Varennes Library – An Overview

The Varennes Library is the first institutional net-zero energy building in Canada.

Figure 1. Varennes Library, entrance south-west view

Constructed in 2014 and inaugurated to the public on May 16, 2016, it achieved LEED certification [1]. It won an Award of Excellence in Real Estate for Innovation from the Urban Development Institute of Quebec and from the Association of Consulting Engineering Companies of Canada (ACEC 2016). The building with dimensions of 54.9 m long x 19.1 m wide x 6.8 m high (internal dimensions) spans two floors and covering a total area of 2,100 m^2 and is extremely well-insulated.

The energy-efficient design along with successful adoption and integration of several renewable technologies enables low energy consumption and high onsite energy production. The main design features are the following:

The roof slope is set to be 37° and directed due south to optimize photovoltaic (PV) production while reducing snow accumulation. To minimize thermal losses in winter, all façades, besides the south, employ triple-glazed, low-e, argon-filled, wood-framed windows. The south façade has double-glazed, low-e, argon-filled windows to increase passive solar gains. The sizes of the windows were selected to have sufficient views to the exterior, but not to have excessive heat gains or losses, and to prevent glare. The window-to-wall ratios along south, north, east, west directions are 30%, 10%, 20% and 30% respectively. The lighting power density is set to 7.64 W/m^2 combined with task lighting and dimmable light. The PV panels with a total 110.5 kW generation capacity are installed on the roof covers 711 m^2 of the roof area with 425 PV panels. 60% of the PV area, or 428 m^2, is vented naturally through a gap of 150 mm between the PV panels and the roof to prevent overheating and maximize generation efficiency. The remaining 40% are vented with a fan through an air gap of 70 mm. 24.3% (173 m^2, 66 panels) of total BIPV area actively recovers heat through the outdoor air which intake is controlled by variable-speed fans. The performance of BIPV/T on a typical cold winter day is shown in Figure 2. Currently, the heat is recovered during the heating period only and is vented out at the roof top on cooling days.

The building's heating and cooling are supplied from four ground-source heat-pumps (GSHP) connected to eight 400 ft (152 m) deep boreholes with a capacity of 105 kW. A radiant slab for both heating and cooling is found on the southern perimeter of the building, alongside fan coils. The ground floor of the building has five zones and a heated slab space of 240.61 m^2 (23% of the total area of the 1st floor). The heating/cooling on the ground floor is provided

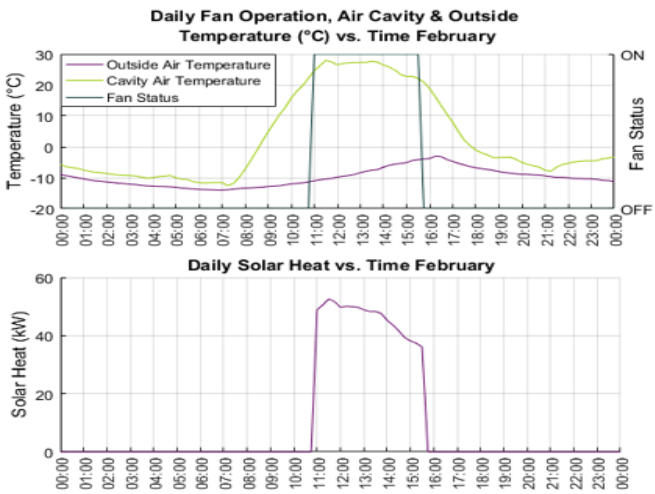

Figure 2: BIPV/T output and operation during typical cold day, February 8, 2018

by both hydronic radiant slab and fan coil in proportions of 63% and 37% respectively. On the second floor, there are six zones each with a heated area of approximately 435.62 m2 (or 41.5% of the total area of the 2nd floor). Space conditioning on this floor is fully provided by a radiant slab. The heating/cooling supply by the radiant slabs is controlled by zone air thermostats. Zones served by radiant slab are highlighted in Figure 3 below. Underfloor air distribution (UFAD) systems are used for the ventilation of the building's upper floor and overhead diffusers for the first floor. The more detailed features of the Varennes Library can be found in [1].

