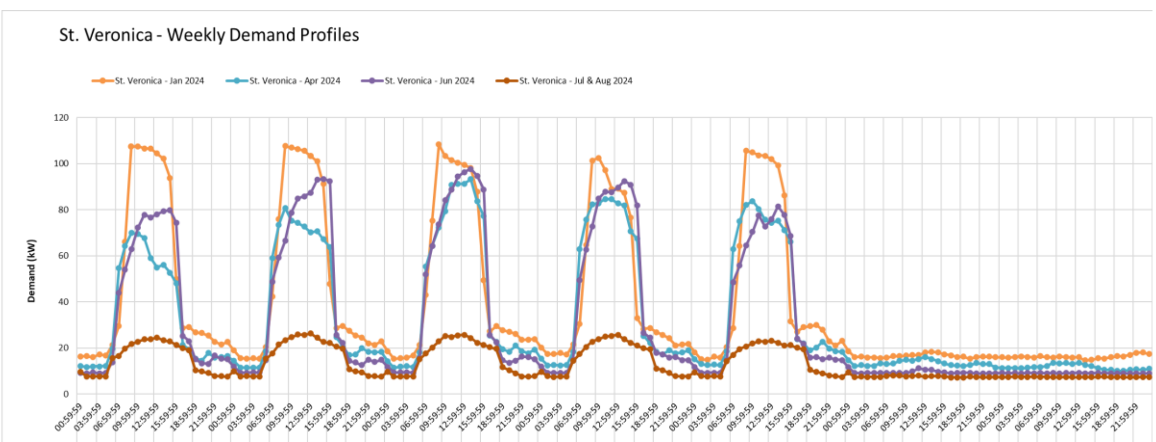



*Figure 3-3 St Veronica weekly demand profiles*

## 3.2 Submetering

Targeted submetering, using 15 minute data intervals, consistent with Natural Resources Canada and ISO50001 energy management guidance, further supports effective commissioning and ongoing operations, validates modeling and informs continuous improvement. Submetering is relatively inexpensive when addressed early in the design stage. All of Halton Catholic DSB's new schools have the recommended level of submetering presented in Table 3-2.

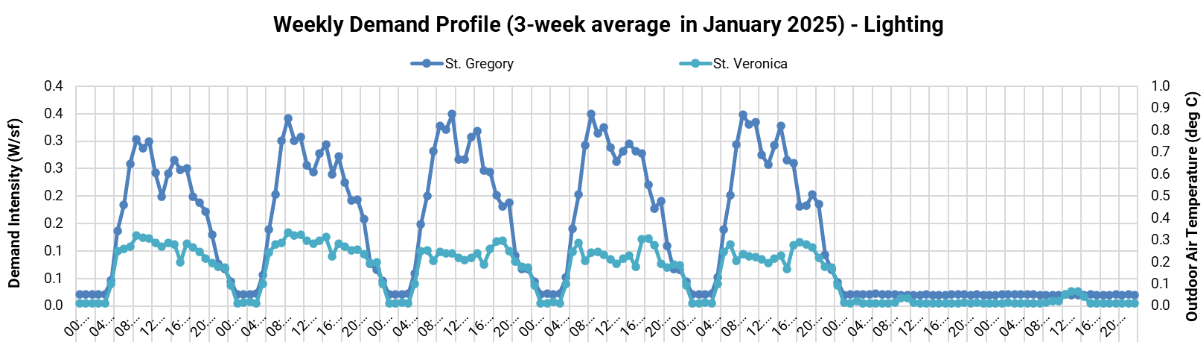
*Table 3-2 Proposed submetering standard*

| End use / system | Typical metering point | Purpose |
|---|---|---|
| **Pumps and fans** | Electrical distribution panels or variable frequency drive outputs | Track mechanical energy for air/water movement |
| **Domestic hot water (DHW)** | DHW heater or storage tank outlet | Monitor gas or electric water-heating use |
| **Lighting** | Dedicated lighting panels | Separate lighting energy from receptacle loads |
| **Plug loads / receptacles** | Select branch circuits | Characterize occupant and equipment impact |
| **Portable classrooms** | Feeder to portable distribution panel or gas line | Separate out portable classroom energy use |
| **Process loads** | Kitchen equipment, tech-shop tools, science labs, swimming pools, sports domes | Capture high-demand specialized uses that distort base EUI |
| **Renewables (PV)** | Inverter output | Verify onsite generation and net-metering impact |

## 3.3 Lighting submetering

The in-depth analysis of Halton Catholic DSB's schools included submetered lighting data for two of the schools, both 100% LED but having different lighting control systems. Figure 3-4 shows electrical profiles for a 3-week period in January, illustrating dramatic differences in peak demand and consumption due to the advanced lighting controls at St. Veronica with daylight sensing and motion/occupancy sensors in addition to time scheduling. This analysis enables tuning of schedules and controls and also makes the business case for advanced lighting controls, serving as a practical example of the value of submetering in achieving and maintaining high energy performance at the system level in schools.

*Figure 3-4 St Gregory and St Veronica weekly lighting demand profiles*



# 4 Energy modeling

Figure 4-1 shows that the recommendations of this section relate to the Design & Engineering project development stage.

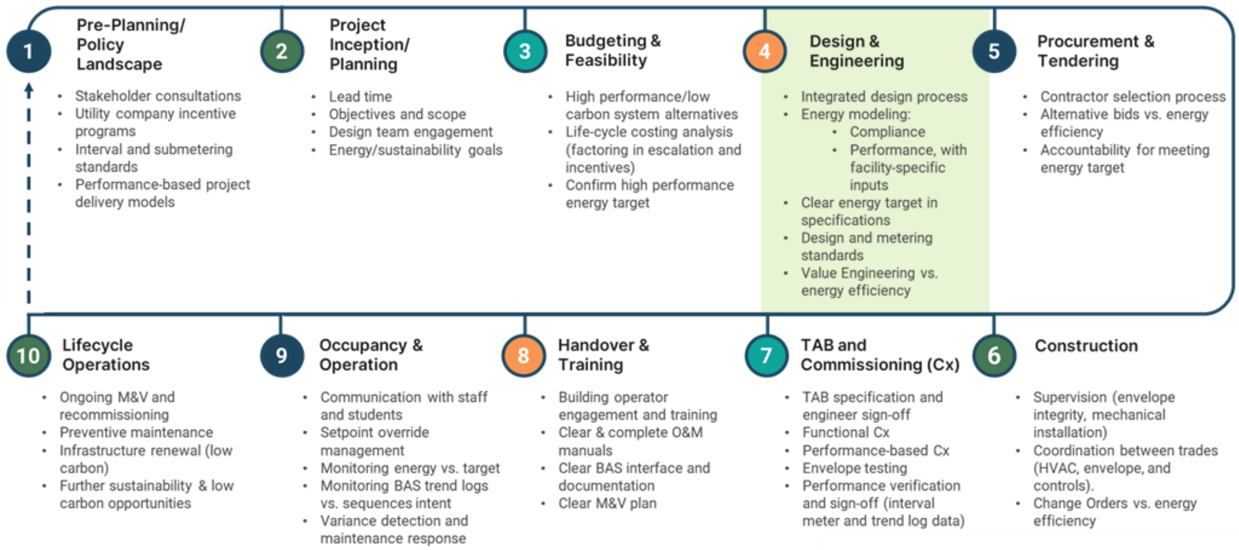



*Figure 4-1 Project development process: Design & Engineering stage*

The conclusions of this research lead to recommendations for significant enhancements to the energy modeling of new schools, summarized in Table 4-1. Adoption of performance modeling is considered necessary to establish site specific energy targets, and to set the stage for effective performance-based commissioning and achievement of the HPET.

*Table 4-1 Energy modeling recommendations*

| # | 4. Recommendations: Energy modeling |
|---|---|
| 4.1 | Adopt performance modeling to evaluate and document expected building energy performance using school-specific design and operational parameters |
| 4.2 | Require compliance modeling as the baseline for building permit, then adapt it into the performance model, avoiding a full model rebuild |
| 4.3 | Update the performance model at the as-built stage using actual weather, intended operating schedules, and as-installed equipment, creating a calibrated as-operated baseline for commissioning verification |
| 4.4 | Use the calibrated as-operated model to produce HPET verification outputs: total, electric and thermal EUI; peak demand; end-use breakdown reconciled with submeters; and scheduling/controls KPIs |

The recommended energy modeling scope of work has the following stages:

- Compliance modeling using standard energy code design and operational assumptions. Required for building permit.
- Performance modeling (design) replacing energy code assumptions:
  - Version 1 based on the HPET archetype school to verify target attainment.
  - Version 2 with adjustments for school specific design and operations.
- Commissioning to confirm operational interval meter data profiles match the version 2 model.
- Performance modeling (operation) to adjust the version 2 model to as-built equipment and operations.

**Design phase**
**↓**
**Compliance modeling**
**↓**
**Performance modeling (design)**
**↓**
**Construction and commissioning**
**↓**
**Building operation**
**↓**
**Performance modeling (operation)**

Table 4-2 summarizes the key differences between compliance modeling, performance modeling at the design stage, and performance modeling at the as-built/operated stage.

*Table 4-2 Compliance modeling compared with performance modeling at design and validation stages*

| Aspect | Design / compliance modeling | Performance modeling (design stage) | Performance modeling (validation stage) |
|---|---|---|---|
| **Primary purpose** | Demonstrate compliance with energy codes + permitting requirements. | Evaluate expected performance using project-specific design and schedules. | Update the design-stage model with actual operational inputs – creating a calibrated "as-operated baseline". |
| **Data source** | NECB/ASHRAE prescriptive values, standard schedules, generic loads. | Design documents, equipment submittals, board standards. | Actual BAS trend logs, interval meters, measured schedules, real plug loads, as-installed equipment performance. |
| **Schedules and loads** | Standardized (code-defined) occupancy, lighting, plug loads. | Board standard school-day hours, permitting assumptions, process loads. | Actual schedules (start/end times, weekend/holiday use, permitting hours), actual plug/lighting load patterns from interval/submeter data. |
| **HVAC and controls** | Standard sequences per code models; simplified HVAC logic. | Intended sequences of operation for AHUs, VAV/FPB, boilers, chillers, ERVs; modeled reset strategies. | Update to match any modifications in BAS programming. |
| **Equipment performance** | Default efficiencies from code. | As-specified equipment from design: capacities, efficiencies, ERV effectiveness, fan power limits. | Update only where needed: as-installed efficiencies, fan curves, pump operation, real ERV performance – *no rebuild of the model required.* |
| **Weather file** | Typical Meteorological Year (TMY). | TMY (for comparability). | Replace with actual operating weather year (AOWY) to allow calibration. |
| **Outputs** | Baseline vs "proposed" compliance metrics; code % improvement. | Expected EUI, end-use breakdown, heating/cooling loads, peak demand profiles. | Updated, "as-operated" model ready for calibration using interval electricity/gas data. |

| Aspect | Design / compliance modeling | Performance modeling (design stage) | Performance modeling (validation stage) |
|---|---|---|---|
| **Role in HPET verification** | None – cannot be used for HPET verification. | Confirms that design meets or is close to HPET under modeled conditions. | Provides the bridge between modeled expectations and actual operation; enables calibrated model + end-use verification. |
| **Work required** | Original model for code compliance. | Adapted from compliance model. | Minimal updates. Only update for weather and unalterable changes to schedules, programming, and equipment performance. |

Performance model (operation stage) outputs are:

- Normalized Mean Bias Error and Coefficient of Variation of the Root Mean Square Error (primary calibration metrics).
- Total, electric and thermal EUI (actual vs. HPET target).
- Peak demand for electricity, heating, cooling and natural gas.
- End-use energy breakdown (lighting, fans/pumps, cooling, heating, DHW), reconciled with submeter data.
- Scheduling and controls KPIs (occupied/unoccupied loads, ventilation schedules, outside air volumes, setpoints).
- Weather-sensitive KPIs (HDD/CDD slope, balance point temperatures).
- Load-shape and day-type correlations (weekday/weekend/holiday alignment) used for performance commissioning and post-occupancy verification.

# 5 Building system design

Figure 5-1 shows that the recommendations of this section relate to the Design & Engineering as well as Procurement & Tendering project development stages.

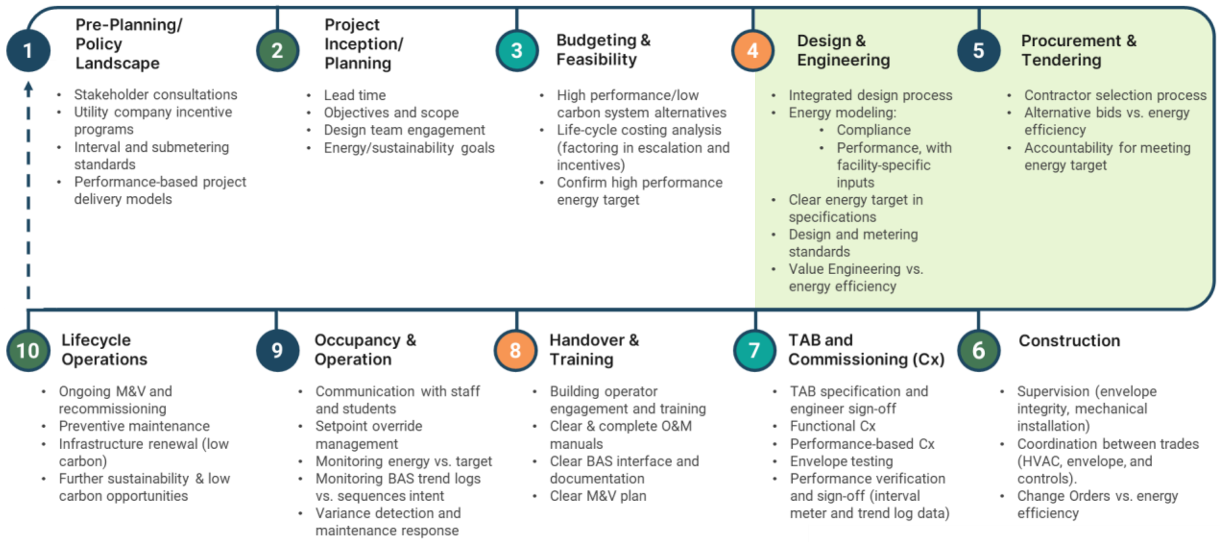



*Figure 5-1 Project development process: Design & Engineering and Procurement & Tendering stages*

Alternative design solutions can meet the HPET. Guide recommendations summarized in Table 5-1 are limited to a number of “design for operations” factors requiring coordination between school boards and project teams, and four other areas which are sometimes overlooked: demand-controlled ventilation, enthalpy wheel heat recovery, building envelope performance and programmable lighting controls.

*Table 5-1 Building system design recommendations*

| # | 5. Recommendations: Building system design |
|---|---|
| 5.1 | Design for operations: HVAC zoning for partial/variable occupancy, independent units for spaces with different operating hours, user-friendly BAS controls, and maintainability features |
| 5.2 | Demand-controlled ventilation with air balancing, right-sized and well sealed outside air dampers, monitoring inputs for outside air control, and partial-occupancy modes |
| 5.3 | Enthalpy wheel heat recovery: reclaim heat and humidity from all exhaust airflows to precondition all outside air makeup |
| 5.4 | Building envelope performance design specifications: include an explicit air leakage target, mandatory whole-building airtightness testing, and close coordination between envelope, HVAC, and mechanical design teams |
| 5.5 | Programmable lighting controls, including daylight sensing and occupancy sensors |

## 5.1 Design for operations

The following design considerations are recommended to facilitate ongoing energy efficient operations:

- HVAC system zoning:
    - Shutoff terminal devices for areas of the school intended for partial occupancy during school days, permitting, school holidays and closures and PA days, with corresponding fan turndown capacities and building automation system (BAS) programming.
    - Provision for areas intended for temporary high occupancy during special events, typically auditoriums and gymnasia.
- Independent HVAC units for daycares and other spaces having significantly different operating periods than the rest of the school.
- User friendly controls:
    - Intuitive BAS user interface.
    - Pre-configured trend logs for troubleshooting.
    - Clear documentation of operating sequences.
    - Priority reporting of alarms.
- Build for maintainability:
    - Accessible dampers, coils, filters, valves, strainers, sensors.
    - Logical equipment layouts, graphics and tagging.

## 5.2 Demand-controlled ventilation

Conditioning of outside air is typically the biggest energy user in Canadian schools, and close control of outside air volumes during school days and partial occupancy periods is required. Recommendations are:

- Precise air balancing to ensure proper supply/return/exhaust airflows.
- Right-sized and well-sealed outside air dampers.
- Airflow stations and CO2 monitoring inputs to outside air control programming.
- Partial-occupancy modes across all school HVAC systems to enable selective zone operation and optimized outside air delivery.

## 5.3 Enthalpy wheel exhaust air heat recovery

Reclaiming heat and humidity from all exhaust airflows to precondition all outside air makeup reduces peak heating and cooling demand as well as energy use. It also elevates indoor relative humidity levels in heating season to improve occupant comfort and health.

## 5.4 Envelope performance design requirements

Envelope design choices (form factor, assemblies, thermal bridging, detailing, QA/QC) drive envelope performance. Getting the envelope right will minimize heating and cooling loads as well as peak demand. Critically, envelope deficiencies are among the hardest to correct after construction. NECB 2020 currently does not mandate whole-building airtightness testing, however, it is included as an optional compliance path.

