The Path to High Performance School Buildings

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<u>Aristotle</u>

"The energy of the mind is the essence of life."

Presentation Outline:

> Green Building Policy Objectives & PSFB Goals

> HVAC Technologies (Pros/Cons):

Ground source heat pumps, ERVs, DOAS, Active Chilled Beams, Displacement ventilation, Variable refrigerant flow heat pump

Case Study of nine High Performance Schools

Lessons Learned

Next Steps

Manitoba's Green Building Policy (April 2007)

Vision: Create a significant improvement in how new and renovated buildings, that are funded by Government, perform over the entire life cycle from an environmental, energy and economic perspective.

Goals: Life cycle costing, reduce non-renewable fossil fuel usage, minimize negative environmental impacts, lower greenhouse gas emissions, improve indoor environment etc..

Requirements:

• IDP or Integrated Design Process (Holistic, collaborative, comprehensive design process)

•Minimum Energy Benchmark: 33% better than MNECB

•Life Cycle Costing (LCC)

•Min LEED Silver Certification

•Preference for low or zero carbon <u>renewable energy sources</u> (eg. Geothermal Heat Pumps, passive solar, thermal solar,

•Designed for flexible energy source (ie low temperature hydronic)

PSFB Process Changes

OLD PARADIGM

- Formula Support(prescriptive)
- Value Engineering (First cost)



NEW PARADIGM

- IDP, scope of work driven (performance)
- Life Cycle Costing (maintenance, durability)
- Factor Environmental cost (renewable & alternate energy)

PSFB's Guiding Principles For High Performance Schools

Guiding Principles:

•**Sustainability:** (energy efficiency, increase use of renewable energy sources, massing, solar orientation...)

•**Durability:** (LCC, long lived materials, simple to maintain, school life expectancy of at least 100 years)

•Livability: (Includes safe, healthy, productive, comfortable environments that promote teacher and student outcomes)

Other PSFB Requirements For Design of High Performance Schools

•LEED Gold: Target of LEED gold for most projects.

•Energy Performance: Goal is to achieve full ten (10) maximum points available from LEED's energy and atmosphere credit. (or 64% better than the MNECB)

•Energy Modelling: Provide energy modelling to assist in design decisions relative to architectural concepts, HVAC systems, and electrical systems. (Schematic, Design Development, and Construction Document stages)

- Best Practice Commissioning: Mandatory on large and complex projects
- **Measurement & Verification:** On larger schools with more complex systems, M & V will be used to assess actual energy use as compared to predicted or modelled energy use. This will assist in evaluation of new technologies.
- Higher Standard of Acoustics: ANSI Standard S12.60-2002

Current Energy Usage:

• Current average energy use index for <u>Canadian Schools is 26</u> <u>kwh/ft2</u>. (source OEE NRC 2005 data)

Zero Energy Capable (ZECs):

• The New Buildings Institute (NBI) defines ZECs as building that uses <10.0 kWh/sq.ft, but have no on-site power generation.

• These buildings achieve energy performance similar to Net Zero Energy Buildings (NZEBs), and could achieve net-zero with the addition of on-site power generation.

•This is PSFB's current Goal.

Zero Energy Capable (ZEC) < 10 kwh/ft2

School Energy Consumption



High Performance Schools (top things to consider):

> Design Team: Select experienced team with owner buy in. Detailed RFP required.

Building Envelope: Must be Highly Efficient (insulation, 2 story building, fenestration area < 35%, vapor barrier..)</p>

Site Selection: Solar orientation to take advantage of passive solar heating and access to utilities, geothermal...

Space Planning: Please Don't forget to allow adequate space for mechanical and electrical systems!! Do this early in process. (This is my personal plug!)

HVAC System Selection: Use criteria, goals, energy modelling, and selection matrix to narrow the choice. Look for synergies.

> Use "KISS" principle (simple, durable, constructible, easily maintained). Be mindful of capabilities of maintenance staff. Consider involving contractor(s) in design process.

Indoor Environmental Quality: This should have priority over energy efficiency.

Post Occupancy surveys and M &V (assess results moving forward and don't repeat mistakes) – School Division feedback is vital!

