CENTRE FOR SUSTAINABLE DEVELOPMENT
CONSTRUCTION
MAISON DU DÉVELOPPEMENT DURABLE

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bouthillette parizeau

COMPLEXITY

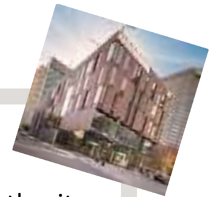
La Maison du Développement Durable - MDD (The Centre for Sustainable Development) wished to make their building a model of sustainable design, to push sustainability boundaries, and to embrace the LEED® certification program by aiming for the highest level: Platinum. In 2005, the owner (Équiterre) launched a quality tender bid to select the professionals that would be involved in the project. Professional teams who coveted the project had to undergo an unusual interview. The selection committee asked each team of candidates to simulate an integrated design meeting as if the project was within its design phase. This way, the selection committee could witness the synergy between each professional.

After several minutes of establishing the needs of the project, Bouthillette Parizeau and our teammates commented on the owner's absence at the design table which would mean that it would be difficult to obtain their requirements and to meet their expectations. The involvement of the building owners in the design meetings in this case is important since the owners must give their input for building design decisions that will impact their occupancy for years to come. Our team considered the owner's involvement as a preamble to the design development. Because of this, and due to our demonstrated expertise in sustainable development which dates back to 2005, our team was selected for the project.

Our firm was well aware of the immense amount of work and the challenges that the project entailed, however the project would also give us a great opportunity to demonstrate the depth of our knowledge in the field of sustainable development, and to showcase our high quality and innovative work.

Right from the start of the project, our team and the building owners pursued an integrated design approach based on collaboration and knowledge sharing. The design period lasted from 2005 to 2009, which is an extended period compared to a typical project of this magnitude, however this was because the project was entirely funded by private donations and fund-raising campaigns, which took some time to raise sufficient funds.

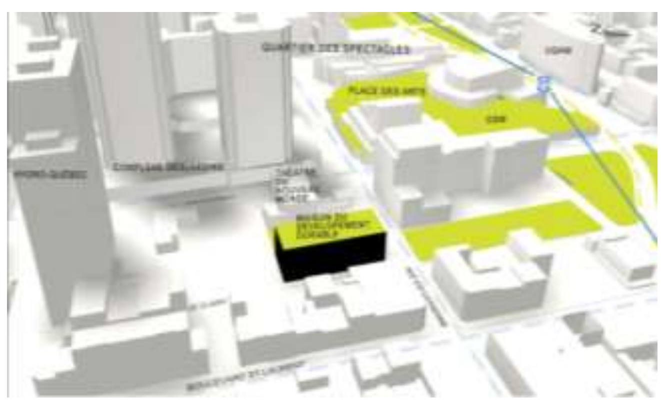
The design charrettes were held at the Integrated Design Laboratory at École de Technologie Supérieure (ÉTS), where all stakeholders could take control of the presentation console to display information and save the results of the discussions and refer to them later. All of the presentations and discussions were recorded and are now part of the educational material and animations which reflect the building's construction and demonstrate the operation of the various technologies. These recorded meetings gathered an average of 30 people including building professionals, experts and observers, who all joined the design team to share their experience and expertise. These meetings were used to develop the design, justify the choices, refine the design details, and analyze every facet of each solution. Many specialists gave their input on the documents, strategies and methods of installation for each of the proposed sustainable measures. It is important to note the presence of the general contractor, Pomerleau, who joined the design team to so that the team could benefit from their expertise and



experience. Also, representatives from Hydro-Québec and experts such as the commissioning authority, building simulators and many other energy specialists who do not normally participate during the design phase were present at the interactive design table in the Integrated Design Lab at ETS and commented on the strategies and choices. The numerous different specialists were present in order to be able to question all the ideas presented from various different perspectives in terms of design choice, sizing and implementation method. Even a Masters student from École Polytechnique de Montréal joined our office to write his thesis on the principles of geothermal heating and cooling at MDD.

The mission of MDD is to become a center for reflection, education, and innovation on sustainable development practices. The vision of the building owners extend far beyond their functional requirements for a building. They wanted to understand every facet of the building's sustainable design, which explains the constant questioning of every design detail. This continuous questioning was beneficial for all involved in order to push the team to excel. Young engineers in particular were able to enrich their knowledge and develop their skills related to sustainability strategies, and developed good habits for innovative engineering practices.