Our recommendations are based on the approach that Nova Scotia Department of Public Works is taking to whole-building envelope specification and testing. The department has shared case studies of several recently built schools. Their testing recorded heating energy use due to infiltration ranging from 17.5 to 39.8 kWh/m2, indicating some envelopes leaking twice as much as others. These values represent up to 22% of the HPET – a significant share of the overall energy target. Building form factors (envelope area/GFA) varied from 1.11 to 2.47, with higher form factors increasing conduction and infiltration-driven heat losses. Thermal bridging can significantly reduce effective insulation performance. Experience from recent school projects identified effective wall insulation values as low as R-12 to R-14 for assemblies with nominal insulation values of approximately R-24. Thermal bridging should be considered during energy modelling and envelope design, particularly at parapets, roof-to-wall transitions, floor slabs and window interfaces.

Design specifications should include an explicit air leakage target, mandatory whole-building airtightness testing, and close coordination between envelope, HVAC, and mechanical design teams. Particular attention should be paid to window interfaces, which are often significant sources of thermal bridging and air leakage.

*Table 5-2 Envelope testing – Nova Scotia case studies*

| School | Leakage coefficient C (lps/Pa$^n$) | Flow exponent (n) | lps/m2 (5 Pa) | lps/m2 (75 Pa) | Form factor | Infiltration EUI (kWh/m2) |
|---|---|---|---|---|---|---|
| **J.L. Ilsley** | 598.2 | 0.597 | 0.104 | 0.521 | 1.11 | 17.5 |
| **Breton** | 827.8 | 0.649 | 0.134 | 0.759 | 1.53 | 34.3 |
| **Wedgeport** | 454.6 | 0.604 | 0.123 | 0.633 | 2.47 | 35.4 |

## 5.5 Lighting controls

As noted in Section 3.3 Lighting submetering, comparison of submetered lighting data from two schools, both with 100% LED lighting, showed that advanced lighting controls made a dramatic difference in both electricity consumption and peak demand. Programmable controls, including daylight sensing and motion sensors, are recommended, with the following strategies:

- Common lighting control platform across all board schools.
- Daylight harvesting in classrooms, corridors, and common areas.
- Occupancy sensors in all spaces.
- Lighting schedules integrated with BAS.
- Commissioning using dataloggers on individual panels and light-level meters.

# 6 Testing and balancing (TAB), commissioning

Figure 6-1 shows that the recommendations of this section relate to the TAB and Commissioning project development stage.

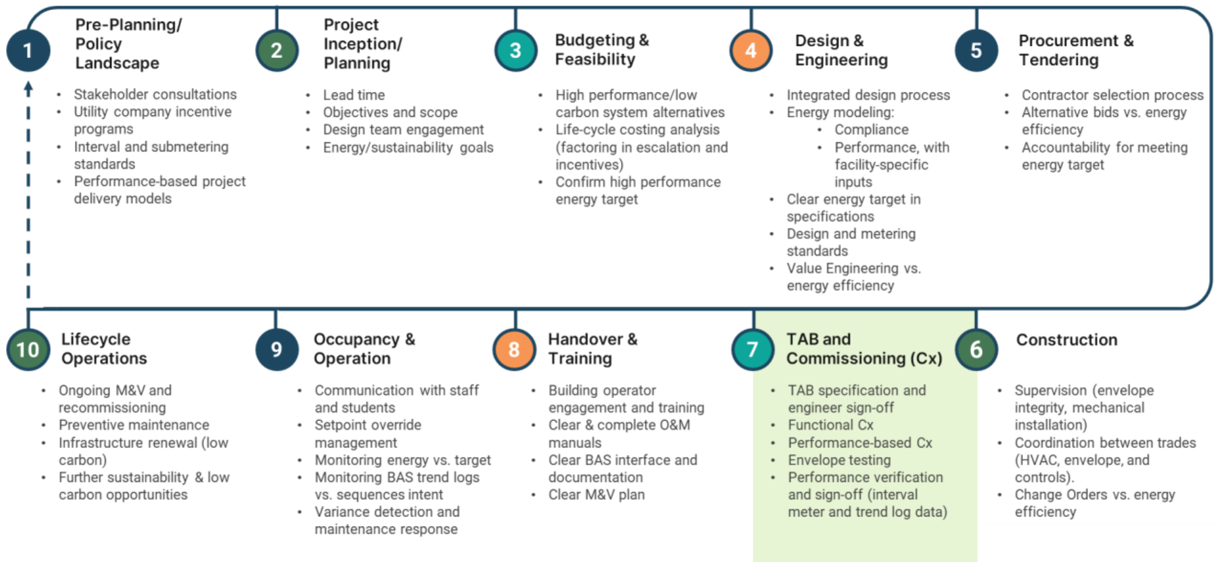



*Figure 6-1 Project development process: TAB and Commissioning stage*

Proper testing, balancing and commissioning of individual building systems, and of how they work interactively to deliver required performance outcomes, were most often cited as success factors in high energy performing schools and causes of failure in underperforming schools. Recommendations in Table 6-1 include the role, responsibilities and procurement of the commissioning agent. We also propose extended, performance-based testing, balancing and operational verification, going beyond functional commissioning to check attainment of individual system performance and energy use measured at the building meters.

*Table 6-1 TAB and Commissioning recommendations*

| # | 6. Recommendations: TAB and commissioning |
|---|---|
| 6.1 | Commissioning agent to be procured based on knowledge of the school board and positive past experience |
| 6.2 | Commissioning agent to be engaged at the outset in decisions relating to energy modelling, design, value engineering, change orders, handover and operator training, with focus on and responsibility for the energy target |
| 6.3 | TAB specification to include engineer sign-off confirming TAB performance indicators including airflows, static pressures and fan power |
| 6.4 | TAB KPI report to be reviewed with the testing contractor and signed off by the engineer and commissioning agent |
| 6.5 | Commissioning agent to produce an AHU performance dashboard and investigate for remedial action |
| 6.6 | Performance commissioning to verify attainment of the HPET metrics by measurement at the utility meters |
| 6.7 | Whole-building airtightness testing as part of the construction contract |

## 6.1 The commissioning agent

Commissioning of the building and its systems provides the crucial bridge between design and facility operations, verifying that individual systems and the building as a whole operate as intended and deliver the required performance outcomes, including the HPET. Specific recommendations relating to the commissioning agent are:

- Procurement based on knowledge of the school board and positive past experience. Halton Catholic DSB has used the same individual for many schools, reporting directly to the board.
- Role, responsibilities and authority – engaged from the outset in decisions relating to energy modelling, design, value engineering, change orders, handover and operator training, with focus on and responsibility for the energy target.

## 6.2 Performance-based TAB

Ventilation systems are typically the highest energy users in schools, and the most common cause of performance variances. Proper balance between supply, return and exhaust airflows is a primary determinant of occupant comfort as well as energy use. Correction of excessive static pressure losses is essential for achieving required airflows and avoiding undue electricity use.

TAB reports should be a diagnostic tool for the project engineer and commissioning agent to identify and correct deficiencies. We recommend a rigorous TAB specification, with engineer sign-off confirming TAB performance indicators including airflows, static pressures and fan power. Figure 6-2 shows a sample TAB KPI report which would be reviewed with the testing contractor and signed off by the engineer and commissioning agent.

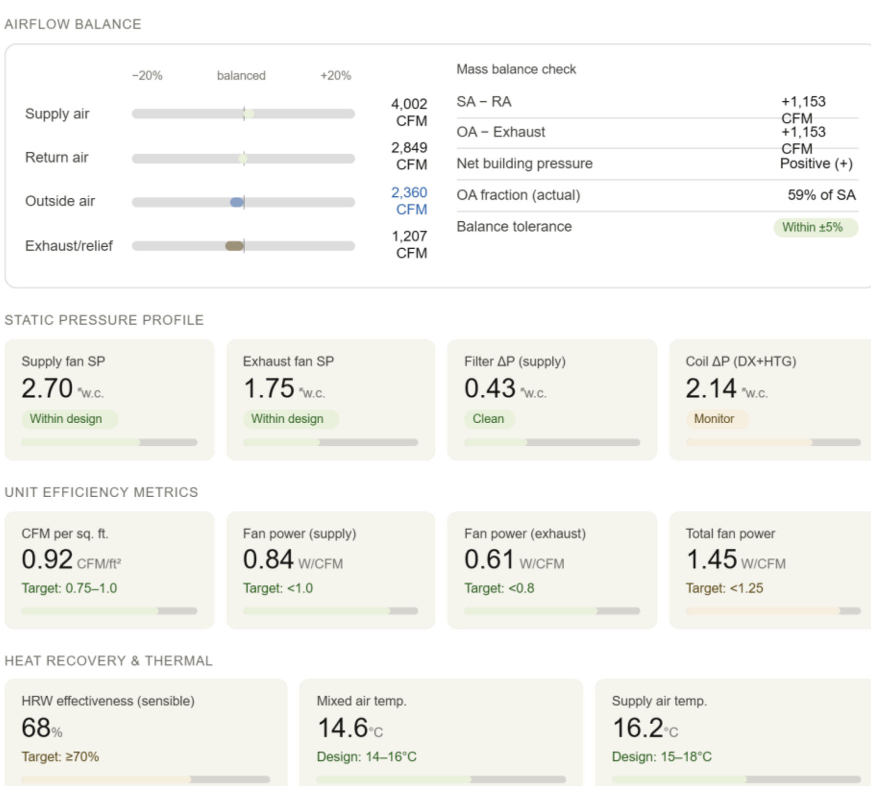
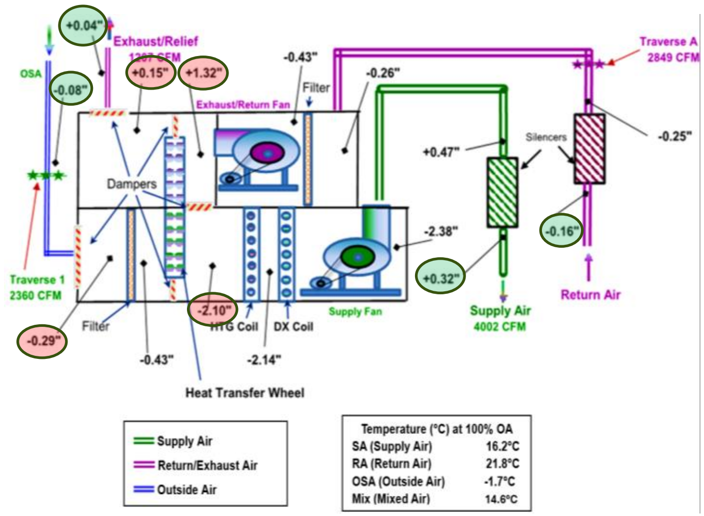



*Figure 6-2 TAB KPIs sample graphics*

Figure 6-3 presents a sample annotated test report graphic highlighting measurements which are in range, and others to be inspected and rectified. Green highlighted numbers are considered in range; the pink numbers are potentially elevated.




| # | Location / Measurement | Value | Status | Recommendation |
|---|---|---|---|---|
| 1 | Exhaust/relief air to atmosphere | +0.04" | Acceptable | No action required – slight positive pressure at exhaust is normal. |
| 2 | Outside air (OA) intake | -0.08" | Acceptable | No action required – minor negative pressure at intake is expected. |
| 3 | Supply air static pressure (downstream) | +0.32" | Acceptable | Good working pressure to feed VAV boxes or downstream distribution. |
| 4 | Return air static (downstream of silencer) | -0.16" | Acceptable | Within normal range for return side. |
| 5 | Pressure between return air fan and supply fan intake (recirculation zone) | +1.32" to -2.10" | Potentially elevated | Inspect and test the recirculation damper — the large pressure differential suggests it is stuck closed. |
| 6 | OA intake pressure drop (vs. upstream) | -0.29" | Potentially elevated | Inspect the outside air intake for blockage, fouling, or undersized ductwork causing excessive restriction. |
| 7 | Heat recovery wheel pressure drop (+1.32" to +0.15") | +1.17" differential | Potentially elevated | Inspect the heat recovery wheel for fouling, blockage, or damage. Verify pressure drop against manufacturer/design values to confirm if excessive airflow restriction is present. |

*Figure 6-3 Air handling unit test report – sample annotated schematic*

Figure 6-4 is a sample AHU performance dashboard to be produced and investigated by the commissioning agent for remedial action.

SYSTEM HEALTH SUMMARY

| Airflow accuracy | |
|---|---|
| SA vs. design | +2.1% |
| RA vs. design | −1.4% |
| OA vs. design | +0.9% |
| Tolerance met? | Yes (±10%) |

| Pressure flags | |
|---|---|
| Filter loading | Normal |
| Coil ΔP | Elevated |
| HRW ΔP | Normal |
| Building pressure | Positive |

| Fan performance | |
|---|---|
| Supply W/CFM | 0.84 |
| Total W/CFM | 1.45 ↑ |
| HRW effectiveness | 68% ↓ |
| Overall status | 2 flags |

*Figure 6-4 Sample AHU performance dashboard*

## 6.3 Functional and performance commissioning

We recommend going beyond normal functional commissioning which verifies that individual equipment and control sequences operate as specified. Performance commissioning goes further, verifying attainment of the energy model metrics by measurement at the utility meters.

Table 6-2 summarizes the key differences between functional and performance commissioning.

*Table 6-2 Functional and performance commissioning*

| Aspect | Functional commissioning | Performance commissioning |
|---|---|---|
| **Primary objective** | Verify that equipment and systems are installed correctly and operate according to specifications. | Verify that the building achieves intended energy performance under school-specific design and operating conditions. |
| **Focus** | Individual equipment and control sequence functionality. | Whole-building operational performance and energy outcomes. |
| **Timing** | During construction and at substantial completion. | Extends into post-occupancy monitoring period (1-1.5 years). |
| **Typical activities** | Equipment start-up verification, functional tests, TAB confirmation, control sequence checks. | Inspection, monitoring interval energy data, BAS trend, load profile analysis, operational verification. |
| **Data used** | Test procedures, equipment checklists, TAB reports. | Measured data: utility meters, sub-meters, BAS trend logs, interval energy profiles. |
| **Verification metrics** | Equipment operation and control sequences meet specifications. | Energy Use Intensity (EUI), peak demand, load profiles, and operational performance match calibrated performance model. |
| **Outcome** | Confirms systems work individually. | Confirms the whole building performs as intended and meets energy targets. |

## 6.4 Envelope testing

As discussed in Section 5.4, we recommend mandatory whole-building airtightness testing as part of the construction contract. Nova Scotia's case study data shows measured infiltration EUI ranging from 17.5 to 39.8 kWh/m2 across new schools, illustrating how much variability exists even in new construction, and how significant the energy impact can be. Envelope deficiencies are among the hardest to correct after the fact; testing during commissioning is the recommended way to confirm that design requirements have been met. Infrared thermography can provide an additional level of verification. Recent school investigations have identified excessive heat loss at parapets, roof-to-wall transitions, windows, canopies and building corners which were not readily apparent through visual inspection alone.

## 6.5 Performance verification

Table 6-3 summarizes recommended HVAC system KPIs to be verified through performance commissioning.

*Table 6-3 Key performance indicators for mechanical system operations and commissioning*

| **Airside system KPIs** |
|---|
| • **Fan efficiency (W/cfm)**<br>Benchmark for AHU/RTU performance; identifies dirty filters and poor balancing<br>• **Ventilation OA fraction vs. schedule**<br>Confirms DCV, heat recovery, and ventilation control logic<br>• **FPB/VAV box runtime and supply airflow**<br>Detects rogue terminal boxes and excessive reheat<br>• **Air handling unit supply temp reset behavior**<br>Ensures optimized heating/cooling and reduced reheat |
| **Hydronic systems KPIs (both heating and cooling)** |
| • **ΔT across hydronic systems and coils (heating and cooling)**<br>Confirms correct flow, valve modulation, and coil performance. Low ΔT usually means: excess flow, control valves stuck open, coils fouled, poor heat transfer (e.g., airside issues, low load). High ΔT usually means: insufficient flow / starvation, failed or closed valves, pump/VFD issue, blocked strainers, air in system<br>• **Boiler/chiller entering and leaving water temperatures (EWT/LWT)**<br>Validates SWT reset and staged capacity control<br>• **Pump efficiency (W/gpm)**<br>Identifies overspeed, missing VFD turndown, incorrect setpoints<br>• **Distribution loop ΔP trends**<br>Detects fouled strainers and stuck valves<br>• **ΔP reset performance (for variable speed pumping)**<br>Confirms differential pressure setpoint resets based on actual valve positions à reduce pump energy use |
| **Heat recovery KPIs** |
| • **Enthalpy wheel effectiveness**<br>Verifies proper operation and captures degradation/failure<br>• **Bypass vs recovery mode runtime**<br>Detects controls issues that increase heating load |
| **Heating and DHW system KPIs** |
| • **Boiler % firing vs outdoor temperature**<br>Confirms modulation sequencing and correct heating slope<br>• **Hydronic loop SWT reset curve adherence**<br>Key driver of high heating efficiency<br>• **DHW system**<br>DHW energy use (ekWh/sf) |
| **Cooling system KPIs** |
| • **kW/ton**<br>Tracks real cooling efficiency and identifies fouled condenser coils<br>• **Compressor staging vs. cooling load**<br>Verifies capacity control and avoids short-cycling |

# 7 Facility operations

Figure 7-1 shows that the recommendations of this section relate to the Occupancy & Operation as well as the Handover & Training project development stages.

