An Affordable, Low-rise, Energy-efficient Multi-unit Residential Building: The "Ateliers Rosemont," Montréal

February 2016 Technical Series

INTRODUCTION

Although the linkages between housing affordability and housing sustainability are generally understood, there is a need for information on the cost-benefit relationships between sustainable technologies and practices, and reduced capital and operating costs in affordable multi-unit residential building projects. There is general acceptance that investments in increased insulation, higher efficiency building services and proactive operation and maintenance can lead to reduced operating costs. Reduced operating costs can represent a favourable return on investment over the life of a building, however, in the context of affordable housing projects, where capital budgets are restrained, project proponents (the owners, sponsors, and developers) need information on how much to invest in sustainable features and what returns they might expect. So informed, they will be in a better position to make design decisions that will impact the overall affordability of the project over its entire service life. To make such information available to housing providers, including the many challenges in developing energy-efficient affordable housing projects, case studies are used to advance and disseminate information on design and construction innovations in the industry.

The housing co-operative, Le Coteau Vert, and the non-profit organization, *Un toit pour tous*, were brought together for the design and construction of 155 affordable housing units on a brownfield site in the Rosemont neighbourhood, in Montréal (figure 1 and figure 2). Collectively known as "*Ateliers Rosemont*," the project is an example of a holistic approach to sustainable development that took into account the social, economic and environmental aspects of affordable housing and urban intensification. The planned improved environmental measures were architectural, landscaping, electrical and mechanical in nature, and included orientation of the buildings to optimize natural ventilation and daylight, arrangement of balconies as shade screens, use of low pollutant emitting finishes, smart management of surface water to reduce demand on the existing sewer system network, choice of local plant species for landscaping, production of renewable energy on site and encouragement of sustainable transit.

Figure 1 View from the cycling path at the east edge of the project *(Credit: Nikkol Rot)*

Figure 2 Official opening of the Ateliers Rosemont Project *(Credit: L'OEUF s.e.n.c.)*

Two additional strategies were included. First, client representatives of both resident groups were at the centre of the decision-making process throughout all phases of the project, from programming to post-construction monitoring and post-evaluation. Second, experience has shown that many non-profits and co-operatives are unable to handle too many technical challenges immediately following initial occupation, and so "*Ateliers Rosemont*" is an ongoing pilot project where the key infrastructure for numerous ecological measures were primed embedded within the project for seamless completion at a later date. This strategy allows residents to take on more maintenance and operations responsibilities when they are ready and to prioritize what measures they want to complete first. The overall objective was to show that sustainable affordable housing projects are possible and offer many benefits, and that their financial and socio-cultural success is dependent on the critical involvement of the project's users, via their caring guidance and vision, over time.

This Research Highlight provides an overview of this innovative affordable housing project with respect to its objectives, the considerations that went into its design and construction and the key features that were included.

CLIENTS AND OBJECTIVES

Le Coteau Vert Housing Co-Operative's objectives:

To provide quality affordable housing for families; cross-through units, with a common staircase with no internal corridors, and direct access to the central courtyard from each unit. The project includes 19 single-bedroom units, 31 two-bedroom units, 29 three-bedroom units, 12 four-bedroom units and 4 five-bedroom units.

Un Toit Pour Tous Non-Profit Organization's objectives:

To accommodate smaller households, such as singles, couples and small families (particularly single-parent families). Taking into account the diversity of clients envisioned, it was decided to house the 60 units in three small, independent apartment buildings. There are 16 studio units, 26 one-bedroom units, and 18 two-bedroom units.

URBAN INTEGRATION AND ARCHITECTURAL CONCEPT FOR THE PROJECT

The concept for the redevelopment of the Rosemont municipal workshops site was first sketched out by the City of Montréal. This early master plan included a new community library and the construction of 400 to 500 affordable housing units with some new shops and services both on site and on nearby Rosemont Boulevard. The development would favour pedestrian circulation, nearby public transit (subway within 300 metres) and active transit (major cycling path adjacent to the eastern edge) and the creation of green spaces throughout the site. According to the development criteria established by the City, the south central block, where the project stands (outlined in red on figure 3), would be comprised of multi-family, three-storey buildings, to house families (with an emphasis on larger units for young families) around a central open space accessible to the residents.

