CANADIAN CONSULTING ENGINEER AWARDS

STM- Stinson Transport Centre

2016

bouthillette
parizeau

systèmes évolués
de bâtiments

PROJECT DESCRIPTION

The building is a reflection of responsible development!

The Société de transport de Montréal (STM), a public transport agency, required a new bus garage, with administration and maintenance quarters. Bouthillette Parizeau, a part of the integrated design team, successfully contributed by designing innovative and efficient mechanical and electrical systems that were compliant with the STM's goals of adhering to sustainable principles and being economically and socially responsible. Priorities included minimizing energy consumption and maximizing energy recovery, while offering improved indoor air quality for the occupants and minimizing the impact to the environment and the community. These goals are reflected in a new LEED® Gold, 38,400 m^2 complex.

HIGHLIGHTS

38,400 m^2 – 2 floors – 700 employees

200 regular sized buses- 100 articulated buses

New construction 24/7/365 day operation

Bus garage, maintenance garage, administration

Unique repair space for articulated buses

Indoor bus circulation

8,000m^2 of green roof (one and a half football fields)

LEED® Gold – Energy Efficiency Strategies- 60% less energy use that other STM garages

Envelope performance RSI value: walls 4.5 (R2x) and roof 5.9 (R35), and SC=0.5 for the glazing

Heating Loads of 11,712 kW, 816kW of cooling, and a minimum of 144,483 L/s of outdoor air

Overall lighting density is 6.57 W/m2; 21 skylights

Passive heating, sequencing controls, and 15 high efficiency condensing natural gas boilers-capacity 878 kW

Energy unit intensity of 302.7kWh/m2/year compared to convention building of 1,204.6 kW/m2/year

Low consumption plumbing fixtures with infrared detectors – 40% reduction of potable water consumption

Rain water collection – Reserved to wash 700 buses a day

Greenhouse gas emissions decreased – 7,235 tons annually: equivalent to 2,896 compact cars/daily commute of 40 km

INNOVATION

In anticipation of an increase in services, the Société de transport de Montréal (STM) expanded their fleet of buses and developed a program for the new Stinson Transport Centre. The complex was not only to accommodate and maintain 300 vehicles and 700 employees but also to showcase the STM's commitment as a responsible and sustainable partner to the City of Montreal. The surrounding residential neighbourhood was concerned with air pollution, the visual impact of a bus garage, and noise. Design decisions to limit neighbourhood disruptions, included indoor bus circulation, bus fleet parking, repair areas, wash bays and refueling areas. Unique to this decision was an expansive roof (seven football fields) that incorporates 8,000 m^2 of green roof, a signature of the project. A distinctive yellow footbridge, the corporate colours of the STM, houses administrative offices and mechanical equipment. Typical mechanical equipment usually located on a roof is, in this case, camouflaged as part of the building fabric.

The Stinson Transport Centre exemplifies innovative solutions:

- The indoor vehicle circulation was the catalyst for innovative design decisions. The expansive roof integrated mechanical equipment into a rooftop canopy and was treated as a fifth elevation of the building. The roof, visible from the surrounding residential apartment buildings, alternated a series of greenery stripes, white roof surfaces, and 21 large skylights providing daylighting to the occupants.
- The ecological development of the brownfield site along Stinson Street, north of the Metropolitan highway, was one of the major challenges. It began with a rehabilitation of the soil, which was mainly contaminated with hydrocarbons, and resulted in the demolition of the small industrial type buildings located on the site. Respecting sustainable initiatives, 75% of materials from the demolished buildings were recycled. The owner was concerned with preserving the integrity of the site and minimizing disruption to the residents. The open and public landscape areas, made available due to the indoor bus circulation, consisted of 500 trees where 20% were preserved, 1,230 new perennials, and grassed areas.
- Integrated design helped optimize the architectural envelope performance, building loads and construction cost. The architectural design with integrated engineered systems combined an effective layout for the users and showcased the STM's sustainable awareness. The overall envelope performance achieved a value of RSI 4.5 for the walls, RSI 5.9 for the roof, and RSI 0.84 and SC=0.5 for the glazing.
- Through the design process, the HVAC system was subject to a thorough analysis, to identify the loads and ventilation airflow requirements. The needs included: heating loads of 11,712 kW, 816 kW of cooling and a minimum of 144,483 L/s of outdoor air for the programed uses. The engineering design team, using eQuest 3.64 software, identified appropriate measures to optimize heat reclaim and minimize HVAC operations and maintenance. The design solutions included high efficiency condensing glycol boilers, ERV on the HVAC infrastructure, and destratification fans in high volume spaces.