Schools Energy Use Breakdown



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Newer HVAC Technologies (pros/cons):

 \succ Energy recovery ventilator units (ERV) Dedicated outdoor air systems with heat recovery (DOAS) \blacktriangleright Active chilled beams (ACB) \geq Displacement ventilation (DV) Ground source heat pumps (GSHP) ➢Condensing Boilers (CB) \succ Variable refrigerant flow heat pump (VRF) >In-floor heating Injection pumping hydronic system Rain water collection for grey water usage

Energy Recovery Ventilation (ERV HRV)

Advantages:

- Preheats incoming outdoor air with waste exhaust air, to reduce energy costs (Eg. Emerado 30% energy savings, no preheat coil)
- Reduces HVAC equipment sizes (e.g. smaller boilers and/or chillers)
- Dual Core (reverse flow) ERV has highest efficiency

Limitations:

- Increased initial cost
- Collecting all exhaust air sources can be a challenge depending on building layout.
- > Frost control must be used on some technologies.

Applications:

- > Glycol Runaround, Heat Pipe, Plate HX, Heat Wheels, Newer Dual Core (or reverse flow)
- Initially Dual Core ERVs installed in existing Frontier SD schools and Alf Cuthbert School..
- > In 2007, a glycol runaround HX (lower efficiency) installed in new Leo-Remillard School.
- > In 2006, Emerado is first new school to have Dual Core ERV (highest efficiency)
- In 2009, Beliveau first existing school to have DOAS with heat wheel (Mid to high eff) for science wing.

Emerado – Dual Core ERV



Dual Core ERV (or Reverse Flow)



Mode 1

Mode 2

- Due to cycling heat exchanger, frost and dust rarely build up on the heat exchanger. This maintains high efficiency and reduces the frequency at which cleaning is needed.
- Can achieve 90% sensible and 70% latent heat recovery

Dedicated Outdoor Air System (DOAS)

Advantage

- AHU that does not re-circulate contaminated return air
- Minimizes spread of odours and contaminants
- Decouples sensible and latent loads.
- DOAS conditions mostly latent load and sensible load now conditioned by other unitary system(Fan coil or Chilled Beam)
- With reduced air flow, ductwork and air handler units can be downsized to reduce first cost of installation
- Reduces over-ventilation compared to recirculation systems
- > Provides heat recovery and some humidification in winter operation.

Limitations

- Possible frost issues on heat wheel systems without proper conditioning of outdoor air.
- Less free cooling capability

Applications

- In 2009, Beliveau is first existing school with DOAS w/ Heat Recovery (science wing)
- > New Schools: Northlands, Steinbach HS, Amber Trails, Woodlands

Dedicated Outdoor Air System (DOAS)

Dedicated outdoor air systems provide 100% outdoor air to the occupied space as specified by ASRAE 62.1. <u>No air is recirculated</u> back into the building.







Active Chilled Beams (ACB) -Advantages

Energy Savings

- Energy savings of 20-30% can be achieved
- Most of the sensible cooling is done in the occupied space
- Uses higher chilled water temperature (59-65°F) which improves efficiency of chiller or heat pump systems
- > Reduces supply fan air volumes as compared to all-air systems

Excellent Indoor Air Quality

- 100% outdoor air is supplied to space with no mixing of return air (used with DOAS)
- No contaminant mixing occurs
- Low Maintenance and Good Acoustics
 - > Fewer moving parts, no internal fans or filters to repair or replace
 - > Coils require periodic maintenance for cleaning
 - > Quiet operation since no fan and low velocity air flow (Noise similar to regular diffuser)

Smaller Equipment and Ductwork

- With reduced air flow, ductwork and air handler units can be downsized to reduce first cost of installation
- ACB uses "hydronic" system which delivers over 3000 more energy, per unit volume, than an "all air" system, resulting in smaller mechanical space requirements (³/₄" tube carrying water can convey the same heat a 14" * 8" duct.)

Active Chilled Beams

Limitations:

- Good control of humidity levels must be provided to prevent condensation. Typically the DOAS system provides humidity control.
- Also Required: good vapor barrier system & building envelope, operable windows closed during periods of high humidity
- > Not suitable for vestibules or lobbies with high infiltration.
- Less effective at heating than cooling, requires supplemental heating in most cases (perimeter radiation or in floor heating)
- Air is not effectively distributed in high-ceiling applications, such as gyms or atria
- > Noisier than displacement ventilation but similar to conventional diffusers.
- Lower ventilation effectiveness than displacement ventilation (1.0 vs 1.2)

Applications:

> New Schools: Northlands, Steinbach HS, Amber Trails, Woodlands



Active Chilled Beams

Warm air from the room is induced into the beam, mixing with the supply air, then sent back into the space by buoyancy forces





Components: cooling coil, primary air duct, air nozzles, and diffusers

Active Chilled Beams

Operation

- Primary air is introduced to chilled beam DOAS (typically only outdoor air) through induction nozzles.
- 2. Nozzles create differential pressure across cooling coil, inducing room air flow over the cooling coil, and mixing with primary air.
- This air is supplied back into the room at relatively low velocity and good acoustic characteristics. Approximately 3 times more air is induced than is supplied through the primary air duct.

