



**CLIMATE
CHALLENGE
NETWORK**

March 2026

Foundations for Net-Zero Buildings Energy Efficient New School Development Guide

Project funded by:



**Natural Resources
Canada**

**Ressources naturelles
Canada**

Technical direction by:



An applied research project of:



**CLIMATE
CHALLENGE
NETWORK**

Land acknowledgement

We acknowledge with respect the ancestral and unceded territory of the Inuit, Métis, and First Nations people that share these lands with us. While we meet today on a virtual platform, I am speaking from the traditional homes of the Huron-Wendat, Haudenosaunee, Anishinaabe and the Mississaugas of the Credit River. We hope that the work we do today contributes to our common responsibility as stewards of the environment.



Climate Challenge Network

About Us

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 members 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 to develop new knowledge and best practices for energy and water efficiency in commercial buildings.

Learn more at climatechallengenetwork.org



Foundations for net zero buildings project

Project Goal: Achieve consistent high energy performance, and corresponding low emissions, for new commercial and institutional building construction

- Research project over 3 years, 5 provinces funded through Natural Resources Canada's Codes Acceleration Fund:
 - Hospitals, K-12 schools, commercial offices, and municipal community centres.
- Benchmark actual energy performance of newly constructed (since 2015) buildings across Canada. Compare against National Energy Code of Canada for Buildings (NECB) archetypes and Green Building Standards.
- Document top-performing new buildings and what makes them exceptional.
- Document underperforming new buildings and recommend process improvements (design, construction, commissioning, and operations).
- Develop best practice guides and case studies to support market transformation and help build industry capacity (**guidance documents**):
 - Support selected new building developments with design/modelling guidance.
 - Guide selected underperforming buildings towards achieving high performance.

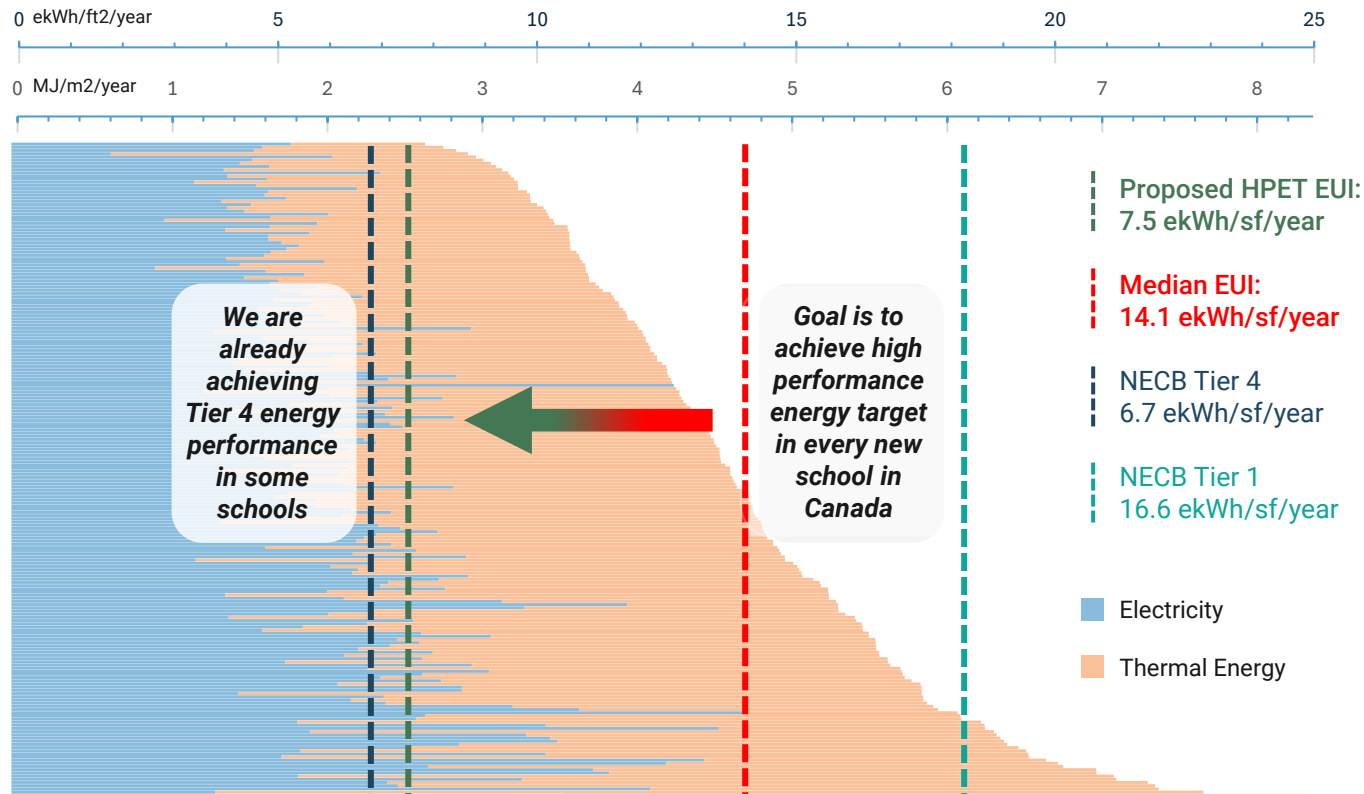
Participating school boards and schools

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
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

Results: (weather normalized to Toronto 2023-2024)

Total EUI benchmark for new elementary and secondary schools built since 2015
(Weather normalized to Toronto 2023-2024 school year)



1 MJ/m² ≈ 3 kWh/ft²

- 234 schools provided annual electric and thermal utility data
- Most heated with conventional heating (natural gas boilers/furnaces)
- No significant capital cost premium for the high-performance energy target (HPET) schools.
- 30-year NPV (Ontario) of median vs HPET school - **\$1.7 to \$6.8 million** utility cost savings and 1,250 to 5,000 tonnes of GHG emission savings (school size ranging from 50,000 to 200,000 ft²).

What we heard – what goes wrong?

1. Lack of standardization in design and specifications

- No consistent 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
- Missed issues, especially with controls
- Rigorous commissioning process (1-year monitoring period) for all newly built schools "incredibly valuable"

4. Limited metering and data access

- Most boards lack submetering or interval data, or are not readily accessible

5. Procurement constraints

- P3 (public-private partnership) models can limit operational flexibility
- Changes in responsibility affect processes and limit board control
- Prequalified teams reduce ability to select based on board-specific needs

6. Training and staffing limitations

- Inadequate performance monitoring
- Limited training for operators
- Insufficient O&M resources
- System complexity exceeds capability of O&M staff

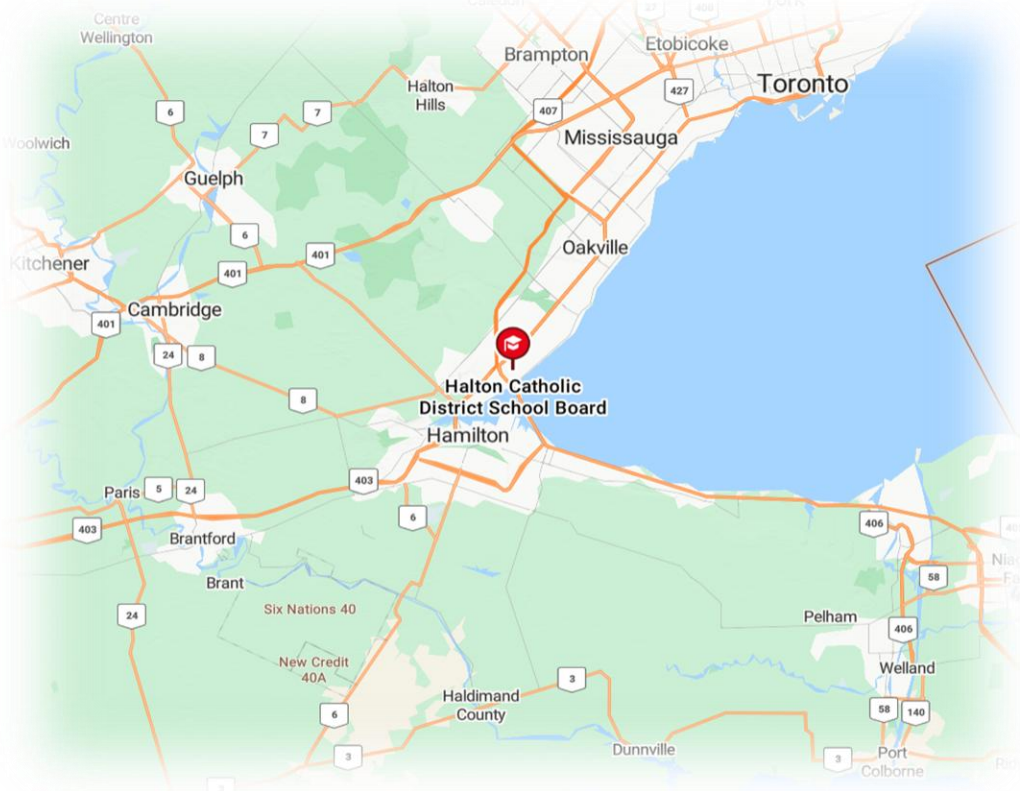
Initial conclusions and recommendations

1. **We know how to build and operate highly energy-efficient new schools (close to NECB Tier 4), without incurring a significant capital cost premium.**
2. **With dozens of new schools opening each year across Canada, there is considerable potential for utility cost savings and emissions reductions.**
3. **Excessive energy use found in a majority of new schools is attributed to failures at different stages of the development, commissioning and facility operations process.**
4. **The development process and case study learnings presented in the Guide aim to help avoid missteps and deliver consistent high-energy performance for all new schools.**
5. **Recommendations include:**
 - a. Interventions with schools now under development to consider process improvements which can lead to better performance outcomes.
 - b. Corrective action for existing underperforming new schools, focused on recommissioning and facility operations.
 - c. Embedding interval electric and gas metering and submetering in specifications, modelling, commissioning and ongoing facility operations.
 - d. Policy and process amendments by governments and school boards, which can enable more consistent high-performance outcomes in future.

Building on the best

Halton Catholic District School Board serves the growing Region of Halton in Southern Ontario.

