AI Enhancement to Building Automation System Case Study

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Building Name/Address	1190 Hornby St. Vancouver, British Columbia
Building Asset Class	Office
Building Size	104,494 sq. ft. – 12 stories of office with ground level retail
Year Built	1985
Building Owner & Manager	Concert Properties
Engineering Consultant	FRESCo Building Efficiency

PROJECT INTRODUCTION

1190 Hornby is located in downtown Vancouver. Built in 1985 of reinforced concrete, it is a 12-storey commercial building comprising office space, a retail component on the ground level and two levels of underground parking.

1190 Hornby is also Concert Properties' Vancouver Head Office. Concert incorporated Ecopilot's AI solution as an application to its HVAC system to not only support their greenhouse gas emission (GHG) reduction objectives, but also with an aim to improve occupant comfort and reduce the building's operating costs.

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BACKGROUND

The Challenge

A common challenge with traditional HVAC systems is they are reactive and often statically scheduled; whereas buildings require a dynamic solution to be able to proactively respond to changing weather, heating and cooling loads, occupancy fluctuations, and utility rates.

Additionally, systems recommissioning for many buildings is provided on a seasonal basis without continuous optimization which doesn't account for daily fluctuations or weather events that are uncharacteristic of the season.

The Solution

AI enhancement resolves these issues, acting as a "brain" for the building management system (BMS), as follows:

- Rather than simply focusing on seasonal temperature set points, AI software captures and leverages the free energy created by users, equipment and changing weather patterns.
- The software applies an acceptable indoor temperature range (eg. 21-24°C) instead of a fixed temperature (eg. 22°C), then automatically and continuously adjusts the set points of the BMS 24/7.

AI controls enhancement essentially offers continuous commissioning, as well as periodic recommissioning, for Building Automation Systems. These enhancements result in improved building comfort for occupants alongside significant reductions in energy consumption.

Any commercial building with the following characteristics is a good candidate for AI building control applications:

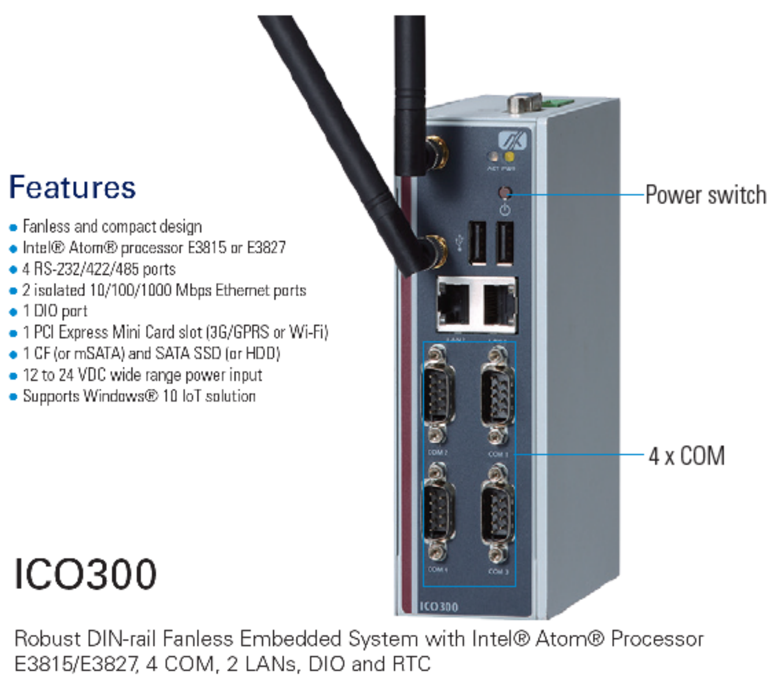
- Concrete construction (thermal mass)
- Reasonably good building envelope (minimal leakage)
- Existing Building Automation System
- Centralized HVAC system

HOW ECOPILOT AI TECHNOLOGY WORKS

Thermal mass is one property of the interior construction of a building which enables it to store heat, providing "inertia" against temperature fluctuations. Ecopilot technology harnesses the thermal mass of a building by understanding periods when heat loss and heat gain are balanced. This balance point temperature is communicated to the Building Automation System (BAS) helping it to introduce heating and cooling only when necessary.

In addition to the physical properties of a building, which remain static, Ecopilot's AI collects real-time data to assess variables such as weather, occupant density, equipment loads, as well as heat received from solar radiation. The algorithm uses these factors to automatically and continuously optimize the building's energy performance. Every 2 minutes the algorithm calculates a new balance point temperature to offset the original BAS setpoint, resulting in HVAC savings without sacrificing occupant comfort. This means that indoor space temperatures will be kept within a comfortable range, (eg. 21-24°C) instead of a fixed temperature (eg. 22°C), while energy consumption will be significantly reduced.

