RETROFIT STRATEGIES FOR FUTURE WARMER CLIMATES

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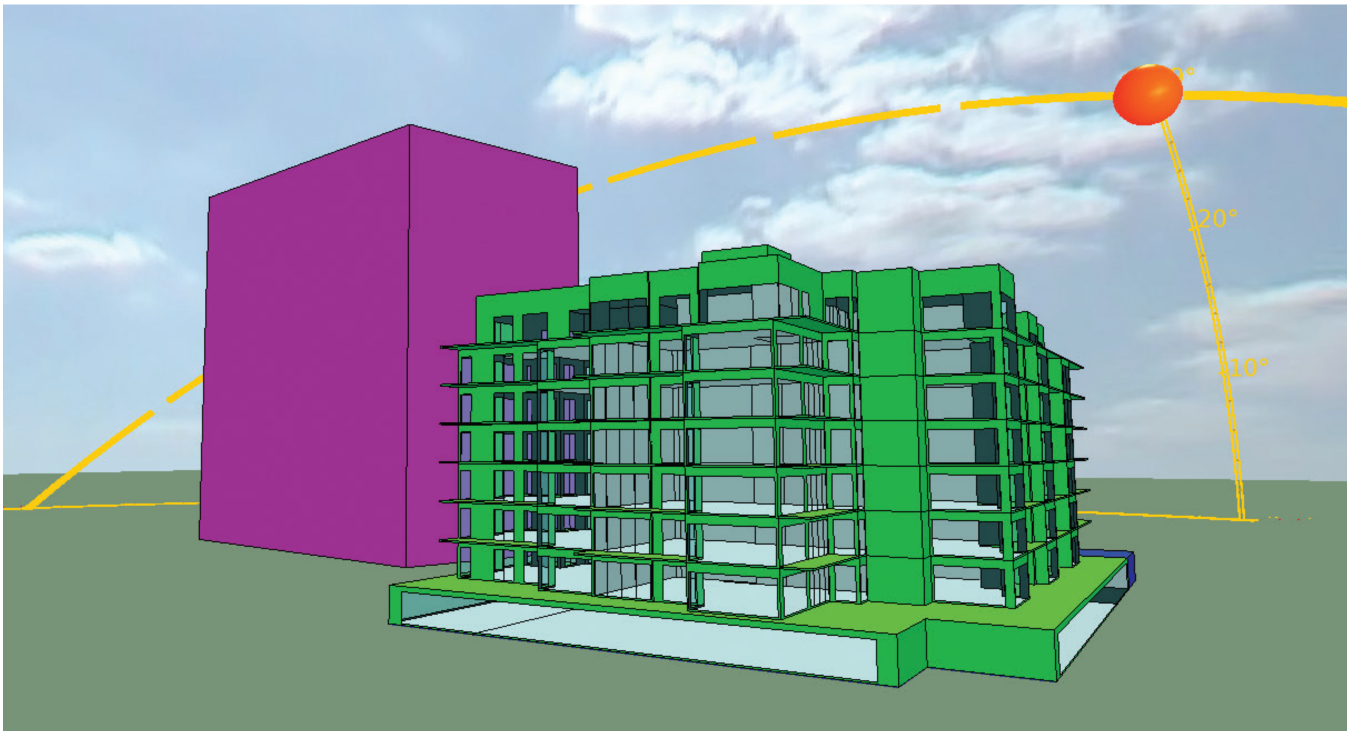

ABOVE

Figure 1. A 3D rendering of building geometry developed in IES VE 2021. All images courtesy of RJC Engineers.

Climate change. What was once a word we used in passing and to which most gave little heed, is now one of the greatest challenges we, as humans, have ever faced. It now seems that every year we are faced with some catastrophic weather event – floods, droughts, storms, heat waves, wildfires – that are labelled one in a 100-year phenomenon. Climate change is a stark reality we experience daily and research shows that the rapid change is mainly due to anthropogenic greenhouse gas (GHG) emissions, which have increased significantly since the pre-industrial era, and more recently break historical records.

When it comes to the buildings we work and live in, the impacts of climate change are apparent. Buildings designed or retrofitted today will see dramatically different climates in the future. Canada is committed to reducing its GHG emissions by 30 per cent below the 2005 level of 732 Mt CO^2 eq. by 2030. To put this into effect, stringent contemporary energy standards have been adopted for new building projects (for example, the *BC Energy Step Code*, the *Toronto Green Standard Version* 3, and *OBC SB-10*).