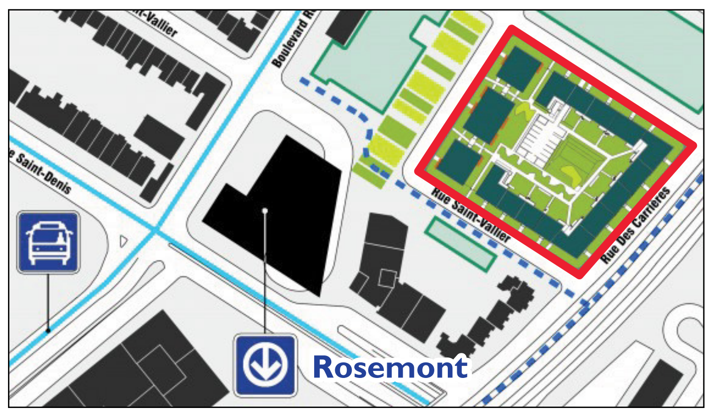

Figure 3 Project site plan and transit connections *(Credit: L'OEUF s.e.n.c.)*

INTEGRATED DESIGN PROCESS (IDP)

Through an integrated design process (IDP), the two housing providers, their representatives and their consultants pooled their skills and developed a strategy for "greening" the development in phases as an environmental improvement demonstration project. With the support of the City of Montréal, Canada Mortgage and Housing Corporation (CMHC), the Novoclimat program and the Green Municipality Fund (GMF) of the Federation of Canadian Municipalities (FCM), the project team (specifically L'OEUF and the technical resource group Bâtir son quartier [BSQ]) organized an integrated design charrette in November 2006 to explore how to integrate green features into the project.

The charrette also helped to develop a design for the project that would better balance occupant quality of life and capacity to operate and maintain buildings with new technologies.

The synergistic work of the partners allowed for the pooling of design expertise, sustainable thinking and construction knowledge. Through this integrated design approach, the housing providers' sustainable development objectives and priorities were assessed in relation to costs, benefits and capacity to satisfy various requirements under the AccèsLogis program and the Novoclimat standard[1] (funded through the AccèsLogis program of the Société d'habitation du Québec [SHQ]). The IDP helped to identify the opportunities and challenges and the development of solutions to obtain a high-performance, holistic result.

STRATEGY BY PHASES

The integration of the green features into the two projects was based on a financially viable, long-term sustainable strategy. The performance objective of the base design concept was to exceed the minimum requirements of the Novoclimat program. A more ambitious, long-term, strategy was then developed that would allow for the seamless addition of various green measures over time as funding becomes available. The projects were designed from the outset to accommodate such changes over the lifecycle of the buildings. The phases of the integration of sustainable features into the projects, as envisioned through the IDP, are shown graphically in figures 4 and 5.