INNOVATION



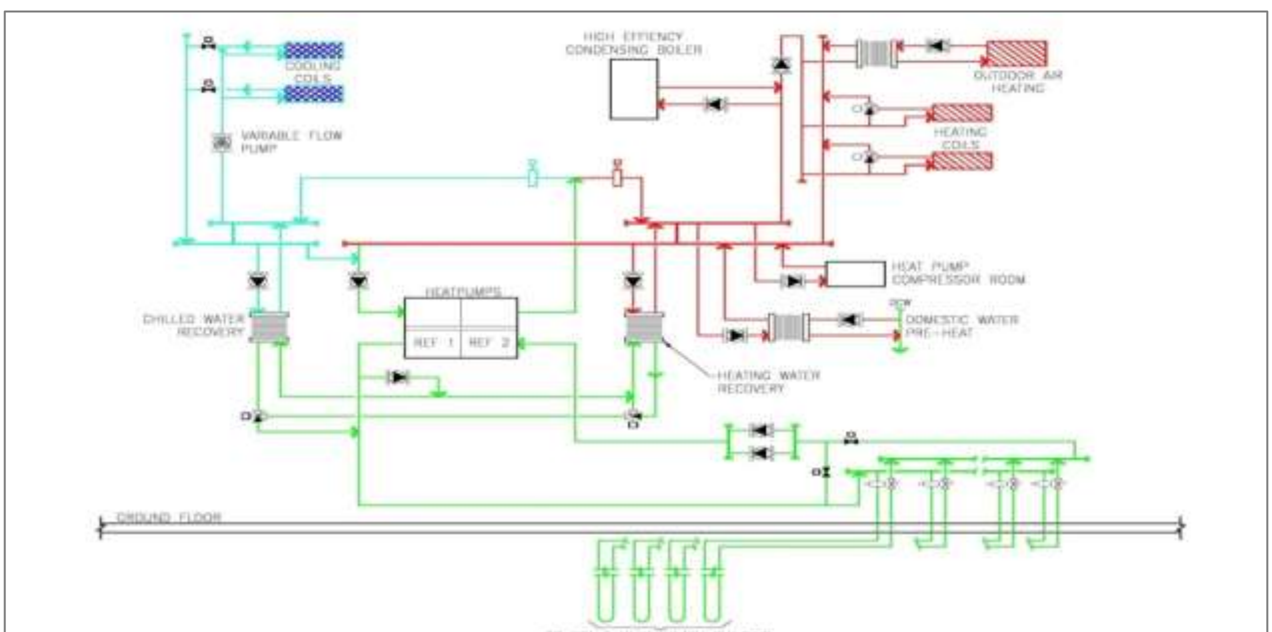
Built on a confined land of 14,900 sq ft in downtown Montreal, the 5-storey building has a total floor area of 68,450 sq ft and an average glazed area of 34%. It houses the offices of eight social and environmental organizations including Équiterre, a kindergarten school, and a restaurant, for an overall population of over 200 adults and 72 children.

Innovation is truly apparent in the Mechanical and Electrical systems of the building with the combination of several energy efficiency measures and an intelligent centralized control system. This control system is the key to implement and maximize the efficiency of each individual energy efficiency measure at the precise moment. In order to optimize the equipment capacity and effectively manage the operation of the building, it is crucial to understand the behavior of the building as a whole.

The Bouthillette Parizeau team was responsible for the implementation of multiple sustainable development measures which includes a rigorous analysis of the needs, functionality, occupancy profiles, and geometry of the building according to Montreal climate conditions. This allowed us to optimize the architectural performance of the building which reduced mechanical and electrical infrastructure required. Through various tools, such as energy balance analyses and energy simulations, Bouthillette Parizeau was able to optimize the mechanical and electrical infrastructure and also the envelope performance in order to reduce energy consumption, capital costs, and operating and maintenance costs on a recurring basis.

To reduce the environmental impact of the building, geothermal energy is used to satisfy nearly 100% of the heating and cooling requirements. The results of test wells, which were drilled early in the design process, were used to characterize the ground and define the thermal conductivity which influenced and helped to optimize the system design. The test wells were then reused for the actual system in order to reduce the investment cost. Having very little land area, the 28 geothermal wells were drilled directly underneath the building to a depth of 152 m.