- The goal of the indoor circulation was to minimize the opening and closing of garage doors for arriving and departing buses, thereby reducing energy loss and pollution while maximizing the efficiency of bus movement.
- The installation of silencers and vibration isolators eliminate vibration transmittal and reduced sound levels of the cooling tower and power generator. Equipment selections were made according to their life expectancy, availability and ease of maintenance in order to reduce materials, operations and labour costs. Service life expectancy of equipment is predicted to be between 18 to 25 years. ASHRAE handbooks, and the STM's maintenance team provided pertinent experience. Out of all the equipment, the natural gas burners have the shortest life (18 years).
- The architectural design of the building represents the values shared by the STM and the construction industry: visibility, accountability and transparency. The latter is reflected by the large-glazed windows on Stinson, providing passers-by, whether walking or on the adjacent Metropolitan Expressway, a view of bus garage activities.
- The service bay areas' HVAC systems supply 100% of the outdoor air continuously and provide heating and ventilation (equivalent to 4 changes/hour for the 3.6 m breathing zone). To maximize energy reclaimed, an ERV with an overall sensible efficiency of 85% (and 70% latent heat) is installed between outdoor airflow and general exhaust air.
- Ventilation systems of 18,878 L/s were identically designed to minimize infrastructure costs, facilitate maintenance and reduce replacement part costs. A smaller version is in place in the refueling area.
- Seven high-volume, low-speed destratification fans, 4.3 m in diameter, improve energy recovery by redistributing the accumulated heat near the roof and then conveying it back to the maintenance workspaces below.
- A glycol loop delivers the generated heat at a temperature of 60°C to the various heating equipment with an expected return at 43°C (3 pumps of 44.7 kW each for a flow of 194 L/s). Loop temperature differentials, maximize piping sizes and lowers pumping power, considering the building footprint.
- The plumbing fixtures used are low consumption models and are equipped with infrared detectors, resulting in a reduction of 40% in potable water consumption (saving of 2.63 million L / year).
- The process water used for bus washing was a concern that was addressed. Typically such an operation would consume up to 360 L/m. Nearly 75% of the water was reused for the pre-rinsing in the wash-bay area. Rainwater harvesting compensates for the remaining 25% of make-up water, collected on the roof, from an area of 2,500 m^2 and drains into a 25,000 L underground tank.
- The Stinson facility is provided with numerous measuring stations (natural gas, electricity, water, chilled water and water used for the wash-bay area) in order to follow and compare consumptions and to eventually reproduce the innovative success stories to other STM facilities.