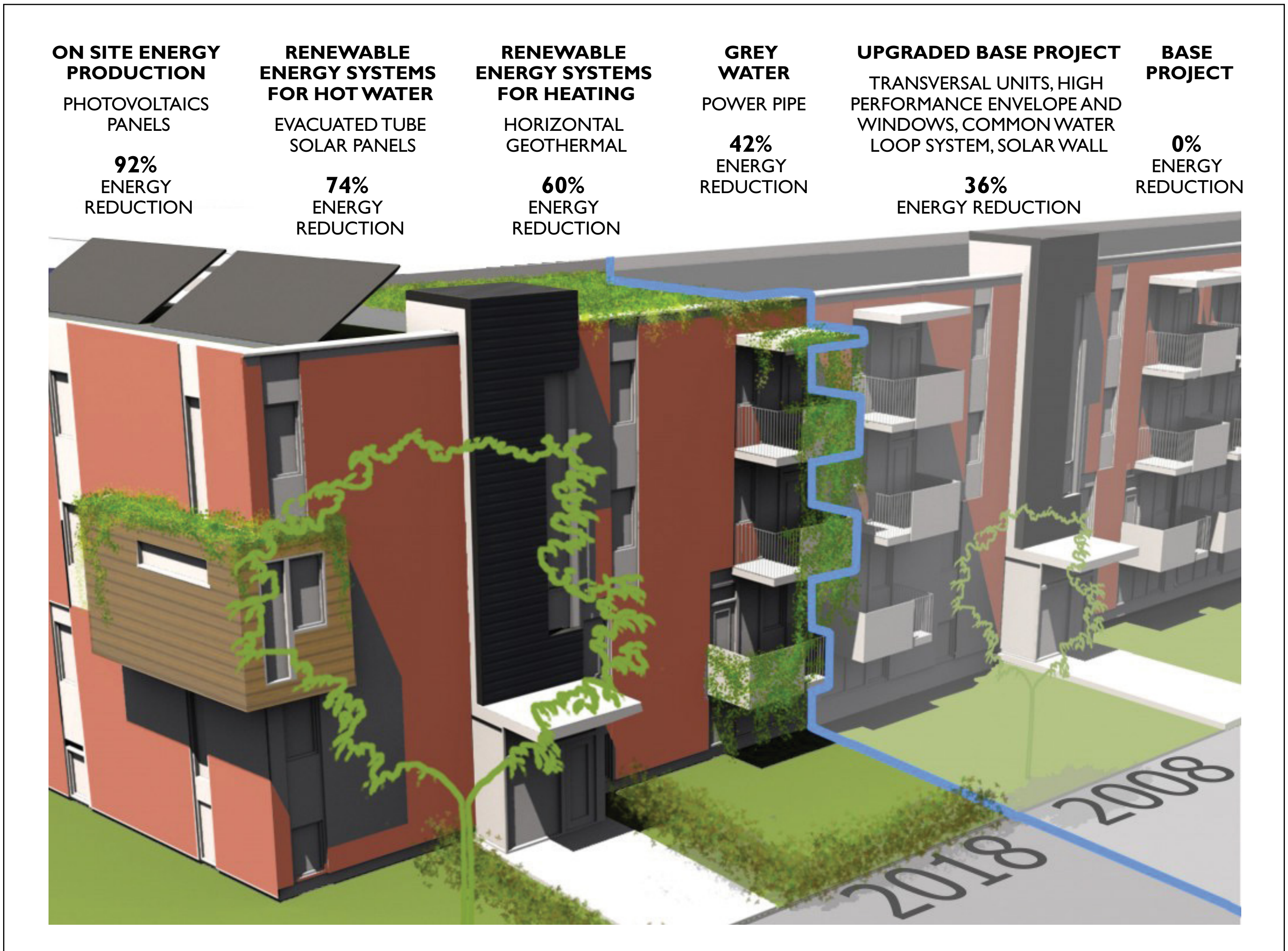

Figure 4 The evolutionary strategy for sustainable features *(Credit: L'OEUF s.e.n.c.)*

[1] *Novoclimat* is a provincial housing standard where energy costs must be reduced by at least 25 per cent below local energy code standards and *AccèsLogis* is a Quebec provincial program for affordable housing.