Significant effort was made to carefully calculate the system equilibrium in order to ensure that it operates optimally under all possible operating conditions including peak summer and winter conditions as well as mid-season conditions. As such, the system is solicited at its maximum throughout the year. Also each geothermal well is independent from all the others in order to minimize any negative impacts on the capacity of the system in the event of a failure of one of the wells.



HEATING/COOLING DIAGRAM

During winter, heat is extracted from deep in the ground in order to satisfy the heating needs of the building. A high efficiency natural gas condensing boiler (efficiency = 97%) is installed to be used only as a backup in case of geothermal failure or for extreme winter conditions (1% of the time).

During summer, air conditioning is provided solely by the geothermal heat pumps using R410a refrigerant, which complies with the Kyoto Protocol. The advantage of this strategy is that the installation of a conventional water tower is not required. This reduces infrastructure and maintenance costs, physical footprint installation, potable domestic water consumption, and chemical treatments required to treat the water in order to prevent algae problems or Legionnaires' disease. The absence of chemical treatments fits perfectly into the philosophy of sustainable design. As a bonus, this strategy also helps to improve architectural aesthetics.

The building has two supply ventilation systems: one for the office spaces and the kindergarten school, which have similar schedules, and one to serve only the ground floor, which is continuously in use. Outdoor air is processed by a dedicated outdoor air system (DOAS), whose variable rate is calculated based on numerous different conditions which take into account the general exhaust requirements and compensations that must be made for systems such as kitchen hood exhausts which also operate at variable speeds and with infrared detection. This complicated control of the outdoor air rate allows a reduction in energy use related to air supply.

A cassette type heat recovery unit is installed between outdoor air flow and exhaust air in order to further reduce energy consumption of the HVAC systems.

Air diffusion in the office spaces is achieved by an under-floor air distribution system (UFAD), which provides increased ventilation effectiveness. This measure allows for a lower airflow supply and increases flexibility for future office reconfigurations. The office spaces benefit from an air stratification strategy which allows the cooled air to be supplied through the floor at 62°F as opposed to typical air handling strategies which usually push cooled air down from the ceiling at 55°F, thus saving energy on cooling. Improved ventilation effectiveness also means the heating and cooling needs are provided solely by the HVAC systems. As a result, no additional perimeter heating equipment is necessary, freeing the perimeter for the installation of office furniture while reducing costs and maintenance, which is not normally the case. This strategy also works harmoniously with the geothermal heating system as both systems operate at lower temperatures.

In many areas, occupancy and light sensors are installed in combination with scheduled programming to reduce the energy consumption from lighting by maximizing the amount of natural lighting used. Occupant comfort was a concern for the owner and thus several devices are installed to ensure that ambient conditions remain within the comfort zone.

The atrium, where the occupation is only short-term, was designed such that it is not required to condition the space. In the event of a temperature rise during the summer, the space can be refreshed through open windows and motorized dampers located at the top and bottom to create air movement similar to the stack effect. Also, motorized blinds and a sophisticated solar detection system reduce heat gains in the summer via the building management system.

The atrium also contains a special feature: a 430 sq ft living wall which extends over 5 floors (65 ft high).

The living wall acts as a filter, humidifier, decontaminant, and an acoustic attenuator and also improves overall aesthetics and ambiance of the atrium. Careful considerations were made in the choice of plants and lighting fixtures in order to promote photosynthesis. Return air is sent to the atrium to be naturally pre-treated before being returned to the HVAC system.

From an electrical perspective, several innovative features have been introduced. According to calculations based on the local building code, the electrical distribution system should have required a capacity of 770 Amps with an input of 800 Amps. However, this would have required costly installations of an outdoor transformer base and other large equipment which would take up valuable building space. In order to avoid this, the capacity was limited to 500 Amps, which allowed for a direct connection to the main electrical network and significantly reduces capital costs and eliminates unprofitable space usage. However, for this to work equipment processes and usage are rationed and the loads are managed by a sophisticated load shedding program. This, combined with continuous monitoring, allows the building loads to remain within the 500 Amps limit. Also, no emergency power generator is installed. Instead, emergency power is supplied via batteries in the event of a power failure. This also reduces the capital costs, frees up valuable floor space and reduces maintenance requirements.