48 elementary, 10 secondary schools



Steve Allum

Manager, Energy
and Environmental

Four high-performing new schools (2023-2024 data)

Name	Type	Location	Area (sq. ft.)	Students	Main heating/cooling systems	Daycare area (sq. ft.)	Daycare HVAC system
St. Gregory the Great	Elementary	Oakville	78,544	775	Heating: Condensing Boilers + VAV system with SFPB and hydronic reheat Cooling: Air-cooled screw chillers	7,212	RTU and electric resistance heaters
St. Scholastica	Elementary	Milton	74,401	920		-	-
St. Nicholas	Elementary	Oakville	56,338	605		-	-
St Veronica	Elementary (Operating as SS from 2022 to August 2024)	Milton	74,088	Not Available		7,524	RTU and electric resistance heaters

Notes:

- HCDSB standard operating schedule is 6am to 6pm for elementary schools and 6am to 4pm to secondary schools.
- Electrically heated and ACed portable classrooms have been excluded from the analysis (separately sub-metered)

Top performing schools - case study

School	Total EUI- excluding portables	ELECTRICITY EUIs (2023-2024) - ekWh/sq. ft.					GAS EUIs (2023-2024) - ekWh/sq. ft.		
		Electricity EUI - excluding portables	Lighting ⁽¹⁾	Cooling ⁽²⁾	Plug Load ⁽³⁾	Pumps and Fans ⁽³⁾	Gas EUI	Heating ⁽²⁾	DHW ⁽²⁾
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	7.8	3.4	1.0	0.2	0.2	2.0	4.5	4.3	0.2
St Veronica * ⁽⁴⁾ (Adjusted for operating hours)	7.7	3.7	0.4	0.1	0.2	3.0	4.0	3.9	0.1

* With Daycare

Notes:

- (1) Sub-metered
- (2) Monthly data regression analysis
- (3) Estimate derived from equipment data and operation schedules/assumptions
- (4) St. Veronica operating schedule adjusted to match other schools

Board review meeting: building systems

- ✓ DCV, CO2 monitoring.
- ✓ Interval meter data – electric and gas.
- ✓ Submetering standard, design and reporting.
- ✓ Lighting, fan, pump power density standards.
- ✓ Fan powered VAV boxes kW, unoccupied operation.
- ✓ Independent daycare HVAC.
- ✓ ERVs type and performance.
- ✓ Heating SWTs. Trend logs.
- ✓ Local electric heaters (only in daycares and portables).
- ✓ Portable HEPA filters in use – only in portables.
- ✓ Consideration of heat pump technology.
- ✓ Lighting controls (occupied, unoccupied).
- ✓ DHW system design and control.

School	HVAC systems	HVAC operation
St. Gregory the Great	<ul style="list-style-type: none"> • Condensing Boilers x2 • AHU w/ ERW (heat wheel non-functional since 2024) • Mainly Series Fan-Powered Boxes with hydronic reheat • RTAC x4 • ERV x1 (Childcare) 	<ul style="list-style-type: none"> • RTUs scheduled based on occupancy. • ERVs start 20-30 minutes after and stop 20-30 minutes before AHU/FPB
St. Scholastica	<ul style="list-style-type: none"> • Condensing Boilers x2 • AHU x2 • Mainly Series Fan-Powered Boxes with hydronic reheat • RTAC x4 • ERV x2 	
St. Nicholas	<ul style="list-style-type: none"> • Condensing Boilers x2 • AHU x2 • Mainly Series Fan-Powered Boxes with hydronic reheat • RTAC x4 • ERV x2 	
St. Veronica	<ul style="list-style-type: none"> • Condensing Boilers x2 • AHU x2 • Mainly Series Fan-Powered Boxes with hydronic reheat • RTAC x5 • ERV x3 	

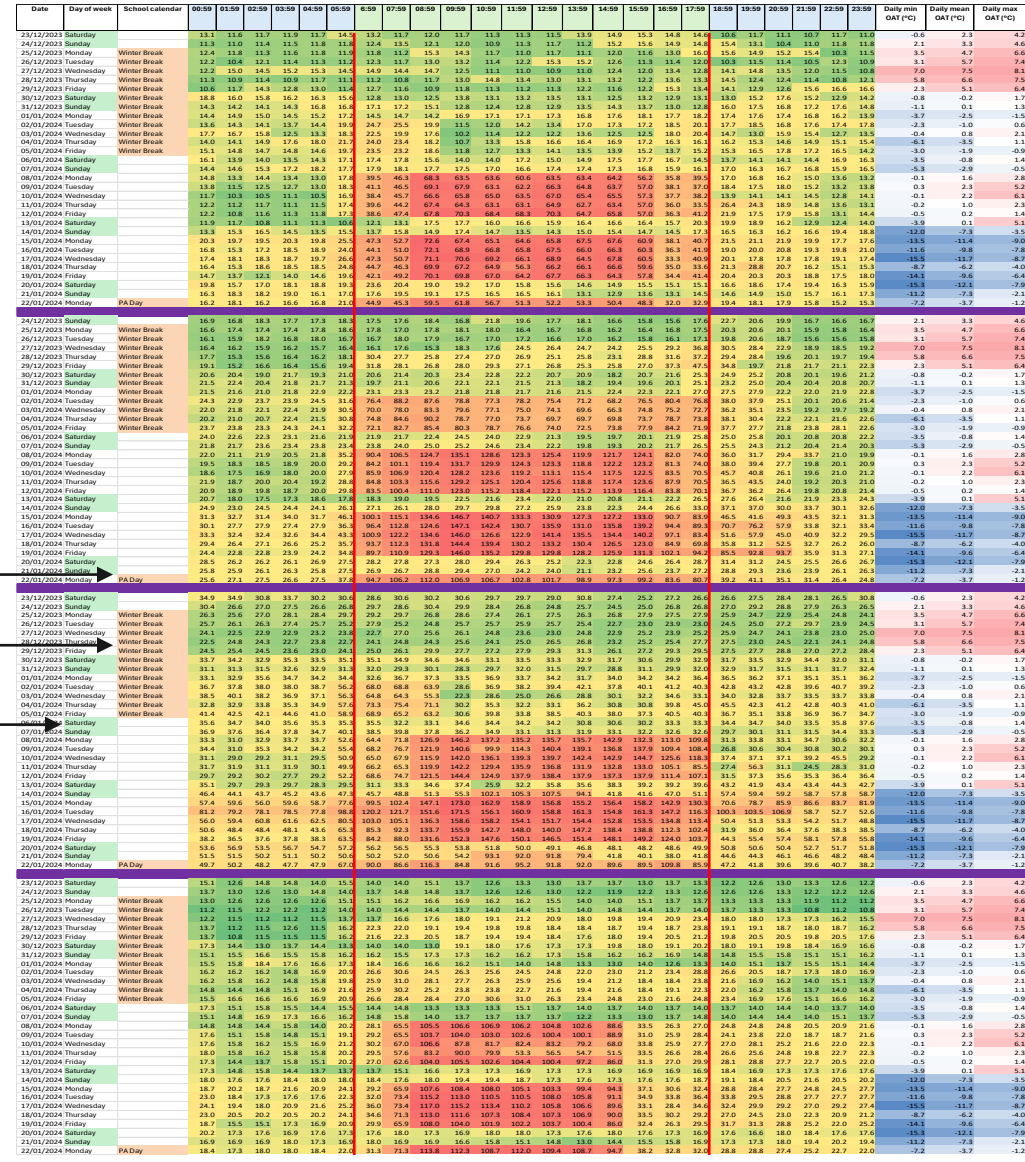
Notes:

- All schools include gas-fired DHW heaters and are 100% LED
- All schools include few VAV and bypass boxes

Data analytics: operations

Electricity heatmap

Daily Mean Temp.



December 23rd, 2023 - Jan 22nd, 2024
Standard school day operation 6AM to 6PM

Notes:

- Heatmap shows hourly electricity consumptions
- Each row represents a day, and each column represents one hour from midnight to midnight
- Colour gradient; green to red = low to high hourly use
- Outdoor temperature columns to the right: blue to red = low to high daily minimum, median and high temperatures

PA/PD Day
Winter Break
Weekends

St. Nicholas

St. Gregory

St. Scholastica

St. Veronica

What went right?

1. Strategic energy management

- a. Full organizational alignment
- b. Real-time utility monitoring (electricity, gas, water) at all schools (= continuous Cx)
- c. All equipment, including unit heaters, controlled by BAS
- d. Electricity submetering in all new builds
- e. Centralized BAS control, no ability for site staff to manually override settings

2. Continuous improvement

- a. Approximately one school built per year, with the same team
- b. Trusted external commissioning agent works closely with board staff

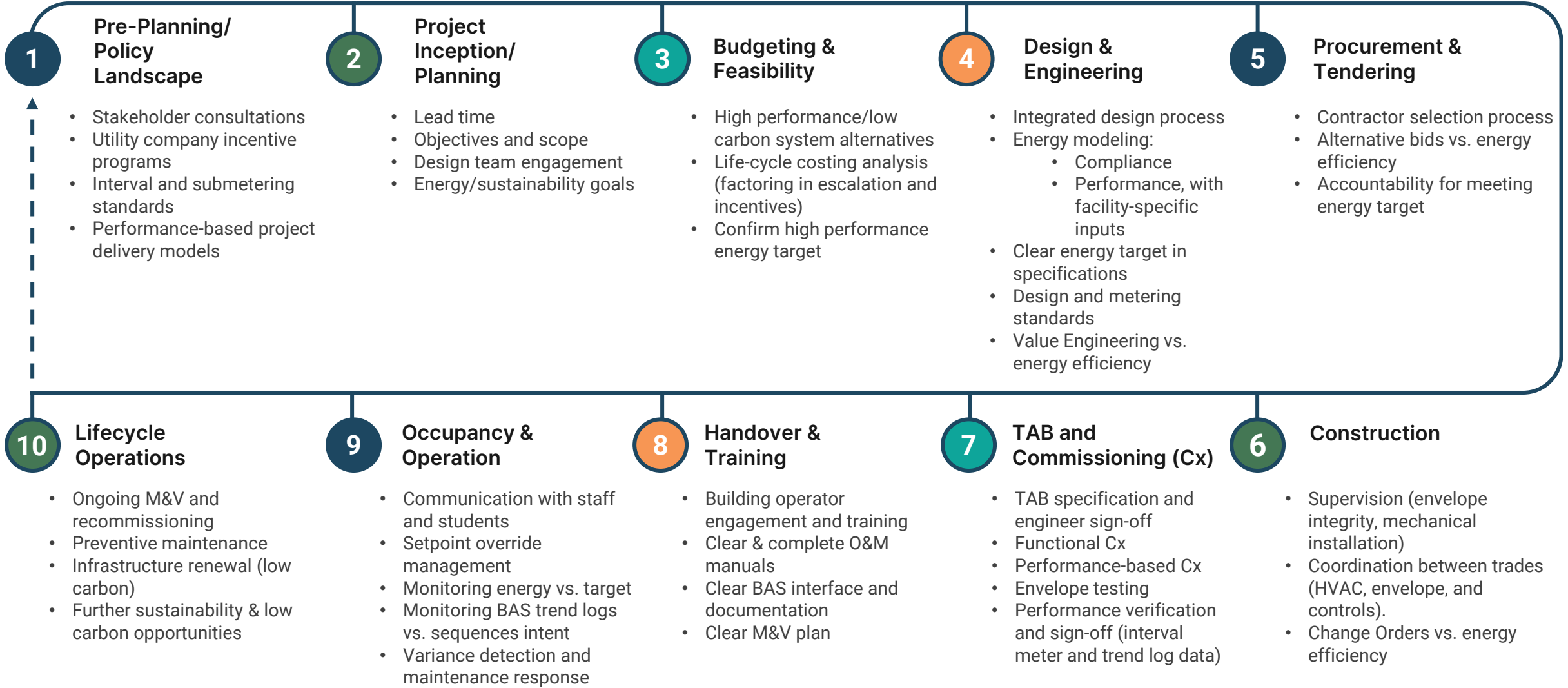
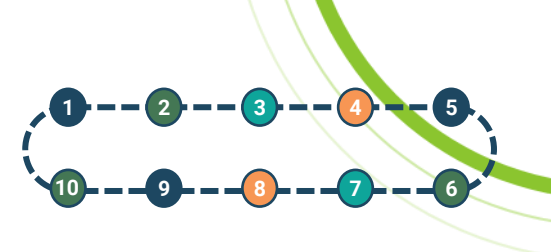
3. Operations team involved from the start with input throughout the new school development process

- a. Lessons learned in operations translate to design
- b. No learning curve for new school operations