For existing buildings, efforts are also underway to develop a code that will help guide energy efficiency. After conducting a literature review, it becomes apparent that for existing buildings in British Columbia, there is a definite lack of understanding on the effects of future warmer weather data on energy retrofits and resilient energy conservation measures (ECMs). In our current practice, we are retrofitting buildings for the past, not for the future.

Considering the future

The main objective of a study we performed last year was to demonstrate that the changing climate must be

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Table 1: A Description of Building Systems for the Existing and Proposed Buildings

Category	Existing Building	Proposed Energy Conservation Measures (ECM)	ECM Category
Exterior Walls	152.4 mm (6 in.) steel framed walls with cavity batt insulation.	Install additional 101.6 mm (4 in.) rigid insulation applied to exterior.	Weather Sensitive
Roofs	76.2 mm (3 in.) rigid insulation.	Replace existing insulation with 101.6 mm (4 in.) polyisocyanurate.	Weather Sensitive
Windows	Double glazed, thermal broken aluminum windows USI 2.64 W/m^2.K (0.47 Btu/h.ft^2.F); SHGC 0.50.	Replace existing windows with triple glazed, thermal broken aluminum windows USI 1.8 W/m^2.K (0.32 Btu/h.ft^2.F); SHGC 0.31.	Weather Sensitive
		Install exterior shades.	Weather Sensitive
		Install exterior shutters that activate in summer months.	Weather Sensitive
Ventilation Systems	Corridor make up air unit supplying ventilation to common areas and suites.	N/A	N/A
Heating Systems	Electric baseboards for common areas and suites.	Install air source heat pumps in suites (COP 4.0) with variable speed fan coils.	Weather Sensitive
Cooling Systems	Cooling limited to mechanical penthouse (COP 2.5).	Add cooling to suites by installing air source heat pumps (COP 4.1) with variable speed fan coils.	Weather Sensitive
Service Hot Water	Electric heater.	Install low flow fixtures.	Weather Neutral
Air Leakage Rate	Air leakage rate of 0.37 L/s/m^2 (0.073 cfm/ft^2) @ normal operation pressure.	Air leakage rate of 0.20 L/s/m^2 (0.039 cfm/ft^2) @ normal operation pressure.	Weather Sensitive
Process Loads	Elevator load at 3kW/unit.	Elevator load reduced by 30 per cent using regenerative motors.	Weather Neutral

Table 2: Unmet Cooling Hours for Setpoint of 24^{o}C (75.2^{o}F)

Scenario	Unmet Cooling Hours
Baseline Building – year 2019	166
Baseline Building – year 2080-2099	1,020

considered in retrofit strategies. Simulations using the building performance software IES Virtual Environment were conducted.

Weather files for the typical meteorological year (TMY) were considered for the current weather scenario, while future weather files were obtained from the Intergovernmental Panel on Climate Change (IPCC). These future weather files vary based on time and emission scenario (RCP). Emission scenarios range from RCP 1.9 to RCP 8.5, where the lower value represents a situation where greenhouse gas emissions have met the goals of the Paris Agreement, while RCP 8.5 represents a 'business as usual' case in which not a lot is done to curb GHG emissions. For this study, RCP 8.5 was used to determine the energy use of the building between years 2080 to 2099.

The study was performed on an existing an eight storey multi-unit residential building with a gross floor area of 9,930 m^2 (Figure 1, on page 33). The building, located in Victoria, British Columbia, includes two parkade floors, one situated below grade; floors two to eight are house apartment units; and there is a mechanical penthouse on the roof.

An airtightness test was performed as per standard ASTM E779. To minimize inconvenience to residents, only floor four was tested. Additional on-site measurements were also taken for the interior and exterior lighting, process equipment – including motors and elevators – and air flow rates for the make-up air unit using powered flow hoods and air temperature thermometers.

Table 1 (above) represents the main building enclosure and mechanical systems of the existing building and proposed retrofit energy conservation measure (ECMs), which have been categorized into two categories: 1) weather sensitive; and 2) weather neutral.

Monthly utility data from the past three years was used to normalize the annual energy consumption. The data collection relied heavily on resident participation and therefore, in cases where data was not available, data from similar units on adjacent floors was used to fill gaps. The model was calibrated to the year 2019 to avoid any biases in building operation resulting from the subsequent COVID 19 pandemic. The energy model was then developed and calibrated using all the collected data in accordance with the principles of ASHRAE Guideline 14-2014. The effects of natural ventilation through operable windows, shading from adjacent buildings, and impacts of Low-E coated windows were all considered in the model.