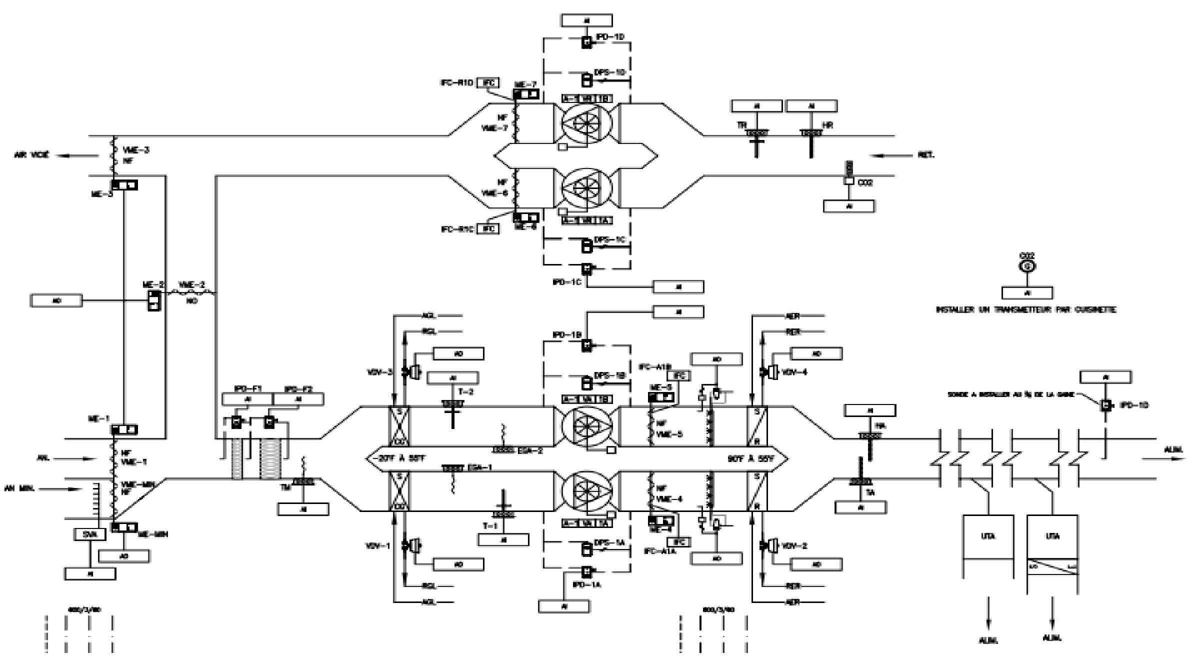
COMPLEXITY

The integrated design team approached the design of the Stinson Transport Centre weaving together client objectives, the urban fabric and innovation. Considerations, including building function, a reduced environmental footprint and the surrounding residential context, continued to be balanced through the design process.

The mechanical and electrical strategies considered by Bouthillette Parizeau were validated and refined by means of space usage analyses, load calculations, energy simulations and detailed heat balances. The tools were fundamental to predict the behaviour of the building with multiple energy recovery strategies and effective sustainability goals to implement.

The HVAC infrastructure needs were as follows: heating loads of 11,712 kW, 816 kW of cooling and a minimum of 144,483 L/s of outdoor air for various uses. The highest demand comes from the amount of outdoor air to treat and supply, as the facility operates continuously (24/7). A minimum of 144,483 L/s is required to respect ASHRAE 62.1-2007 in order to address the heating requirements, to ensure indoor air quality, to meet the local health and safety codes and to achieve the owner's requirements.