4. Construction management process

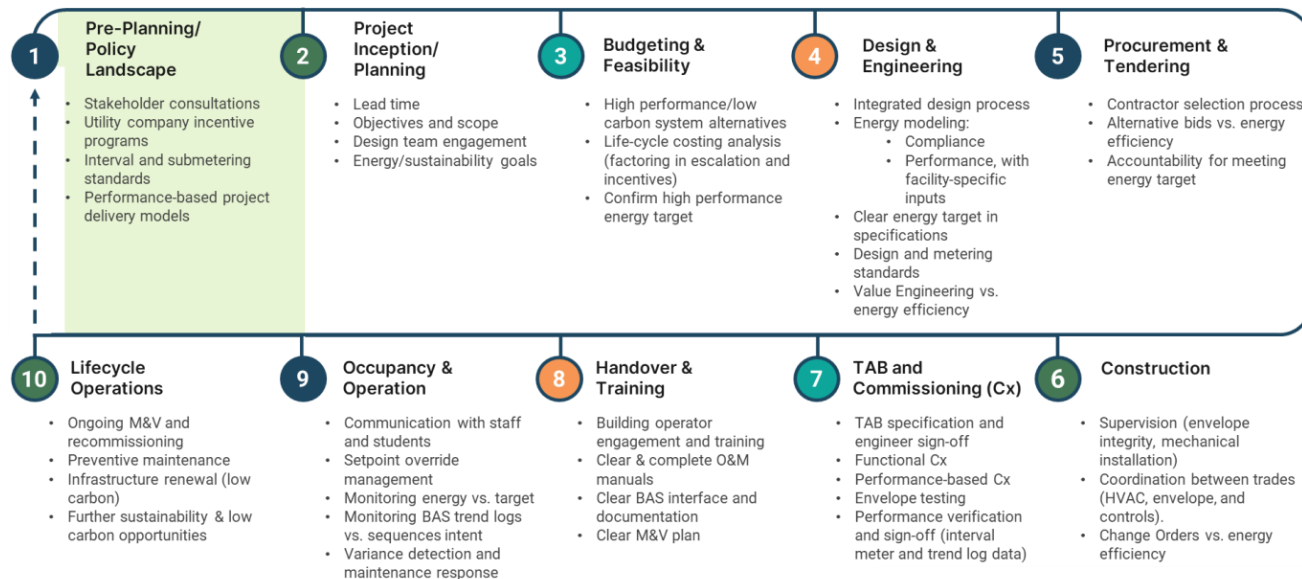
- a. Not having general contractor hire subtrades – cost savings go towards better equipment

Improved project development process



1. Government policy and regulations

Project Development Stage		Recommendations
1	Government policy and regulations	Align energy codes and standards to support consistent high energy performance for new schools.
		Require site-specific, evidence based high-performance energy target for every new school, to be verified post-construction.
		Develop contract terms that link project team engagement to target achievement.
		Introduce utility incentive programs for commercial new construction to support energy target achievement and verification.
		Set interval metering and submetering standards for new schools.

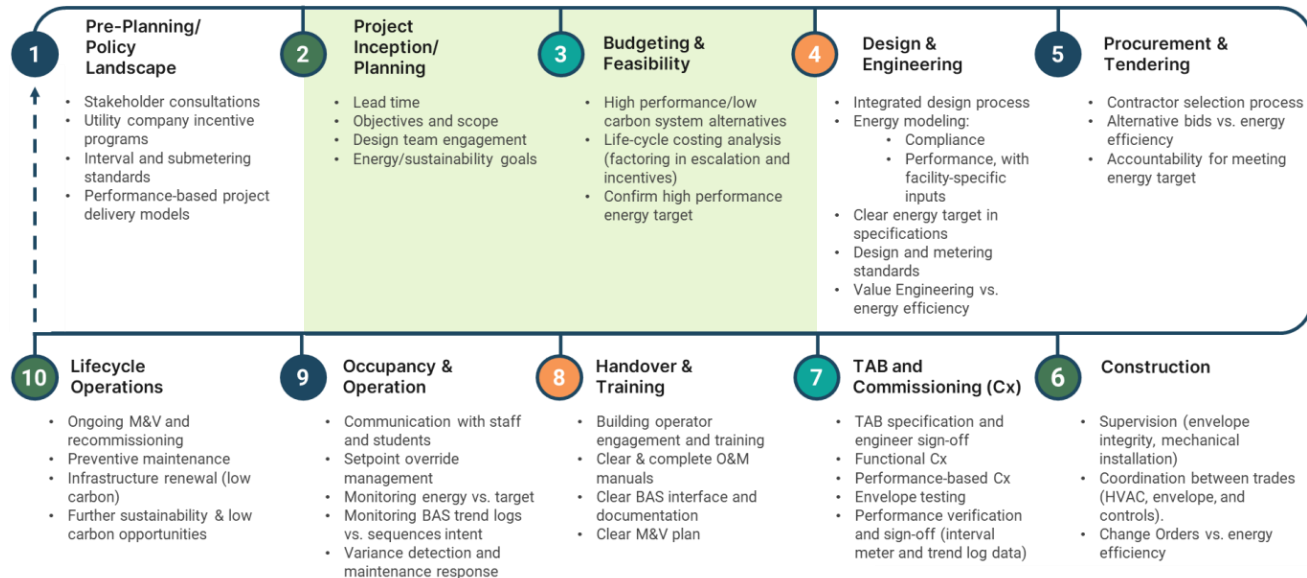


New commercial construction incentive programs

Province	Program	Eligible Buildings	Key Requirements	Primary Measures Supported	Financial Support
British Columbia	CleanBC Better Buildings	New commercial & institutional buildings	<ul style="list-style-type: none"> Must be new construction (or major renovation) in BC Hydro territory. Project must deliver ≥ 400 t CO₂e lifetime GHG savings 	<ul style="list-style-type: none"> All-electric HVAC, ventilation, and DHW systems. High-performance envelopes and heat-recovery systems 	<ul style="list-style-type: none"> Energy Study Incentive: Up to \$15,000 per project Capital Incentives: Up to \$500,000 based on lifetime GHG emissions reduced (\$30–\$120 per tCO₂e)
British Columbia	FortisBC Commercial New Construction	Commercial new construction	<ul style="list-style-type: none"> Complete FortisBC engagement process Provide energy modelling and design-stage verification Exceed Step Code or achieve $\geq 30\%$ better than BCBC 	<ul style="list-style-type: none"> Energy modelling support HVAC efficiency and ventilation optimization Airtightness testing 	<ul style="list-style-type: none"> Modelling incentive: 10% up to \$25k Airtightness rebate up to \$5k Performance-based post construction incentives
Manitoba	Efficiency Manitoba – Efficiency Manitoba New Buildings 3.0	Commercial, Institutional, Multi-Unit Residential	<ul style="list-style-type: none"> Project must be new construction or major renovation. Energy model comparing proposed design to NECB baseline. Post-construction verification of installed measures and updated energy model. Energy performance improvement must exceed minimum code requirements. 	<ul style="list-style-type: none"> High-efficiency HVAC systems Enhanced building envelope Heat recovery and ventilation improvements High-efficiency lighting and lighting controls Optimized building controls and system integration. 	<ul style="list-style-type: none"> Performance incentive: ~\$0.60–\$3.50 per ft² (eligible floor area) Energy modelling bonus: Up to \$12,000 per project
Ontario	Savings By Design – Enbridge	Commercial & multi-residential ($\geq 25,000$ sq ft)	<ul style="list-style-type: none"> Engage during early design Target $\geq 25\%$ better than code 	<ul style="list-style-type: none"> Integrated design facilitation Energy modelling HVAC and envelope optimization 	<ul style="list-style-type: none"> Airtightness incentive up to \$45k Additional project-specific incentives
Nova Scotia	Commercial New Construction	Commercial, institutional	<ul style="list-style-type: none"> Energy modelling required Demonstrate improved performance vs. baseline 	<ul style="list-style-type: none"> HVAC, lighting, envelope improvements 	<ul style="list-style-type: none"> Modelling incentive up to \$15k Performance based incentives

2. High performance energy target (HPET)

Project development stage		Recommendations
2	High performance energy target	Set the target early on, based on climate zone and adjustment factors in the Guide.



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

Target by end use for climate zone 5 (Toronto Pearson Airport) based on the specified school archetype

Energy use intensity (EUI)

School	Total EUI-excluding portables	ELECTRICITY EUIs (2023-2024) - ekWh/sq. ft.					GAS EUIs (2023-2024) - ekWh/sq. ft.		
		Electricity EUI excluding Portables	Lighting	Cooling	Plug Load	Pumps and fans	Gas EUI	Heating	Domestic hot water
Any zone 5 school	7.5	3.5	0.7	0.3	0.2	2.3	4.0	3.8	0.2

HPET archetype

Climate zone	5
Standard school day operating hours	6:00 AM to 6:00 PM
Permitting hours per year*	6%
Heating system	Condensing boilers
Air distribution	Variable air volume air handling units (AHUs) (x2) 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
Lighting	LED throughout
Domestic water heaters	Gas-fired condensing

* Percent additional annual standard operating hours due to permitting, adjusted for the areas of school in use.

HPET adjusted by climate zone

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/sq. ft)	Electricity EUI (kWh/sq.ft.)	Gas EUI (ekWh/sq.ft.)
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

Note: Adjustment factors for the different system variations, process loads, and portables can be found in 'Appendix 1: High-performance energy target adjustment factors' of the main guidance document

15°C heating balance temperature

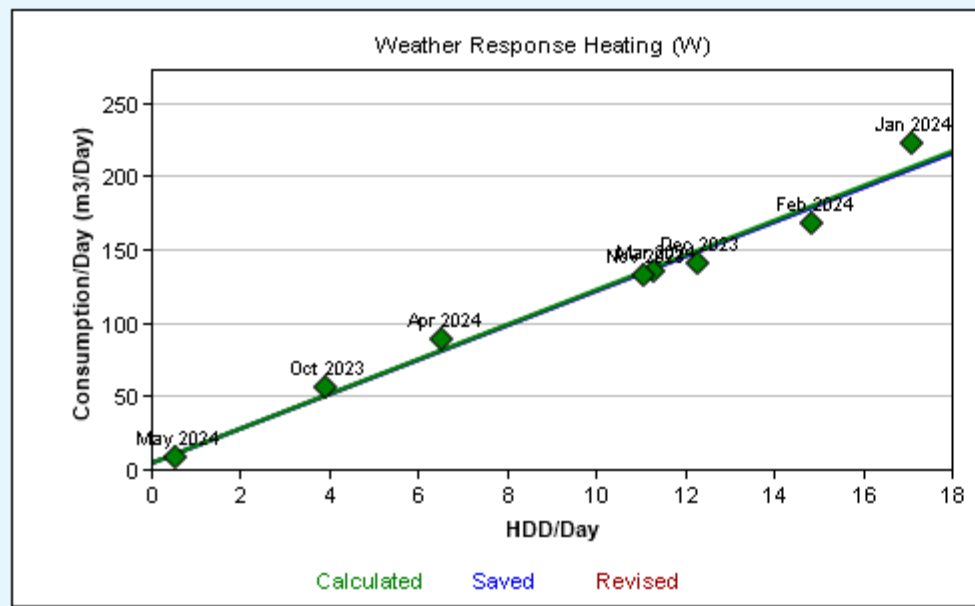
Baseline calculation

Winter

Summer

Heating Balance Temperature:
15 °C

Cooling Balance Temperature:
10 °C



	Auto calculated	Saved	Revised
Base (m³/Day)	4.24	3.83	<input type="text" value="3.83"/> Manual ▼
Slope (m³/HDD)	11.8402	11.7757	<input type="text" value="11.7757"/> Manual ▼
	<input type="button" value="Copy to revised"/>	<input type="button" value="Copy to revised"/>	<input type="button" value="Redraw revised graph"/>
R ²	0.9784		
NDB (%)	0.0040	0.8617	28.0960
CVSTD (%)	295.10		
CVRMSE (%)	7.22		