Displacement Ventilation

Advantages:

- Only first six feet of the room must be conditioned
- High ventilation effectiveness leads to lower outdoor air requirement (effectiveness of 1.2 compared to 0.8 to 1.0 for other systems)
- Low supply air velocity reduces draft and noise (air velocity of only 40 fpm)

Limitations:

- Typically not used for heating so supplement heating must be added
- Thermal stratification limits set by ASHRAE 55 for thermal comfort, limit cooling capacity (cannot have people's feet too much colder than their heads)
- Floor grilles not suitable for tight office environments. Cannot sit near diffuser.

Applications:

- In 2009, Beliveau is first existing school with DOAS w/ Displacement ventilation (science wing)
- New Schools: Northlands

Displacement Ventilation

Cool air is sent into the room at a low level and low velocity. As the cool air reaches a heating source (e.g. a person or computer) it is heated up and sent to the return air supply by buoyancy forces, removing contaminants along the way







Displacement Ventilation Types of Diffusers:

In-Wall Diffuser

> 90° Corner Diffuser

> 180° Wall-Mounted Diffuser



Ground Source Heat Pump

Advantages:

- Provides both heating and cooling
- Uses renewable heat source from the earth (sun's energy)
- Provides 3 to 5 times more heating or cooling energy than electricity input (COP = 3 to 5)
- Ground loop can provide "free" cooling in shoulder seasons (still requires pump energy)
- Wide selection of system types (central plant, distributed, modular heat pumps, packaged HP chiller) and ground heat exchangers designs (open well, vertical, horizontal slinky/boring/trench)

Limitations:

- > Ground and site conditions can make installation cost prohibitive.
- Ground loop is sized for cooling, since heating load is larger (in cold climates) than the cooling load. Supplemental heating source (boiler) is required for the difference.
- > Higher initial cost due to excavation and installation of ground heat exchanger.
- > More design time is required for geothermal system rather than conventional system.
- It is highly recommended to use designer with many years experience in geothermal system design.

Applications:

- > Approximately 25 heat pumps systems were installed in the 1980's. (some success/failures)
- > Recent New Schools: Prairie Dale, Clearspring, Arborgate, Northlands, Steinbach HS, Amber Trails
- > Recent Existing Schools: St John HS, Maples, Churchill HS

Ground Source Heat Pump

The vapour-compression cycle exchanges heat between the ground loop reservoir (heat sink or source) and the interior space Energy is exchanged with hot/chilled water pipes and used to heat/cool the building





Condensing Boiler

Advantages:

- Higher efficiency (92%) than conventional boilers under all operating conditions
- Ideal for low temperature applications, such as supplementing a ground source heat pump
- No thermal shock issues

Limitations:

- Condensate requires corrosion resistant materials, leading to higher initial costs
- Return water must be below 130°F for condensing to take place
- Chimney requirements are more stringent

Applications:

- Existing Schools: Since 2003 PSFB has installed 177 high efficiency boilers (130 condensing & 47 near condensing).
- Recent New Schools: Emerado, Prairie Dale, Clearspring, Arborgate, Northlands, Steinbach HS

Condensing Boiler

The flue gases produced by the combustion of natural gas are sent to a heat exchanger that preheats the return water by condensing the steam contained in the flue gases. This results in an increase in efficiency over conventional boilers from 70-80% (conventional) to 90-95% (condensing)



Combustion gases pass over heat exchanger and into flue. About 30% of the heat is wasted.

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Combustion gases pass over primary heat exchanger and are then directed over secondary heat exchanger. As the gases condense on the sides of the exchanger they release their heat.