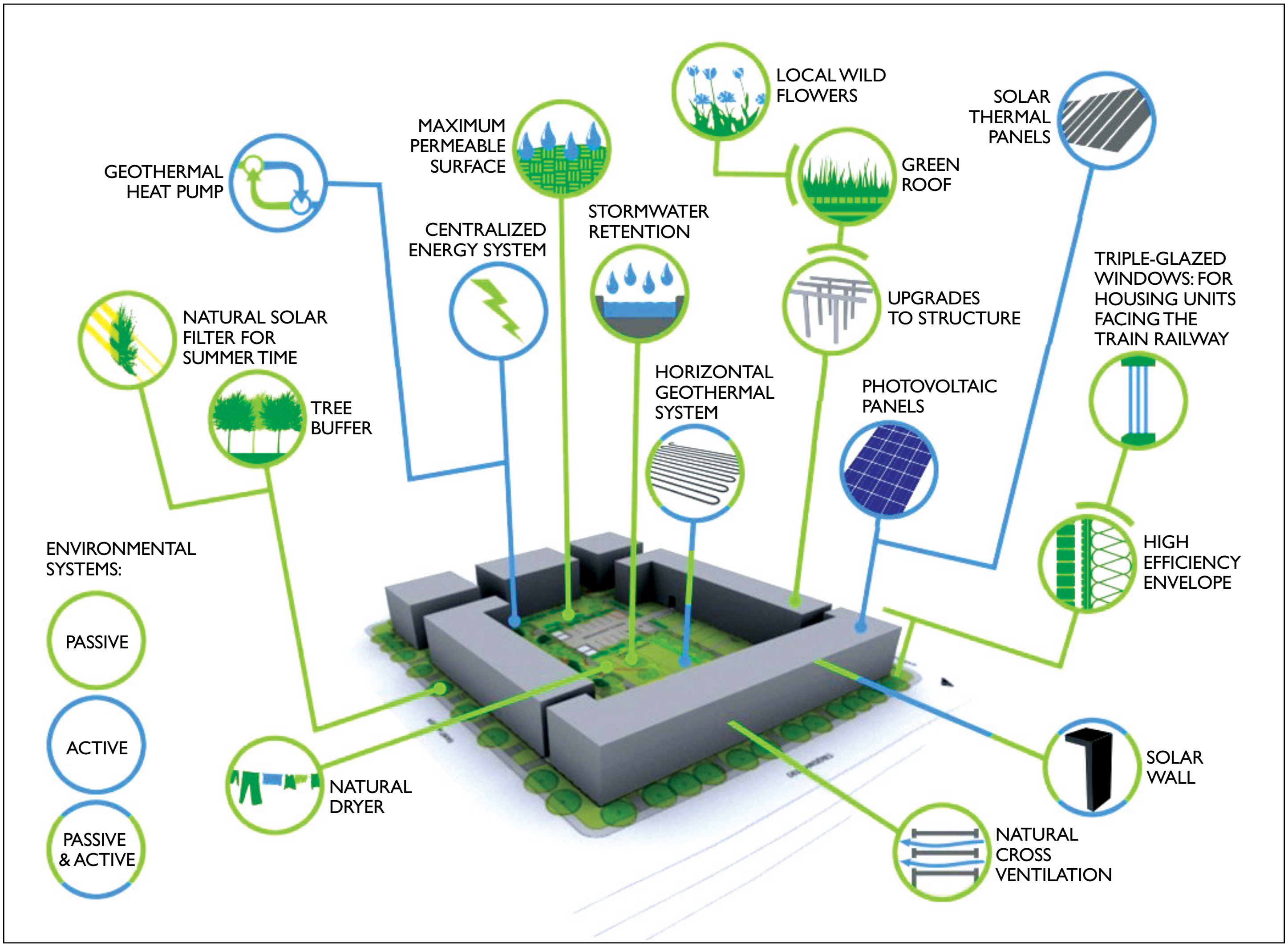

Figure 5 Sustainable features – present and future *(Credit: L'OEUF s.e.n.c.)*

ENERGY STRATEGIES

As part of the first integrated design charrette, energy simulations were carried out of the building design under four scenarios that targeted progressively higher levels of performance: the reference baseline model, and then upgrade options A, B and C. Although it would not be possible to implement all options in the construction of the projects given budget limitations, they were designed to accommodate future improvements, such as the addition of solar thermal panels for domestic hot water and green roofs to reduce urban heat islands and retain stormwater. This initial research helped to map out the features necessary to progress performance from Novoclimat toward near net-zero energy consumption as resources become available. The three critical steps to achieve this objective were as follows:

- **Option A:** Design a well-performing basic project with a centralized energy system (around 36 per cent better than the baseline of multi-residential housing projects in Quebec or 14 per cent better than Novoclimat[2]).

[2] The baseline for residential collective housing projects in Quebec was assumed to be a total of 170 to 220 kWh/m²/year, of which half (or about 100 kWh/m²/year) is attributed to heating.

- **Option B:** Produce renewable energy on site for building heating and domestic hot water (around 60 to 74 per cent better than the baseline of multi-residential housing projects in Quebec or 35 to 49 per cent better than Novoclimat).
- **Option C:** Produce renewable electrical energy on site, with a long-term energy savings management strategy (around 90 to 92 per cent better than the baseline of multi-residential housing projects in Quebec).

Additional considerations were given to:

- installing triple-glazed windows instead of double-glazed; and
- using external shading to address overheating in some units during the summer months—recognizing that the overhangs would also have a negative impact on heating and daylighting during the winter months.

The features used to attain the energy, water, indoor environment and environmental objectives for the baseline project are described below.

BUILDING ENVELOPE

The insulation levels and airtightness performance of the building envelope to reduce heat losses are shown in table 1. The arrangement of the buildings (where most "plexes" have two common walls) reduces the exterior surface area of the envelope significantly, which decreases overall heat losses. The majority of the units within each block benefit from a double orientation. Attention was paid to the interior layout of the units and the placement and size of windows to optimize this advantage in terms of solar gains and natural daylighting and ventilation. The balconies were arranged to act as shade screens, where possible, to decrease heat gains on the south side of the buildings during the summer months.

Table 1 Summary of thermal insulation levels in building envelope

Thermal Insulation R- / RSI-Values				Airtightness
Under Slab	Foundation	Wall	Roof	
7.5 / 1.32	17 / 2.99	24.5 / 4.31	41 / 7.22	1.5 ac/h at 50 pascals

Roofs

The roofs of the buildings were insulated to RSI 7.22 (R41). The project budget did not permit the initial installation of green roofs; however, structural improvements were included to allow for the addition of a green roofing system in the future.

Water service to the roofs was provided to allow for the maintenance and irrigation of the future green roofs and for the cleaning of the roof-mounted heat recovery ventilation units (HRVs). The decision to locate the HRVs on the roofs reduced the surface area available for the green roofs but the centralized locations on the roof (rather than individual HRVs in each unit) make access and maintenance easier and less costly.