Interactive energy display boards with touch screens, located in various public spaces throughout the building, display, in real time, the current energy consumption and the savings in comparison to a reference building. Sensors and meters are installed on various mechanical and electrical equipment to measure air flow rates, air temperatures, humidity, lighting power consumption, etc. The results of these readings are used in equations that were developed to calculate the real time energy use of the different operations within the building (e.g. ventilation, heating, cooling, lighting, humidification, etc.). The consumption of the simulated reference building is then normalized with real time weather data and operation schedules, and compared to the actual building to determine the performance of the actual building, which is displayed on the energy display boards for all to see and analyze. This helps to

give building occupants a better idea of how their activities affect the energy consumption of the building and is also used to educate the general public.

The mechanical and electrical systems also include the following additional strategies, which are adapted to the building needs in order to meet all the owner's requirements:

- Heat is recovered from cold room and freezer compressors and transferred into the heating system to preheat domestic hot water and space heating air.
- CO_2 sensors are used to ensure adequate indoor air quality.
- Water, electricity and energy meters are installed to monitor real-time consumption and demonstrate the impact of usage. Metering also provides historical data and helps detect unusual patterns.
- Building height was limited according to city potable water pressure available in order to prevent the installation of a fire booster pump.
- LED, T5 and HID lighting fixtures are selected in relation to the space usage and to maintain visual comfort in the light spectrum of the occupant's eyes which results in an overall reduction of 20% in lighting power density.
- Only energy efficient appliances are installed throughout.
- Light pollution is reduced by installing directed outdoor lighting and interior lighting is turned off during the night.
- Only high efficiency transformers are used.
- Service configuration is flexible to adapt to any future changes.
- All materials and equipment considered underwent a life-cycle analysis to determine their overall environmental impact. 87 eco-friendly materials have been classified using Athena software (software for the evaluation of life-cycle environmental impacts of materials).

From the start, all mechanical and electrical efficiency strategies considered by Bouthillette Parizeau were validated and refined by means of space usage behavioral pattern analyses, load calculations, energy simulations and detailed heat balances. These tools were fundamental to adequately predict the behavior of the building with multiple energy efficiency strategies and sustainability measures and to implement the most appropriate solutions.

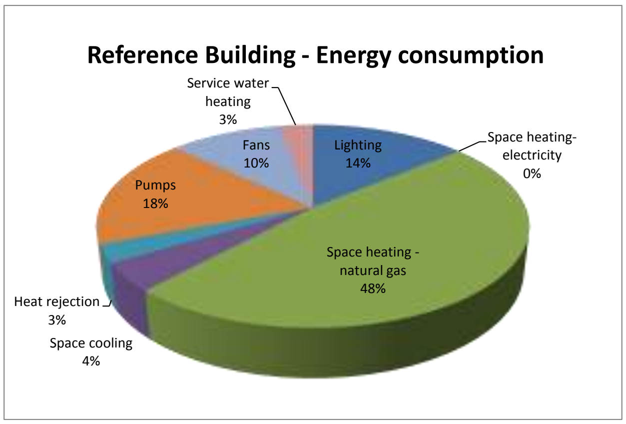
ENVIRONMENTAL IMPACT

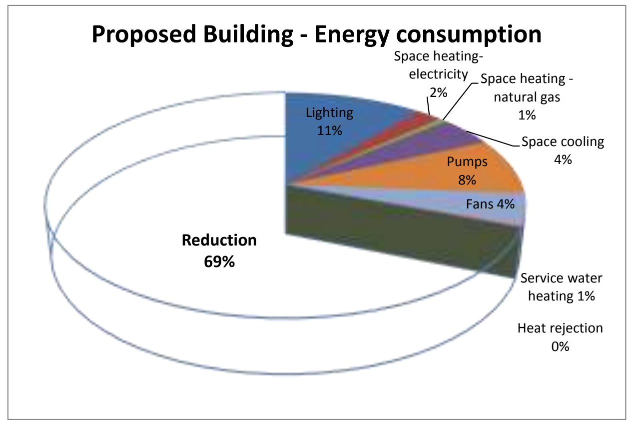
Since the project aimed for LEED® platinum certification (the highest possible LEED® certification where 57 out of 70 credits are anticipated), Bouthillette Parizeau aimed for the maximum possible of 10 points for energy reduction according to the LEED®-Canada certification requirements. In order to achieve this, high accuracy energy simulations were used to confirm that the MDD building consumes 64% less energy compared to the Model National Energy Code for Buildings (MNECB) reference building. Due to Bouthillette Parizeau's extensive experience and involvement with the US and Canadian Green Building

Councils, our team was able to contribute 26 points and 4 prerequisites to the LEED® certification of this building.