Variable Refrigerant Flow Heat Pump

Advantages:

- > Does both heating and cooling. Outdoor air is the heat sink/source.
- > Multiple DX cooling coils can be hooked up to one chiller.
- > High efficiency at part-load conditions (most common operating condition)
- Can do simultaneous heating and cooling and recover heat from spaces that need extra cooling, such as computer rooms, to heat other spaces or to preheat the domestic hot water supply
- Systems can be ductless

Limitations:

- > Higher initial cost than conventional DX cooling systems.
- > Limited to -20 F operation. Requires supplement heating.
- Long refrigerant runs and many connections increases chance of leak (leak detection may be required on some systems)
- Shorter life expectancy than chiller systems

Applications:

- Northlands: computer room cooling & domestic water heating with refrigerant to water heat pump.
- > Bonnycastle: Multiple fan coils/dx on air source heat pump (refrigerant to air)

Variable Refrigerant Flow Heat Pump

The vapour-compression cycle exchanges heat between an outdoor temperature reservoir and the interior space. The outdoor reservoir can be a water source or an air source

Refrigerant lines are sent directly to the terminal units or fan coils in the conditioned space





Injection Pumping System

Advantages:

- Eliminates need for control valves resulting in lower pressure drop and less pump energy consumption.
- Peak power demand is reduced
- Limitations:
 - More design time required for series connection (ie cascading temperature)
 - More circulators require more maintenance

Applications:

New Schools: Northlands, Amber Trails, Woodlands

Injection Pumping System

Small circulating pumps replace conventional control valves for temperature control Dedicated Coil Circulators (Control valves not required) Terminal Unit (Chilled Beam) LOFIC Mixing Block Single Pipe Loop 42°F 58°F Air Separator Primary System Pump Expansion Tank Chiller

In-Floor Heating

Advantages:

- Water carries energy more efficiently than air (over 3000 times more energy per unit volume)- ³/₄" dia pipe = 14" * 8" Duct
- > Radiant heat transfer keeps objects in room warm and reduces thermostat settings
- Unlike radiators and baseboards, no floor space is taken up
- Reduced noise
- Good application for early year grade levels since kids play on the floor.

Limitations:

- > Higher initial cost than conventional perimeter fin tube.
- Less responsive to quick temperature changes. Large thermal mass takes longer to cool.
- > Lower heating capacity per linear foot than radiators and baseboards.
- > Less suitable for applications requiring in-floor services or future space reallocation

Applications:

Recent New Schools: Emerado, Prairie Dale, Clearspring, Arborgate, Northlands, Steinbach HS, Amber Trails, Woodlands

In-Floor Heating

Warm water is sent through pipes embedded in the subfloor, heating the floor surface and consequently, the space





Rainwater Collection

Benefits:

- Used mainly for grey water use and irrigation.
- Reduced municipal water usage
- Increases sustainability

Limitations:

- Extra costs incurred due to installation, extra material, and maintenance costs
- Water is non-potable
- Filtration can be an issue
- Running large storm drainage piping in existing building requires extra space and coordination.

Applications:

> New schools: Northlands, Amber Trails

Rainwater Collection

Rain water is collected from the roof and stored in an underground cistern for grey water use throughout the building





Up to 16,000L (4225 gal) can be stored

Case Studies of High Performance Schools

- Emerado School (2006 Winkler; pre-Green Building Design Policy)
- Aurele Lemoine (2010 St Laurent; Target LEED Silver)
- Prairie Dale (Sept 2011 Winkler; Target LEED Silver, similar to Emerado except w/geothermal)
- Clearspring Middle (Sept 2012 Steinbach; Target LEED Gold)
- Arborgate (Sept 2012 La Broquerie; major addition; Target LEED Gold)
- Northlands (Sept 2013 Winkler, Target LEED Gold)
- Steinbach High School (Sept 2014 Steinbach, Target LEED Gold)
- Amber Trails (Sept 2015 Winnipeg, Target LEED Gold)
- Woodlands (Sept 2015 Woodlands, Target LEED Gold)

Emerado Centennial School - GASD

Building at a Glance:

Consultants: MCM arch ; MCW m&e Substantial Completion: Sept 2006 Square Footage: 56,000 ft2 Mid. Sch. Location: Winkler, MB Occupancy: 400 students ; 500 core Construction Cost: \$8.5M Cost per square foot: 152 \$/ft2 Design Goal: High Performance Est. Savings over MNECB: 33% Actual Savings over MNECB: 42% (cons) Actual Annual Energy Use: 12-13kwh/ft2 (set new benchmark for energy use)