Comments

R² - coefficient of determination

NDB - net determination bias

CVSTD - coefficient of variation of the standard deviation

CVRMSE - coefficient of variation of the root mean square error

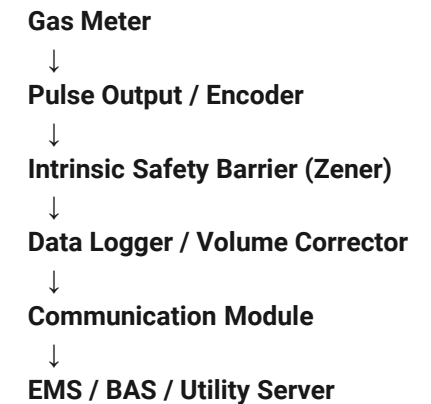
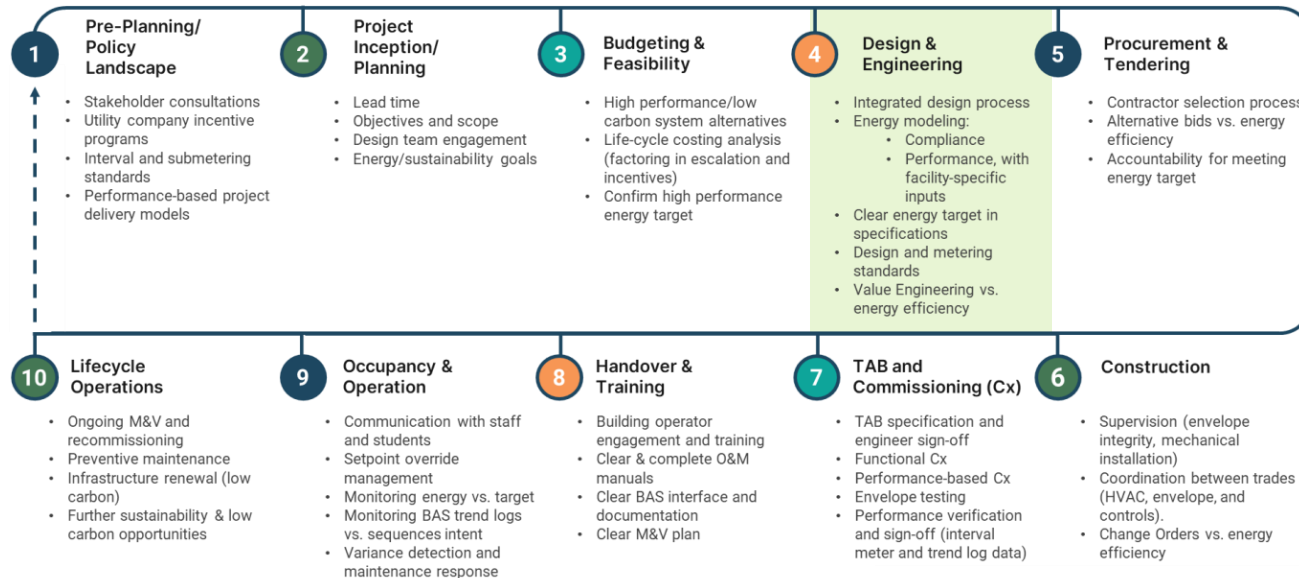
HPET adjustments

Adjustments to energy targets:

- Performance year weather
- Portable classrooms
- Process loads – swimming pools, kitchen/canteen, sports dome, greenhouse
- Heating system alternatives (GSHPs, ASHPs)
- Electric heat (based on % of school)
- Air conditioning (based on % of school)
- Solar PV (metered kWh and kW)
- School day schedules (operating hours)

3. Energy metering

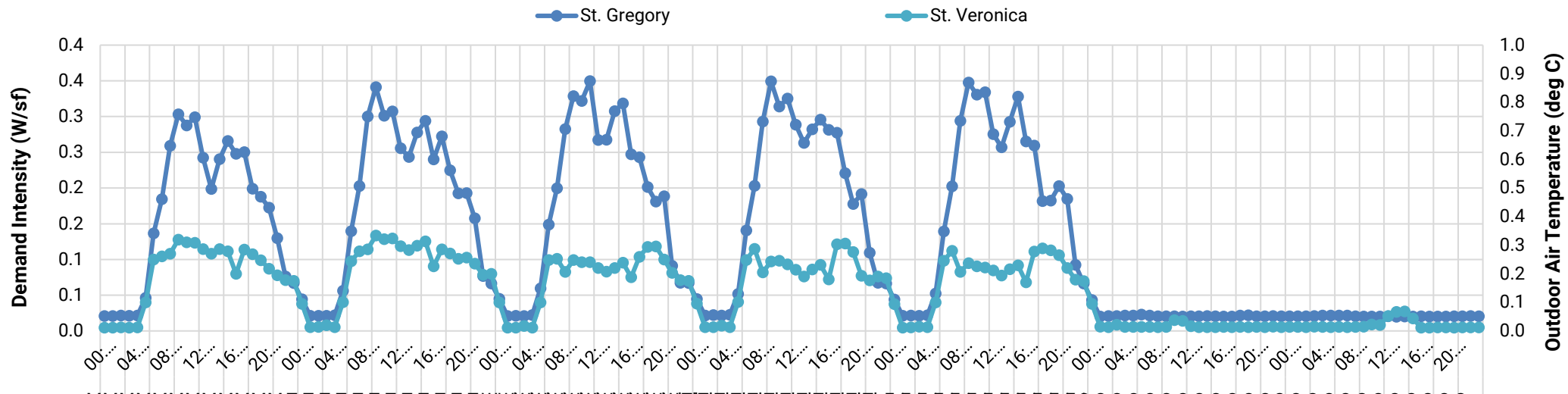
Project development stage		Recommendations
3	Energy metering	Interval metering – require central interval electric, gas (and water) metering.
		Submetering – require submetering of main systems including portables.
		Remote data access – ensure readily accessible and timely reporting.



Lighting submetering

- Two schools' comparison, both 100% LED
- Operations – time schedule vs advanced controls (daylight, motion & occupancy sensors)
- Verify demand and consumption savings

Weekly Demand Profile (3-week average in January 2025) - Lighting



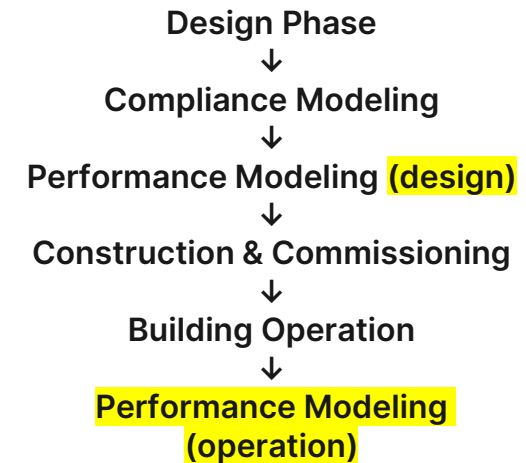
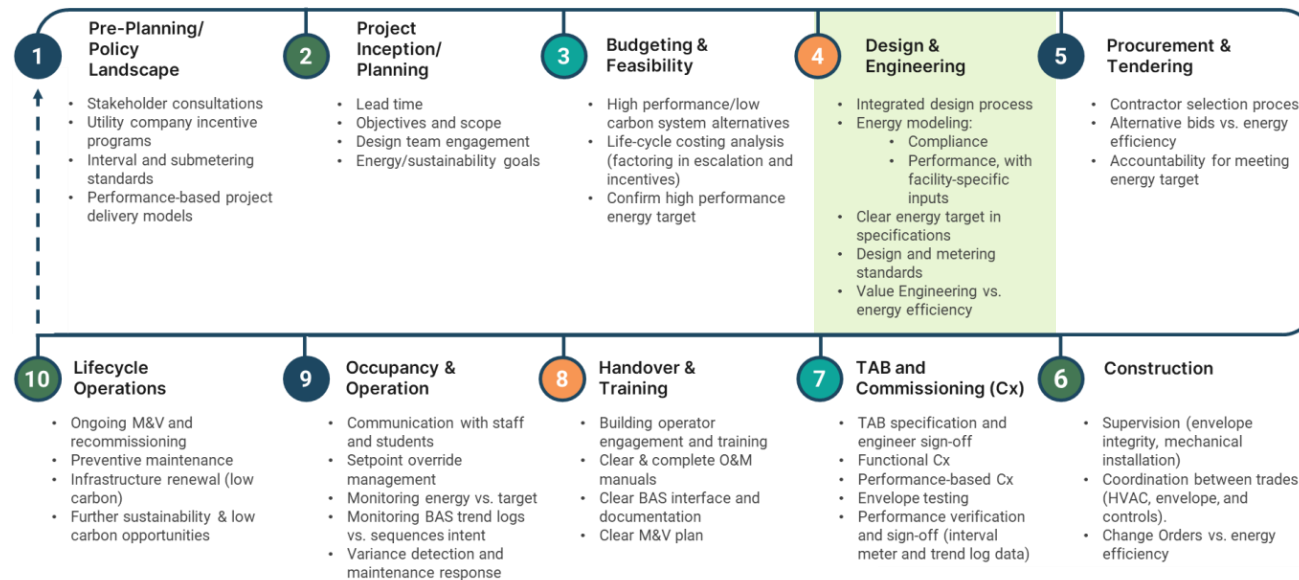
Submetering standard

- Provide interval energy submetering at the end-use level
- Ensure submeters are connected to the data network, synchronized, and compatible with BAS
- Provide 15-minute granularity, consistent with Natural Resources Canada and ISO50001 energy management guidance
- For propane and fuel oil, include one central smart/pulse-output flow meter on the main supply line

End Use / System	Typical Metering Point	Purpose
Pumps & 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	Monitor temporary or satellite classroom energy use separately
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

4. Energy modeling

Project Development Stage		Recommendations
4	Energy modeling	Compliance modeling for the building permit.
		Performance modeling to evaluate and document expected building energy performance using school-specific design parameters and operational parameters.
		Produce required HPET electric and thermal energy demand profiles for commissioning and facility operations.



Performance modeling

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 & 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 & 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 – <i>no rebuild of the model required</i> .
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.
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 energy modeling

How performance modeling verifies HPET:

- **Design-stage performance model** ensures the design can meet or is close enough to the HPET target before construction (board standard schedules, plug loads, control sequences, equipment performance).
- **Operation-stage performance model** updates any unalterable inputs, enabling a fair, apples-to-apples comparison against HPET using real operating conditions.
- **Calibration** uses measured energy and operational data to tune the model.