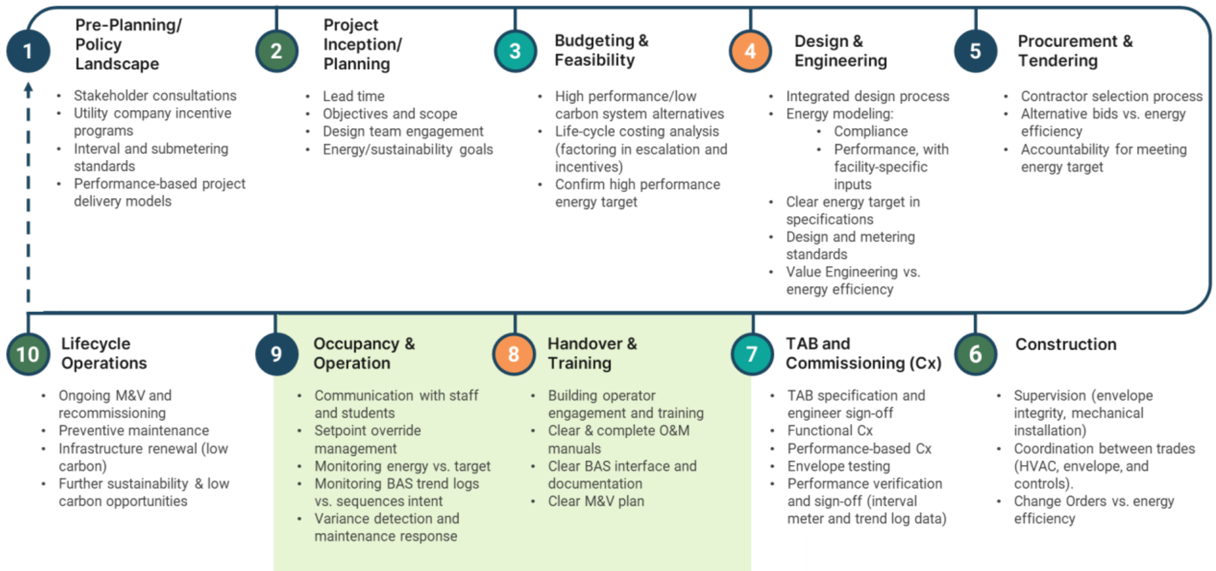



*Figure 7-1 Project development process: Occupancy & Operation and Handover & Training stages*

Operational practices were found to vary significantly between school boards, accounting for a large part of the energy performance differences between participating schools. Halton Catholic DSB is known for exceptional energy efficient operations. They are consistently ranked number one in the Sustainable Schools annual reporting on Ontario's 72 school boards. Recommendations summarized in Table 7-1 are primary factors found to differentiate high energy performing school boards.

*Table 7-1 Facility operations recommendations*

| # | 7. Recommendations: Facility operations |
|---|---|
| 7.1 | Implement and monitor unoccupied and partial occupancy HVAC scheduling |
| 7.2 | Monitor outside air volumes through the building automation system (BAS) and retest air handling systems periodically |
| 7.3 | Adopt continuous commissioning, with a standard set of KPIs for HVAC system operation covering airside systems, hydronic systems, heat recovery, heating and DHW, and cooling |

Critical success factors for energy efficient operations are:

- Scheduling – ensuring HVAC systems, lighting and plug loads are turned off or down when the school or areas within the school are unoccupied or only partially occupied. This extends to school days, holidays, PA days and permitting periods.
- Outside air volume monitoring and control – in Canadian climates, conditioning of outside air makeup is the largest component of energy use. Monitoring outside air volumes through the building automation system (BAS) and periodic retesting of air handling systems as described in Section 6.2 help ensure proper ventilation for occupant health and comfort as well as efficient energy use.

- Continuous commissioning – Halton Catholic DSB and other top performing boards make extensive use of energy data reporting, BAS trend logs, maintenance staff engagement and facility renewal projects for continuous improvement, and to avoid performance deterioration over time. We recommend a standard set of KPIs for mechanical system operation, covering airside systems, hydronic systems, heat recovery, heating and DHW, and cooling. These metrics can be established during commissioning and carried forward as a reference baseline for the ongoing life of the building. Board staff and service contractors should check whether the building is still performing at the level it achieved when first commissioned and identify where performance has drifted or further improvements can be made.

## 7.1 Interval meter analytics and reporting

The Enbridge Gas Pay-for-Performance (P4P) DSM program in Ontario has demonstrated use of natural gas interval meter data for identifying and correcting inefficiencies and verifying operational performance over time. These analytics and resulting reports are referenced throughout the Guide, including the case study in Section 9 and the energy performance assessment process in Section 10. Continuous monitoring of electricity and gas (and water) interval meters is recommended to produce:

- School comparison profiles which identify peak demands and operational anomalies (see Figure 9-1 and Figure 9-2).
- Heat maps which verify operating schedules for all day types (see Figure 9-3 and Figure 9-4).
- Time of day metrics for comparison against other schools, and to trigger out of range alarms.

> Enbridge's Whole Building Pay for Performance (P4P) program takes a data-driven approach to improving the energy efficiency of school buildings. Over a three-year period, participating schools implement operational improvements and receive incentives for achieving annual reductions in natural gas consumption, measured at the meter.

# 8 Organizational alignment – strategic energy management

Figure 8-1 shows that the recommendations of this section relate primarily to the Lifecycle Operations project development stage.

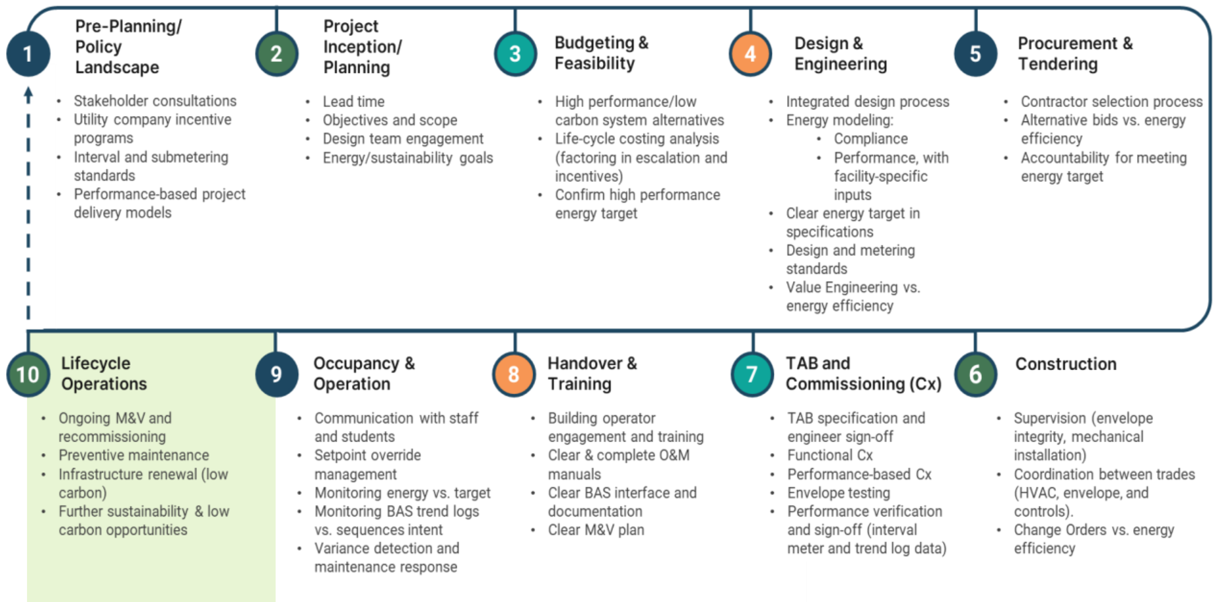



*Figure 8-1 Project development process: Lifecycle Operations stage*

Strategic energy management (SEM) refers to alignment of policies and management practices with the principles of energy efficiency, many of which are presented in the Guide. Halton Catholic DSB and other high energy performing school boards consistently demonstrate high standards of SEM. Recommendations in Table 8-1 relate to strategically important aspects of new school development and operations.

*Table 8-1 Strategic energy management recommendations*

| # | 8. Recommendations: Strategic Energy Management | |
|---|---|---|
| 8.1 | Provide direction to school boards on energy targets and practices | |
| 8.2 | Provide direction on energy efficiency standards addressing design and operational parameters for new schools and infrastructure renewal, commissioning, space temperature setpoints and HVAC operating schedules. | Provinces |
| 8.3 | Work with post-secondary institutions to develop curriculum and training for energy efficient building operations staff | |
| 8.4 | Embed high performance energy targets in development processes and operations | |
| 8.5 | Implement energy information management and reporting | School boards/districts |
| 8.6 | Make the project manager, project engineer and commissioning agent explicitly responsible for setting and delivering the HPET for each school | |
| 8.7 | Implement centralized HVAC scheduling with limited or no override authority for school staff | |

| # | 8. Recommendations: Strategic Energy Management | |
|---|---|---|
| 8.8 | Implement regular energy performance variance reporting | |
| 8.9 | Adopt energy efficiency standards addressing design and operational parameters for new schools and infrastructure renewal, commissioning, space temperature setpoints and HVAC operating schedules. | |
| 8.10 | Implement training programs to address existing staff, staff turnover and onboarding | |
| 8.11 | Inform and engage staff, students, parents and communities in energy efficient behaviour and pride in their performance | |
| 8.12 | Embed SEM practices in board policies, management and operational systems and documentation | |

The following primary recommendations reflect practices found in top energy performing school boards.

- Setting expectations. The economic and environmental benefits of energy efficient buildings, and the degree to which many new schools are falling short, indicate that energy efficient standards cannot be left to chance. We recommend that provinces provide direction to school boards on energy targets and practices, and that school boards embed high performance energy targets in development processes and operations.
- Energy information management and reporting – school boards should have energy management information systems which record, analyze and report in a timely and effective manner on utility billing, interval and submeter data.
- Development process roles and responsibilities – the project manager, project engineer and commissioning agent should be explicitly responsible for setting and delivering the HPET for each school.
- Operational roles and responsibilities:
  - Centralized HVAC scheduling: high energy performing school boards have strong building automation systems and manage HVAC scheduling centrally with limited or no override authority for school staff.
  - Energy monitoring and response to variances: school boards should implement real-time or at least monthly variance reporting with maintenance work order generation and sign off that issues causing energy increases have been corrected.
- Policies and standards – we recommend that provinces provide direction, and school boards adopt energy efficiency standards addressing design and operational parameters for new schools and infrastructure renewal, commissioning, space temperature setpoints and HVAC operating schedules.
- Operations staff development and support – provinces should work with post-secondary institutions to develop curriculum and training for energy efficient building operations, and school boards should implement training programs to address existing staff, staff turnover and onboarding.
- Communications – school boards should inform and engage staff, students, parents and communities in energy efficient behaviour and pride in the energy performance of their schools.
- Resilience and succession planning. High energy performing school boards can be over reliant on individual internal leaders and champions, risking reversals when key individuals leave the organization. SEM practices must be embedded in board policies, management and operational systems and documentation.

# 9 Case study: Halton Catholic District School Board


Located in southern Ontario, Halton Catholic District School Board has a history of high energy performance across its whole portfolio of schools. The board operates 48 elementary schools and 10 secondary schools and consistently appears at the top of the Sustainable Schools school board rankings[2]. They serve a region with high population growth, opening approximately one new school each year.

Four of this board's recently built schools form the basis for this case study. We worked closely with Steve Allum, Manager, Energy and Environmental, who was generous in helping us review energy use data and discuss the factors contributing to observed energy performance outcomes. Steve's work and experience informed both the analysis and the recommendations put forward in the Guide. Replicating and adapting the practices that Halton Catholic DSB has tested and proven over time can help all school boards and provincial governments deliver exceptional energy performance outcomes in their own jurisdictions.

## 9.1 Organizational and operational practices: what went right?

Several themes emerged from discussions with Halton Catholic DSB.

1. Strategic energy management is approached as an organizational practice rather than solely as a technical exercise, applying across both new and existing schools.
2. Real-time energy monitoring plays a significant role, supported by investment in systems and active engagement by operations staff.
3. The board maintains high building automation system standards and applies a standardized approach to sub-metering that breaks out key elements, providing sufficient detail without undue complexity.
4. HVAC scheduling is managed centrally, with no authority for custodial staff to override settings locally.
5. Continuous improvement is treated as an ongoing process, with each new school used as an opportunity to refine standards and practices for future projects.

[2] Sustainable Schools, a program of the Climate Challenge Network, has been reporting on energy efficiency of K-12 school buildings since 2007. Our data, webinars and reports provide evidence-based knowledge, and a platform for the whole sector to share, learn, make improvements and track progress over time. The program's data analytics are designed to provide the foundation for each board to begin mapping its own practical pathway to utility cost savings and emissions reductions. Our latest results and resources are available at https://sustainableschools.ca/publications/.

6. The board contracts with a dedicated commissioning agent who works on every school project and is familiar with the board's systems and expectations.
7. The operations team is involved from the earliest stages of new school development, a critical factor for seamless handover and achieving/maintaining high energy performance.
8. The board's construction management process hires and manages sub-trades directly, with cost savings used to support selection of preferred equipment.

## 9.2 School profiles

The four Halton Catholic DSB schools are located in Ontario, west of Toronto. All four use natural gas-fired condensing boilers as their primary heating source, with gas-fired domestic hot water (DHW) systems. Two have daycares. They have LED lighting throughout with varying standards of lighting controls. The board's standard school day operating hours are from 6:00 am to 6:00 pm. All four schools are equipped with interval meters for both gas and electricity, and electricity submetering for portable classrooms and lighting. Most fans are controlled through variable air volume (VAV) systems, while pumps are equipped with variable frequency drives (VFDs). Exhaust air heat recovery systems are installed in all 4 schools. School details are summarized in Table 9-1.

*Table 9-1 Halton Catholic DSB's high-performing new schools*

| School | Details and HVAC systems |
|---|---|
| **St. Gregory the Great (elementary), Oakville, Ontario** | General info:<br>• 78,544 sf, 775 students<br>• 5 portable classrooms (electric heat; submetered)<br>• Interval gas and electricity metering<br><br>Main heating/cooling systems:<br>• Heating: condensing boilers + VAV system with SFPB and hot water reheat coils<br>• Cooling: Air-cooled scroll chillers<br><br>Systems:<br>• Condensing boilers x2<br>• AHU with energy recovery wheel (heat wheel non-functional since 2024)<br>• Mainly Series fan-powered boxes with hydronic reheat<br>• RTAC x4<br>• ERV x1 (childcare)<br>• LED lighting (submetered)<br>• Gas-fired DHW<br><br>Daycare: 7,212 sf; RTU and electric resistance heaters<br><br>Operations:<br>• 6:00 am to 6:00 pm<br>• RTUs scheduled based on occupancy |
| **St. Scholastica (elementary), Milton, Ontario** | General info:<br>• 74,401 sf, 920 students<br>• 10 portable classrooms (electric heat; submetered)<br>• Interval gas and electricity metering<br><br>Main heating/cooling systems:<br>• Heating: condensing boilers + VAV system with SFPB and hot water reheat coils<br>• Cooling: Air-cooled scroll chillers<br><br>Systems:<br>• Condensing boilers x2 |

| School | Details and HVAC systems |
|---|---|
| | • AHU x2<br>• Mainly Series fan-powered boxes with hydronic reheat<br>• RTAC x4<br>• ERV x2<br>• LED lighting (submetered)<br>• Gas-fired DHW<br><br>Operations:<br>• 6:00 am to 6:00 pm<br>• RTUs scheduled based on occupancy |
| **St. Nicholas (elementary), Oakville, Ontario** | General info:<br>• 56,338 sf, 605 students<br>• 2 portable classrooms (electric heat; submetered)<br>• Interval gas and electricity metering<br><br>Main heating/cooling systems:<br>• Heating: condensing boilers + VAV system with SFPB and hot water reheat coils<br>• Cooling: Air-cooled scroll chillers<br><br>Systems:<br>• Condensing boilers x2<br>• AHU x2<br>• Mainly Series fan-powered boxes with hydronic reheat<br>• RTAC x4<br>• ERV x2<br>• LED lighting (submetered)<br>• Gas-fired DHW<br><br>Operations:<br>• 6:00 am to 6:00 pm<br>• RTUs scheduled based on occupancy |
| **St. Veronica (elementary), Milton, Ontario** | General info:<br>• 74,088 sf<br>• Operated as a secondary school from 2022 to August 2024<br>• No portable classrooms<br>• Interval gas and electricity metering<br><br>Main heating/cooling systems:<br>• Heating: condensing boilers + VAV system with SFPB and hot water reheat coils<br>• Remote condensers for the AHUs<br><br>Systems:<br>• Condensing boilers x2<br>• AHU x2<br>• Mainly Series Fan-Powered Boxes with hydronic reheat<br>• RTAC x5<br>• ERV x3<br>• LED lighting (submetered)<br>• Gas-fired DHW<br><br>Daycare: 7,524 sf; RTU and electric resistance heaters<br><br>Operations:<br>• 6:00 am to 6:00 pm<br>• RTUs scheduled based on occupancy |

## 9.3 Energy use intensities

Table 9-2 summarizes energy use intensities (EUIs) for the 2023–2024 school year, with totals ranging from 7.5 to 9.6 ekWh/sf per year. The portable classrooms located at 3 of the schools are submetered, and their electricity use has subtracted from the totals.