Exterior walls

The exterior walls of the project were insulated to RSI 4.31 (R24.5). To optimize the airtightness of the buildings as originally designed, a decision was made to test selected blocks using multiple blower doors. The test helped to ensure the targeted maximum air leakage rate of 1.5 air changes per hour at 50 pascals indoor-outdoor pressure difference was achieved.

Reduction of thermal bridges

The junction of the above-grade exterior wood stud walls with the concrete foundation walls represented a thermal bridge where the insulation crossed from the inside to outside. To reduce thermal bridging in this location, spray-applied urethane foam insulation was used on the upper part of the interior surface of the concrete foundation wall. Overlapping the insulation between the interior and the exterior considerably reduced cold air infiltration at that vulnerable location.

Windows

High-performance windows were specified with fibreglass frames, argon gas-fill, double glazing, low-e coating and insulated spacers. In addition, improvements of the standard detailing around the window and door openings were developed to ensure that the overall targeted airtightness of the envelope would be achieved. During construction, another window type was selected, but most of the energy performance standards were respected.

MECHANICAL SYSTEMS

Space heating

Space heating is supplied by a combination of electric baseboards and a centralized geothermal system coupled to the heat recovery ventilators. Electric baseboard heaters in each unit provide supplementary heating as needed. The designers and owners opted for in-suite simplicity and electric baseboard heating provided a low-cost approach. The cost of operating the electric baseboards is reduced by the energy-efficient building envelope and windows and the contribution of the geothermal system to meeting the space heating load.

Geothermal energy system

During the preliminary design charrette, the team developed a proposal for a geothermal heat pump system with a horizontal bed that would rest on the bedrock immediately under the project site, to save money and be as efficient as possible. The heat produced from the geothermal system was to be integrated via a hot water / glycol loop to the HRVs to preheat the fresh air introduced into the units in each of the blocks. Later, a vertical exchanger was selected on the recommendation of the general contractor based on past experience with this type of system, at no extra cost to the client.

Although there was no air conditioning included in the design of the project, the geothermal system was designed to dehumidify incoming ventilation air during the summer to partially cool and to improve the overall thermal comfort for the residents.

Domestic hot water heaters

The gas-fired domestic water heaters for the projects (figure 6) were located and centralized in the buildings. The objective was to reduce the length of service water pipe between the hot water tanks and the units, while locating the hot water systems in easily accessible locations in the basement service rooms. This also saved space in the units and eliminated the higher operation and maintenance costs that would come with hot water tanks located in each unit. The locations of the domestic water heaters were also planned to allow for the installation of additional storage tanks should a solar thermal system be installed in the future.

Greywater heat recovery

Greywater heat recovery units were installed on the sanitary drainage system. The units transfer heat from drainwater to the incoming water supply that flows through copper piping wrapped around the outside of the drain (figure 7).

Figure 6 Gas-fired water heater and storage tanks *(Credit: L'OEUF s.e.n.c.)*

Figure 7 Drainwater heat recovery unit *(Credit: L'OEUF s.e.n.c.)*

The energy recovered from the outgoing drain water helps to offset water heating energy consumption and costs. The passive nature of the units (no moving parts) offers ongoing energy savings with little or no maintenance.

Mechanical ventilation

Rooftop heat recovery ventilators (HRVs) supply fresh outdoor air to the units below. Exhaust air is drawn from the bathroom areas back to the HRVs where the heat in the outgoing air is used to raise the temperature of the incoming air. The kitchen range hoods exhaust directly to the outside. The geothermal system provides additional heat in the winter to the ventilation air to ensure that it is delivered at a comfortable temperature and to help offset space heating loads. The geothermal system also dehumidifies the incoming outdoor air in the summer, which, in Montréal, can be quite humid. The ducts of the mechanical ventilation systems are oversized to accommodate higher airflow rates than would otherwise be required for ventilation alone.

Although many of the apartment units have two exposures that encourage natural cross-flow ventilation, Montréal's extreme cold winter climate, coupled with the airtight building envelope, made mechanical ventilation necessary to ensure a healthy indoor environment.

Solar walls

The design of the buildings allows for the eventual installation of solar walls to preheat the outdoor air drawn in by the HRVs (see figure 9 for the proposed solar wall concept). However, since the solar walls would be installed upstream from the HRVs, the actual heat savings would be much lower than the theoretical values and the cost benefits less attractive—at current energy costs. The concept was therefore maintained as a potential "future" measure that could be installed should the cost of solar wall technologies decrease or energy costs increase—or both. The spaces planned for the solar panel walls have conventional metal cladding (visible above the entranceways in figure 8) that can be replaced with a solar wall system without affecting the overall appearance of the buildings.