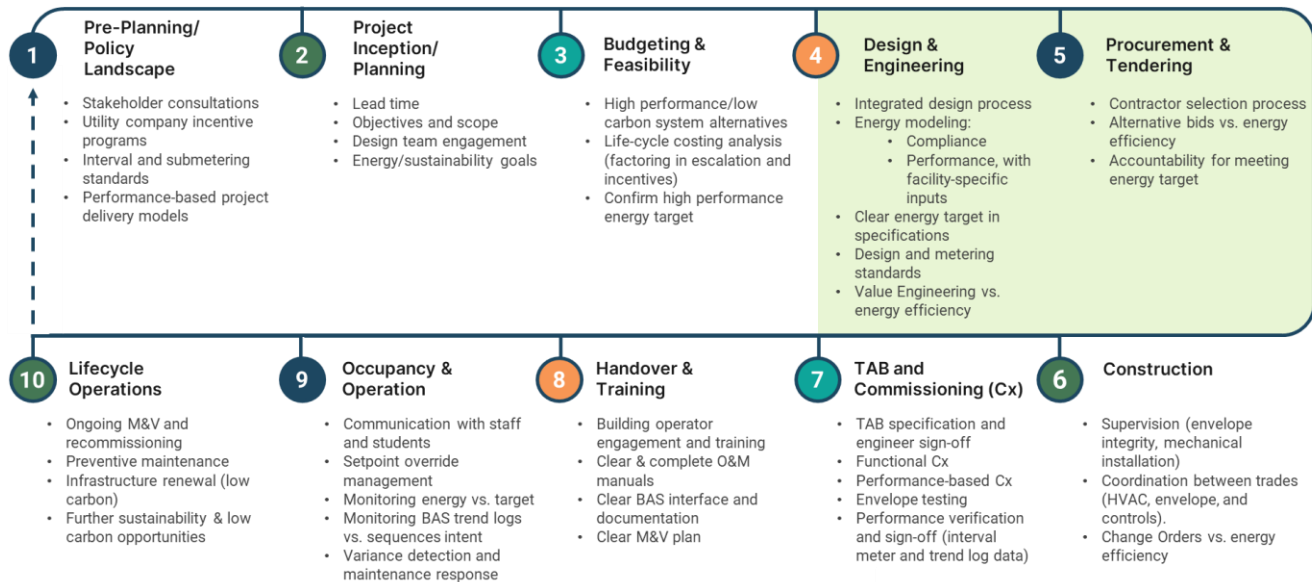
Results identify and correct deficiencies and confirm achievement of the HPET.

Performance model (operation stage) outputs

- NMBE and CVRMSE (primary calibration metrics)
- Total, electric and thermal EUI (actual vs. HPET target)
- Peak electric and gas demand, baseload, and demand density
- End-use energy breakdown (lighting, fans/pumps, cooling, heating, DHW)
- Schedule & controls KPIs (occupied/unoccupied loads, ventilation schedules, setpoints, runtimes)
- Weather-sensitive KPIs (HDD/CDD slope, heating balance point)
- Load-shape and day-type correlation (weekday/weekend/holiday alignment) used for performance commissioning and post-occupancy verification

5. Building system design

Project Development Stage		Recommendations
5	Building system design	Adopt high performance design standards including airflows, power densities, supply temperatures, ΔT s.
		Specify programmable BAS with advanced control capabilities (including DCV) and lighting controls with remote access.
		Specify high performance building envelope standard including whole-building envelope testing.
		Perform life cycle cost analysis of design alternatives.



Envelope performance – design requirements

1. Why envelope performance matters to achieve HPET

- High-performance outcomes *depend on* low infiltration.
- NECB doesn't mandate testing, but it is recommended to hit Tier 3/Tier 4 and HPET.
- Envelope design *choices* (form factor, assemblies, thermal bridging, detailing, QA/QC) drive envelope performance.

2. Design-phase evidence (from NS case studies):

- Measured infiltration EUI ranged **17.5–39.8 kWh/m² (up to 22% of HPET for the lower end)**.
- Building form factor (enclosure/GFA) varies from **1.11–2.47**, and higher form factors **increase envelope heat and infiltration-driven losses**.
- Leakage coefficient (C) and normalized leakage rates reflect **envelope build quality**.

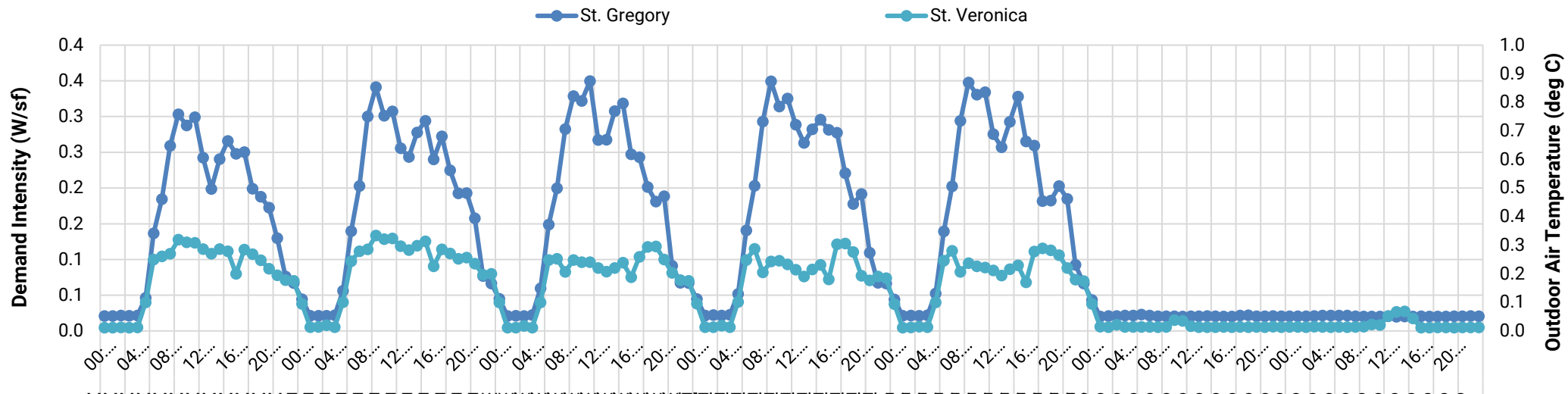
3. What needs to be included in design requirements

- Envelope performance standard (air leakage target).
- **Whole-building airtightness testing *required* as part of the contract.**
- Coordination between envelope, HVAC, and mechanical design.

Lighting controls

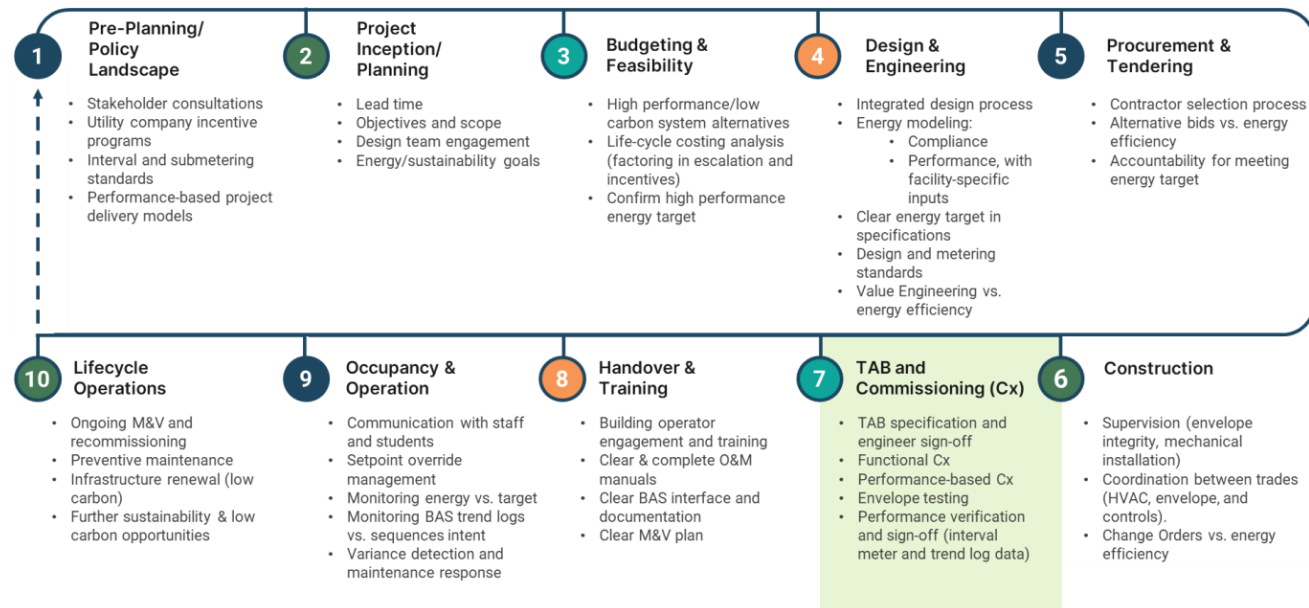
- Two schools' comparison, both 100% LED
- Basic vs. networked, programmable lighting control systems
- Operations – time schedule vs advanced controls (daylight, ambient light, motion & occupancy sensors)

Weekly Demand Profile (3-week average in January 2025) - Lighting



6. Testing and balancing (TAB), commissioning (Cx)

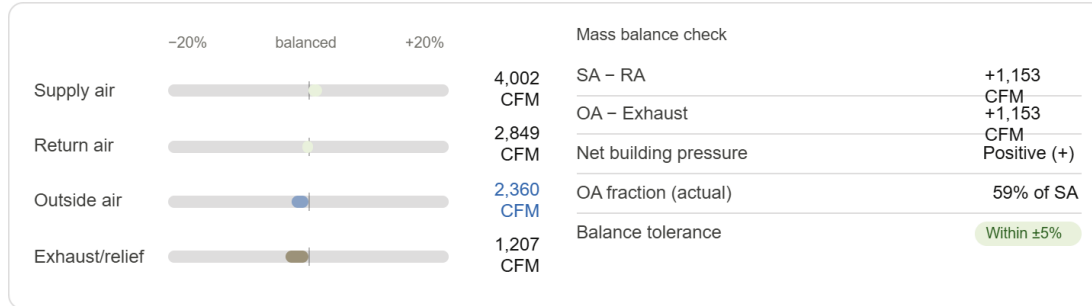
Project Development Stage		Recommendations
6	TAB and commissioning (Cx)	Employ owner-directed commissioning agent early on.
		Specify role, responsibilities, scope of work and output reports:
		Functional equipment testing.
		Performance testing to confirm EUI, peak demand, required interval meter and BAS trend log profiles.
		Verify required TAB performance indicators, including airflows, static pressures and fan power, with engineer sign-off.
		Conduct interval meter data diagnostics to verify required day type and time of day performance.
		Match trend log charts with required HVAC and lighting operational and controls profiles.
		Conduct whole-building airtightness testing and verify against design requirements.