*Table 9-2 High-performing new schools – electricity and gas intensities*

| School | Total EUI (excluding portables) | Electricity use intensities (2023-2024) - ekWh/sf | | | | | Gas use intensities (2023-2024) - ekWh/sf | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Electricity EUI (excluding portables) | Lighting (submetered) | Cooling [3] | Plug load [4] | Pumps and fans[5] | Gas EUI | Heating [5] | DHW[5] |
| St. Gregory the Great * | **9.6** | **4.4** | 1.0 | 0.3 | 0.2 | 2.9 | **5.2** | 5.0 | 0.2 |
| St. Scholastica | **7.5** | **3.5** | 0.7 | 0.3 | 0.2 | 2.3 | **4.0** | 3.8 | 0.2 |
| St. Nicholas | **7.9** | **3.4** | 1.0 | 0.2 | 0.2 | 2.0 | **4.5** | 4.3 | 0.2 |
| St Veronica [6] * | **7.7** | **3.7** | 0.4 | 0.1 | 0.2 | 3.0 | **4.0** | 3.9 | 0.1 |

* *Includes daycare*

## 9.4 Performance analysis

Using interval meter and submeter data, we conducted in-depth analysis of the 4 schools to understand the differences between them, and to validate the observed energy use intensities which form the basis for the HPET proposed in the Guide. We conclude that these schools (in particular St. Veronica) provide a valid basis for the empirical energy target proposed in the Guide and still have some limited potential for operational improvements which could achieve further savings.

**Demand profiles**

Figure 9-1 shows electric power density (Watts per sf) interval meter charts from Monday to Sunday averaged for the 3 weeks in January 2024 when the schools were fully open. The red dotted line is the mean hourly outdoor temperature over this period. Submetered electricity use by the portable classrooms has been subtracted from the data.

[3] Monthly data regression analysis
[4] Calculated from EUI of other end uses and the total EUI
[5] Estimate derived from equipment data and operation schedules/assumptions
[6] Adjusted for operating hours

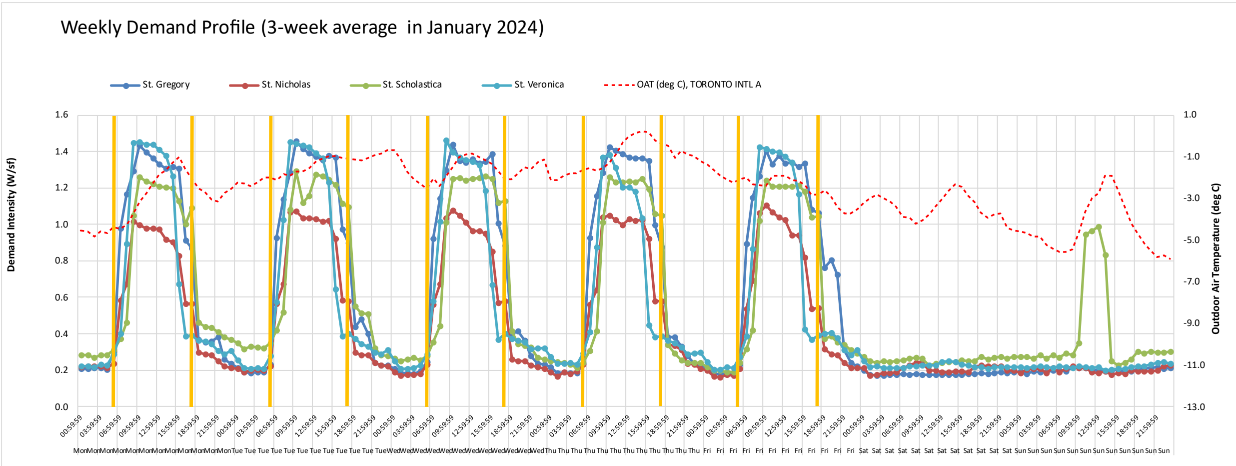



*Figure 9-1 Weekly demand profile for 4 Halton Catholic DSB schools*

The charts profile energy efficient electricity use of these schools, and also highlight some anomalies:

- 3 of the schools at 1.2-1.4 W/sf during the day but St. Nicholas significantly lower.
- Consistent overnight and weekend use around 0.25 W/sf.
- Higher use at St. Scholastica overnight on Monday-Tuesday and on Sunday.

Figure 9-2 shows corresponding gas data for the same period. In this case:

- St. Scholastica is the lowest, but again showing elevated use on Monday-Tuesday and on Sunday suggesting some extended air handling unit operation.
- St. Gregory has the highest consumption, attributed to the failed enthalpy wheel.
- Morning spikes reflect effectiveness of unoccupied space temperature setback, most pronounced at St. Nicholas.

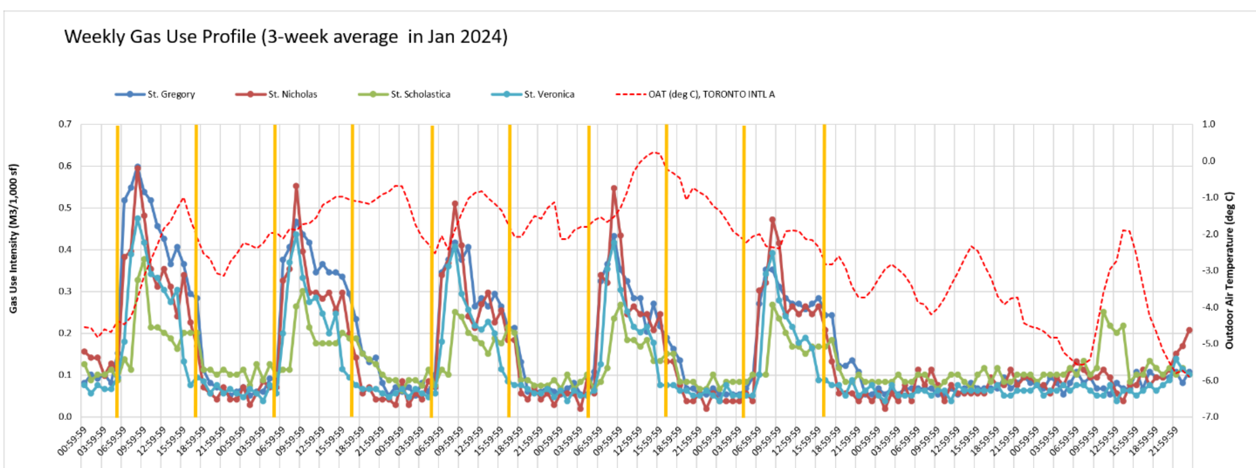



*Figure 9-2 Weekly gas use profile for 4 Halton Catholic DSB schools*

### Heatmaps

Figure 9-3 presents the electricity heatmap for the four Halton Catholic DSB schools for the period from December 23, 2023 to January 22, 2024. Each row is a day, and each column shows hourly electricity consumption for each hour from midnight to midnight. The colour gradient for the hourly values varies from green to red (low to high hourly use). The colour gradient for the outdoor temperature column on the right-hand side varies from blue to red (low to high daily minimum, median and high temperatures). Standard school day HVAC system operating hours are 6AM to 6PM indicated by the red vertical lines. Electricity use by the portable classrooms has been subtracted from the data. Figure 9-4 presents the corresponding hourly data for natural gas consumption.

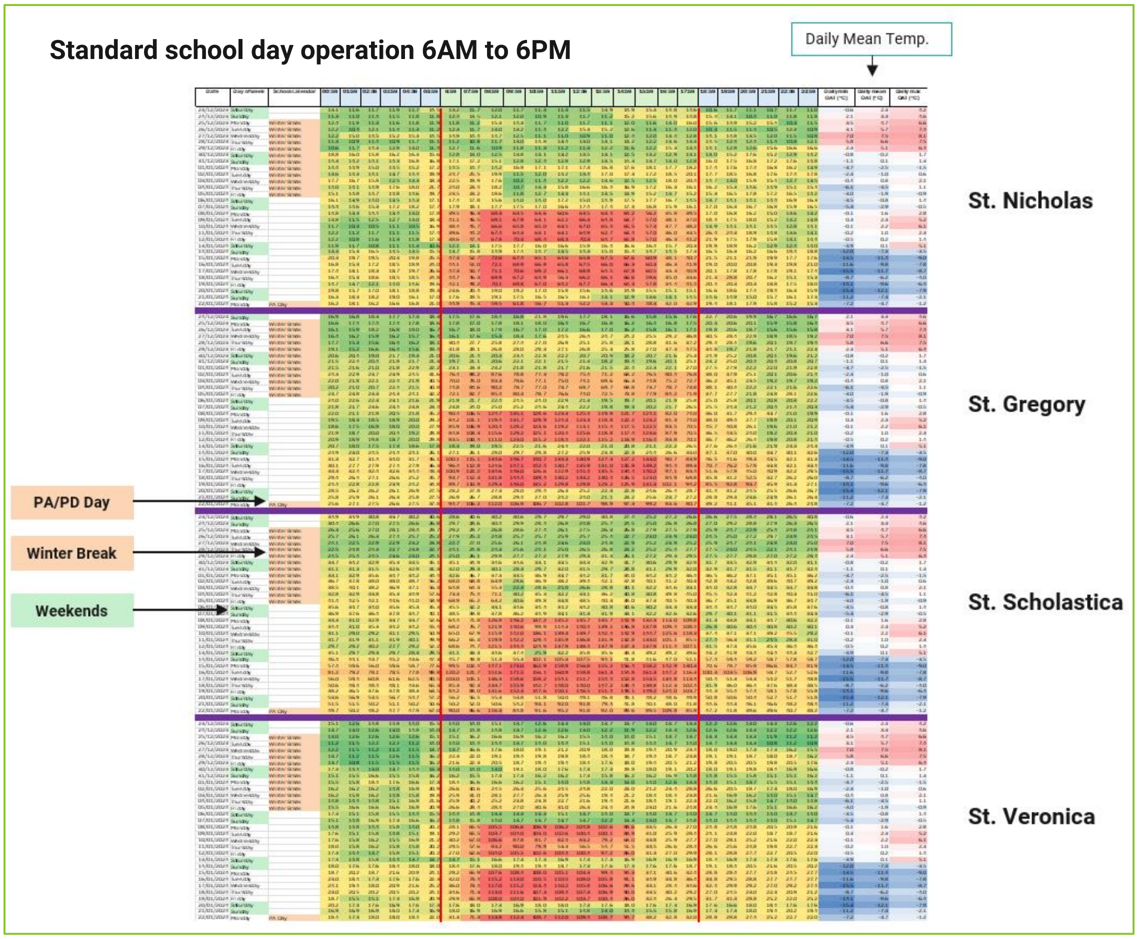



*Figure 9-3 Electricity heatmap for 4 Halton Catholic DSB schools*

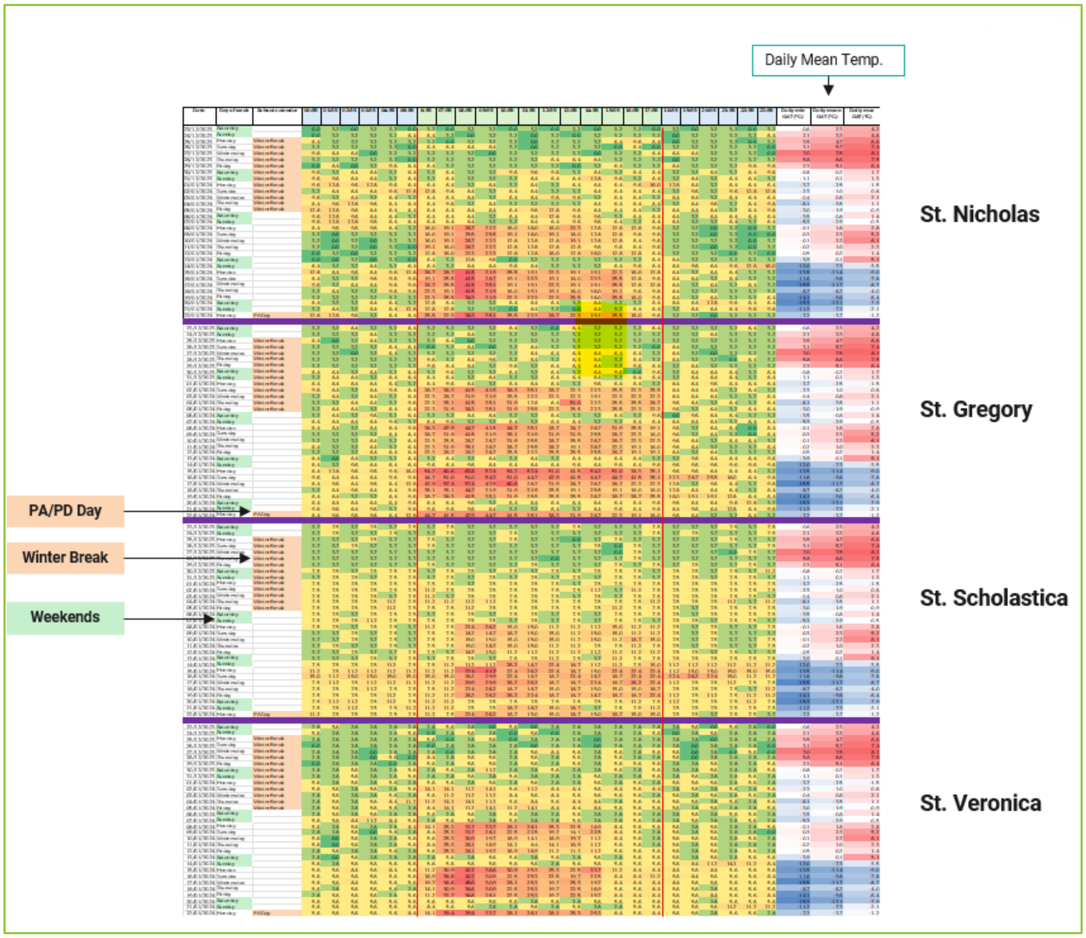



*Figure 9-4 Gas heatmap for 4 Halton Catholic DSB schools*

The heatmaps validate energy efficient operations at all 4 schools:

- Higher electricity and gas use contained within the 6AM to 6PM school day timeframe, confirming tight scheduling. Note that St. Veronica was used as a high school during this period with earlier finish times.
- Low consumption throughout the winter break indicating generally tight control. Note the morning activity for the last few days at St. Nicholas and St, Scholastica indicating caretaker presence leading up to school reopening. This activity extended for the full day at St. Gregory.
- Low consumption on weekends confirming unoccupied operation.
- Relatively high electricity use on the PA Day suggesting potential for improved operations.
- Higher overnight electricity use in cold weather, indicating some electric heat.

### Interval benchmarks

Interval metering of electricity and gas enables benchmarking (comparative examination) of energy use during different time periods. This analysis for the four schools has been used to analyze variances, and to validate HPET metrics for use in calibrating energy models and assessing performance of other schools.

Table 9-3 presents the time periods used for this analysis, together with corresponding typical measures for remedial action where actual use is higher than the HPET benchmark. The list is generic, and most of the measures are already addressed by Halton Catholic DSB.

*Table 9-3 Interval benchmark time periods and recommended measures*

| School operating period | Indicated energy efficiency measures |
|---|---|
| P1 warm up<br>(5 am – 9 am) | - Revisit optimized start programming to validate or modify<br>- Ensure OA damper closed in morning warm-up cycle |
| P2 school day<br>(9 am – 5 pm) | - Test for high OA%, consider TAB to optimize ventilation rates and fan power<br>- Ensure temperature setpoints are not overridden. Reset any manual overrides within 24hr<br>- Check for simultaneous heating/cooling during economizer operation<br>- Switch off lighting in unoccupied areas |
| P3 evenings<br>(5 pm – 11 pm) | - Update scheduling to include only lighting and equipment serving spaces in use during permitting periods<br>- All other spaces subject to setbacks. Address staff comfort concerns<br>- Reduce OA% to minimum setpoints |
| P4 unoccupied<br>(11 pm – 5 am) | - Verify scheduling, setbacks, and ensure OA dampers are closed<br>- Ensure all interior and exterior lighting is off<br>- Cycle heating pumps in mild weather<br>- Ensure doors, penthouses and hatches close tightly<br>- Check for exhaust fans running<br>- Check OA and relief air dampers shut tightly<br>- Consider thermographic scan if leaky envelope/windows are suspected |
| P5 school closed<br>(24 hrs) | - Verify scheduling, setbacks, and ensure OA dampers are closed<br>- Ensure all interior and exterior lighting is off<br>- Check for exhaust fans running<br>- Run HVAC systems selectively when custodial work is in progress |
| P6 PA days<br>(24 hrs) | - Revise scheduling to include only HVAC serving spaces in use<br>- Reduce OA% to match actual occupancy<br>- Switch off lighting in unoccupied areas |
| P7 weekends<br>(24 hrs) | - Verify scheduling, setbacks, and ensure OA dampers are closed<br>- Update scheduling to include only equipment feeding spaces in use during permitting<br>- Check for exhaust fans running continuously |
| P8 summer break<br>(24 hrs) | - Update scheduling to include only lighting and equipment serving spaces in use during permitting<br>- Schedule/cycle DHW recirculation pump<br>- Reset and monitor DHW supply temperature. Connect supply and return water temperatures to BAS and trend log<br>- Reinsulate recirculation piping |

Figure 9-5 shows electricity and gas interval EUI benchmarks for the 4 schools for the period from September 2023 to August 2024. Note that, even for these highly efficient schools, variances exist in each interval period which merit investigation. Also, EUIs cannot be summed up to get to the building total, because of the overlap of period 4 (all days unoccupied 11pm to 5am) with period P5, P6, and P7.