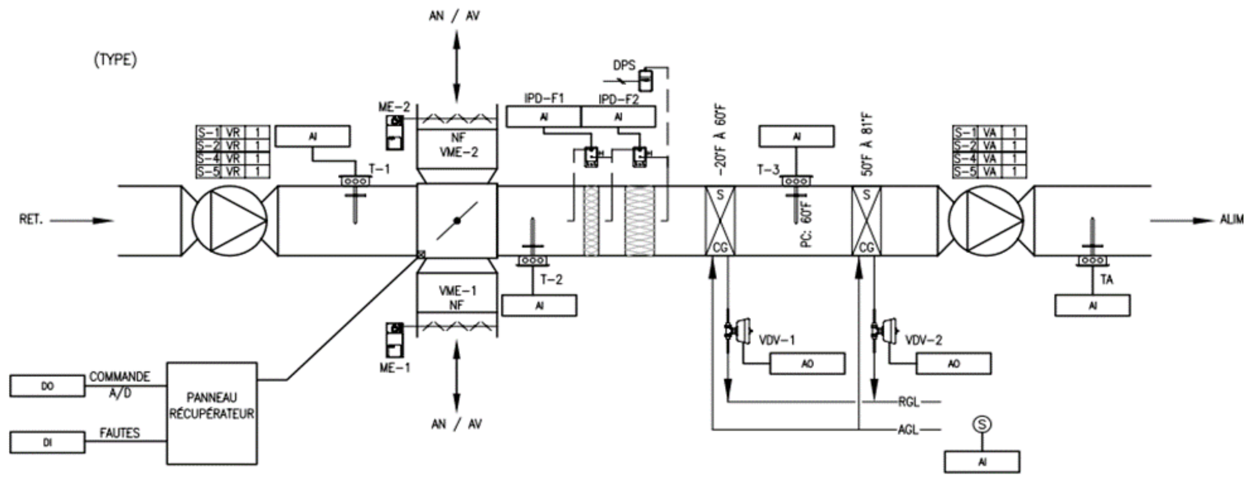
Two types of HVAC systems are used in the building. In the office area, two systems provide heating and cooling to the occupants while distributing variable airflow via terminal units and controlled sensors. In mid-season, minimum outdoor air can be increased and allowed to free cool the spaces while chillers are not in operation. The minimum outdoor air requirement for these areas are 3,455 L/s, which surpasses the 2,065 L/s required by ASHRAE standard 62.1-2007. An additional LEED® point (EQc2) was assigned.



Offices Area HVAC Systems

The service bay areas' HVAC systems supply 100% outdoor air continuously and provide heating and ventilation (equivalent to 4 changes/hour for the 3.6 m breathing zone). To maximize energy reclaimed, an ERV with an overall sensible efficiency of 85% (and 70% latent heat) was installed between outdoor airflow and general exhaust air. The ventilation systems of 18,878 L/s were designed to be identical to in order to minimize infrastructure costs, facilitate maintenance and reduce replacement part costs.

Seven (7) high-volume, low-speed, 4.3 m diameter destratification fans improve energy recovery by redistributing the accumulated heat near the roof and conveying the energy back to the maintenance workspaces below.



Service / Maintenance Bays area HVAC systems

Along with passive heating and sequencing controls, 15 high efficiency condensing natural gas fired boilers, with a capacity of 878 kW each (ε=91.5%) are used to satisfy Montreal's extreme winter conditions. A glycol loop delivers the generated heat at a temperature of 60°C to the various heating equipment with an expected return at 43°C (3 pumps of 44.7 kW each for a flow of 194 L/s).

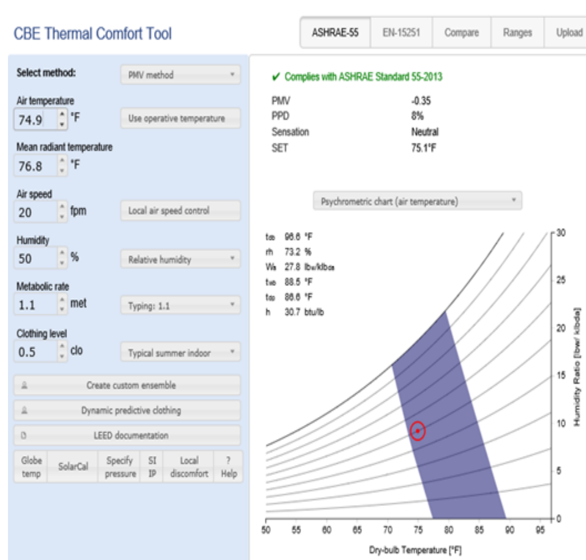
Two high-efficiency 457 kW chillers (EER 20, IPLV 0.361 kW/ton) use magnetic bearing compressors with no mechanical abrasion and use R134a refrigerant (Kyoto Protocol compliant) are installed to produce chilled water. They are combined with variable speed cooling towers which are located in a depression on the roof; protected from harsh winter conditions and invisible to the surroundings. The chilled water loop is variable flow. In mid-season, the HVAC systems are in a free cooling mode and the chillers can be non-operational.