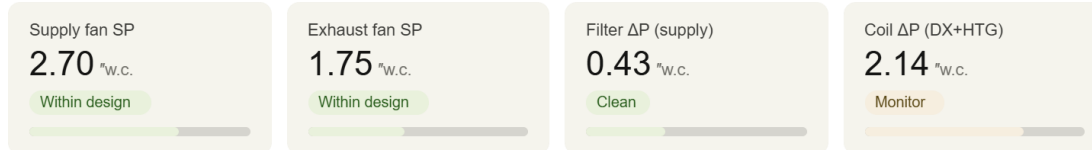
Performance-based TAB

TAB KPIs sample graphics

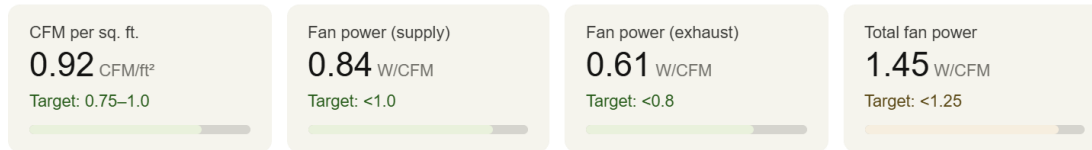
AIRFLOW BALANCE



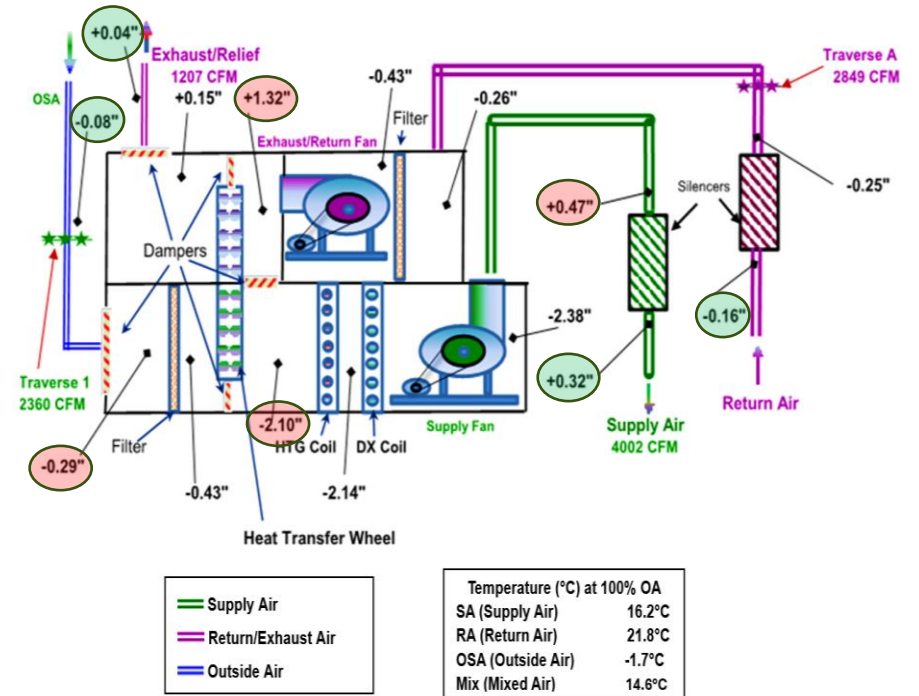
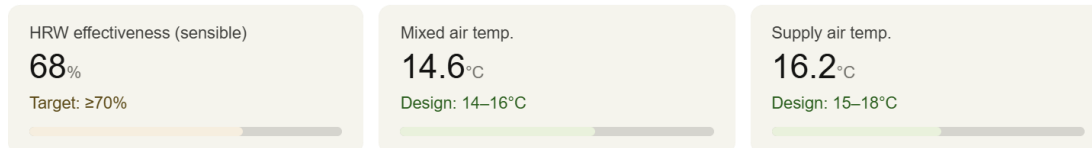
STATIC PRESSURE PROFILE



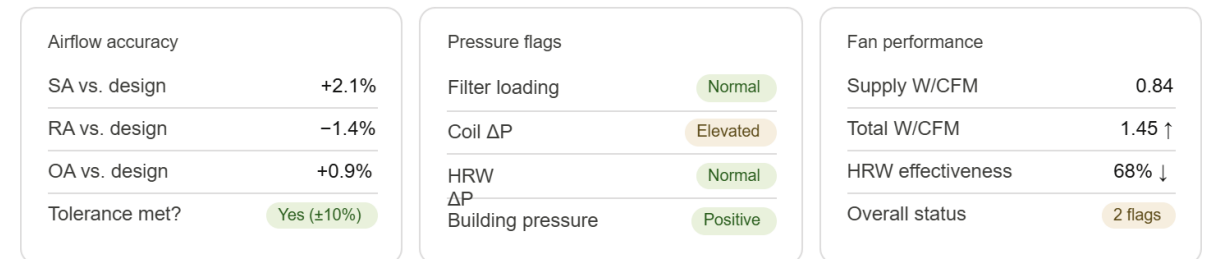
UNIT EFFICIENCY METRICS



HEAT RECOVERY & THERMAL



SYSTEM HEALTH SUMMARY



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.

Envelope testing (Nova Scotia case studies)

- Measured infiltration EUI range from 17.5 to 39.8 kWh/m².
- Building form factor range (Enclosure/GFA) range from 1.11 to 2.47.
- Higher form factors correlate with increased transmission and infiltration-driven energy losses.
- Leakage coefficient (C) and normalized leakage rates reflect envelope build quality.
- Testing is critical to outperform code minimums and quantify real envelope performance.

School	Leakage coefficient C (lps/Pa ⁿ)	Flow exponent (n)	lps/m ² (5 Pa)	lps/m ² (75 Pa)	Form factor	Infiltration EUI (kWh/m ²)
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

Verifying day type and time of day energy use

Electricity Interval Benchmarks

Sep 2023-Aug 2024

Board	School	1. School Day (5:00 AM-9:00 AM) - Pre-school HVAC operation due to early startup - Gas use intensity (ekWh/sf)	Board	School	2. School Day (9:00 AM-5:00 PM) - Outside air volumes with all HVAC running - Gas use intensity (ekWh/sf)	Board	School	3. School Day (5:00 PM to 11:00 PM) - HVAC operation during evenings due to extended operating hours or permitting - Gas use intensity (ekWh/sf)	Board	School	4. All Days Unoccupied from 11:00 PM to 5:00 AM - HVAC operation (including elevated space temperatures) when there's nobody there - Gas use intensity (ekWh/sf)
HCDSB	St. Nicholas	0.48	HCDSB	St. Nicholas	1.45	HCDSB	St. Veronica	0.31	HCDSB	St. Veronica	0.32
HCDSB	St. Veronica	0.54	HCDSB	St. Veronica	1.53	HCDSB	St. Nicholas	0.34	HCDSB	St. Nicholas	0.34
HCDSB	St. Scholastica CES	0.60	HCDSB	St. Gregory the Great CES	2.05	HCDSB	St. Scholastica CES	0.51	HCDSB	St. Gregory the Great CES	0.35
HCDSB	St. Gregory the Great CES	0.68	HCDSB	St. Scholastica CES	2.11	HCDSB	St. Gregory the Great CES	0.52	HCDSB	St. Scholastica CES	0.54

Gas Interval Benchmarks

Sep 2023-Aug 2024

Board	School	1. School Day (5:00 AM-9:00 AM) - Pre-school HVAC operation due to early startup - Gas use intensity (ekWh/sf)	Board	School	2. School Day (9:00 AM-5:00 PM) - Outside air volumes with all HVAC running - Gas use intensity (ekWh/sf)	Board	School	3. School Day (5:00 PM to 11:00 PM) - HVAC operation during evenings due to extended operating hours or permitting - Gas use intensity (ekWh/sf)	Board	School	4. All Days Unoccupied from 11:00 PM to 5:00 AM - HVAC operation (including elevated space temperatures) when there's nobody there - Gas use intensity (ekWh/sf)
HCDSB	St. Scholastica CES	0.53	HCDSB	St. Scholastica CES	1.05	HCDSB	St. Veronica	0.37	HCDSB	St. Veronica	0.56
HCDSB	St. Veronica	0.99	HCDSB	St. Veronica	1.26	HCDSB	St. Nicholas	0.38	HCDSB	St. Nicholas	0.62
HCDSB	St. Gregory the Great CES	1.11	HCDSB	St. Nicholas	1.61	HCDSB	St. Scholastica CES	0.59	HCDSB	St. Gregory the Great CES	0.67
HCDSB	St. Nicholas	1.20	HCDSB	St. Gregory the Great CES	1.82	HCDSB	St. Gregory the Great CES	0.61	HCDSB	St. Scholastica CES	0.84

Verifying day type and time of day energy use

Electricity Interval Benchmarks

Sep 2023-Aug 2024

Board	School	5. School Closed 24 hrs / Day - HVAC operation during winter and spring breaks (including weekends), statutory holidays - Gas use intensity (ekWh/sf)	Board	School	6. PA Days 24 hrs/ Day - HVAC operation during these days - Gas use intensity (ekWh/sf)	Board	School	7. Saturdays and Sundays 24 hrs / Day - HVAC operation on weekends - Gas use intensity (ekWh/sf)	Board	School	8. Summer Break 24/7 – DHW system losses assuming little DHW consumption during this period - Gas use intensity (ekWh/sf)
HCDSB	St. Nicholas	0.13	HCDSB	St. Nicholas	0.09	HCDSB	St. Veronica	0.32	HCDSB	St. Scholastica CES	0.22
HCDSB	St. Veronica	0.13	HCDSB	St. Veronica	0.10	HCDSB	St. Nicholas	0.36	HCDSB	St. Veronica	0.29
HCDSB	St. Gregory the Great C	0.20	HCDSB	St. Scholastica CES	0.13	HCDSB	St. Gregory the Great C	0.38	HCDSB	St. Nicholas	0.30
HCDSB	St. Scholastica CES	0.22	HCDSB	St. Gregory the Great C	0.13	HCDSB	St. Scholastica CES	0.63	HCDSB	St. Gregory the Great C	0.60