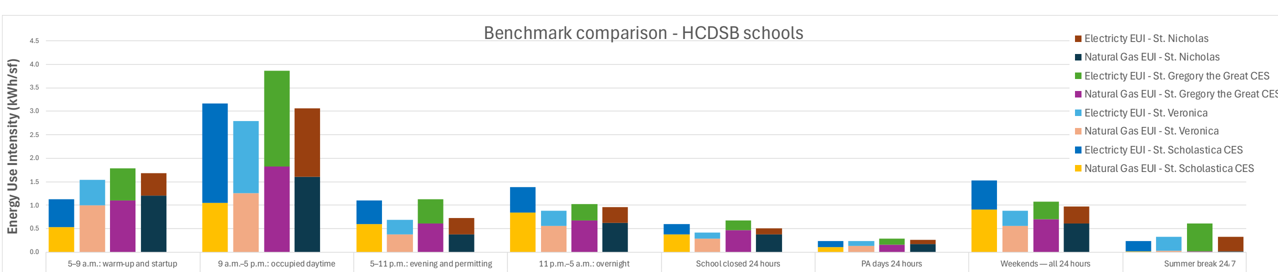



*Figure 9-5 Electricity and gas interval EUIs for 4 Halton Catholic DSB schools*

**Monthly savings monitoring and reporting**

Figure 9-6 shows monthly gas savings for St. Scholastica since the 2023-24 baseline to the end of the 2025 school year. The blue dots are monthly gas consumption, the red dots are the weather normalized baseline amounts. The results confirm continuing high performance, with the exception of the increase observed in January 2025 during the coldest weather conditions which is being investigated. The whole year showed 1% savings relative to the baseline. These results are similar for both electricity and gas use for all 4 schools.

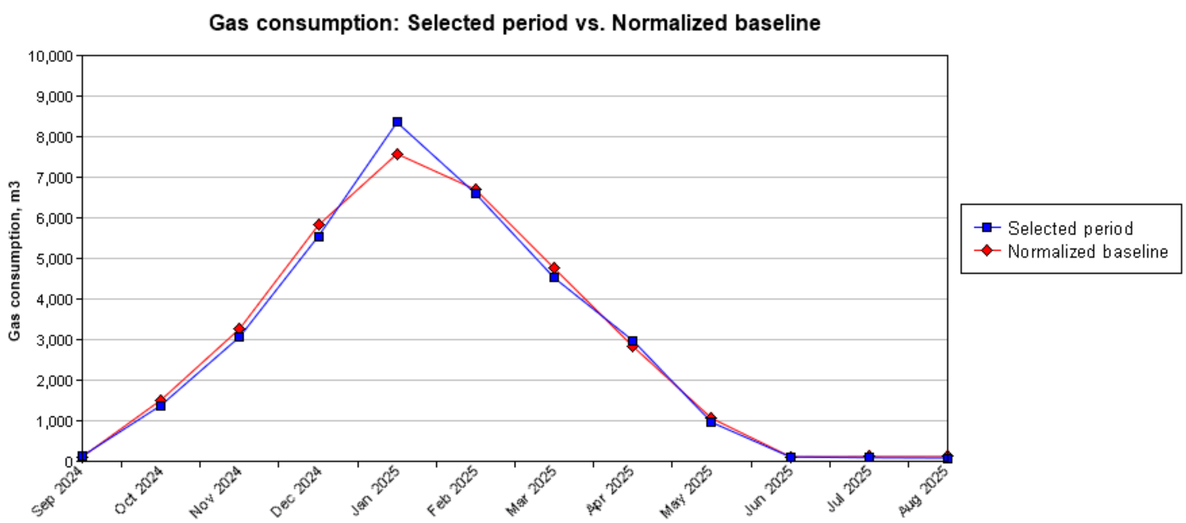



*Figure 9-6 Monthly gas savings chart for St. Scholastica*

# 10 School energy performance assessment

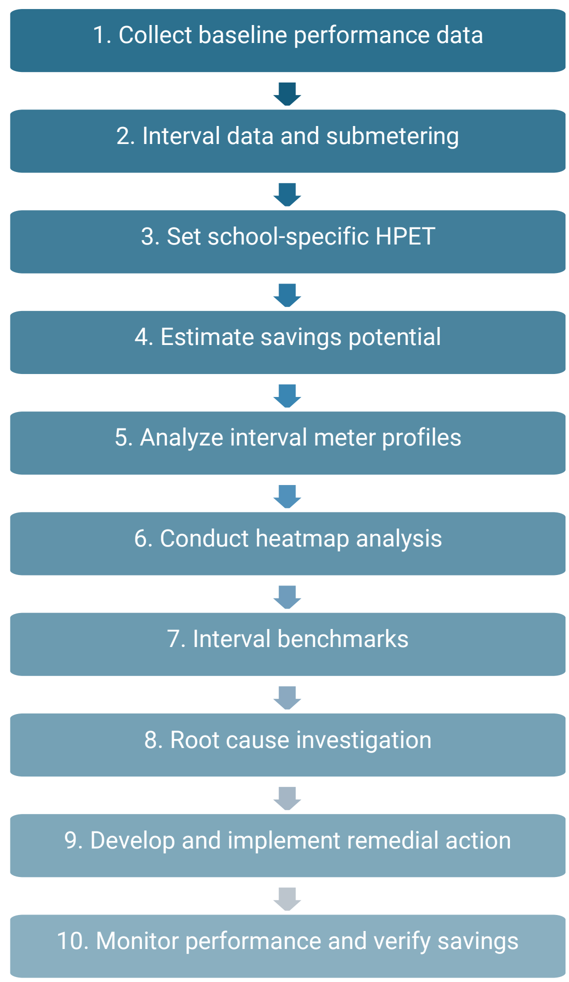
Most recently built schools have the technical capability to meet or approach the proposed HPET. They typically include modern HVAC, building automation and lighting systems, advanced controls, and high-quality building envelopes. Design documentation, commissioning and test reports should be available, providing a strong foundation for performance assessment, verification, recommissioning, and operational optimization. The energy performance assessment is designed to apply the interval data analytical methodology used for the Guide to readily identify energy inefficiencies and appropriate remedial action. A completed example assessment is provided in Appendix 2, and a blank template is available for download at https://climatechallengenetwork.org/wp-content/uploads/2026/07/CAF-School-Energy-Performance-Assessment_Template.docx.

We recommend that the provinces conduct assessments for all their recently built schools, with the following individual and collective benefits:

- Significant energy, emissions and utility cost savings.
- Working experience with energy targets, performance-based testing and commissioning and high energy performance operations.
- Workforce training in application of interval metering and the performance-based methodology.
- Testing and refinement of the HPET.

The steps involved in completing these assessments are detailed below.

1. Collect baseline performance data for the reference year.
    a. Monthly billing data
    b. Interval electricity and gas data if available
    c. Submeter data as available
    d. Standard school day HVAC operating schedule
    e. Building characteristics and key operational information
2. Interval data and submetering.
    a. Initiate installation and begin collecting data
    b. Confirm completeness and accuracy of utility, submeter, and BAS data
3. Set the adjusted school specific HPET as described in Section 2.
    a. Reference year weather conditions
    b. Heating and cooling system type
    c. Building characteristics and configuration
    d. School-specific operating factors
    e. Site variables such as portables, special-use spaces, and other significant loads
4. Estimate the energy, emissions and utility cost savings potential.
    a. Compare baseline performance against the adjusted HPET
    b. Quantify savings potential at whole-building and submeter levels



    c. Apply appropriate assumptions where data is unavailable (e.g., portable operation or missing submeters)
    d. Incorporate local utility rates and grid emissions factors
5. Analyze interval meter profiles against HPET performance.
    a. Compare measured interval consumption against expected HPET profiles
    b. Identify periods where energy use deviates from expected performance
    c. Flag potential operational issues such as:
        i. Excessive overnight and weekend operation
        ii. Abnormal heating or cooling profiles
        iii. Unexpected electrical demand patterns
6. Conduct heatmap analysis to identify operational anomalies
    a. Analyze daily and weekly patterns
    b. Evaluate operation by day type (weekday, weekend, holiday, PA day)
    c. Identify excessive runtime, scheduling issues, and opportunities for operational optimization
7. Interval benchmarks.
    a. Calculate for reference period. Identify and quantify intervals with excessive use
    b. Reconcile with step 4 estimated savings
    c. Prioritize opportunities based on magnitude and operational impact
8. Conduct root cause investigation.
    a. Review BAS trends, schedules, setpoints, equipment operation, and control sequences
    b. Validate suspected causes through:
        i. Operator interviews
        ii. Equipment testing
        iii. Targeted BAS analysis
        iv. Review of maintenance and commissioning records
    c. Determine whether performance gaps are related to design, commissioning, controls, operation, or maintenance
9. Develop and implement remedial action
    a. Identify and prioritize corrective measures
    b. Focus on low-cost/high-impact operational improvements where possible, including:
        i. HVAC scheduling optimization
        ii. Setpoint adjustments
        iii. Controls corrections
        iv. Ventilation optimization
        v. Sequence of operation improvements
        vi. Targeted recommissioning measures
10. Monitor performance and verify savings.
    a. Monitor monthly energy use to track weather normalized savings against the baseline and achievement of the target

# 11 New school development process checklist

Table 11-1 brings together all the recommendations from each section of the Guide. The checklist is intended for use by governments and school boards to first prioritize each line item (Importance to our organization), pick out the most important items and then plan action. An excel copy of the template is available at the following URL or by scanning the QR code.

https://climatechallengenetwork.org/wp-content/uploads/2026/07/CAF-New-School-Development-Guide-Checklist.xlsx

*Table 11-1 New school development process checklist*

| # | Recommendations | User | Importance to our organization (0 = not applicable / 1 = low / 2 = medium / 3 = high) | Current practice (0 = not doing / 1 = early stage / 2 = partially in place / 3 = fully in place) | Priority for improvement (0 = none / 1 = low / 2 = medium / 3 = high) | Further support needed (None / Guidance / Financial support / Policy change / More than one of the above) | Timeline to act (Now / 1–2 years / 3-5 years / Not applicable) |
|---|---|---|---|---|---|---|---|
| **1. Recommendations: Government policy and regulations** | | | | | | | |
| 1.1 | Review, adopt, update and align codes and design standards with the high performance energy target | Provincial education ministries | | | | | |
| 1.2 | Require interval central and submetering | | | | | | |
| 1.3 | Replicate, evaluate and continuously improve standard designs | | | | | | |
| 1.4 | Develop project delivery models that reward project team integration throughout the project lifecycle and are linked to achieving the HPET | | | | | | |
| 1.5 | Require the modeled energy target for every new school to meet or exceed the HPET standard in Section 2 of the Guide, with post occupancy verification | | | | | | |
| 1.6 | Develop and implement performance-based modeling and commissioning standards | | | | | | |
| 1.7 | Update operational directives to school boards and districts in line with the HPET | | | | | | |
| 1.8 | Ensure local authorities and utility companies have the necessary resources to inspect and verify that codes and standards are met | | | | | | |

| # | Recommendations | User | Importance to our organization (0 = not applicable / 1 = low / 2 = medium / 3 = high) | Current practice (0 = not doing / 1 = early stage / 2 = partially in place / 3 = fully in place) | Priority for improvement (0 = none / 1 = low / 2 = medium / 3 = high) | Further support needed (None / Guidance / Financial support / Policy change / More than one of the above) | Timeline to act (Now / 1–2 years / 3-5 years / Not applicable) |
|---|---|---|---|---|---|---|---|
| 1.9 | Introduce public reporting of building energy use data for all schools | Provincial energy ministries | | | | | |
| 1.10 | Implement DSM programs for new commercial construction | | | | | | |
| 1.11 | Explicitly reference new commercial construction in integrated resource planning requirements | | | | | | |
| 1.12 | Implement advanced metering infrastructure (AMI) for both electricity and natural gas | | | | | | |
| 1.13 | Support demonstration projects and application guides to derisk transition to low energy and emissions technologies | | | | | | |
| 1.14 | Further develop the NECB to incorporate empirical data with additional energy targets and archetypes | Federal government | | | | | |
| 1.15 | Develop, test and promulgate performance based modeling, energy targets and commissioning standards and specifications | | | | | | |
| 1.16 | Support workforce training in high energy performance design, construction and operations | | | | | | |
| 1.17 | Establish an intergovernmental advisory group to share best practices through the transition | | | | | | |
| 1.18 | Establish/maintain/support municipal green standards and carbon targets | Municipal government | | | | | |
| **2. Recommendations: High performance energy target (HPET)** | | | | | | | |
| 2.1 | Adopt the empirically derived archetypal high performance energy target (HPET) proposed in the Guide | School boards / districts | | | | | |
| 2.2 | Use the energy model to adjust for project-specific weather, heating system and other variances from archetype for the individual school design, operations and weather year | | | | | | |
| 2.3 | Embed the HPET in project procurement, contracts and design briefs as an explicit, measurable deliverable, with assigned accountabilities | | | | | | |

| # | Recommendations | User | Importance to our organization (0 = not applicable / 1 = low / 2 = medium / 3 = high) | Current practice (0 = not doing / 1 = early stage / 2 = partially in place / 3 = fully in place) | Priority for improvement (0 = none / 1 = low / 2 = medium / 3 = high) | Further support needed (None / Guidance / Financial support / Policy change / More than one of the above) | Timeline to act (Now / 1–2 years / 3-5 years / Not applicable) |
|---|---|---|---|---|---|---|---|
| 2.4 | Apply climate zone adjustments (Table 2-4) and adjust for archetype variances (including portable classrooms, process loads, heating system type, solar PV) as listed in Table 2-5 | | | | | | |
| 2.5 | Track and report actual post-occupancy EUI against the adjusted HPET for every new school, and use variances to inform continuous improvement in design standards and operational practices | | | | | | |
| **3. Recommendations: Metering** | | | | | | | |
| 3.1 | Require central interval metering of electricity, natural gas and other heating fuels | School boards / districts | | | | | |
| 3.2 | Require submetering of main systems, including lighting and portables | | | | | | |
| 3.3 | Data access: ensure readily accessible and timely reporting | | | | | | |
| **4. Recommendations: Energy modeling** | | | | | | | |
| 4.1 | Adopt performance modeling to evaluate and document expected building energy performance using school-specific design and operational parameters | School boards / districts | | | | | |
| 4.2 | Require compliance modeling as the baseline for building permit, then adapt it into the performance model, avoiding a full model rebuild | | | | | | |
| 4.3 | Update the performance model at the as-built stage using actual weather, intended operating schedules, and as-installed equipment, creating a calibrated as-operated baseline for commissioning verification | | | | | | |

| # | Recommendations | User | Importance to our organization (0 = not applicable / 1 = low / 2 = medium / 3 = high) | Current practice (0 = not doing / 1 = early stage / 2 = partially in place / 3 = fully in place) | Priority for improvement (0 = none / 1 = low / 2 = medium / 3 = high) | Further support needed (None / Guidance / Financial support / Policy change / More than one of the above) | Timeline to act (Now / 1–2 years / 3-5 years / Not applicable) |
|---|---|---|---|---|---|---|---|
| 4.4 | Use the calibrated as-operated model to produce HPET verification outputs: total, electric and thermal EUI; peak demand; end-use breakdown reconciled with submeters; and scheduling/controls KPIs | | | | | | |
| **5. Recommendations: Building system design** | | | | | | | |
| 5.1 | Design for operations: HVAC zoning for partial/variable occupancy, independent units for spaces with different operating hours, user-friendly BAS controls, and maintainability features | School boards / districts | | | | | |
| 5.2 | Demand-controlled ventilation with air balancing, right-sized and well sealed outside air dampers, monitoring inputs for outside air control, and partial-occupancy modes | | | | | | |
| 5.3 | Enthalpy wheel heat recovery: reclaim heat and humidity from all exhaust airflows to precondition all outside air makeup | | | | | | |
| 5.4 | Building envelope performance design specifications: include an explicit air leakage target, mandatory whole-building airtightness testing, and close coordination between envelope, HVAC, and mechanical design teams | | | | | | |
| 5.5 | Programmable lighting controls, including daylight sensing and occupancy sensors | | | | | | |
| **6. Recommendations: TAB and commissioning** | | | | | | | |
| 6.1 | Commissioning agent to be procured based on knowledge of the school board and positive past experience | School boards / districts | | | | | |
| 6.2 | Commissioning agent to be engaged at the outset in decisions relating to energy modelling, design, value engineering, change orders, handover and operator training, with focus on and responsibility for the energy target | | | | | | |

| # | Recommendations | User | Importance to our organization (0 = not applicable / 1 = low / 2 = medium / 3 = high) | Current practice (0 = not doing / 1 = early stage / 2 = partially in place / 3 = fully in place) | Priority for improvement (0 = none / 1 = low / 2 = medium / 3 = high) | Further support needed (None / Guidance / Financial support / Policy change / More than one of the above) | Timeline to act (Now / 1–2 years / 3-5 years / Not applicable) |
|---|---|---|---|---|---|---|---|
| 6.3 | TAB specification to include engineer sign-off confirming TAB performance indicators including airflows, static pressures and fan power | | | | | | |
| 6.4 | TAB KPI report to be reviewed with the testing contractor and signed off by the engineer and commissioning agent | | | | | | |
| 6.5 | Commissioning agent to produce an AHU performance dashboard and investigate for remedial action | | | | | | |
| 6.6 | Performance commissioning to verify attainment of the HPET metrics by measurement at the utility meters | | | | | | |
| 6.7 | Whole-building airtightness testing as part of the construction contract | | | | | | |
| **7. Recommendations: Facility operations** | | | | | | | |
| 7.1 | Implement and monitor unoccupied and partial occupancy HVAC scheduling | School boards / districts | | | | | |
| 7.2 | Monitor outside air volumes through the building automation system (BAS) and retest air handling systems periodically | | | | | | |
| 7.3 | Adopt continuous commissioning, with a standard set of KPIs for HVAC system operation covering airside systems, hydronic systems, heat recovery, heating and DHW, and cooling | | | | | | |
| **8. Recommendations: Strategic Energy Management** | | | | | | | |
| 8.1 | Provide direction to school boards on energy targets and practices | Provinces | | | | | |
| 8.2 | Provide direction on energy efficiency standards addressing design and operational parameters for new schools and infrastructure renewal, commissioning, space temperature setpoints and HVAC operating schedules. | | | | | | |

| # | Recommendations | User | Importance to our organization (0 = not applicable / 1 = low / 2 = medium / 3 = high) | Current practice (0 = not doing / 1 = early stage / 2 = partially in place / 3 = fully in place) | Priority for improvement (0 = none / 1 = low / 2 = medium / 3 = high) | Further support needed (None / Guidance / Financial support / Policy change / More than one of the above) | Timeline to act (Now / 1–2 years / 3-5 years / Not applicable) |
|---|---|---|---|---|---|---|---|
| 8.3 | Work with post-secondary institutions to develop curriculum and training for energy efficient building operations staff | | | | | | |
| 8.4 | Embed high performance energy targets in development processes and operations | School boards / districts | | | | | |
| 8.5 | Implement energy information management and reporting | | | | | | |
| 8.6 | Make the project manager, project engineer and commissioning agent explicitly responsible for setting and delivering the HPET for each school | | | | | | |
| 8.7 | Implement centralized HVAC scheduling with limited or no override authority for school staff | | | | | | |
| 8.8 | Implement regular energy performance variance reporting | | | | | | |
| 8.9 | Adopt energy efficiency standards addressing design and operational parameters for new schools and infrastructure renewal, commissioning, space temperature setpoints and HVAC operating schedules. | | | | | | |
| 8.10 | Implement training programs to address existing staff, staff turnover and onboarding | | | | | | |
| 8.11 | Inform and engage staff, students, parents and communities in energy efficient behaviour and pride in their performance | | | | | | |
| 8.12 | Embed SEM practices in board policies, management and operational systems and documentation | | | | | | |