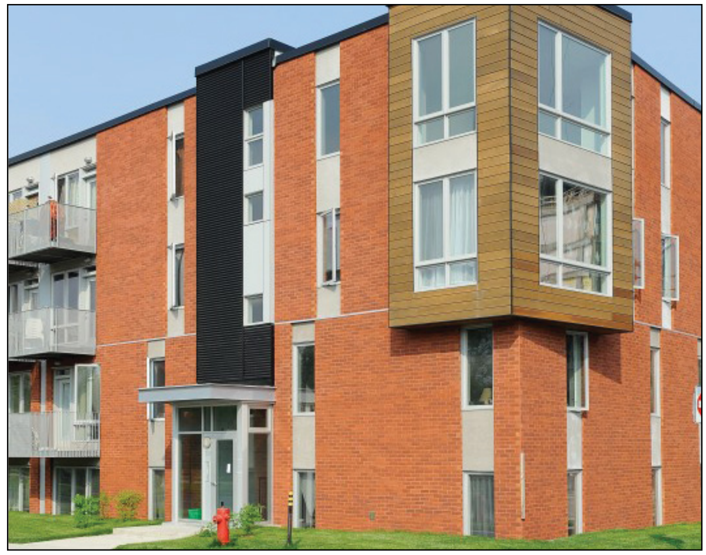

Figure 8 Proposed location of the future solar wall for preheating ventilation air over the building front entrance on the south-facing facade *(Credit: L'OEUF s.e.n.c.).*

Solar wall principles

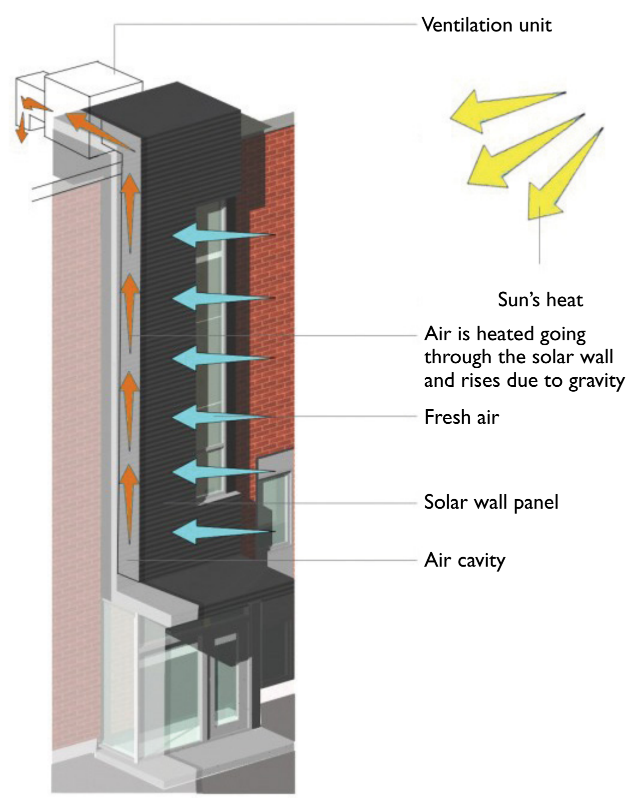

Figure 9 Proposed solar wall concept for preheating ventilation air *(Credit: L'OEUF s.e.n.c.)*

WATER EFFICIENCY STRATEGIES

Water consumption reduction

Low-flow plumbing fixtures (for example, shower heads 6.6 Litres/minute) were specified as they are measures that required little additional cost and that would allow for a significant decrease in annual water consumption.

Greywater and Blackwater reuse

Greywater and blackwater reuse measures were assessed. However, given the associated costs (both capital and operating) and to the clients' priorities resting mostly in energy measures, thermal comfort, landscape measures and heat island sink reduction, these strategies were not retained in the final design of the project.

SURFACE WATER MANAGEMENT

The landscaping was designed to require little maintenance and no irrigation. Permeable surfaces throughout the project were conceived and planned right from the initial charrette. A centralized retention basin for surface water management during significant rainstorms (and regular snowmelt) was included in the project. It is a grassed area (figure 10) that allows for the direct return of stormwater to the subsurface soil to reduce the hydraulic load on the existing sewer system. During its construction, protection measures had to be put in place to prevent any breaches of the geothermal network of piping installed under the central courtyard.