When comparing ventilation rates, according to space usage, it was demonstrated that the installed outdoor airflow exceeds ASHRAE standard 62.1-2007 at normal occupancy density. This contributes to a higher indoor air quality for the occupants. The airflow respects the local health and safety code regulations and meets the LEED® credit for increased ventilation (EQc2). Considering that the treated air was delivered and returned by ceiling grilles/diffusers and a minimum number of baseboard units were installed at the perimeter (to limit maintenance, obstruction and piping routing), the zone air distribution effectiveness Ez value was set at 0.80 as per table 6.2 of ASHRAE standard 62.1-2007. Outside supply air rates considered the actual occupancy of the spaces.

Between 7% and 10% of outdoor air is present in the office area HVAC systems. 100% of outdoor air is supplied in the service bay areas while maintaining a negative pressure of at least 5 Pa. This tactic avoids having bus contaminants infiltrate the office workspaces.

Space usage	Installed Outdoor airflow rate (L/s/sq.m.)	Outdoor airflow rate as per ASHRAE 62.1 (L/s/sq.m)
Offices	0.95	0.43
Conference room	1.57	1.57
Service Bay	4.16	0.61
Refueling Bay	4.62	0.61
Indoor Bus Parking area	4.11	0.61

Since the service bay areas are not conditioned, destratification fans are provided to ease employee comfort which creates air displacement of 330,376 L/s.



The outdoor airflow is adjusted according to the readings and the limits regarding the Clothing level (clo) and the Metabolic rate (met). For the office area, it ranges from 0.5 clo in summer to 1.0 clo in winter with an average of 1.1 met. For the service areas, it ranges from 0.65 clo in summer to 1.3 clo in winter with an average of 1.25 met, as recommended by Appendix C of ASHRAE Standard 62.1-2007 and by ASHRAE Standard 55-2010. Calculations were undertaken with the operative temperature to ensure compliance and to predict PPD and PMV values.

Several CO_2 sensors were installed in densely populated spaces. They adjust outdoor air quantity based on CO_2 concentration in the air. A differential of 650 ppm is established, instead of 700 ppm, to ensure that the allowable limit of the ASHRAE Standard is never reached and provide sufficient delays for readjustment.

Several sensors are also installed in order to maintain temperature and humidity levels within the ranges established by ASHRAE standard 55-2004. In service bays and large volume areas, outdoor air is delivered constantly, justifying the installation of an air flow switches device instead of an outdoor airflow meter. Combustion gas detection is installed in the service bays area to monitor indoor air quality. As such, 18 months after occupancy, the employees were surveyed to ensure their satisfaction for their workplace environment Adjustments, made feasible by the robust systems, were made by the O&M personnel.

The air louvers were carefully positioned such that outdoor air intakes are away from possible contaminants, while the exhaust air outlets are away from the community. HVAC systems are equipped with filtration media with a MERV13-A minimum efficiency, as per ASHRAE 52.2, and subject to a regular maintenance program.

The plumbing fixtures used are low consumption models and are equipped with infrared detectors, resulting in a reduction of 40% in potable water consumption (saving of 2.63 million L / year). Two high efficiency, instantaneous condensing water-heaters of 293 kW are installed (ε=95%). The plumbing fixtures are wall-mounted in order to facilitate floor maintenance. The process water used in bus washing was also a concern that was addressed. The washing of 300 buses may consume up to 360 L/m. Nearly 75% of the water was reused for the pre-rinsing operations in the wash-bay area. Rainwater harvesting compensated for the remaining 25% of make-up water, which is collected on the roof and drained into a 25,000 L underground tank.