# Appendix 1: New commercial construction incentive programs

*Table A.1 1 New commercial construction incentive programs*

| Province | Program | Eligible buildings | Key requirements | Primary measures supported | Financial support |
|---|---|---|---|---|---|
| **British Columbia** | **CleanBC Better Buildings** (not accepting new applications) | *New commercial & institutional buildings* | • *Must be new construction (or major renovation) in BC Hydro territory.*<br>• *Project must deliver ≥400 t CO2e lifetime GHG savings* | • *All-electric HVAC, ventilation, and DHW systems.*<br>• *High-performance envelopes and heat-recovery systems* | • *Energy Study Incentive: Was up to $15,000 per project*<br>• *Capital Incentives: Was up to $500,000 based on lifetime GHG emissions reduced ($30–$120 per tCO2e)* |
| **British Columbia** | **FortisBC – Commercial New Construction** | Commercial new construction | • Complete FortisBC engagement process<br>• Provide energy modelling and design-stage verification<br>• Exceed Step Code or achieve ≥30% better than BCBC | • Energy modelling support<br>• HVAC efficiency and ventilation optimization<br>• Airtightness testing | • Modelling incentive: 50% up to $15,000<br>• Airtightness rebate up to $5,000 |
| **Manitoba** | **Efficiency Manitoba – Efficiency Manitoba New Buildings 3.0** | Commercial, Institutional, Multi-Unit Residential | • Project must be new construction or major renovation.<br>• Energy model comparing proposed design to NECB baseline.<br>• Post-construction verification of installed measures and updated energy model.<br>• Energy performance improvement must exceed minimum code requirements. | • High-efficiency HVAC systems<br>• Enhanced building envelope<br>• Heat recovery and ventilation improvements<br>• High-efficiency lighting and lighting controls<br>• Optimized building controls and system integration. | • Performance incentive: ~$0.60–$3.50 per sf (eligible floor area)<br>• Systems manual bonus: Up to $12,000 per project |
| **Ontario** | **Enbridge – Savings By Design** | Commercial & multi-residential (≥25,000 sf) | • Engage during early design<br>• Target ≥25% better than code | • Integrated design facilitation<br>• Energy modelling<br>• HVAC and envelope optimization | • Airtightness incentive up to $45,000<br>• Additional project-specific incentives |
| **Nova Scotia** | **Commercial New Construction** | Commercial, institutional | • Energy modelling required<br>• Demonstrate improved performance vs. baseline<br>• As-built energy modelling | • HVAC, lighting, envelope improvements | • Modelling incentive: 50% up to $15,000<br>• Implementation incentive: based on as-built modelling from $0.13 - $0.18/kWh with exceptions. |

# Appendix 2: School energy performance assessment example

This example assessment applies the methodology described in Section 10 to an anonymous school. A blank template (.docx) is available at the following URL or by scanning the QR code.

https://climatechallengenetwork.org/wp-content/uploads/2026/07/CAF-School-Energy-Performance-Assessment_Template.docx

# School energy performance assessment

## Case study

This assessment applies the methodology described in Section 10 of the *Energy Efficient New School Development Guide* (the Guide) published by Climate Challenge Network. This sample case study demonstrates a replicable assessment approach that can be applied to any school with suitable utility and operating data. While the methodology is consistent across schools, the energy target adjustments must be tailored to each school's specific characteristics, including building size, operating schedule, community use, weather context, portables, mechanical systems and other site-specific factors that materially affect energy performance.

## 1. School profile

*Table A.2 1 School profile summary*

| School | ***Anonymous school*** |
|---|---|
| **School board** | *Anonymous school board* |
| **Location** | Ontario |
| **School type** | Elementary (Junior Kindergarten to Grade 8) |
| **Year opened** | 2016 |
| **Gross floor area** | 30,268 sf |
| **Standard operating hours** | School day: 6:00 am – 8:00 pm |
| **Heating type** | Natural gas – condensing boilers (hydronic) |
| **Cooling %** | Fully air-conditioned |
| **Year of energy data** | September 2024 – August 2025 |
| **Portables** | 6 portables, electrically heated, no submetering. Interval data has been adjusted to exclude portables |

## 2. Methodology

The methodology described in Section 10 of the Guide uses hourly gas and electricity interval data for a reference year to assess the school's energy performance against the High-Performance Energy Target

(HPET) for K-12 schools, recommended in Section 2 of the Guide. The analysis identifies specific areas of energy efficiency in different day types and time periods and recommends targeted corrective action.

The assessment includes three diagnostic views: energy consumption heatmaps to reveal operating patterns and scheduling issues; interval benchmarks to compare gas and electricity EUIs against HPET for eight time periods; and overlaid demand profiles to identify anomalies and opportunities in peak demand, baseload, morning warm up and operating hours.

This assessment relies on interval data. If your school doesn't have interval metering or access to interval data, install and set up that functionality now and perform this in-depth assessment when sufficient (at least 8 months') data have been collected.

# 3. Adjusted high-performance energy target

## 3.1 Adjusted energy target

Table A.2 2 lists the original HPET target along with the relevant adjustments required for this school. For further details on adjustments, refer to Section 2 of the Guide.

*Table A.2 2 Adjusted high-performance energy target*

| Adjustment / Target EUIs | Electric baseload (kWh/sf) | Electric cooling (kWh/sf) | Electric heating (kWh/sf) | Fuel baseload (ekWh/sf) | Fuel heating (ekWh/sf) | Total EUI (ekWh/sf) |
|---|---|---|---|---|---|---|
| **Base target - HPET** | 3.2 | 0.3 | - | 0.2 | 3.8 | 7.5 |
| **+ Portables adjustment *** | 0.3 | 0.2 | 0.3 | | | 0.8 |
| **+ Permitting adjustment **** | 0.2 | | | | 0.2 | 0.5 |
| **+ Weather adjustment** | | 0.1 | | | 0.7 | 0.8 |
| **Adjusted HPET** | 3.7 | 0.6 | 0.3 | 0.2 | 4.7 | 9.6 |

** Portables adjustment based on yearly electricity use: baseload 4,000 kWh, heating 6,250 kWh, cooling 350 kWh*
*** 15.2% additional permitting over standard school day hours vs 6% for the HPET archetype*

## 3.2 Target savings

*Table A.2 3 Target savings summary*

| School | Actual electricity EUI (kWh/sf) | Actual gas EUI (ekWh/sf) | Electricity target (kWh/sf) | Gas target (ekWh/sf) | Electricity % savings potential | Gas % savings potential | GHG savings (tCO2e/year) | Utility cost savings ($/year) |
|---|---|---|---|---|---|---|---|---|
| ***Anonymous school*** | 8.2 | 8.8 | 4.6 | 4.9 | 61% | 44% | 27.7 | $22,156 |

*Emissions factors: electricity 0.0767 Kg C02e/kWh, natural gas 0.183 Kg CO2e/ekWh*
*Utility rates: electricity $0.172 per kWh, natural gas $0.32 per m3*

# 4. Interval benchmark comparison

Gas and electricity EUIs are presented for each operating period to highlight where the school's performance diverges from the HPET archetype. Priority periods are identified in Section 9 of the Guide, based on the magnitude of the absolute EUI gap from the archetype, reflecting the largest savings opportunities for further investigation and targeted corrective action.

## 4.1 Electricity and gas EUIs by period

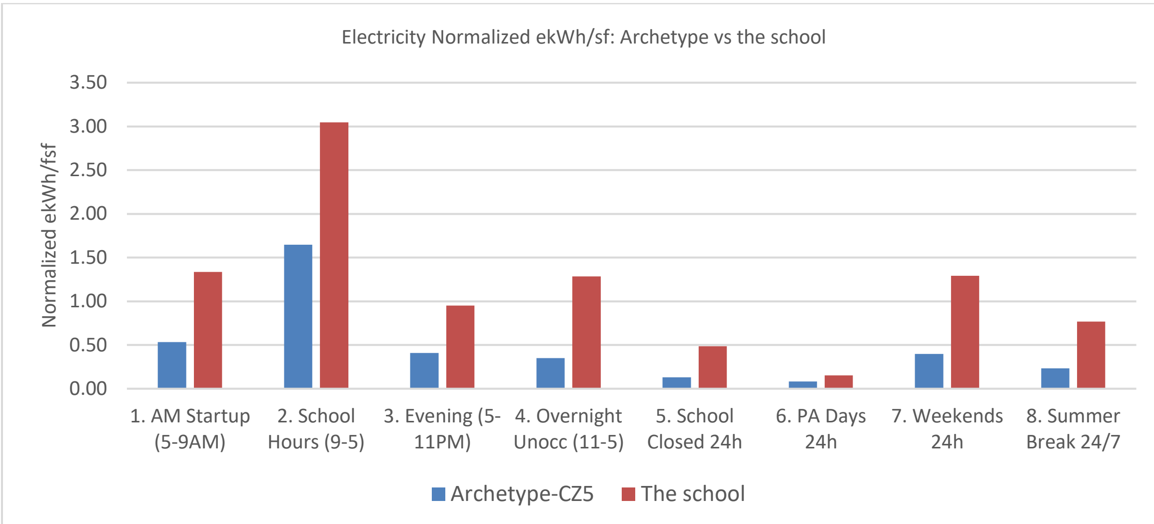



*Figure A.2 1 Electricity EUI comparison, eight operating periods*

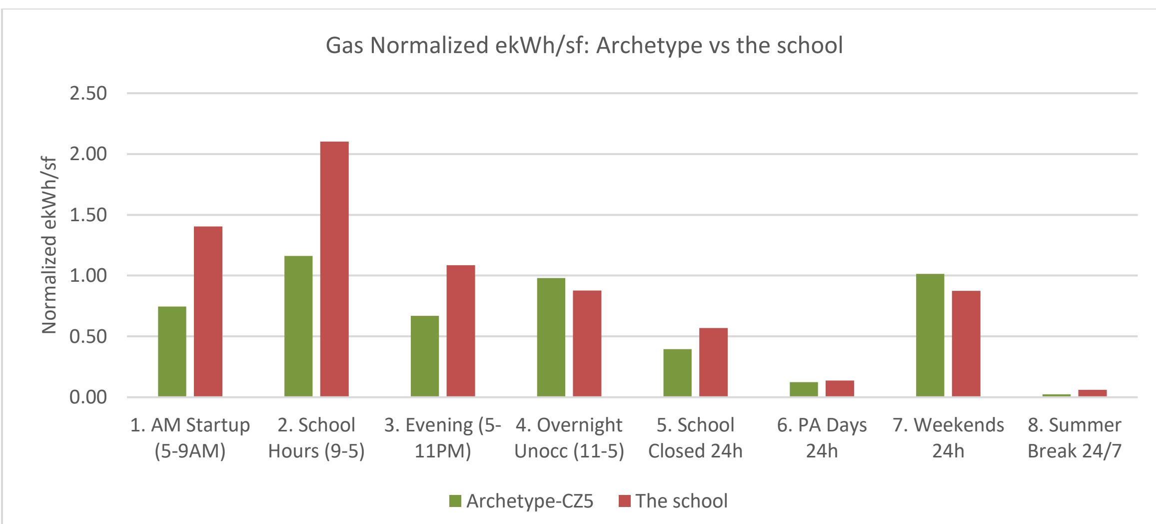



*Figure A.2 2 Gas EUI comparison, eight operating periods*

## 4.2 Key observations

- Electricity exceeds archetype in all eight operating periods
- Gas is within target overnight, on PA days and weekends, but over target during startup, school day and school closed periods
- Electricity is elevated during unoccupied periods when gas is within target, indicating proper outside air control during those periods

- Gas and electric startup demand are elevated. Review warm up duration, OA damper control and fan speed at startup
- Gas and electric use are elevated during the school day. Check fan speeds and outside air volumes

## 5. Indicated energy conservation measures

If your school doesn't have interval metering or access to interval data yet, proceed with measures in the table below as found by visual or BAS inspection.

Priority is based on the absolute EUI gap from HPET (ekWh/sf), reflecting the magnitude of the savings opportunity. High = largest gap; Low = smallest gap or within target.

*Table A.2 4 Energy conservation measures by operating period*

| Period | Priority | Priority measures |
|---|---|---|
| **P1 5–9 am Warm-up** | High | • (Both) Check BAS scheduling; verify HVAC start times not overridden<br>• (Gas) Verify OA dampers closed; test actuators<br>• (Gas) Recalibrate optimal start to minimum required for warm up<br>• (Both) Review startup sequencing for lighting, fans and pumps |
| **P2 9 am–5 pm Occupied** | High | • (Both) Conduct TAB to verify supply/return/exhaust balance, proper OA rates and undue static pressure losses<br>• (Gas) Check for simultaneous heating and cooling, proper economizer and mixed air controls<br>• (Elec) Verify occupancy-based lighting and daylighting controls<br>• (Elec) Check supply/return fan VFD control and static pressure reset. |
| **P3 5–11 pm Evening** | Medium | • (Gas) Confirm HVAC runs only for permitting. Review end-of-day schedule<br>• (Gas) Implement setbacks in all non-permitted zones from 5 pm; reduce OA to minimum<br>• (Elec) Implement end-of-day lighting schedule |
| **P4 11 pm–5 am Overnight** | Medium | • (Elec) Check fan, pump, and lighting operation<br>• (Elec) Audit exhaust fans and circulation pumps for overnight scheduling<br>• (Elec) Check for large plug loads running continuously |
| **P5 Closed days (24 hrs)** | Low | • (Both) Check HVAC and lighting scheduling<br>• (Both) Update BAS holiday calendar to all board-designated break days, not only statutory holidays<br>• (Both) Schedule HVAC for custodial hours<br>• (Elec) Verify complete plug load shutdown |
| **P6 PA days (24 hrs)** | Low | • (Both Limit HVAC operation and lighting to occupied areas<br>• (Elec) Reduce fan airflow, duct static pressure and OA damper position to suit actual occupancy |
| **P7 Weekends (24 hrs)** | Medium | • (Elec) Verify lighting schedule<br>• (Elec) Inspect exhaust fans and circulation pumps to confirm shutdown scheduling is active<br>• (Elec) Check for large plug loads running continuously |
| **P8 Summer break (24 hrs)** | Medium | • (Gas) Schedule DHW pump cycling; inspect pipe insulation<br>• (Elec) Verify classroom and common area lighting are off except for areas with permitting |

## 6. Electricity and gas demand profiles

Figure A.2 3 and Figure A.2 4 show hourly electricity and gas demand profiles during the selected winter week compared with the HPET archetype. Circled callouts identify periods where demand differs materially from the archetype profile. Green shaded bars refer to the school standard operating hours. The notes below summarize observed patterns and identify follow-up checks for BAS schedules, equipment operation, and control settings.

## 6.1 Electricity demand profile

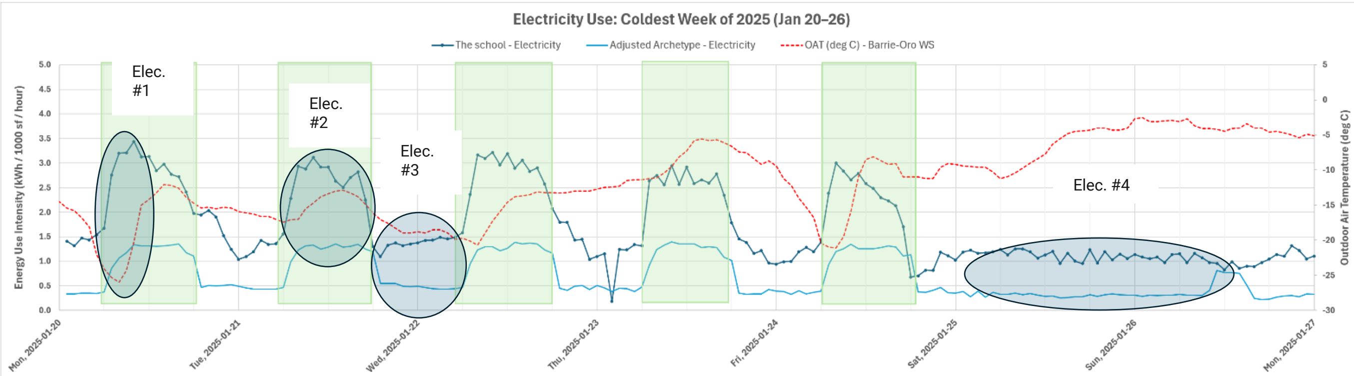



*Figure A.2 3 Electricity demand profile, peak winter week, January 2025*

- Monday startup and baseload: Demand increases during Monday morning startup and remains above the HPET profile across occupied and unoccupied hours. Check fan, pump and lighting schedules, including any BAS overrides or equipment operating outside the intended schedule (Elec. #1).
- Weekday occupied and unoccupied demand: Weekday occupied and unoccupied demand is approximately 2x and 2.5x the HPET profile respectively. Review supply and return fan operation, VFD control, duct static pressure reset, outside air settings and lighting control operation. Also verify setback schedule and plug loads (Elec. #2 and #3).
- Weekend baseload: Weekend electricity intensity remains above the HPET profile. Check weekend schedules for fans, pumps, lighting, exhaust fans, circulation pumps and large plug loads (Elec. #4).

