A GRID-CONNECTED ENERGY EFFICIENT BUILDING POWERED BY RENEWABLES

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The LTE (Hydro-Québec's energy technologies laboratory) building is an all-electric building with a power demand of more than 1 MW. By integrating new energy storage and power generation technologies, the LTE is being converted into a full-scale test bench to develop the building of the future, i.e., a smart, green building that contributes to grid optimization. One of the project's important goals is to improve demand-side management and therefore limit peak periods, which occur primarily in winter. It is thus important to be able to reduce peak demand for the grid by leveraging the building's load flexibility. Load flexibility in a building's net electricity demand is an essential part of the solution for future electrical grids and improved customer experience and comfort.

Today's environmental context and the drive to decarbonize the Québec economy provide Hydro-Québec with an opportunity to sell more clean energy. However, decarbonization can also present a challenge: replacing fossil fuels with electricity can lead to increased pressure on the existing electricity generation and distribution infrastructure, especially during the winter peak. Upgrading this infrastructure will require investments that, if not addressed, will in turn impact electricity rates.

To support Hydro-Québec's performance in the energy transition, Hydro-Québec's energy technology laboratory (LTE) is carrying out research and development to design the building of the future: a zero-emission (or low-emission) building that is both energy efficient and comfortable for users while interacting with the power grid to improve its resilience and performance. This is the idea behind the Grid-Interactive Efficient Building (GIEB), a building that is more than just a passive energy load needing to be powered. A GIEB usually combines four technological features:

- Energy storage
- Autonomous power generation
- Renewable energy
- Smart controls to coordinate the building's technologies as well as the building's interaction with the power grid

The ultimate goal is to increase the building's load flexibility so that the customer has better control of their energy consumption while also providing energy services to the grid. It's a win-win situation between the client and the utility. A GIEB will provide the following benefits, among others, to the customer and the grid:

- Lower the customer's energy costs by reducing his billable peak demand
- Maintain customer comfort in any situation, even in case of peak shaving
- Provide an emergency power supply to the customer in case of a power failure
- Reduce the grid peak demand
- Support the grid after a power failure
- Regulate power grid demand increases and decreases

Located in Shawinigan, Hydro-Québec's LTE building is a research facility whose activities are focused on energy efficiency to benefit customers and the power grid.

As part of this research project, the LTE building will be significantly transformed to convert it into a full-scale GIEB test bench. It will serve two purposes: 1) test, develop and demonstrate innovative and promising technologies that will support the energy transition; and 2) develop and demonstrate the GIEB's overall concept through the development of smart controls that bring together the building's technologies to meet the customer's and network's needs .

Four technologies will be added to the LTE's building operations:

1. HEATERS WITH THERMAL STORAGE CAPABILITIES

Two central electrical heaters with thermal storage capabilities will be installed at LTE to preheat almost all of the LTE's fresh air intake. These two heaters are capable of storing approximately 1,000 kWh of thermal energy. These heaters will generate thermal energy during off-peak hours, when the energy cost is low, and then use the stored energy during peak periods to reduce the demand. In addition to these two central units, 13 decentralized electrical heating units with thermal storage capacity will heat the building's peripheral area. The additional combined storage potential of these units is 200 kWh.

ThermElect Hydronic heaters with thermal storage capabilities were developed by LTE 15 years ago. The devices store sensible heat at 850°C in a high-density medium. Two of them will be installed at LTE to preheat fresh air intake.

2. COMPRESSED AIR GENERATING SET

A 150-kVA zero-emission generating set using compressed air as "fuel" will be installed in the LTE to supply power to the building. Air will be compressed and stored during off-peak hours (approximately 800 kWheq of mechanical energy stored as compressed air), while the generating set will supply electricity on demand to the building to reduce the net dependence of the building from the grid. This is a second-generation prototype of the compressed air energy storage that will be installed at LTE. LTE is currently working on the development of a zero-emission generator capable of replacing diesel-powered generating sets.

3. CURTAIN WALL MADE OF HYBRID SOLAR PANELS

On the LTE's southwest facade, approximately 32 m2 of hybrid solar panels will be installed. These panels will simultaneously generate electricity and hot water. This innovative panel potentially offers four times the performance of traditional photovoltaic panels. The electricity generated will be transferred to the building, and the hot water will be used inside the building.

4. CENTRALIZED CONTROLS USING ARTIFICIAL INTELLIGENCE

The previously mentioned systems will operate in an optimal, integrated manner through centralized artificial intelligence controls. The controls will continuously be fed data from various measuring devices installed throughout the LTE to meet real-time and forecasted needs.

The LTE's total energy flexibility gain is estimated at approximately 250 kW, a significant improvement representing 25% of the building's maximum electrical demand.

Converting the LTE building into a GIEB is a significant project that will take about three years. Commissioning for the thermal energy storage is planned for 2020, while the generating set and solar panels are planned for autumn 2021. The installation of centralized logic controls to connect the building's systems is set for 2022.

Conclusion

A Living Lab for the optimization and continuous optimization of DER (decentralized energy resources) will naturally be a vivid and evolutive laboratory, a physical and virtual platform for exchange in the LTE's environment, in which users actively participate in the development of innovative products and services (co-creation). The LTE's lab aims to bring together public institutions, companies, the academy and users in order to imagine and co-develop new viable energy solutions. Encouraging bottom-up dialogue and turning ideas into sustainable business products or services and empowered users.