Ecopilot utilizes BACNet/IP and Modbus to communicate with the BAS / DDC to 'write' control points for temperature setpoints. It then sends on and off commands to the building equipment. Some programming adjustments are required by the existing BAS controls contractor to apply the on/off command and setpoint offsets in a way that best complements BAS and the building systems, without disrupting any functional/safety requirements of the equipment.



Ecopilot hardware box, installed onsite

Ecopilot doesn't over-complicate the building's existing controls dashboard, but instead adds just one screen to the existing BAS software that allows building operators to enable or disable Ecopilot and view what its commands are compared to those of the BAS. Ecopilot's application program interface (API) is also available remotely, providing even more detail on its operations, including visualized energy savings.

PROJECT SUMMARY

Existing Building Systems

1190 Hornby's existing building systems are as follows:

- Heating Plant – Consists of two gas-fired boilers and a set of pumps that circulate hot water to various heating coils throughout the building.
- Chilled Water Plant – Consists of a chiller and cooling tower, with a heat exchanger that provides free cooling when conditions permit. The plant delivers chilled water to the air handling units throughout the building.
- Air Handlers - Consist of VFD controlled supply and return fans that deliver tempered air to VAV and Fan-Powered terminals on each floor throughout the building. Each AHU has a cooling coil, heating coil, and fresh/mixed air damper section that modulate in sequence to maintain supply air temperatures.

- Building Controls – Consists of a Reliable Controls BACnet IP DDC System. It controls all central plant systems/AHUs that Ecopilot is reading from/writing to, as well as multiple Fan Powered Boxes and VAV boxes that control temperatures on a zone level.

Implementation

The investigation of Ecopilot as a fit for 1190 Hornby began in January 2020, then installation began in September 2020. A full 15 months of AI learning was undertaken at the building, with Ecopilot being considered fully optimized by December 2021. The building's heating and ventilation systems were subsequently commissioned in February 2022, and the chilled water system was commissioned in June 2022 upon seasonal startup.

Full building commissioning is required before Ecopilot is installed. By installing Ecopilot software, the building's HVAC control is essentially recommissioning how the building is being controlled every 2 minutes, by consistently re-analyzing how the building is being controlled, as new information collected and recalculated using Ecopilot algorithms. This recalculation is done by determining the building's dynamic "balance point temperature", replacing a traditional, and static, outside air reset. This is because heating and cooling equipment should be activated at different outside air temperatures given fluctuating building needs due to occupancy scheduling and weather changes. With an Ecopilot install, the commissioning process consists of two major steps:

- Verifying that the integrated points are reading and writing between Ecopilot and the BAS.
- Running the system through the programming adjustments done by the BAS contractor as part of the installs (for example, have Ecopilot turn "On" the heating plant and ensure it properly follows Ecopilot's setpoint offsets).

Total investment in the project was $50,000. The project was co-managed by Concert Properties with Ecopilot.