The simulations revealed an annual energy reduction of 4,126 MBTU, or $63,500 in annual savings, compared to the reference building and resulted in a reduction in greenhouse gas emissions of 292 tons. For perspective, this represents a reduction equivalent to the energy use of 15 average single-family homes in Montreal.

Actual energy bills obtained after construction indicate that the design achieved an energy intensity of 63 kBTU/sq ft/year compared to a conventional building of similar size which typically uses approximately 180 kBTU/sq ft/year.





Efforts have also been made to reduce water consumption and sewer discharge. Low flow fixtures, waterless urinals, infrared faucets and an underground tank that collects rainwater from the green roof, which because of the choice of plants requires no watering, are installed. Thus, an annual volume of 90,600 US gallons is managed by a water treatment system that ensures its clearness and prevents stagnation. The rainwater cistern volume was calculated from tabulated precipitation data over the past 25 years from Environment Canada. The result is a reduction in potable water consumption of 54% and a reduction of sewer discharge of 54% as well.

To reduce the energy use associated with domestic hot water heating, heat recovered from the cooling system is used to preheat the incoming city water, and high efficiency natural gas water heaters provide the hot water needed for the cooking equipment in the restaurant. Energy simulations showed that the result is an 80% reduction in energy used specifically for hot water heating compared to the MNECB reference building.

All of the HVAC systems are equipped with filtration media with a minimum efficiency of MERV13 and are part of a regular maintenance program. When comparing ventilation rates while considering space usage, it was demonstrated that the installed outdoor airflow exceeds ASHRAE standard 62.1 at normal occupancy density. The office space has an average outdoor airflow rate of 0.104 cfm/sqft compared to the required ASHRAE outdoor rate of 0.085 cfm/sqft while still achieving a reduction in energy consumption above 60%.

All the equipment was selected according to their life expectancy and their simplicity of maintenance in order to reduce the costs of materials, operation and labor. Equipment capacity only meets the current needs; there is no provision for the future or redundancy which means that the equipment is not oversized, as is common practice, and operates optimally for the current requirements of the building.

Other strategies for sustainable development also include storm water management, heat-island effect reduction, native plants for landscaping, waste management, more than 75% usage of FSC certified wood, reclaimed wood from the bottom of a river bed, green cleaning products, and low VOC (volatile organic compound) products.

Sustainable development involves an awareness of the availability and usage of our resources such as water, air and energy. Bouthillette Parizeau has demonstrated its capabilities by introducing strategies that minimize consumption and usage of these resources while offering an improved environment and excellent indoor air quality for the occupants and reduced cost and maintenance requirements.

SOCIAL AND ECONOMIC BENEFITS

Built to meet or exceed the latest environmental standards and vowing to be a center of education in green building design and construction, MDD must be a model for the future where the public could visit and learn about green buildings and sustainable design. The building is a showcase in sustainable design and promotes professional and public awareness. During the design, an education pathway for visitors, professionals and the public has been integrated into the space. This special feature includes windows into the mechanical room to expose the services required to operate this type of building, glass floor tiles in the raised flooring to expose the operation of the UFAD, and an educational display with explanatory notes detailing what goes on behind-the-scenes. The recorded meetings previously mentioned are also used as integral part of the educational material for the visitors.

From the beginning, the owners demonstrated their belief in Sustainable Design by hiring consulting engineers for this purpose, which demonstrates awareness and confidence in our profession. If this project had been a typical turn-key type contract, the numerous periods of reflection and questioning would not have happened and the sustainability measures would likely not have been optimized properly. Bouthillette Parizeau has influenced the market by demonstrating the value of the involvement of consulting engineers for sustainable design integration in buildings. Our employees use this project to implicate themselves in various associations to explain the complexity of such a project through numerous presentations. These presentations contribute to the education of numerous professionals by sharing the lessons-learned from this project while demonstrating the importance of the consulting engineer’s role in an aggressive and evolving market.

