"Getting to Net-Zero: Feedback from Power Monitoring in our own Passive Studio"

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1 Introduction

River Architects has completed the retrofit of our Passive Studio- a small, commercial building that once was a horse-shoeing shop, and now is a workspace for 5 architects and support staff. Recently certified under PHIUS + 2015, we have been in the space and working for a year, and we have learned a few things about our new environment. We will share performance feedback from energy use monitoring to compare modeled energy use and assumptions with field data. We will review the systems installed, including automated solar shading and indoor/outdoor climate sensors. And we will review the design and construction process briefly, sharing tips and results- like our remarkable air-tightness in a retrofit: .0167CFM50/sf surface area, or .20 ACH- the equivalent of 2 square inches.

The Studio has been essential as both a learning lab and a marketing tool. Building our own passive building and installing its systems has been vital in translating abstract concepts into reality for ourselves and our staff. And the learning hasn't stopped once we moved in and got on with our careers. Being in this space more than in our own house gives us an intimate knowledge of what we created. But sometimes you need numbers too.

Commercial passive buildings can have unique challenges. In our case, peak heating and cooling loads out of sync with workday occupancies and multiple computers. But thankfully there are some great opportunities- like increased loads during peak solar power generation. Our solar installers provided power use monitoring via e-Gauge, which tracks the power usage, and what our photovoltaics are giving back. We can dig through the graphs and evaluate what equipment needs to be reprogrammed, evaluate practices such as leaving computers on overnight, and to adjust our own behavior to optimize energy performance. As the saying goes, knowledge is power.

If the design team needs to see graphically that the HRV is incorrectly set to run on maximum while the office is vacant, for instance, how would homeowners know? And resting on the laurels of being in a super-efficient, solar-studded habitat can make you lazy: running hot water doesn't seem too sinful and can feel like a much-earned splurge, until you see the red spike on the graph shoot up like a dagger. Energy use monitoring is both a systems optimization tool and a behavior modification feedback loop. It keeps you aware of how impactful your decisions and habits are in staying true to your mission.
2 Methods

Passive House Retrofit:
The siding and interior finishes were removed to expose the timber frame structure, which was braced and moved off the foundation by a building moving company. The cobblestone foundation, which was originally intended to be reused, was found to be structurally unsound and removed. A new, double-wythe block foundation that supports an 8” deep stone facing comprised of the original cobbles was installed, including new windows into the basement space that was previously unglazed. A 4” thick structural thermal insulation was installed at the top of the foundation, onto which the timber frame was reset. Basement insulation and air/vapor barrier was installed under the concrete slab and up the interior face of the block foundation.

New plywood was installed on the timber frame and wrapped in a peel-and-stick air barrier, and I-joists and WRB were installed, and dense packed with cellulose. The existing plywood that was installed on the roof over cedar lath boards was left in place, and airsealed with the same peel-and-stick air barrier, and I-joists were overlaid and screwed into the existing rafters to make a composite roof structure, which was similarly dense packed with cellulose insulation. The walls and roof were finished with a rainscreen siding and standing seam roof, which eventually received solar panels. The timber frame and pre-painted plywood were left exposed as interior finishes.

Systems:
The building has a heat recovery ventilator with a brine preconditioning loop that is situated under the slab insulation, providing selective ground contact to pre-temper the incoming airstream. Heating and cooling is provided by a single head mini-split heat pump. Instant hot water heater for handwashing and kitchen use only, no bathing facilities are on premises. An Energy Star dishwasher is installed, and uses cold water supply.

A grid-tied, 7.2 kW photo-voltaic solar array with Solar Edge inverter, and e-Gauge solar performance monitoring with 12 datapoints collected on circuits/equipment. TapHome automated controls for motorized exterior shades, biometric access, and motorized window for nighttime flushing, connected to Somfy roof-mounted weather station.

3 Results

As a retrofit the building’s orientation is preestablished at approximately 40° from due south, making solar optimization difficult. Both historic district and zoning board requirements also precluded reorientation or substantial adjustments to the orientation. This required the use of exterior shades in controlling for heat gain. Automating these of course helps ease managing the performance, but the
programing of the shades is not complete yet, so we are currently operating them manually. When we are not using the shades properly we get very interesting results.

The e-Gauge Solar Monitoring compares realtime electricity generation to consumption, tracking energy consumption by major pieces of equipment and plugloads. We can see graphically when we are generating electricity (the sun is up) and correlating cooling loads as the heat pump kicks in (the shades are up). Starting the day in a comfort deficit is slow to recover from, consuming more energy and creating greater discomfort. But when the shades are down the cooling loads stay low as one would expect and can see graphically- and the expected comfort is maintained throughout the day.

The data set can also reveal improper programing of equipment. This is how we discovered that the HRV was improperly programeed, stepping up ventilation rates when the building is unoccupied, and minimizing ventilation rates when the building is fully occupied during the day. Obviously, knowing we need to reprogram the HRV to match occupancy has its own merits. But the data also shows electricity waste. The energy difference is small, but not insignificant when we are trying to minimize our consumption when we are not producing energy.

The energy spikes from the on-demand hot water heater made very clear that this was convenience not worth having. The luxury of warm water for lavatory use could not be justified by the data, and the hot water heater was switched off.

Washing dishes with a high-efficiency dishwasher is extremely efficient in both water savings and related energy use for water heating. For that reason, and for general office productivity, we encourage the use of the dishwasher. The resultant energy spikes were considerable but limited to only one or two days a week. The timing of using the dishwasher becomes important though so that its draw is easily met during peak energy production.

4 Discussion

The feedback provided by the solar monitoring software is vital in understanding how our building performs, what equipment is not programed or running properly, and in adjusting occupant behavior to reduce waste. Optimizing the efficiency of our building, its systems, and occupant behavior gives us the tools to minimize grid power consumption so that our net-zero goals are met or exceeded. Ultimately, energy management through monitoring, smart systems, and automation will make the transition to off-grid with minimized battery storage possible.

5 References

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6 Images

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