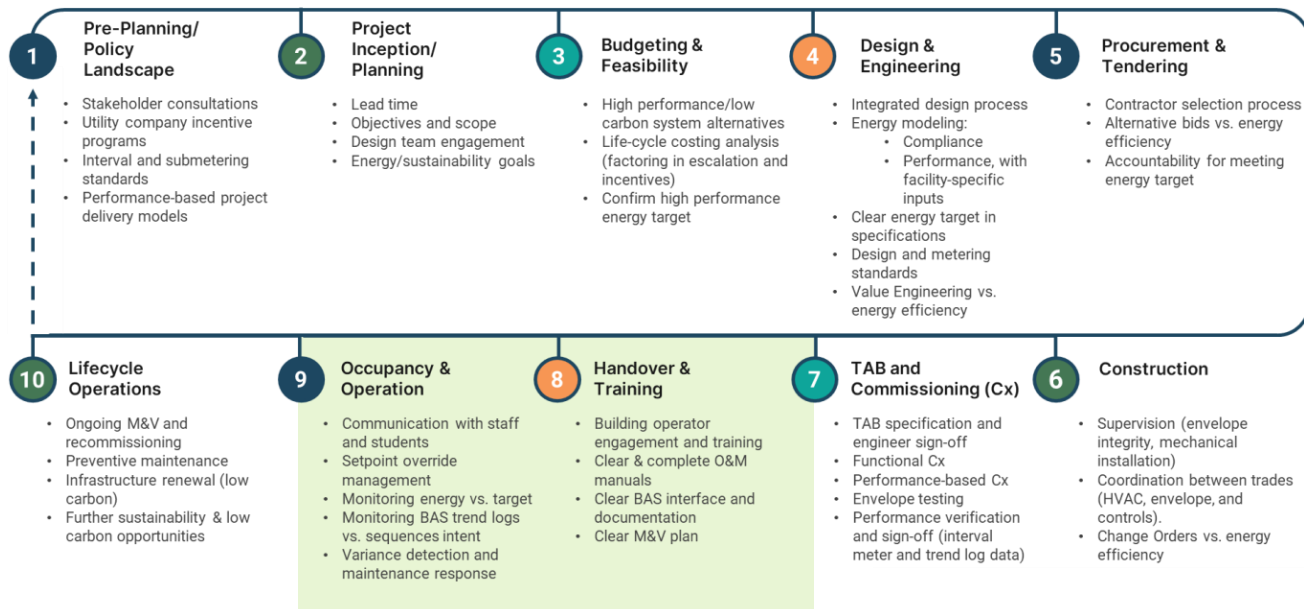
Gas Interval Benchmarks

Sep 2023-Aug 2024

Board	School	5. School Closed 24 hrs / Day - HVAC operation during winter and spring breaks (including weekends), statutory holidays - Gas use intensity (ekWh/sf)	Board	School	6. PA Days 24 hrs/ Day - HVAC operation during these days - Gas use intensity (ekWh/sf)	Board	School	7. Saturdays and Sundays 24 hrs / Day - HVAC operation on weekends - Gas use intensity (ekWh/sf)	Board	School	8. Summer Break 24/7 – DHW system losses assuming little DHW consumption during this period - Gas use intensity (ekWh/sf)
HCDSB	St. Veronica	0.28	HCDSB	St. Scholastica CES	0.11	HCDSB	St. Veronica	0.56	HCDSB	St. Veronica	0.01
HCDSB	St. Scholastica CES	0.37	HCDSB	St. Veronica	0.13	HCDSB	St. Nicholas	0.61	HCDSB	St. Gregory the Great C	0.01
HCDSB	St. Nicholas	0.38	HCDSB	St. Gregory the Great C	0.16	HCDSB	St. Gregory the Great C	0.70	HCDSB	St. Nicholas	0.02
HCDSB	St. Gregory the Great C	0.47	HCDSB	St. Nicholas	0.17	HCDSB	St. Scholastica CES	0.90	HCDSB	St. Scholastica CES	0.03

7. Facility operations

Project Development Stage		Recommendations
7	Facility operations	Define standards, authorities, limits and reporting for:
		HVAC and lighting scheduling for school days, PA days and permitting.
		Occupied and unoccupied temperature setpoints.
		Outdoor air (OA) volume requirements and CO ₂ setpoints.



Mechanical systems performance indicators (KPIs for operation & commissioning)

Airside System KPIs

- **Fan efficiency (W/cfm)**
Benchmark for AHU/RTU performance; identifies dirty filters & poor balancing.
- **Ventilation OA fraction vs. schedule**
Confirms DCV, heat recovery, and ventilation control logic.
- **FPB/VAV box runtime & supply airflow**
Detects rogue terminal boxes and excessive reheat.
- **Air handling unit supply temp reset behavior**
Ensures optimized heating/cooling and reduced reheat.

Hydronic Systems KPIs (both heating & cooling)

- **ΔT across hydronic systems and coils (heating & cooling)**
Confirms correct flow, valve modulation, and coil performance.
- **Boiler/chiller entering & leaving water temps (EWT/LWT)**
Validates SWT reset and staged capacity control.
- **Pump efficiency (W/gpm)**
Identifies overspeed, missing VFD turndown, incorrect setpoints.
- **Distribution loop ΔP trends**
Detects fouled strainers and stuck valves.
- **ΔP reset performance (for variable speed pumping)**
Confirms differential pressure setpoint resets based on actual valve positions → reduce pump energy use.

Heat Recovery KPIs

- **Enthalpy wheel effectiveness**
Verifies proper operation and captures degradation/failure.
- **Bypass vs recovery mode runtime**
Detects controls issues that increase heating load.

Heating and DHW System KPIs

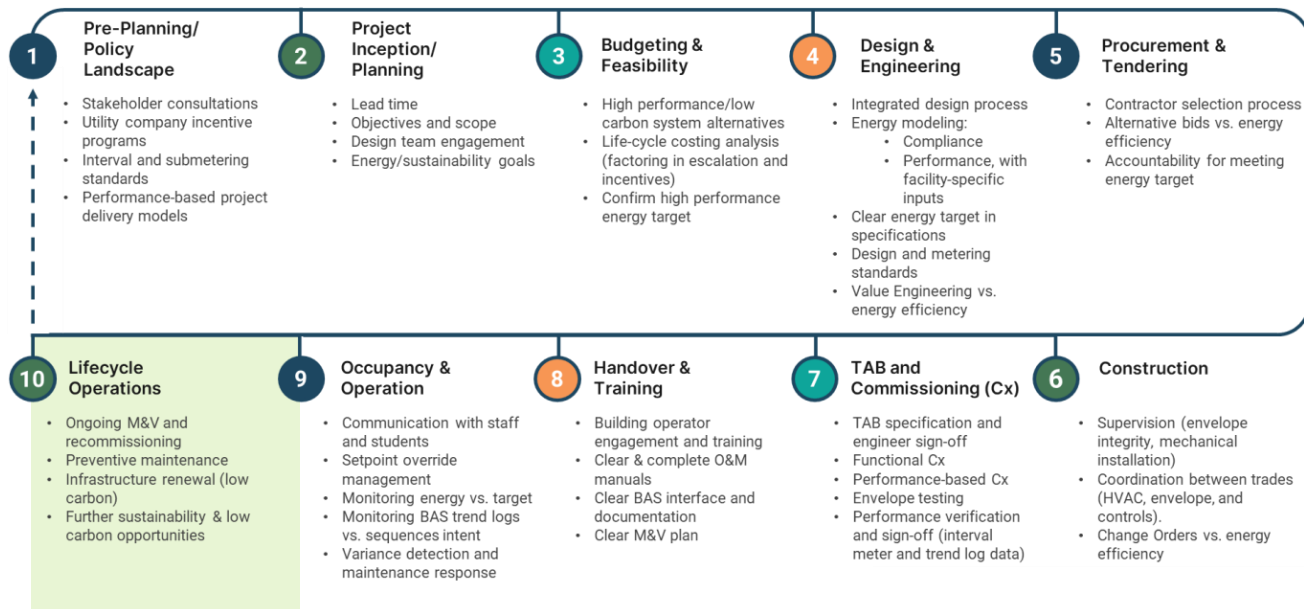
- **Boiler % firing vs outdoor temperature**
Confirms modulation sequencing and correct heating slope.
- **Hydronic loop SWT reset curve adherence**
Key driver of high heating efficiency.
- **DHW system**
DHW energy use (ekWh/ft²)

Cooling System KPIs

- **kW/ton**
Tracks real cooling efficiency and identifies fouled condenser coils.
- **Compressor staging vs. cooling load**
Verifies capacity control and avoids short-cycling

8. Strategic energy management

Project Development Stage		Recommendations
8	Strategic energy management	Clarify project team roles and responsibilities for achieving and maintaining the HPET.
		Ensure proper documentation and succession/continuity planning.
		Implement energy management information system (EMIS), continuous energy monitoring and reporting.
		Institute maintenance management response to performance variances.
		Conduct staff training and continuous recommissioning.



Design for operations

1. Engage operators early

- Bring operations into HVAC system selection, programming, design reviews, and value engineering
- Validate maintainability, zoning, HVAC sequences, and BAS logic

2. Standardize design requirements

- Airflows, ΔT s, fan/pump power limits
- BAS naming/alarms, metering, and envelope performance

3. Usable Controls

- Intuitive BAS graphics
- Pre-configured trend logs for troubleshooting
- Avoid overly complex sequences

4. Build for maintainability

- Accessible coils, filters, valves, strainers, sensors
- Logical equipment layouts and tagging

5. Commissioning-ready design

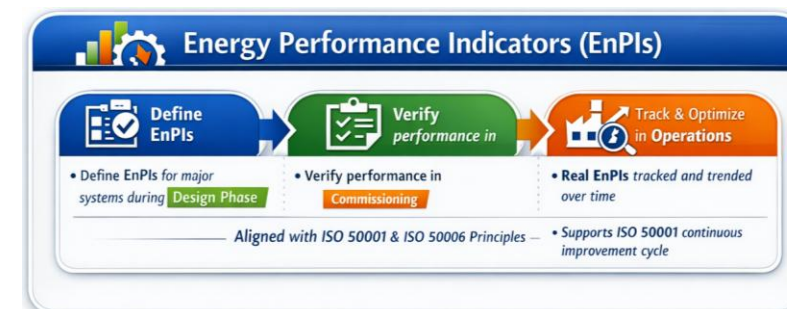
- Interval metering for electricity + gas + fuel oil/propane
- Required BAS points for verification & continuous Cx
- TAB, envelope testing, and performance sign-off

6. Energy Performance Indicators (EnPIs)

- Define system-level EnPIs during the design phase (e.g., heating plant seasonal efficiency).
- Use EnPIs as objective acceptance criteria during commissioning.
- Track EnPIs in operations to verify long-term performance. Aligns with ISO 50001 & ISO 50006 energy management principles.

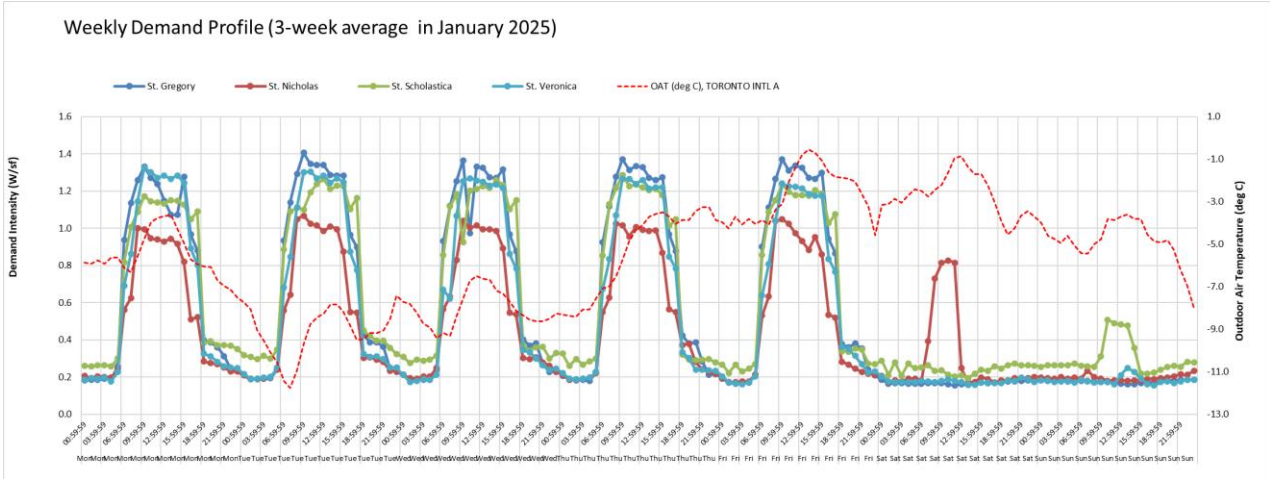
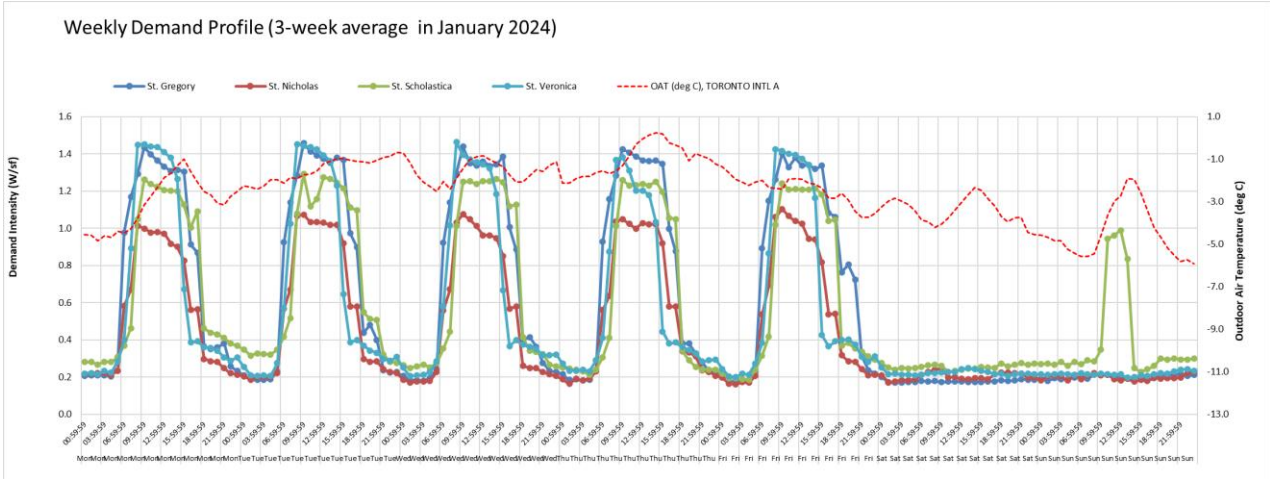
7. Training & documentation