The building used finishing products with low VOC content in HVAC adhesives as well as for the insulation. As per SMACNA recommendations, ductwork installation was sealed after each working day and were delivered on site sealed. As per LEED® requirements and considering scheduling, flush-out procedures took place nine days prior to occupation and a maximum of 24 additional days afterwards. Indoor temperatures and humidity was monitored. The duration was calculated for each HVAC system and executed simultaneously with stringent system values. Both credit EQc3.1 and EQc3.2 were confirmed achieved by the Canada Green Building Council (CaGBC).

SOCIAL AND ECONOMIC BENEFITS

The Stinson Transport Centre, the first industrial bus barn and maintenance garage in Quebec to receive LEED® Gold Certification, consumes on average 60% less energy per m^2 than the STM's other facilities. "*We welcome the STM's initiative, as it is fully consistent with Ville de Montréal's objectives in terms of sustainable development. This green building is a reflection of our Administration's vision and commitment to promoting responsible development for the future of our great city and future generations*," stated a Montréal executive committee member responsible for Transportation. Bolstered by the success, future STM reconstructions are tasked with similar goals.

The decision to take bus circulation indoors provided the ground work for social and economic benefits. With the arrival of 700 workers to the neighbourhood, the facility was a catalyst for regeneration of the area. The impact of pollution was lessened while operational efficiencies increased. The large building footprint created an opportunity for the innovative roof design, providing a pleasant view to the surrounding residents. The work area design provides natural light through fenestration and skylights, promoting positive attitudes to the workplace. The available open space was landscaped and provides greenspace to the urban surroundings.

Of the 700 employees during the day, 600 are bus drivers receiving their daily assignments, or meeting their supervisors to deal with issues in the workplace. Drivers and maintenance workers spend their breaks in between assignments in two lunchrooms, which open onto terraces with potted plants, picnic tables and lounge chairs. There are small television rooms and sleep rooms for napping so drivers can relax between shifts. The building has a gym, an indoor storage room for bicycles, and showers. The building provides these amenities to enable drivers to spend their off-time in close proximity to their parked buses, and improves the STM's punctuality for customers.

The complex was designed in March 2011, tendered in March 2012, started construction in October 2012 (delays due to site expropriations) and occupied in March 2014. The anticipated building budget of $90 M was respected. The mechanical budget was estimated at $21.2 M, and the tender bid was $20.5 M. The STM received subsidies of $660K. Benefits from an integrated design process not only included defined requirements but experience and knowledge from the STM's experienced operation, maintenance and project management teams. Overall site change orders amounted to less than 2% of the entire budget. Energy efficiency measures totaled $4.48 M with a profitability of 4 years or 3.75 years if subsidies are included in the calculations.

Utility rates decreased: Electricity is $0.044 for the first 210,000 kW-h/month and $0.032 for additional kW-h and natural gas varies from $0.311 for a monthly consumption of 900,000 m^3 and $0.376 for a consumption of 30,000 m^3. For the first year, the building operation bills were $176k in natural gas and $465k in electricity.

The owners hired consulting engineers, demonstrating their commitment to *sustainable design* and the integrated design process, and highlights their awareness and confidence in the engineering profession. Bouthillette Parizeau continues to promote the involvement of professional engineers and the importance of the engineer's role using this project example in publications, and presentations to associations and the public.

ENVIRONMENTAL BENEFITS

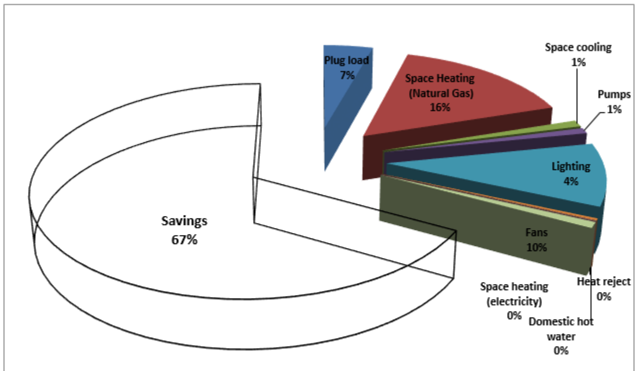
"*We decided this project would set an example as a sustainable initiative, one that opens the way for our future endeavours,*" said Philippe Schnobb, chairman of the STM board of directors. "*Experience has shown us that running a project according to principles of sustainability is financially sound! The heat recovery system, that cost us $4.1 M to buy, produces recurrent energy savings of some $925,000 annually.*"

Opened in 2014, the LEED® Gold facility featured a number of green innovative characteristics for a bus garage dedicated to housing, maintaining and servicing 300 buses (200 standard and 100 articulated) and a workplace for 700 employees.