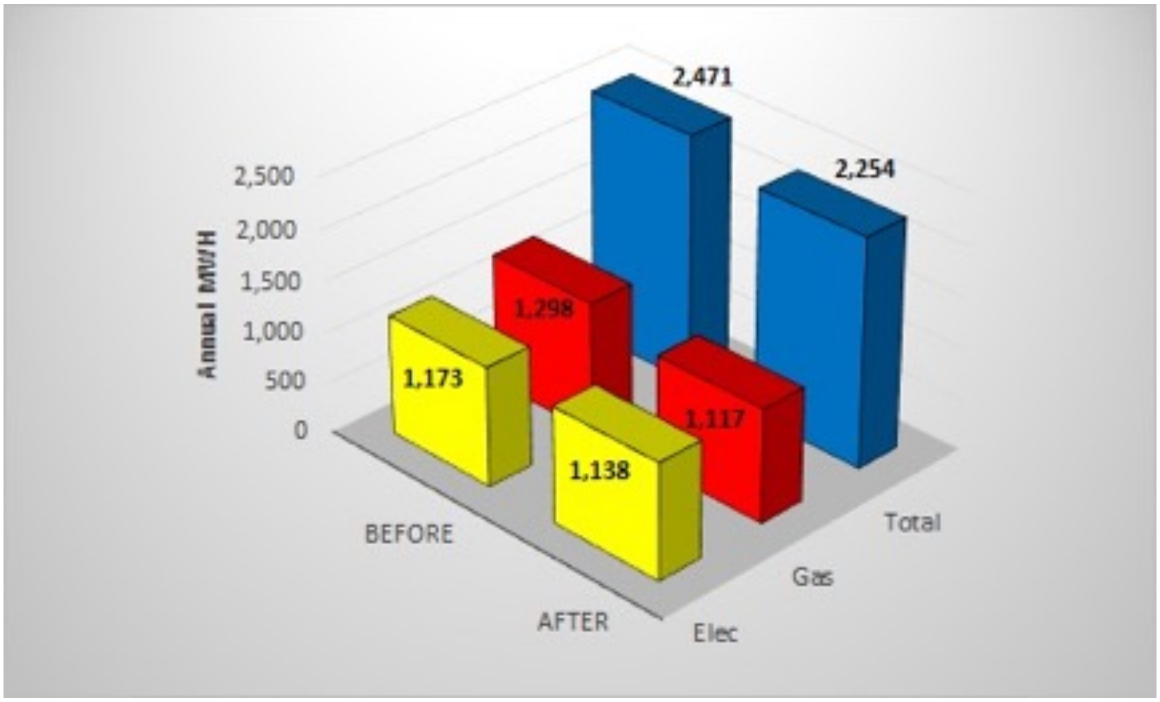
Results

Measurement & Verification of energy and GHG emissions savings was performed by Ecopilot as a part of project implementation support service by using the CUSUM method with RETscreen software. CUSUM (Cumulative SUM of Differences) is a powerful analysis of the variance between energy consumption predicted by an energy performance model and the actual measured consumption.

The post-project energy usage was compared to the average of the pre-project baseline energy usage, normalized to weather. Annual energy savings is the difference between the two values, which indicates that the benefits from the Ecopilot project are significant.

The associated first-year benefits with this upgrade are impressive:

Energy savings and environmental review				
Annual energy consumption prior to Ecopilot install		Savings after Ecopilot commissioning		
Gas Consumption	Electricity Consumption	Gas GJ (%)	Electricity kWh (%)	GHG tCO_2e/year
4,670 GJ	1,173,000 kWh	654 (14%)	35,200 (3%)	34
Economical review				
Total investment	$50,000			
Utility consumption savings	$13,300			
ROI	26%			
Simple payback	4 yrs			



Note: The reported savings reflect a full year of consumption between the periods of February 22nd, 2022 – March 1st, 2023. Taken from completed Ecopilot year one analysis and M&V data.

CHALLENGES AND LESSONS LEARNED

- Often maintenance issues are identified during the commissioning process, as the systems are being tested to ensure they follow the adapted sequence of operations. For example, a pump may not be starting or a valve may not opening/closing properly; these scenarios are typically something that's caught and corrected at that point in the process. The systems in 1190 Hornby were well maintained, so this didn't apply. Ecopilot often monitors PID loop programming that needs to be tuned and with automatically capturing historical data for all integrated BAS points, supply temperatures not following setpoints can be quickly caught as a result.

- The building maintenance team at 1190 has reported challenges with keeping certain spaces in the building cool enough for tenants in the summer months. While this issue existed before Ecopilot was implemented, during the first summer with Ecopilot in operation, the operations team again reported some spaces that were struggling to keep cool. With Ecopilot monitoring zone sensors and various parameters including wind and solar radiation, the cooling issues were isolated to smaller, more specific areas and adjusted through the chiller and AHUs sequencing to enhance and further optimize cooling.

- Ecopilot automatically arranged the setpoints between the chilled water system and air handling units to work together in a more efficient manner. It first tries to cool the space using supply air setpoints in the low part of the range (ex. 14°C) while starting the chilled water system in the high end of its range (ex. 13°C). As zone and outdoor temps begin to increase, both systems bring their setpoints lower, but in a manner that makes the best use of the chilled water by keeping the cooling valves as open as possible. Essentially, it's doing its best to avoid a scenario where the chiller is supplying 6°C water to the building while the AHUs are controlling a 19°C supply air setpoint, which might keep the cooling valve operating at 20% open. This would be much less efficient than how they're currently being controlled, where we can achieve the same level of comfort but keep the valves around 70-80% - this is a much better use of the electricity used to cool the building.

- During commissioning, Ecopilot adjusted the indoor CO_2 minimum setpoints from 400ppm to 600ppm, allowing the mixed air dampers to reduce the amount of fresh air being introduced to the air handling systems and thereby further reducing energy consumption. For reference, global average outdoor CO_2 levels are 421ppm; so the original setpoint of 400ppm, lower than that of the outdoors, could force the air handling systems to run at 100% outdoor air continuously and they would almost never meet this aggressive setpoint.

- Establishing a reliable baseline against which to measure savings was a challenge. As the initial assessment for consumption data was completed in 2020 where Covid-19 mandates changed typical building occupancy, the baseline data may not necessarily reflect a "normal" year. This should be reviewed with the Concert team and may be recommended to adjust the original baseline to a year that reflects more typical building operating conditions.

FUTURE OPPORTUNITIES

- Floors 2, 3, 11, 12 were identified as being the largest drivers for heating demand. Ecopilot suggests looking into insulation and air sealing upgrades, while acknowledging that the highest and lowest floors are often the biggest draw for heating.

- Reducing the minimum outdoor air damper set point from 20% to 15% will reduce the amount of fresh air, thereby increasing efficiency while maintaining the ability to reduce CO_2 ppm on-demand when required.

- Sequencing could be enhanced between the central air handlers and zone terminal equipment during the transitional period between unoccupied and occupied times.

- Ecopilot also identified opportunities to reduce passive heating and cooling loads during times without occupancy at night.