## 6.2 Gas demand profile

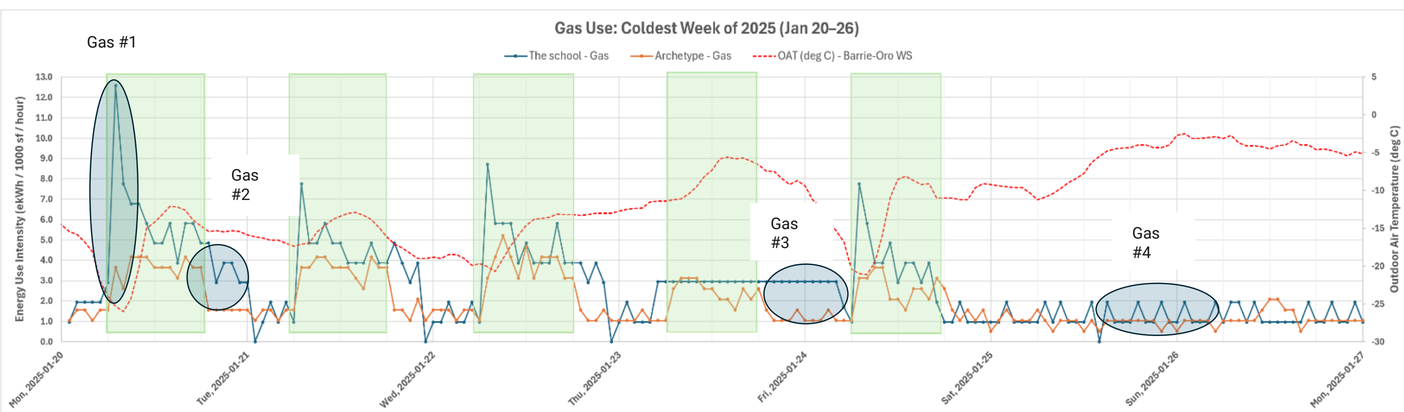



*Figure A.2 4 Gas demand profile, peak winter week, January 2025*

- Peak intensity (5am-9am): The school reaches 3 times the archetype peak, consistent with OA dampers stuck open and possible simultaneous heating/cooling (Gas #1).
- Community use (5pm-11pm): The school seems to have extended operation till 11pm, consistent with the interval benchmark findings (Gas #2 and #3).
- Weekends: The school heating systems cycle frequently reaching twice the energy intensity of the archetype (Gas #4).

# 7. Energy consumption heatmaps

The heatmaps below reveal operating patterns and scheduling issues. Each cell represents the energy intensity of one hour of the year; colour intensity reflects consumption magnitude on a consistent normalized scale (green = low, red = high). Gas and electricity are shown on the same colour scale for each utility to enable direct comparison. To improve readability, all energy intensity values have been scaled by a factor of 1000.

## 7.1 Electricity heatmap

| Date | Day of week | School calendar | 00:59 | 01:59 | 02:59 | 03:59 | 04:59 | 05:59 | 06:59 | 07:59 | 08:59 | 09:59 | 10:59 | 11:59 | 12:59 | 13:59 | 14:59 | 15:59 | 16:59 | 17:59 | 18:59 | 19:59 | 20:59 | 21:59 | 22:59 | 23:59 | Daily Total (kWh/sfx1000) | Daily min OAT (°C) | Daily mean OAT (°C) | Daily max OAT (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2024-12-28 | Saturday | Winter Break | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.7 | 0.6 | 0.7 | 0.9 | 0.7 | 0.8 | 0.9 | 0.7 | 0.8 | 0.9 | 19.7 | -0.9 | 2.1 | 6.2 |
| 2024-12-29 | Sunday | Winter Break | 0.8 | 0.8 | 1.0 | 0.8 | 0.8 | 1.0 | 0.8 | 0.9 | 0.8 | 0.7 | 0.8 | 0.8 | 0.7 | 0.8 | 0.1 | 0.3 | 0.7 | 0.9 | 0.6 | 0.6 | 0.8 | 0.6 | 0.6 | 0.8 | 17.6 | -0.7 | 2.9 | 7.8 |
| 2024-12-30 | Monday | Winter Break | 0.7 | 0.6 | 0.7 | 0.7 | 0.7 | 0.8 | 0.6 | 0.9 | 0.7 | 0.7 | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 18.7 | 0.5 | 3.2 | 8.2 |
| 2024-12-31 | Tuesday | Winter Break | 0.9 | 0.9 | 0.8 | 1.0 | 0.9 | 0.8 | 1.1 | 0.7 | 1.0 | 0.7 | 0.8 | 0.8 | 0.6 | 0.7 | 0.8 | 0.7 | 0.7 | 0.9 | 0.9 | 0.8 | 1.0 | 0.8 | 0.9 | 0.9 | 20.1 | 0.1 | 0.9 | 2.2 |
| 2025-01-01 | Wednesday | Winter Break | 0.9 | 0.9 | 1.0 | 0.8 | 1.0 | 0.9 | 1.0 | 0.9 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 0.8 | 1.0 | 0.9 | 1.1 | 0.9 | 1.1 | 0.9 | 0.9 | 1.0 | 22.0 | -1.5 | -0.2 | 0.3 |
| 2025-01-02 | Thursday | Winter Break | 0.9 | 1.0 | 1.1 | 0.9 | 1.0 | 1.0 | 1.6 | 1.7 | 1.7 | 1.4 | 1.5 | 1.4 | 1.4 | 1.5 | 1.2 | 0.9 | 1.1 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 28.1 | -3.8 | -2.1 | -0.7 |
| 2025-01-03 | Friday | Winter Break | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.5 | 2.0 | 1.7 | 1.9 | 1.8 | 1.8 | 1.6 | 1.6 | 1.4 | 0.8 | 1.2 | 1.1 | 1.2 | 1.2 | 1.1 | 1.2 | 1.3 | 1.2 | 31.9 | -10.4 | -6.1 | -3.9 |
| 2025-01-04 | Saturday | | 1.3 | 1.3 | 1.2 | 1.3 | 1.4 | 1.3 | 1.3 | 1.3 | 1.1 | 1.2 | 1.2 | 1.0 | 1.1 | 1.0 | 0.9 | 1.1 | 1.1 | 1.0 | 1.2 | 1.0 | 1.2 | 1.2 | 1.1 | 1.3 | 27.9 | -11.0 | -7.2 | -4.6 |
| 2025-01-05 | Sunday | | 1.0 | 1.1 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 1.2 | 1.0 | 1.1 | 0.9 | 1.1 | 0.9 | 1.1 | 1.0 | 1.1 | 1.0 | 1.1 | 1.2 | 1.1 | 1.2 | 1.1 | 1.2 | 1.2 | 26.2 | -9.3 | -7.4 | -5.7 |
| 2025-01-06 | Monday | | 1.3 | 1.3 | 1.1 | 1.4 | 1.3 | 1.3 | 2.7 | 3.0 | 2.7 | 2.8 | 2.8 | 2.9 | 2.5 | 2.7 | 2.6 | 2.8 | 2.4 | 2.0 | 2.0 | 1.9 | 1.7 | 1.4 | 1.0 | 1.0 | 48.5 | -12.7 | -11.5 | -10.1 |
| 2025-01-07 | Tuesday | | 1.0 | 1.2 | 1.3 | 1.3 | 1.3 | 1.5 | 2.3 | 2.9 | 2.6 | 3.1 | 2.9 | 3.1 | 2.8 | 2.9 | 2.8 | 2.8 | 2.4 | 1.8 | 1.6 | 1.5 | 1.7 | 1.4 | 1.2 | 1.2 | 48.4 | -13.7 | -10.2 | -7.6 |
| 2025-01-08 | Wednesday | | 1.2 | 1.3 | 1.4 | 1.6 | 1.5 | 1.5 | 2.5 | 3.1 | 3.2 | 3.4 | 3.1 | 3.3 | 2.9 | 3.0 | 2.8 | 2.9 | 2.6 | 2.1 | 1.8 | 1.8 | 1.6 | 1.6 | 1.3 | 1.0 | 52.3 | -18.0 | -14.0 | -10.1 |
| 2025-01-09 | Thursday | | 1.0 | 1.5 | 1.4 | 1.5 | 1.5 | 1.7 | 2.4 | 3.1 | 3.2 | 3.4 | 3.0 | 3.3 | 2.8 | 2.9 | 2.9 | 2.9 | 2.5 | 2.0 | 1.6 | 1.7 | 1.3 | 1.2 | 1.0 | 1.1 | 51.0 | -17.1 | -13.3 | -8.7 |
| 2025-01-10 | Friday | | 1.4 | 1.4 | 1.3 | 1.5 | 1.5 | 1.6 | 2.3 | 3.1 | 3.1 | 3.1 | 2.9 | 3.0 | 2.5 | 2.8 | 2.6 | 2.9 | 2.3 | 1.8 | 1.5 | 1.3 | 1.2 | 1.2 | 0.9 | 0.9 | 48.1 | -21.3 | -10.8 | -4.7 |
| 2025-01-11 | Saturday | | 0.8 | 0.9 | 0.8 | 1.0 | 0.9 | 1.1 | 0.9 | 1.2 | 0.8 | 1.0 | 0.8 | 0.8 | 0.7 | 0.9 | 0.8 | 0.7 | 0.9 | 0.8 | 1.0 | 0.9 | 0.9 | 0.9 | 1.1 | 0.8 | 21.6 | -9.1 | -4.6 | -1.7 |
| 2025-01-12 | Sunday | | 1.1 | 1.0 | 1.1 | 1.1 | 1.2 | 1.1 | 1.2 | 1.1 | 1.0 | 1.0 | 0.9 | 0.9 | 0.8 | 0.6 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 1.1 | 0.9 | 1.0 | 1.0 | 0.9 | 23.3 | -4.8 | -2.7 | -0.2 |
| 2025-01-13 | Monday | | 1.1 | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | 2.2 | 2.5 | 2.3 | 2.5 | 2.6 | 2.6 | 2.4 | 2.7 | 2.5 | 2.7 | 2.2 | 1.9 | 1.7 | 1.8 | 1.2 | 1.0 | 0.8 | 0.9 | 42.7 | -7.7 | -3.0 | -0.7 |
| 2025-01-14 | Tuesday | | 0.8 | 1.0 | 1.2 | 1.1 | 1.2 | 1.2 | 2.0 | 2.8 | 2.5 | 2.9 | 2.7 | 2.8 | 2.7 | 2.7 | 2.7 | 2.6 | 1.9 | 1.0 | 0.9 | 0.8 | 1.1 | 1.1 | 1.2 | 1.3 | 42.1 | -10.4 | -8.5 | -6.5 |
| 2025-01-15 | Wednesday | | 1.1 | 1.3 | 1.3 | 1.2 | 1.3 | 1.6 | 2.2 | 3.0 | 3.0 | 3.0 | 2.7 | 3.0 | 2.8 | 2.9 | 2.7 | 2.7 | 2.2 | 1.8 | 1.6 | 1.6 | 1.3 | 1.0 | 1.1 | 0.8 | 47.4 | -14.8 | -9.5 | -5.5 |
| 2025-01-16 | Thursday | | 1.0 | 0.9 | 1.1 | 1.0 | 1.2 | 1.3 | 2.0 | 2.8 | 2.5 | 2.8 | 2.7 | 2.8 | 2.6 | 2.7 | 2.6 | 2.6 | 2.4 | 1.9 | 1.4 | 1.3 | 1.2 | 1.1 | 1.0 | 0.8 | 43.8 | -10.2 | -7.7 | -4.6 |
| 2025-01-17 | Friday | | 0.8 | 0.8 | 0.9 | 0.8 | 0.9 | 1.2 | 1.7 | 2.6 | 2.3 | 2.8 | 2.5 | 2.5 | 2.3 | 2.5 | 2.5 | 2.5 | 2.0 | 1.4 | 1.2 | 1.1 | 1.1 | 1.0 | 0.8 | 0.9 | 39.1 | -4.6 | -1.7 | 1.3 |
| 2025-01-18 | Saturday | | 0.7 | 0.8 | 0.8 | 0.7 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 1.0 | 0.8 | 0.8 | 0.6 | 0.9 | 0.7 | 0.9 | 0.9 | 1.0 | 1.1 | 1.0 | 1.2 | 1.2 | 1.0 | 1.2 | 21.5 | -9.9 | -2.1 | 1.3 |
| 2025-01-19 | Sunday | | 1.2 | 1.2 | 1.2 | 1.4 | 1.2 | 1.3 | 1.3 | 1.2 | 1.2 | 1.2 | 1.1 | 1.0 | 1.1 | 0.9 | 1.1 | 1.0 | 1.0 | 1.2 | 1.1 | 1.3 | 1.3 | 1.2 | 1.3 | 1.4 | 28.6 | -13.9 | -11.5 | -9.9 |
| 2025-01-20 | Monday | | 1.4 | 1.3 | 1.5 | 1.4 | 1.5 | 1.7 | 2.8 | 3.2 | 3.2 | 3.4 | 3.1 | 3.1 | 2.8 | 3.0 | 2.8 | 2.7 | 2.4 | 2.0 | 1.9 | 2.0 | 1.9 | 1.5 | 1.2 | 1.0 | 53.1 | -26.0 | -17.0 | -12.1 |
| 2025-01-21 | Tuesday | | 1.1 | 1.2 | 1.4 | 1.3 | 1.4 | 1.6 | 2.3 | 2.9 | 2.9 | 3.1 | 2.9 | 2.9 | 2.6 | 2.5 | 2.7 | 2.8 | 2.2 | 1.3 | 1.1 | 1.3 | 1.4 | 1.3 | 1.3 | 1.4 | 47.0 | -19.0 | -15.9 | -12.9 |
| 2025-01-22 | Wednesday | | 1.4 | 1.4 | 1.5 | 1.5 | 1.5 | 1.6 | 2.4 | 3.2 | 3.1 | 3.2 | 3.0 | 3.2 | 2.9 | 3.1 | 2.8 | 2.9 | 2.6 | 2.1 | 1.8 | 1.8 | 1.4 | 1.4 | 1.0 | 1.1 | 51.8 | -20.7 | -16.1 | -13.0 |
| 2025-01-23 | Thursday | | 1.2 | 0.2 | 1.2 | 1.2 | 1.3 | 1.3 | 2.6 | 2.7 | 2.6 | 2.9 | 2.6 | 2.9 | 2.6 | 2.7 | 2.6 | 2.8 | 2.3 | 1.8 | 1.5 | 1.4 | 1.2 | 1.2 | 1.0 | 0.9 | 44.7 | -12.7 | -9.1 | -5.6 |
| 2025-01-24 | Friday | PA Day | 1.0 | 1.0 | 1.2 | 1.3 | 1.2 | 1.4 | 2.4 | 3.0 | 2.8 | 2.7 | 2.8 | 2.6 | 2.5 | 2.3 | 2.2 | 2.1 | 1.7 | 0.7 | 0.7 | 0.8 | 0.8 | 1.2 | 1.1 | 1.0 | 40.5 | -21.1 | -12.7 | -8.1 |
| 2025-01-25 | Saturday | | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.1 | 1.3 | 1.3 | 1.2 | 1.1 | 1.1 | 1.2 | 1.0 | 1.2 | 1.0 | 1.0 | 1.2 | 1.0 | 1.2 | 1.0 | 1.1 | 1.1 | 1.1 | 27.2 | -11.2 | -7.3 | -4.0 |
| 2025-01-26 | Sunday | | 1.1 | 1.1 | 1.1 | 1.0 | 1.1 | 1.1 | 1.0 | 1.2 | 1.1 | 1.0 | 1.0 | 0.8 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.1 | 1.1 | 1.3 | 1.2 | 1.0 | 1.1 | 25.0 | -5.4 | -3.8 | -2.5 |