<u>Sustainable Design Features:</u>

- Heat Plant: 2 *1.0MBTU High Eff Condensing Boilers & 70 ton central air cooled chiller.
- Central VAV AHU & boxes/rhs
- 7,500 cfm Dual Core ERV for preheating outdoor air w/ exhaust air (outdoors)
- Redirect main AHU supply air to gym during assemblies
- In-floor heating for instructional areas
- Demand control ventilation in the gym

Other:

- Very efficient building envelope
- Low flow plumbing fixtures
- Use of non-toxic paints and sealants

Aurele Lemoine – St. Laurent



Aurele Lemoine – DSFM

Building at a Glance:

Consultant: Stantec

Substantial Completion: Sept 2010

Square Footage: 28,632 ft2

Location: St Laurent MB

Occupancy: 125 students

Construction Cost: \$8.5 M

Cost per square foot: \$300/ft2

Design Goal: LEED Silver (First)

Predicted Savings over MNECB: 36.5%(cons) 33% (NRC)

Actual Savings over MNECB: 30-33%

Est. Annual Energy Use: 15-20 kwh/ft2

Actual Annual Energy Use: 19.9 kwh/ft2

Sustainable Design Features:

HVAC:

- 300 kw Electric Boiler w/ capability for tie in to district biomass heating plant (plant did not proceed)
- Fan coils c/w plate type HRVs (25-50% eff) for fresh air
- Packaged air cooled chiller (outdoors) for cooling (geothermal not feasible because of site conditions and higher cost)
- In-floor heating for daycare
- Demand control ventilation in the gym Other:
- Low flow plumbing fixtures
- Occupancy sensors for Lighting (0.5 w/ft2)
- Site plantings selected for passive solar benefits
- Large windows for daylighting

Marca	Degree Days (°C)			Actual Usage (kWh)				Adjusted to 2013/2014				Adjusted	Adjusted					
теаг		Area (ft*)		Gas	Elec.	Total		Gas	Elec.	Total	1	Total/ft ²	Total/m ²					
	During-Construction																	
2009/2010	5,126.9	28,632		0	393,737	393,737		0	572,235	572,235		19.9858	215.1259					
	Post-Construction																	
2010/2011	5,669.9	28,632		0	438,840	438,840	Γ	0	576,706	576,706		20.1420	216.8069					
2011/2012	4,565.5	28,632			0	ſ			0	390,240	390,240		0	636,894	636,894		22.2441	239.4339
2012/2013	6,039.0	28,632				0	487,440	487,440	487,440	0	601,423	601,423		21.0053	226.0989			
2013/2014	7,451.2	28,632		0	598,320	598,320		0	598,320	598,320		20.8969	224.9323					

DI- Aurèle-Lemoine Summary



Detailed Chart Notes



New school opens September 2010.

Note: Values are interpolated to a full year. First and last years may have skewed results due to incomplete monthly data. Each year is defined from August-July.

Prairie Dale Middle - Winkler



Prairie Dale Middle School - GASD

Building at a Glance:

Consultants: MCM arch ; MCW m&e Substantial Completion: Sept 2011 Square Footage: 65,000 ft2 Middle sch Location: Winkler, MB Occupancy: 450 students Construction Cost: \$16M Cost per square foot: 248 \$/ft2 Design Goal: LEED Silver Min. Est. Savings over MNECB: 50% Actual Savings over MNECB: 64%? Pred. Annual Energy Use: 10 kwh/ft2 Actual Annual Energy Use: 7-8 kwh/ft2 (two years operation)

Sustainable Design Features:

HVAC: (same as Emerado except add heat pump)

- 90 ton (2* 45 Ton) ground source heat pumps for heating & cooling (Horizontal Boring Type)
- 1*1000 MBH supplement condensing boiler
- Central VAV AHU & boxes/RHs
- 10,000 cfm ERV for preheating outdoor air w/ exhaust air (indoors)
- Use crawlspace utilidor as exhaust plenum for ERV
- In-floor heating throughout
- Free cooling with HX and ground loop
- Water cooled heat pumps for computer rm
- Demand control ventilation in the gym Other:
- Very efficient building envelope
- Low flow plumbing fixtures
- Use of non-toxic paints and sealants

Prairie Dale Energy Use Summary

Year	Deerse	A		Actual Usage (kWh)				Adj to 2013/2014				Adi	Adjusted	
	Degree Days (°C)	(ft ²)		Gas	Elec.	Total	otal	Gas	Elec.	Total		Total/ft ²	Total/m ²	
	Post-Construction													
2011/2012	4,687.1	64,814		125,029	349,265	474,295		188,590	425,000	613,590		9.47	118.81	
2012/2013	5,797.5	64,814		98,450	347,520	445,970		120,057	423,793	543,850		8.39	90.32	
2013/2014	7,069.9	64,814		150,334	357,120	507,454		150,334	357,120	507,454		7.83	84.27	

GA- Prairie Dale Summary



Detailed Chart Notes

School opens in September 2011. Operational issues with heat pump system in first year.