Figure 10 Stormwater retention basin in bottom right-hand corner *(Credit: Nikkol Rot)*

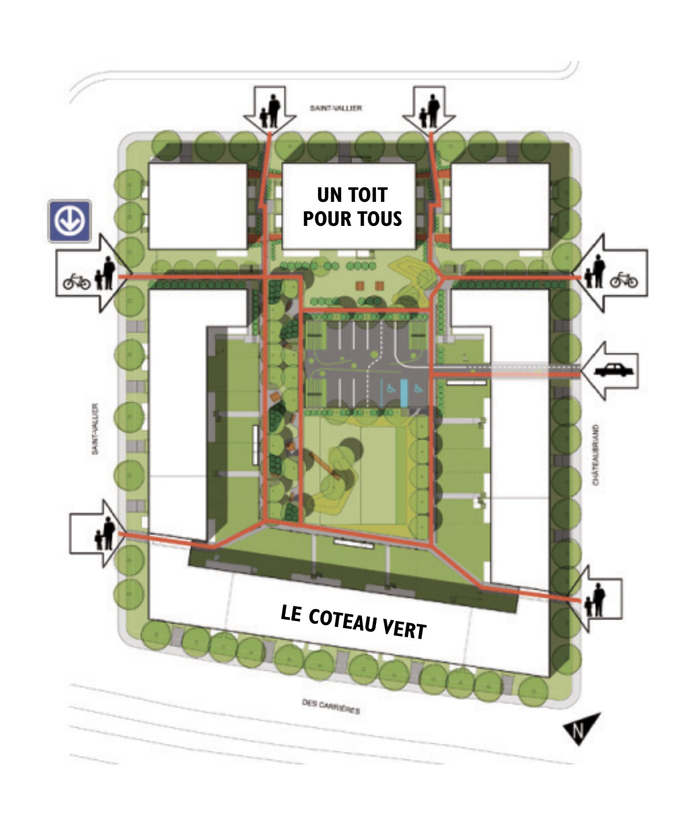

Figure 11 Site plan green space planning *(Credit: L'OEUF s.e.n.c.)*

HEAT ISLAND REDUCTION

Reduction of paved areas

The compact urban form of the buildings and their arrangement around the perimeter of the block enabled great flexibility for the addition of water and energy management infrastructure. This arrangement also allows for significant green space within the site (figures 10 and 11). Municipal bylaws originally required a total of 78 parking spaces, which was eventually reduced to 35 parking spaces in the centre of the block, which would still take up one third of the available space, while not adequately meeting the green space needs for the many families and their children. At the client's wish, negotiations were successfully undertaken with the City of Montréal to further reduce the number of required parking spaces to 12, of which 2 to 6 would be reserved for users of the "Communauto" car-sharing service.

Green roofs

The project budget did not permit the installation of green roofs. However, the roof was structurally reinforced to accommodate the addition of a green roof system at some point in the future should additional resources become available. As designed, certain parts of the structural system of the project could accommodate the extra dead and live loads but others had to be modified in anticipation of future loads associated with green roofing. The roof membranes were changed, and the colour white was specified, to help reduce heat island effect until the addition of the green roofs, and parapets were designed and built higher from the outset, to not require any significant changes over time.

INDOOR AIR QUALITY

For indoor air quality, the design set out to eliminate most construction materials with potential toxic gas emissions (volatile organic compounds [VOCs]). Low-VOC paint was specified for the project but many follow-ups were required to ensure that the products specified were actually supplied and installed on site.

Most of the units of the co-operative Le Coteau Vert benefit from a double exterior exposure and particular attention was paid to the interior layout of each unit to encourage cross-flow ventilation and access to natural lighting. Most of the units of the NPO project, Un toit pour tous, have two exposed exterior sides that help induce natural air change.

The HRVs provide a continuous supply of outdoor air throughout all the units of the project. The HRVs are equipped with filters having a rating of MERV 13—the best possible efficiency in the range of 50-mm (2-in.) thick disposable flat filters—an important feature in urban environments that can experience high particulate matter concentrations. However, the filters also impose significant pressure loss, which must be taken into account when designing the systems. The higher static pressure losses meant more powerful fan-motor sets were required. Considering the winter and summer smog episodes frequently observed in Montréal, though, it was deemed that the overall benefit on indoor air quality outweighed the additional energy consumption.

However, high efficiency filters tend to get dirty faster than conventional filters (MERV 8) and will represent additional maintenance costs over time.

OTHER ENVIRONMENTAL FEATURES

FSC wood

One of the many intentions of the project, with respect to the wood structure, was to have all components certified by the Forest Stewardship Council (FSC). At the time of tendering, the reading of the market conditions and the opinion of the various stakeholders and business partners indicated that there could be a significant increase in the costs of FSC wood. However, during construction, it was noted that the general contractor used FSC-certified wood, at negligible additional cost and the materials were available in sufficient quantities so as not to impede the work schedule.