*Figure A.2 5 Electricity intensities heatmap, Dec 2024-Jan 2025 (kWh/sf x1000)*

## 7.2 Gas heatmap

| Date | Day of week | School calendar | 00:59 | 01:59 | 02:59 | 03:59 | 04:59 | 05:59 | 06:59 | 07:59 | 08:59 | 09:59 | 10:59 | 11:59 | 12:59 | 13:59 | 14:59 | 15:59 | 16:59 | 17:59 | 18:59 | 19:59 | 20:59 | 21:59 | 22:59 | 23:59 | Daily Total (ekWh/sfx100 | Daily min OAT (°C) | Daily mean OAT (°C) | Daily max OAT (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2024-12-28 | Saturday | Winter Break | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 9.2 | -0.9 | 2.1 | 6.2 |
| 2024-12-29 | Sunday | Winter Break | 0.3 | 0.3 | 0.3 | 0.7 | 0.0 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 1.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 8.9 | -0.7 | 2.9 | 7.8 |
| 2024-12-30 | Monday | Winter Break | 0.0 | 0.0 | 1.4 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.0 | 0.7 | 9.2 | 0.5 | 3.2 | 8.2 |
| 2024-12-31 | Tuesday | Winter Break | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 9.6 | 0.1 | 0.9 | 2.2 |
| 2025-01-01 | Wednesday | Winter Break | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 11.0 | -1.5 | -0.2 | 0.3 |
| 2025-01-02 | Thursday | Winter Break | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 2.1 | 2.7 | 2.1 | 1.7 | 1.4 | 1.4 | 1.4 | 1.0 | 1.4 | 0.3 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 20.9 | -3.8 | -2.1 | -0.7 |
| 2025-01-03 | Friday | Winter Break | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 2.4 | 1.7 | 1.4 | 1.4 | 1.4 | 1.0 | 1.4 | 1.0 | 1.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 18.1 | -10.4 | -6.1 | -3.9 |
| 2025-01-04 | Saturday | | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.0 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 10.6 | -11.0 | -7.2 | -4.6 |
| 2025-01-05 | Sunday | | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.7 | 0.3 | 0.7 | 0.3 | 12.0 | -9.3 | -7.4 | -5.7 |
| 2025-01-06 | Monday | | 0.7 | 0.7 | 0.7 | 0.7 | 0.3 | 0.7 | 3.8 | 3.1 | 2.4 | 2.1 | 2.1 | 2.1 | 1.7 | 1.7 | 1.7 | 2.1 | 1.4 | 1.4 | 1.4 | 1.4 | 1.0 | 1.0 | 1.0 | 0.7 | 35.6 | -12.7 | -11.5 | -10.1 |
| 2025-01-07 | Tuesday | | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 2.4 | 1.4 | 1.7 | 1.7 | 1.4 | 1.4 | 1.0 | 2.1 | 1.0 | 1.7 | 1.4 | 1.0 | 1.4 | 1.0 | 1.0 | 1.4 | 1.4 | 0.0 | 26.7 | -13.7 | -10.2 | -7.6 |
| 2025-01-08 | Wednesday | | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 2.7 | 2.1 | 2.1 | 1.7 | 1.4 | 1.0 | 1.0 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.0 | 1.0 | 1.4 | 1.0 | 0.0 | 27.4 | -18.0 | -14.0 | -10.1 |
| 2025-01-09 | Thursday | | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 3.1 | 1.7 | 2.1 | 1.7 | 1.4 | 1.0 | 1.4 | 1.0 | 1.0 | 1.7 | 1.0 | 1.0 | 1.0 | 1.4 | 1.4 | 1.0 | 1.0 | 0.0 | 26.7 | -17.1 | -13.3 | -8.7 |
| 2025-01-10 | Friday | | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 2.7 | 1.7 | 1.7 | 1.7 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.4 | 1.4 | 1.0 | 1.0 | 0.7 | 1.0 | 0.7 | 1.0 | 0.3 | 24.3 | -21.3 | -10.8 | -4.7 |
| 2025-01-11 | Saturday | | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 8.6 | -9.1 | -4.6 | -1.7 |
| 2025-01-12 | Sunday | | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.0 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 9.2 | -4.8 | -2.7 | -0.2 |
| 2025-01-13 | Monday | | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 2.4 | 1.7 | 1.7 | 1.4 | 1.7 | 1.7 | 1.4 | 1.4 | 1.0 | 1.4 | 1.4 | 1.0 | 1.0 | 1.0 | 1.0 | 0.7 | 1.0 | 0.7 | 26.0 | -7.7 | -3.0 | -0.7 |
| 2025-01-14 | Tuesday | | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 1.4 | 1.7 | 1.4 | 1.4 | 1.4 | 1.4 | 1.0 | 1.4 | 1.4 | 1.4 | 1.0 | 1.0 | 1.4 | 1.0 | 1.0 | 1.0 | 1.0 | 0.3 | 24.0 | -10.4 | -8.5 | -6.5 |
| 2025-01-15 | Wednesday | | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 2.4 | 1.7 | 2.1 | 1.7 | 1.4 | 1.0 | 1.0 | 1.7 | 1.0 | 1.7 | 1.4 | 1.0 | 1.0 | 0.7 | 1.0 | 1.0 | 0.7 | 0.3 | 25.3 | -14.8 | -9.5 | -5.5 |
| 2025-01-16 | Thursday | | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 2.1 | 1.4 | 1.7 | 1.4 | 1.4 | 1.4 | 1.0 | 1.4 | 1.0 | 1.4 | 1.4 | 1.0 | 1.0 | 1.0 | 0.7 | 0.7 | 1.0 | 0.3 | 23.6 | -10.2 | -7.7 | -4.6 |
| 2025-01-17 | Friday | | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 1.4 | 1.0 | 1.4 | 1.4 | 1.0 | 1.0 | 0.7 | 1.0 | 0.7 | 1.0 | 0.7 | 1.0 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 18.5 | -4.6 | -1.7 | 1.3 |
| 2025-01-18 | Saturday | | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 8.6 | -9.9 | -2.1 | 1.3 |
| 2025-01-19 | Sunday | | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.7 | 0.3 | 0.7 | 0.3 | 0.7 | 0.7 | 11.6 | -13.9 | -11.5 | -9.9 |
| 2025-01-20 | Monday | | 0.3 | 0.7 | 0.7 | 0.7 | 0.7 | 1.0 | 4.4 | 2.7 | 2.4 | 2.4 | 2.1 | 1.7 | 1.7 | 2.1 | 1.4 | 2.1 | 2.1 | 1.7 | 1.7 | 1.0 | 1.4 | 1.4 | 1.0 | 1.0 | 38.3 | -26.0 | -17.0 | -12.1 |
| 2025-01-21 | Tuesday | | 0.0 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 2.7 | 1.7 | 1.7 | 2.1 | 1.7 | 1.7 | 1.4 | 1.4 | 1.4 | 1.7 | 1.4 | 1.4 | 1.7 | 1.4 | 1.0 | 1.4 | 0.0 | 0.3 | 28.4 | -19.0 | -15.9 | -12.9 |
| 2025-01-22 | Wednesday | | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 3.1 | 2.1 | 2.1 | 2.1 | 1.4 | 1.7 | 1.4 | 1.4 | 1.4 | 2.1 | 1.4 | 1.4 | 1.4 | 1.0 | 1.4 | 1.0 | 0.0 | 0.3 | 29.1 | -20.7 | -16.1 | -13.0 |
| 2025-01-23 | Thursday | | 0.7 | 0.3 | 0.3 | 0.3 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 22.6 | -12.7 | -9.1 | -5.6 |
| 2025-01-24 | Friday | PA Day | 1.0 | 1.0 | 1.0 | 1.0 | 0.6 | 0.3 | 2.7 | 2.1 | 1.4 | 1.4 | 1.7 | 1.0 | 1.4 | 1.4 | 1.0 | 1.4 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 23.9 | -21.1 | -12.7 | -8.1 |
| 2025-01-25 | Saturday | | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.0 | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 10.3 | -11.2 | -7.3 | -4.0 |
| 2025-01-26 | Sunday | | 0.7 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.7 | 0.7 | 0.3 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 | 0.7 | 0.3 | 11.0 | -5.4 | -3.8 | -2.5 |

*Figure A.2 6 Gas intensities heatmap, Dec 2024-Jan 2025 (ekWh/sf x1000)*

## 7.3 Key observations

- Evening (P3): High intensity electricity and gas through 11 pm, indicating significant systems running during community use hours.
- Winter break (P5): The school shows near full school-day gas intensities and partial electric intensities on several weekdays during winter break (till 3pm) indicating custodial use.
- PA days (P6): Full occupied-day electricity and gas profile; no reduction in startup or daytime load. Significant opportunity for zone-based setback.

## Appendix 3: Development process evaluation case studies

# Case study 1: Poplar Road Junior Public School

Toronto District School Board

Toronto, Ontario


*Toronto District School Board*

Table A.3 1 documents the information collected through discussions with the school board team. The board provided the Energy Model Report as well as 80% design drawings and specifications for review. Table A.3 2 assesses alignment of the reported development process with the Guide's main recommendations for consideration in future projects.

*Table A.3 1 Case study 1: School information*

| Project profile | School details |
|---|---|
| • School type: Elementary<br>• Location: Toronto, Ontario<br>• Student capacity: 341 students + 5-room daycare<br>• Climate zone: NECB Zone 5<br>• Gross floor area: 4,076 m2 (43,874 sf)<br>• Co-located uses: Daycare (separate operating hours)<br>• Project category: New construction – replacement school<br>• Project status: End of design development stage<br>• Architect: Moriyama Teshima<br>• Mechanical designer and energy modeler: MCW<br>• Design objectives: Mass timber structure with high focus on sustainability. Low GHG<br>• Energy modeling: Compliance model (TGS v4, Tier 1, Relative Performance Pathway 4)<br>• Compliance target: Toronto Green Standard (TGS) v4 Tier 1 (37.6% energy savings and 33.3% GHG savings vs. SB-10 reference building); ASHRAE 90.1 compliance<br>• Proposed energy use intensity: ~8.9 ekWh/sf (exceeds the system-adjusted Zone 5A HPET of ~6.2 ekWh/sf) | Systems<br>• Heating: Combined air-to-water and air-to-air heat pumps with gas boiler auxiliary; hydronic distribution with perimeter radiation, VFD pumps<br>• Ventilation: VAV DOAS for ventilation with demand-controlled ventilation (DCV) and CO2 monitoring; enthalpy wheel heat recovery; VFDs on fans<br>• Air conditioning: FCUs for classrooms, ASHP for gym<br>• Lighting: LED with daylight controls, reduced power densities vs. NECB reference<br>• Envelope: High-performance glazing specified (U 1.36 W/m²K); roof R-40<br>• BAS: Delta controls platform<br><br>Operations<br>• Dynamic control sequence proposed to optimize heat pump vs. boiler operation hourly based on temperatures and energy rates<br>• Cooling: Summer design temperature of 24°C (classrooms) |

**Alignment with New School Development Guide recommendations:**

**Poplar Road Junior Public School**

*Table A.3 2 Case study 1: Alignment with the Guide's recommendations*

| # | Guide section | Key recommendations | Notes |
|---|---|---|---|
| 1 | Government policy and regulations | Not applicable | |
| 2 | High Performance Energy Target (HPET) | Adopt school-specific HPET, embed in contract | Proposed design at 8.9 ekWh/sf; board beginning to consider adopting specific targets for future projects |
| 3 | Metering | Implement interval metering and submetering | Electricity interval data via Green Button; gas meter to be connected to BAS. No submetering currently specified; heat pump submetering under consideration |
| 4 | Energy modeling | Adopt performance modeling, calibrated post-occupancy | Compliance model only; performance modeling recommended but not yet undertaken |
| 5 | Building system design | Adopt envelope airtightness testing; advanced lighting controls; DCV; heat recovery | Airtightness testing not specified but under consideration; lighting controls not documented; DCV and heat recovery in place |
| 6 | TAB and commissioning | Specify performance commissioning; 12-month post-occupancy period | Independent Cx agent in place; scope does not include performance-based commissioning or 12-month monitoring (acknowledged as a gap) |
| 7 | Facility operations | Define scheduling and override standards; centralized BAS control | BAS platform in place; trend archiving under consideration; daycare/main building loop combined |
| 8 | Strategic Energy Management | Assign HPET accountability, continuous monitoring, energy efficiency standards addressing design and operational parameters for new schools | Board beginning to engage with these issues; no formal energy target or monitoring program in place for new schools; submetering and performance Cx identified as possible future board standards |

# Case study 2: Clayton Park-Fairview School

Halifax Regional Centre for Education

Halifax, Nova Scotia

*Lydon Lynch Architects / CS&P Architects*

Table A.3 3 documents the information collected through discussions with the Clayton Park design team and Nova Scotia Department of Public Works. The board provided the latest set of pre-tender drawings and specification documents for our team's review. Table A.3 4 assesses alignment of the reported development process with the Guide's main recommendations for consideration in future projects.

*Table A.3 3 Case study 2: School information*

| Project profile | School details |
| --- | --- |
| • School type: Grades 6-9 (junior high)<br>• Location: Halifax, Nova Scotia<br>• Student capacity: 950 students<br>• Climate zone: NECB Zone 6A<br>• Gross floor area: 12,077 m2 (130,000 sf)<br>• Project category: New construction<br>• Project status: Tender period closing; construction underway<br>• Architect: Lydon Lynch Architects / CS&P Architects<br>• Mechanical designer: Dumac Energy Limited<br>• Design objectives: LEED Silver targeted<br>• Energy modeling: Compliance model only (LEED / ASHRAE 90.1<br>• Compliance target: LEED Silver; ASHRAE 90.1 compliance<br>• Proposed energy use intensity: 100 ekWh/m2 (9.3 ekWh/sf) | Systems<br>• Heating: Air-to-water heat pumps with natural gas-fired boiler auxiliary; hydronic distribution with multiple pump loops (heating, DHW)<br>• Ventilation: AHUs with VAV terminal units serving classroom wings, gym, cafeteria; VFDs on AHU and exhaust fans; regenerative core heat recovery; DCV/CO2 monitoring referenced in design intent<br>• AC: AHU cooling coils.<br>• Lighting: digital lighting management system with PIR vacancy sensors, digital photosensors; continuous daylight dimming not currently permitted by DPW for classrooms<br>• Envelope: SHGC 0.17; center-of-glass U 1.4 winter / 1.2 summer. Roof insulation poly-iso, thickness referenced on drawings<br>• BAS: Native BACnet platform<br><br>Operations<br>• 12-month post-occupancy performance-based commissioning with performance Verification<br>• Two-stage controls training committed: initial session plus mid-warranty follow-up |

**Alignment with New School Development Guide recommendations:**

**Clayton Park-Fairview School**

*Table A.3 4 Case study 2: Alignment with the Guide's recommendations*

| # | Guide section | Key recommendations | Notes |
|---|---|---|---|
| 1 | Government policy and regulations | Not applicable | |
| 2 | High Performance Energy Target (HPET) | Adopt school-specific HPET, embed in contract | Proposed design at 9.3 ekWh/sf referenced in owner project requirements questions; will be considered for integration in formal documents for future projects |
| 3 | Metering | Implement interval metering and submetering | Main electrical meter with interval data included. Gas interval metering to BAS not specified. Submetering per LEED Advanced Metering credit requirements |
| 4 | Energy modeling | Adopt performance modeling, calibrated post-occupancy | Compliance model only; performance modeling estimated too costly due to calibration requirements |
| 5 | Building system design | Adopt envelope airtightness testing; advanced lighting controls; DCV; heat recovery | Component air leakage testing specified. Whole-building air leakage testing will be considered for future projects subject to cost implications. Digital lighting management hardware specified. DCV/CO2 monitoring considered. Heat recovery in place |
| 6 | TAB and commissioning | Specify performance commissioning; 12-month post-occupancy period | Independent Cx agent in place; 12-month Monitoring-based Cx already committed, ahead of typical practice; not tied to a specific EUI target. Performance TAB discussed as feasible; under consideration for future projects |
| 7 | Facility operations | Define scheduling and override standards; centralized BAS control | BAS platform in place with trending Two-stage controls training (initial + mid-warranty) already committed |
| 8 | Strategic Energy Management | Assign HPET accountability, continuous monitoring, energy efficiency standards addressing design and operational parameters for new schools | No formal board-level target or monitoring program; design team applying lessons to other schools in progress. No submetering standard yet. MBCx is being applied as standard. Performance commissioning will be assessed in the future |

## Appendix 4: List of terms and acronyms

AHU – Air Handling Unit

AMI – Advanced Metering Infrastructure

ASHP – Air Source Heat Pump

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

AOWY – Actual Operating Weather Year

BAS – Building Automation System

CDD – Cooling Degree Days

CO2 – Carbon Dioxide

Cx – Commissioning

DCV – Demand-Controlled Ventilation

DHW – Domestic Hot Water

DOAS – Dedicated Outdoor Air System

DSB – District School Board

ekWh/sf – equivalent kilowatt-hours per square foot

EMS – Energy Management System

EMIS – Energy Management Information System

ERV – Energy Recovery Ventilator

EUI – Energy Use Intensity

EWT – Entering Water Temperature

FPB – Fan Powered Box

GFA – Gross Floor Area

GHG – Greenhouse Gas

HDD – Heating Degree Days

HPET – High Performance Energy Target

HVAC – Heating, Ventilation and Air Conditioning

IAQ – Indoor Air Quality

ISO 50001 – International Organization for Standardization 50001 (Energy Management Systems standard)

KPI – Key Performance Indicator

kW – kilowatt

kWh – kilowatt hour

LED – light emitting diode

LEED – Leadership in Energy and Environmental Design

LWT – Leaving Water Temperature

m2 – square meters

M&V – Measurement and Verification

NECB – National Energy Code of Canada for Buildings

OA – Outdoor Air

EPV – photovoltaics

P3 – Public-Private Partnership

RCx – Recommissioning

RTAC – Rooftop units Air-Cooled

RTU – Rooftop Unit

SEM – Strategic Energy Management

sf – square feet

SFPB – Series Fan-Powered Boxes

SWT – Supply Water Temperature

TAB – Testing, Adjusting and Balancing

TMY – Typical Meteorological Year

VAV – Variable Air Volume

VFD – Variable Frequency Drive

W/gpm - Watts per gallon per minute

WSHP – Water Source Heat Pump

ΔP – Differential Pressure

ΔT – Differential Temperature