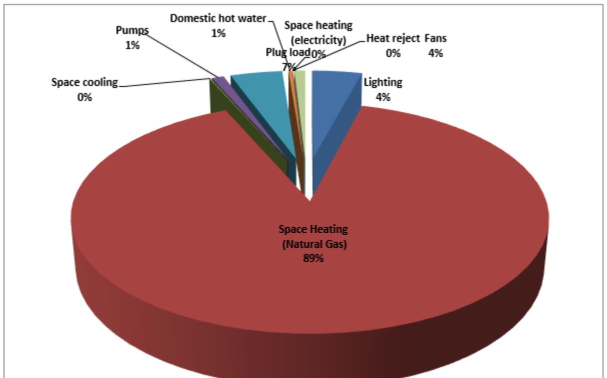
Energy efficiency was addressed with a heat recovery system with an 80% efficiency rating. Internal bus circulation reduced energy losses. Twenty-one skylights reduced the need for artificial lighting. A reduction in heat island effects was accomplished with a green roof extending over 8,000m^2 and a light reflecting material covering the remaining roof surface. Landscaping the site included the addition of over 500 trees, 1,300 shrubs and plants with 22,000m^2 of lawn and wooded area. Resource consumption was reduced with rainwater catchment systems and water recovery systems that recycles bus washing and rinsing water and lowers potable water consumption by 75%.

Sustainable materials including wood and steel from regional sources, promote the local economy and limit GHG emissions related to transportation. Conservation of energy was included by including parking spaces for car sharing vehicles, recharging stations for electric cars and indoor parking spaces for 70 bicycles.

Since the project embraced the LEED® certification, a detailed energy simulation was used to confirm the consumption compared to ASHRAE Standard 90.1-2007. Annual energy consumption is reduced by almost 60%. eQuest3.64 simulation demonstrates that the proposed design results in a reduction of natural gas by 136,609 GJ and an increase of 5,398 GJ in electricity compared to the ASHRAE 90.1-2007 reference building, resulting in a savings of $1,159,088 annually to the utility bill, and a savings of 7,235 tons in greenhouse gas emissions (GHG) for the community. The result is 19 LEED® points out of 19 possible (maximum 48% reduction).



Proposed Building - Energy consumption



Reference Building - Energy consumption

In total, 17 months' data of utility bills are available. Considering the cold 2014-15 winter, simulation values were updated to match the actual weather conditions in order to compare the utility bills and simulation parameters. Electricity bills reveal a consumption of 8.4% above simulation predictions. This small margin is mainly explained by process assumptions that are difficult to foresee (compressed air, vacuum, etc.). On the other hand, natural gas bills show a 2.8% decrease confirming assumptions accuracy.

Theoretical reduction in energy consumption is 67.4% compared to ASHRAE-90.1-2007. Actual performance is 66.2% compared to the reference building; thus an energy cost savings of 59.5%.

Actual invoices indicate that the design was indeed refined since it achieves an energy use intensity (EUI) of 302.7 kWh/m^2/year compared to a conventional building of 1,204.6 kWh/m^2/year.

The STM's requirements were largely exceeded and energy recovery is achieved throughout the year. Responsible resources management design is evident.