Figure 3: Varennes library plan. Highlighted areas show zones supplemented by hydronic radiant slab circuit [3]

The load duration curves for the first two years of the library's opening are shown in Figure 4. Considering the production of renewables, the net EUI (energy use intensity) of the Varennes Library is at 4.60 kBtu/ft^2 yr (14.5 kWh/m^{2}yr). As a comparison, the average major fuel consumption for commercial and institutional buildings in Canada is 105 kBtu/ft2y (330 kWh/m2) of energy [2].

The EUI breakdown of the Varennes Library is shown in Table 1 below. During the period considered in the table, no

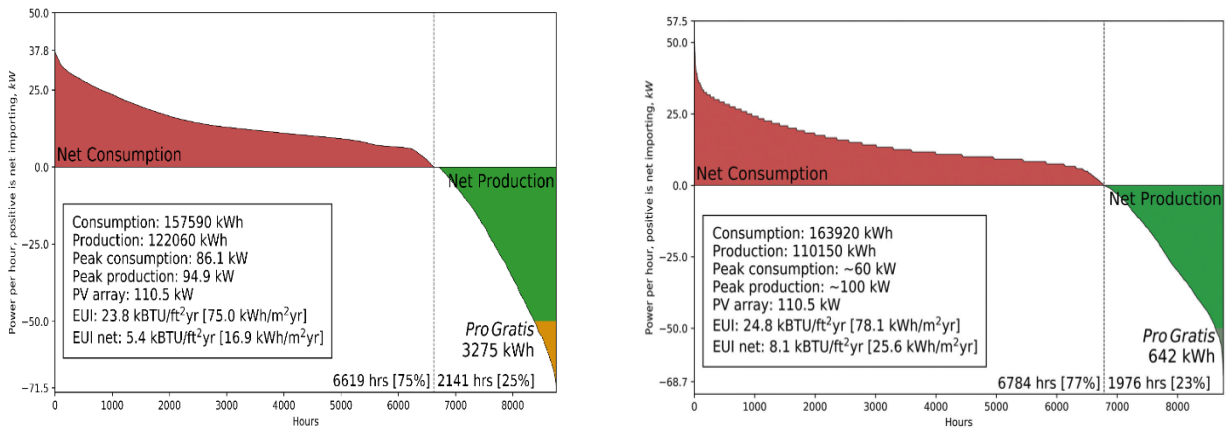

Figure 4: Electrical load duration curve. Data from May 31, 2017 to June 1 2018 (left); Data from May 31, 2016 to June 1 2017. The difference is because some inverters were not working in first year of library's operation and fixed schedule light instead of dimmable

dimmable light was used, so one can expect the lighting portion to decrease further if dimmable light is used. Pumps and fans for the circulating pumps in the radiant slab, fans in fan-coil units and BIPV/T systems take up a substantial portion.

Table 1: EUI breakdown of the total electricity consumption [1]

Category	Energy, kWh (% of total)
Consumption	163,920 (100%)
Lights	40,980 (25%)
Heating/Cooling	47,540 (29%)
Pumps	32,780 (20%)
Fans	32,780 (20%)
Other	9840 (6%)
Production	110,150 (67%)
Difference	53,770 (33%)

Data from June 1, 2016 to May 31, 2017: First year after inauguration.

Table 2: EUI breakdown of the total electricity consumption [1]

References

1. Dermardiros V., Athienitis A.K. and Bucking S. (2019). "Energy Performance, Comfort and Lessons Learned from an institutional building designed for Net-Zero Energy". ASHRAE Transactions Vol. 125 (1).
2. NRCan. 2014. Survey of Commercial and Institutional Energy Use (SCIEU)—Buildings 2014—Data Tables. Ottawa: Natural Resources Canada.
3. Dermardiros V. 2020, 'Data-Driven Optimized Operation of Buildings with Intermittent Renewablesand Application to a Net-Zero Energy Library', PhD thesis, Concordia University, Montreal.