Note: Values are interpolated to a full year. First and last years may have skewed results due to incomplete monthly data. Each year is defined from August-July.

Comparison of Energy Use – Prairie Dale vs Emerado Identical Schools except geothermal on Prairie Dale



Clearspring Middle School -Steinbach



Clear Spring Middle School - HASD

Building at a Glance:

Consultant: Stantec

Substantial Completion: Sept 2012

Square Footage: 113,000 ft2 Middle sch

Location: Steinbach MB

Occupancy: 700 students; core for 800

Construction Cost: \$23.5M

Cost per square foot: 208 \$/ft2

Design Goal: LEED Gold

Est. Savings over MNECB: 66.5 %(cons) **50.4%** (NRC)

Actual Savings over MNECB: 25%

Pred. Annual Energy Use: 7-10 kwh/ft2

Actual Annual Energy Use: **15-16 kwh/ft2** (two years operation)

Sustainable Design Features:

HVAC:

- 155 tons (4*39 tons) ground source heat pumps for heating & cooling (Horizontal Open Trench Type)
- 1*2000 MBH supplement condensing boiler
- Central VAV AHU & boxes/RHs for Classrooms
- 3 * VAV AHUs for gym/daycare/shop
- 3 * ERVs for preheating outdoor air w/ exhaust air (outdoors); Classrooms/gym/daycare
- Condensing boilers for DHW
- Use crawlspace utilidor as exhaust plenum for ERV
- In-floor heating throughout
- Demand control ventilation in the gym

Other:

- Very efficient building envelope
- East/West orientation for passive solar
- Low flow plumbing fixtures
- Occupancy sensors for Lighting (0.5 w/ft2)
- Full measurement & verification (M & V) planned (No data as of yet)

Clear Spring Energy Use Summary

Year	Degree Days (°C)			Actual Usage (kWh)			Π	Adjusted to 2013/2014				Adjusted	Adjusted
		Area (IC.)		Gas	Gas Elec. Total	Gas	Elec.	Total		Total/ft ²	Total/m ²		
During Construction													
2011/2012		93,128		1,466,705	84,480	1,551,185		1,466,705	84,480	1,551,185		16.66	179.26
	Post-Construction												
2012/2013	6,337.7	93,128		232,359	1,082,880	1,315,239		268,465	1,251,148	1,519,613		16.32	175.64
2013/2014	7,322.5	93,128		470,824	1,018,473	1,489,297		470,824	1,018,473	1,489,297		15.99	172.14
	Average Yearly Usage Adjusted to 2013/14												

HA- Clearspring Middle Summary

40 8 30 \mathbf{O} 6 Energy Usage 16.66 16.32 15.99 (kWh/ft²) 20 Degree Days (x1000°C) 10 2 (2)0 Gas Electricity 23/24 12/13 Weather

Detailed Chart Notes

- High gas use since new boiler and in floor heating system used for temporary
 - heating during construction. The weather data only reflects degree days after
- School opens in September 2012. Data available since February.

Note: Values are interpolated to a full year. First and last years may have skewed results due to incomplete monthly data. Each year is defined from August-July.

Arborgate School - SESD

Building at a Glance:

Consultant: Stantec

Substantial Completion: Sept 2012

Square Footage: 46,642 ft2 addition

Location: Labroquerie, MB

Occupancy: 450 students core

Construction Cost: \$12.4 M

Cost per square foot: \$265/ft2

Design Goal: LEED Gold

Est. Savings over MNECB: 77%(Cons); 58.3%(NRC)

Actual Savings over MNECB: ?? Pred. Annual Energy Use: **10-14 kwh/ft2** Actual Annual Energy Use:

- Addition only 6 kwh/ft2
- Blended rate w/ existing 16.90 kwh/ft2 (two years of post construction)

Sustainable Design Features:

HVAC:

- 65 ton (2* 32 Ton) ground source heat pumps for heating & cooling (Horizontal Boring Type)
- 1*1,500 MBH supplement condensing boiler
- 2* built-up VAV AHUs & boxes/RHs (Classrooms)
- 1* constant volume AHU for Gym
- 7500 cfm ERV for preheating outdoor air w/ exhaust air (outdoors)
- Use crawlspace utilidor as exhaust plenum for ERV
- In-floor heating
- Demand control ventilation in the gym Other:
- Very efficient building envelope
- East/West orientation for passive solar
- Low flow plumbing fixtures
- Use of non-toxic paints and sealants
- Occupancy sensors for Lighting (0.5 w/ft2)

Vers	Degree Days (°C)	1 mm	Actual Usage (kWh)				Adjusted to 2013/2014				Adjusted	Adjusted
Tear		Area (IC)	Gas	Eleo.	Total		Gas	Eleo.	Total		Total/ft ²	Total/m ²
Pre-Construction												
2009/2010	5,177.8	22,000	554,396	254,537	808,934		753,795	346,086	1,099,881		49.9946	538.1373
2010/2011	5,762.6	22,000	473,344	313,400	786,744	1	578,286	382,882	961,168		43.6894	470.2693
	During Construction											
2011/2012	4,677.9	68,642	767,891	324,000	1,091,891		1,155,658	487,612	1,643,270		23.9397	257.6850
	Post-Construction											
2012/2013	6,127.3	68,642	683,463	510,560	1,194,023		785,283	586,622	1,371,905		19.9864	215.1315
2013/2014	7,040.1	68,642	429,059	630,720	1,059,779		429,059	630,720	1,059,779		15.4392	166.1864
Addition	N/A	46,642	N/A	N/A	N/A		28,885	225,789	254,674		5.4602	58.7729

SE- Arborgate School Summary



Average Gas Savings: 66.3% Average Elec Savings: 49.0%

Detailed Chart Notes

- (1) Large gas spike. Likely due to in floor heating of construction area. This year not included in savings calculations
- (2) School addition opens in september. School size increased by 210%.
- (3) Heat pumps fully operational.
- This is the bar representing only the 46 000 ft² addition to the school. It is found by averaging the two years after the renovation and subtracting the values from before.

Note: Values are interpolated to a full year. First and last years may have skewed results due to incomplete monthly data. Each year is defined from August-July.

Northlands Collegiate



Northlands Parkway Collegiate Overview: The Building

- Garden Valley School Division
- Prairie Architect / Enermodal (mech/elec)
- Location: Winkler, Mb
- Capacity: 800 Students, provisions for expansion to 1000 students
- Square Footage:112,400 sq.ft
- Construction Cost: \$32.7 million, \$290/sq.ft
- Mechanical (20%) ; Electrical (10%) of total cost
- Predicted energy use index of 8 kWh/ft2, or 64% better than MNECB (target max 10 LEED points for Energy)
- Design Goal: LEED Gold Certification



Northlands Parkway Collegiate Overview: Key Mechanical Features

- > Ground source heat pumps & Condensing Boiler
- Energy recovery ventilator units
- Dedicated outdoor air systems with heat recovery
- Active chilled beams
- Displacement ventilation
- Variable refrigerant flow heat pump
- Injection pumping hydronic system
- In-floor heating
- > Rain water collection for grey water usage
- Separate ventilation systems for areas in use outside of school hours



Steinbach HS Addition - HASD

Building at a Glance:

Consultant: Stantec

Substantial Completion: Sept 2013

Square Footage: 105,000 ft2

Location: Steinbach MB

Occupancy: 600 students; core for 800

Construction Cost: \$34.2M

Cost per square foot: 325 \$/ft2

Design Goal: LEED Gold

Est. Savings over MNECB: ??%

Actual Savings over MNECB: ??