Period	Reference Building		Proposed Building		Actual consumption		Actual invoices (without taxes)	
	Natural Gas (MJ)	Electricity (MJ)	Natural Gas (MJ)	Electricity (MJ)	Natural Gas (MJ)	Electricity (MJ)	Natural Gas ($)	Electricity ($)
March 2014	22 775 802	1 580 440	3 230 354	2 000 174	3 350 643	2 238 248	36 437 $	45 634 $
April 2014	13 676 855	1 525 914	2 194 788	1 931 476	1 765 571	2 100 353	19 379 $	37 270 $
May 2014	6 180 160	1 606 608	2 115 973	2 082 611	437 760	2 110 287	4 782 $	38 524 $
June 2014	4 415 847	1 565 608	1 626 941	2 041 945	113 024	2 227 569	1 503 $	40 373 $
July 2014	2 022 703	1 606 597	1 289 736	2 151 374	29 473	2 363 616	374 $	39 816 $
August 2014	1 967 628	1 615 795	1 140 863	2 159 762	117 396	2 280 384	1 076 $	39 174 $
September 2014	5 438 857	1 543 943	1 411 493	2 004 404	302 362	2 068 313	2 314 $	36 886 $
October 2014	9 646 536	1 581 649	1 589 907	2 010 650	950 850	2 126 983	6 781 $	37 060 $
November 2014	17 275 855	1 518 358	2 462 463	1 925 788	2 481 919	2 134 825	15 458 $	37 949 $
December 2014	22 225 997	1 564 484	2 956 981	1 988 280	3 573 652	2 255 934	20 618 $	39 163 $
January 2015	29 471 793	1 565 014	4 240 175	1 992 247	4 935 057	2 131 101	29 749 $	36 684 $
February 2015	29 001 014	1 418 450	3 230 354	1 801 850	5 562 252	2 094 217	37 236 $	36 021 $
March 2015	22 775 802	1 580 440	2 194 788	1 997 338	3 997 417	2 133 108	26 184 $	34 714 $
April 2015	13 676 855	1 525 914	2 115 973	1 935 410	2 457 021	2 076 579	16 067 $	35 964 $
May 2015	6 180 160	1 606 608	1 626 941	2 046 060	407 911	2 395 470	3 350 $	38 805 $
June 2015	4 415 847	1 565 608	1 289 736	2 047 946	100 505	2 463 073	1 079 $	39 990 $
July 2015	2 022 703	1 606 597	1 140 863	2 137 781	43 023	2 571 299	507 $	40 239 $
TOTAL	**213 170 416**	**26 578 026**	**35 858 328**	**34 255 098**	**30 625 835**	**37 771 358**	**222 895 $**	**654 266 $**

MEETING CLIENT'S NEEDS

The construction of the Stinson Transport Centre was an essential initiative to enhance the STM's quality of services. Not only does the complex facilitate distribution of the bus fleet through the STM's territory but it is also accommodates articulated buses. The facility houses 300 vehicles and 700 employees. Considerations remained in place to accommodate electric vehicles in the future. With the public use of the transportation systems, the STM set goals to meet sustainable targets, enhance the adjacent communities, develop a project as an integrated team, remaining on schedule and within the allocated overall budget of $165M.

The LEED® Gold Certification, achieved with 19 points attributed to Energy initiatives exceeded the STM operational objectives. The integrated design process helped optimize the architectural envelope selection, building loads and construction cost. The decision of indoor vehicle circulation provided opportunities for additional green spaces, a roof that reduced heat island effects and appeased the neighbourhood by addressing noise and air pollution. Since the project embraced LEED® certification, the detailed energy simulations proved annual energy consumptions were reduced by almost 60%. The design resulted in a savings of $1,159,088 annually in utilities, and a savings of 7,235 tons in greenhouse gas emissions (GHG) for the community. The integrated design team, including the client, considered this undeniable success. There were neither high-end technologies nor elaborate equipment involved. Simple and efficient measures were implemented.

_bouthillette
parizeau

9825, rue Verville, Montréal (Québec) H3L 3E1 | (514) 383-3747 | (514) 383-8760_télec www.bpa.ca