Within the Bouthillette Parizeau team, engineers had to conduct research on the various strategies implemented and develop functional and coherent methodologies for the implementation of these strategies for future projects. The results of extensive research and expertise benefited the projects that followed. Bouthillette Parizeau's pride resides in a job well done and with the owner satisfaction.

MEETING CLIENT'S NEEDS

The client's main needs were that the budget and schedule are respected. The 16.8M$ budget came solely from fund-raising campaigns and public donations. Since it was a tight budget, every dollar was spent wisely. The cost estimate was carefully followed throughout the project. The mechanical/electrical budget was evaluated at $4.3M and the tender bid was awarded at $3.97M accompanied by $365K in subsidies. Moreover, since the projected tenants were mostly various social and environmental organizations, most of which are non-profit organizations, one of the objectives was to minimize the cost of rent. It was a requirement that the tenants must not pay more than their current leases, which can often be a challenge in downtown Montreal. The end of the owner's and tenant's current leases also needed to be considered, since lease extensions can be quite expensive. This extra expenditure was avoided thanks to a tight construction schedule which was executed with minimum delays. The construction lasted from January 2010 to June 2011. As planned the building was turned over to the owner in June 2011.

Before this, the design phase was extended over a period of four years because of the fund-raising campaigns. The team of professionals even participated in activities to raise funds in order to make this project a reality.

The tender bid period was also the subject of thorough study in order to reduce costs. It was decided that the tender bid would strategically take place in December because at this time, contractors are still looking to fill their summer with contracts and are more likely to offer a better price. Also, this meant that the construction would take full advantage of the summer season to minimize the added costs of construction during the winter (reducing heating costs and temporary envelope protection).

During the construction phase, the number of field orders for costly changes was kept to a minimum. This is evidence that the original needs were understood and well defined due to the multiple design meetings and participation of all stakeholders during the design phase, including a commissioning agent and the site supervisor, which do not normally participate at this stage.

The building has been the subject of several analyses to find the optimal solution in terms of cost, energy and functionality. Each strategy was analyzed not only individually but as an ensemble to identify cumulative impacts. During the integrated design meetings, several strategies were considered and only the ones that were beneficial in numerous different areas were implemented. The design was not merely an addition of technology currently available on the market; the technologies selected were thoroughly considered and adapted to the behavior and needs of the building and its tenants with the consensus of all the different professionals involved.

The actual energy bills of the building from August 2011 to July 2012 showed an electricity consumption of 4,328 MBTU and a natural gas consumption of 8,322 m^3. The energy simulations completed during the design phase had predicted an electricity consumption of 4,185 MBTU and a natural gas consumption of 1,070 m^3. The prediction in terms of electricity consumption proved to be remarkably accurate

while it was expected that the gas consumption was under-estimated since the restaurant cooking equipment, which is powered by natural gas, was not considered for the simulations. Furthermore, the geothermal ground loop was not fully charged during the first year, which also contributes to the discrepancy in gas consumption. Regardless, the energy simulations performed during the design phase gave the owner a good idea of what to expect in terms of real consumption and energy bills, while the commissioning process did an excellent job at ensuring that the building systems were functioning as planned.

Design, preparation of drawings, and specifications all followed a rigorous path to meet the owner's requirements. The simplicity of the system was a priority to facilitate the maintenance and extend the useful life of the equipment because no internal skilled labor was available to make sure the systems attained their full potential. Ease of operation and maintenance after construction was also considered. For example, all facilities are located within the building away from the harsh winter conditions, making it easier to access and extending equipment life. In addition, the simplicity of the system allows the owner to understand the operation and ensure that it operates at its full performance while providing exemplary comfort for the occupants.

Finally, the owner had made it very clear right from the beginning of the project that minimizing energy consumption was not just a priority, but a requirement. As such, the team aimed for the maximum amount of LEED® points available for energy (10 points). As a result, the building performs optimally in terms of energy consumption, which is the result of utilizing latest trends available on the market in intelligent manners. The building is a collection of coherent and adapted strategies tailored specifically for this building and climatic conditions. Each measure is employed at the precise moment it is required in order to benefit from maximum returns with a minimal investment. The end result is an excellent building that will be considered as a model in sustainable development for years to come.

Maison du Développement Durable is synonymous of doing more with less, and for a sustainable posterity.

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