Pred. Annual Energy Use: 8-10 kwh/ft2

Actual Annual Energy Use: ?? kwh/ft2

Sustainable Design Features:

HVAC:

- 233 tons (4*58 tons) ground source heat pumps for heating & cooling (Horizontal Open Trench Type)
- 1*3,000 MBH supplement condensing boiler
- 1* constant volume AHU c/w ERV for Gym
- 3 * DOAS c/w chilled beams (ACB) for instructional areas
- Demand Control Ventilation(CO2) for VAV boxes
- 4 * ERVs (dual core) for preheating outdoor air w/ exhaust air (outdoors);
- Condensing boilers for DHW
- Use crawlspace utilidor as exhaust plenum for ERV
- In-floor heating throughout
- Demand control ventilation in the gym Other:
- Very efficient building envelope
- Low flow plumbing fixtures
- Occupancy sensors for Lighting (0.5 w/ft2)

Amber Trails – SOSD

Building at a Glance:

Consultant: Prairie Arch./Enermodal Substantial Completion: Sept 2014 Square Footage: 83,465 ft2 k-8 Location: Winnipeg MB Occupancy: 600 students; core for 800 Construction Cost: \$22.3M Cost per square foot: \$267/ft2 Design Goal: LEED Gold Est. Savings over MNECB: 60% (Cons) Actual Savings over MNECB: ??% Pred. Annual Energy Use: 8.8 kwh/ft2 Actual Annual Energy Use: ?? kwh/ft2

Net Zero Carbon Emissions Buiilding

Sustainable Design Features:

HVAC:

- 150 tons (3*50 tons) ground source heat pumps for heating & cooling (Horizontal Boring Type)
- 300 Kw supplement electric boiler (Zero carbon emissions)
- 1* constant volume AHU c/w ERV for Gym
- 3 * DOAS c/w chilled beams for classrooms & and most areas
- 1*ERV (plate 72% eff) c/w ACB for daycare
- 1* ERV (plate 72%) & fan coil to serve manufacturing
- Demand Control Ventilation(CO2) for VAV boxes
- Water source heat pump for heating DHW
- In-floor heating throughout
- DOAS serving core areas bypasses air to gym during assemblies.

Other:

- Very efficient building envelope
- Rain water collection for grey water usage
- Partial measurement & verification (M & V) planned

Woodlands – INSD

Building at a Glance:

Consultant: Prairie Arch. Substantial Completion: Sept 2014 Square Footage: 25,000 ft2 Location: Woodlands MB Occupancy: 200 students Construction Cost: Cost per square foot: \$/ft2 Design Goal: LEED Gold Est. Savings over MNECB: 60%(cons) Actual Savings over MNECB: ?? Pred. Annual Energy Use: 9 2 kwb/ft2

9.2 kwh/ft2

Actual Annual Energy Use: ?? kwh/ft2

Net Zero Carbon Emissions Building

Sustainable Design Features:

HVAC:

- 85 ton air cooled chiller (indoors) for cooling with remote ACCU (Geothermal not feasible because of site conditions)
- 225kw electric boiler(s) for heating (no nat gas available)
- 1* constant volume AHU for Gym
- 1 * DOAS c/w chilled beams (ACB) for instructional areas and daycare
- Use crawlspace utilidor as exhaust plenum for ERV
- In-floor heating throughout
- Demand control ventilation in the gym

Other:

- Very efficient building envelope
- Low flow plumbing fixtures
- Occupancy sensors for Lighting (0.5 w/ft2)

Energy Analysis of Recent New Schools





Lessons Learned

• Excellent Energy Use index (<10 kwh/ft2) can be achieved with proper selection of HVAC systems and using integrated building design.

• Up to 65-70% energy savings, as compared to the MNECB or Canadian Average Schools, can be achieved with High Performance Schools.

• Enhanced VAV systems with Dual Core heat recovery has worked well in Emerado, Prairie Dale, and Clearspring. Proven w/ actual consumption data.

• **DOAS & Chilled Beam systems** have excellent potential for energy savings. Actual data not yet available for Northlands, Amber Trails, and Woodlands.

• Geothermal heat pumps can greatly reduce carbon foot print.

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• Building envelope construction and architectural floor plan have significant impact on building energy performance.

• Net Zero Energy Building (NZEB) is an achievable goal. High Cost of PV is still a factor.

Next steps

- Perform post occupancy review of select schools
- Perform measurement and verification of energy savings.
- Assess HVAC technologies to determine which ones are most effective at reducing energy consumption, without adversely affecting indoor environmental quality.
- Optimize the HVAC system selection based on feedback from the end user, maintenance staff, consultants and results of M &V.
- Share results various Stakeholders (school divisions, consultants, suppliers, Manitoba Hydro, etc..)

Set Target To Net Zero Energy Building (NZEB)

(Hopefully introduce on site renewable energy source such as photovoltaic in near future)

THANK YOU

SEE YOU NEXT TIME!!