Reuse of rock

Bedrock quarried during the excavation phase was reused as fill on site. However, the presence of rock crushers resulted in significant clouds of dust and high-decibel noise that had to be managed in consideration of neighbouring properties. The crushed bedrock largely exceeded what is permitted and recommended for backfill in contact with the foundation membranes and insulation. To overcome this challenge, additional sheathing was installed between the insulation and the crushed rock backfill before completing the backfilling process. Nonetheless, significant construction site management was required by the contractor with regard to the sequence of the work and the location of the piles of bedrock for crushing and reuse. Considerable delays were experienced between the time that the bedrock was extracted, crushed and put into place after the foundations were poured.

QUALITY ASSURANCE

For this project, the quality assurance process was not limited to the construction period. It started at the initial design stage and continued through construction. The process began with the designation of commissioning authority responsible for quality assurance. For this project, before the start of construction, the commissioning authority completed the following three deliverables:

- independent design review by an engineer on the definition and proposed project's bio-climatic (electrical and mechanical) design as well as a review of the post-occupancy performance monitoring protocol;
- development of a commissioning plan; and
- specifications defining the role of the commissioning agent to be retained by the general contractor.

After awarding the construction contract to the general contractor and following the first meetings between the commissioning authority and the various stakeholders and trades on the project, the shop drawings and the various plans for the mechanical systems were reviewed by the engineer and the commissioning authority. This stage already exists in conventional projects, except that, in this project, there were two other reviewers in addition to the general contractor, to ensure that various elements were properly integrated into the project (and its complex construction schedule): one by the commissioning agent and another by the commissioning authority.

During construction, the commissioning agent's role was to proactively ensure that the contract documents were understood by all trades. The agent also oversaw the coordination for testing and quality assurance to ensure it was fully planned out in advance and was completed at the appropriate times—with follow-up and corrective measures as needed.

CONCLUSION

The development of the Rosemont project provides a useful example of how sustainable features can be embodied into an affordable housing project. It demonstrated that building envelope insulation and airtightness improvements can represent an important starting point for making significant reductions in energy use and operating costs. Such improvements can be cost-effective in comparison with the installation of renewable energy systems.

Incremental construction cost for the development of AHS' "green measures" was approximately 10 per cent higher than a conventional project budget. There was approximately a 2-per-cent increase for adherence to the Novoclimat program, 5- to 6-per cent cost increase for the energy recovery and geothermal systems (of which 20 per cent was used for drainwater heat recovery and HRVs and 80 per cent for the geothermal energy system) and a 2- to 3-per-cent increase for future-proofing the project. The overall construction budget was approximately $1,184/m² ($110/sq. ft.).

Preliminary results from performance monitoring indicate a total project annual energy use of 80 to 100 kWh/m² (7.43 kWh/ft² to 9.29 kWh/ft²) of which space heating constitutes approximately 50 per cent or 50 kWh/m² (4.65 kWh/ft²). This performance compares favourably with other energy-efficient sustainable housing projects constructed elsewhere across Canada.

Although the project required significant investments in time, effort and commitment from all stakeholders, consultants, local and regional authorities and municipal employees, the effort demonstrated that sustainable features can be cost-effectively implemented in affordable housing projects.

IMPLICATIONS FOR THE HOUSING INDUSTRY

This project demonstrated the challenges and opportunities associated with integrating energy-efficient, environmental and indoor air quality features into an affordable multi-unit residential building project. It showed that implementing sustainable features into such projects is more than simply adding them to the design of the building. It requires the ongoing attention of the project development and property management team to ensure the features are properly installed, commissioned and then monitored to ensure objectives are met. The outcome of the project is important as it demonstrates that higher performing affordable residential buildings are possible with only modest increases in capital costs.

PROJECT PROFESSIONALS

Architects: L'OEUF s.e.n.c.
(L'office de l'éclectisme urbain et fonctionnel)

Structural engineer: CPF Groupe Conseil Inc.

Mechanical/electrical engineers: Pageau Morel et associés inc.

Civil engineer: Vinci Consultants

Landscape architects: NIPpaysage

Commissioning authority: Ian Ball, GES Technologies inc.

ACKNOWLEDGEMENT

The documentation of the Ateliers Rosemont Project was funded by Canada Mortgage and Housing Corporation under Part IX of the National Housing Act and Natural Resources Canada through the Program for Energy Research and Development (PERD).

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Housing Research at CMHC

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