- Hands-on operator training before occupancy
- Simple SOOs (detailed + operator-friendly versions)
- Clear O&M manuals and trend-log templates



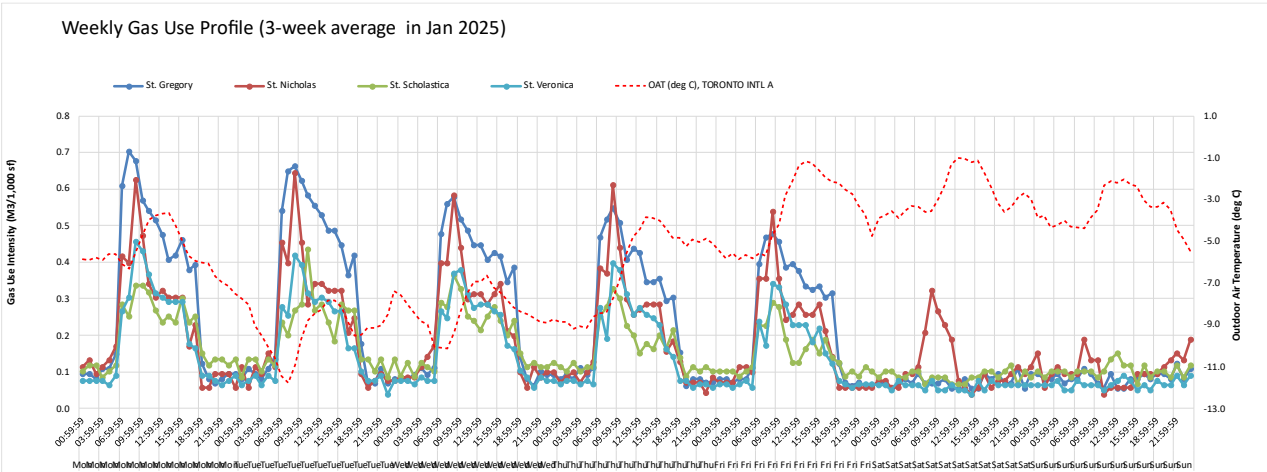
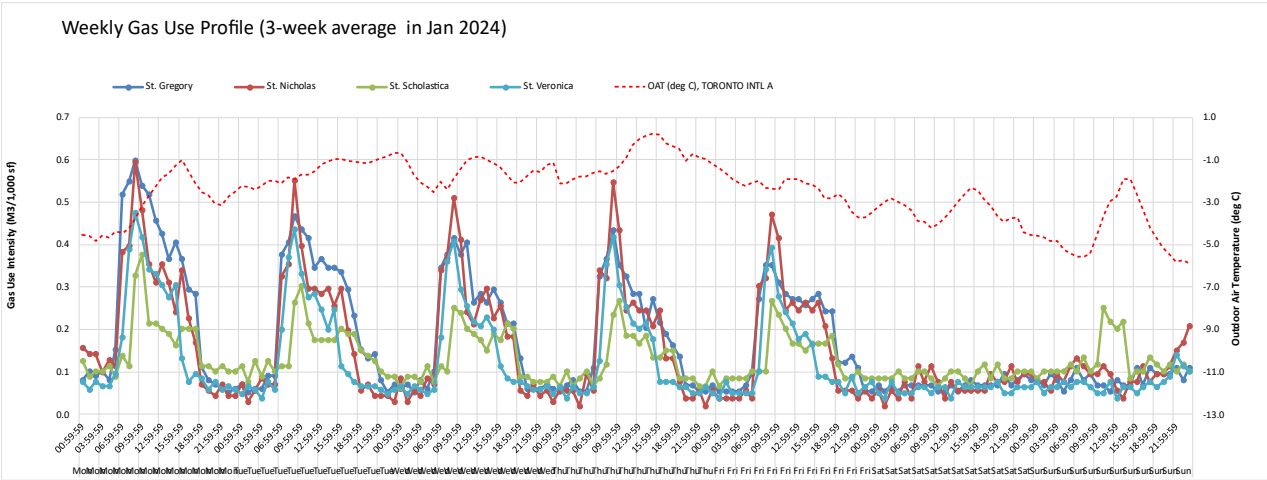
Monitoring performance over time - electricity

3-week average use in January



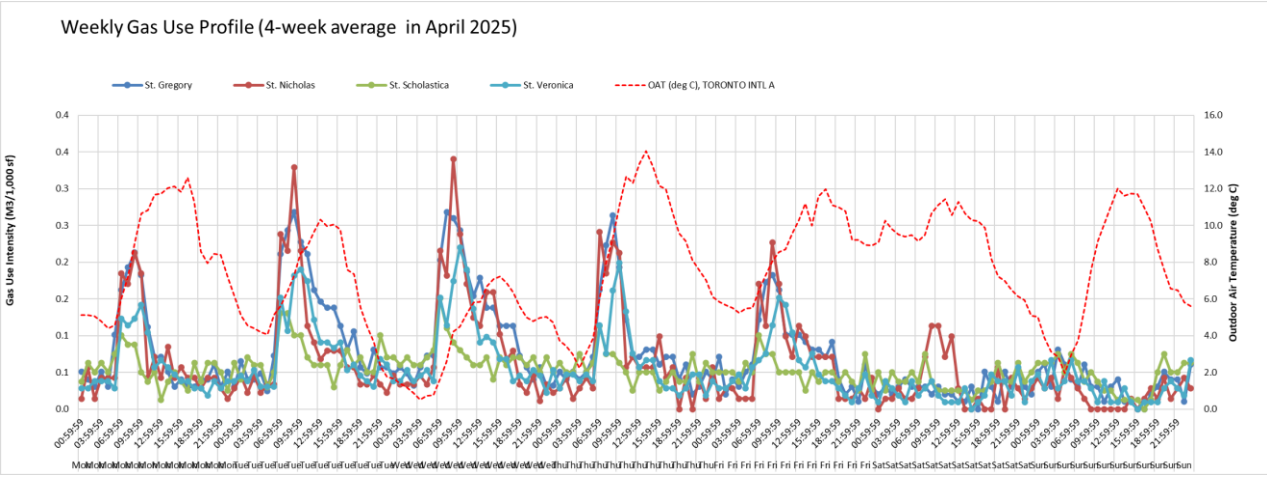
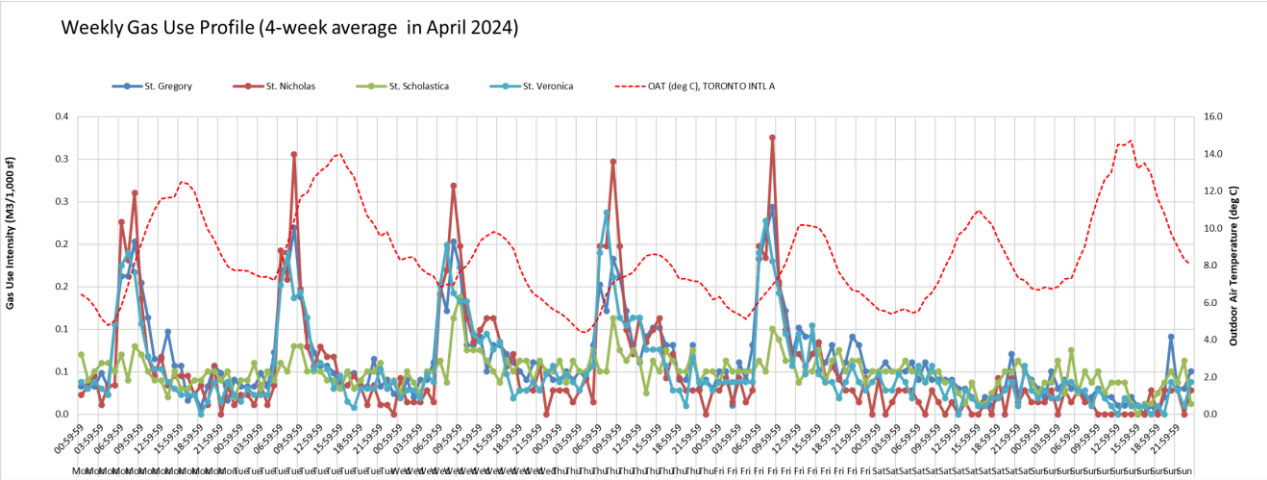
Monitoring performance over time - gas

3-week average use in January



Monitoring gas use over time – shoulder season

4-week average in April



Performance KPIs for dashboards

1. Whole-Building Energy KPIs

- **Total EUI (ekWh/ft²)** – Annual efficiency indicator
- **Electric EUI / Gas EUI** – System-level breakdown
- **Gap to HPET target** – Measures performance drift

2. Weather-Normalized Heating & Cooling KPIs

- **Heating slope vs. HDD** – Efficiency of heating response
- **Cooling slope vs. CDD** – Confirms proper cooling control
- **Heating balance temperature** – Verifies setback & control logic
- **Seasonal baseload** – Detects excess ventilation or night operation

3. End-Use KPIs from Submetering

- Lighting EUI
- Pumps & fans EUI
- Cooling EUI
- DHW energy
- Portable classroom consumption

4. Controls & Operations KPIs

- Occupied vs. unoccupied load ratio
- Weekend/holiday energy profile
- Ventilation & CO₂ levels vs. schedule
- Peak demand (kW)
- Runtime hours (AHUs, boilers, RTUs, chillers)



Q&A

Next Steps

- **Publish Guide in April**
- **Follow-up meetings with provinces and boards:**
 - Achievability of the high-performance energy target (HPET)
 - Adoption of recommendations
 - Practical interventions with schools in the development pipeline
 - Remedial action for underperforming schools
 - Application of Guide recommendations to future new school development projects

Thank you!

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