Figure 2 (on page 35) shows the annual end use breakdown of the baseline building energy models for the year 2019 and projections for 2080 to 2099, based on RCP 8.5. A shift in demand for the building energy, particularly in the space heating category, was noted. Heating consumption in the year 2019 accounted for 46 per cent of the annual energy consumption. Through simulation, it is estimated that this percentage will decrease to 36 per cent in future weather conditions – RCP 8.5.

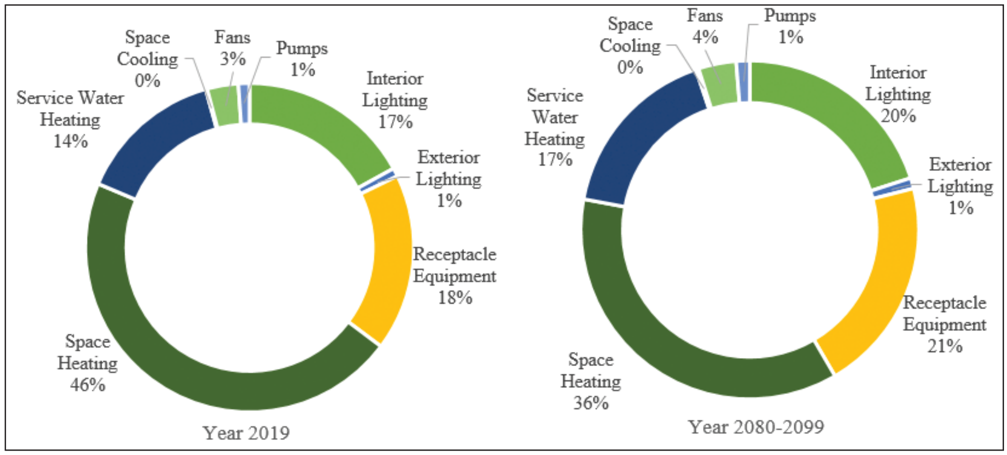
One important end use category not captured in both graphs (Year 2019 and Year 2080 to 2090), is the space cooling demand as the existing building was not fitted with any cooling systems, instead relying on natural ventilation. Active cooling retrofit strategies will be an important consideration for the future to increase resiliency and meet cooling demands, as seen in Table 2 (on page 34).

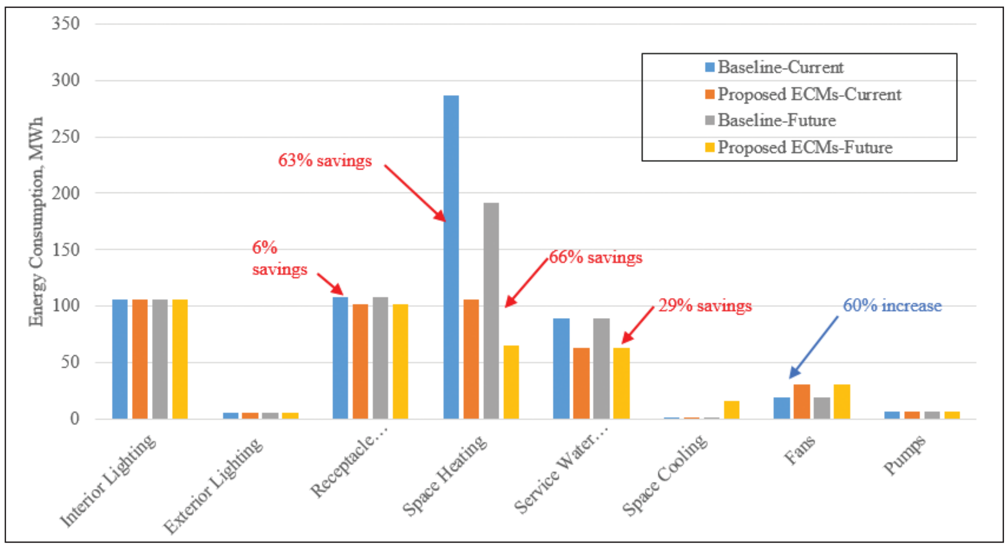
The impacts of implementing ECMs on the current baseline and projected future baseline are visualized in Figure 3 (to the right). It was observed that the ECMs impacting space heating, which include improved envelope performance, installation of triple pane windows, heating via heat pumps, and installing external shading devices, reduce the space heating energy by a whopping 63 per cent in the current weather scenario.

The same ECMs, if applied in the future morphed weather data (RCP 8.5) conditions, yield a reduction of 66 per cent. Therefore, retrofitting the same ECM strategies would have a similar impact on the overall heating energy consumption in both present day and future conditions.

Space cooling loads increase significantly in the future, as shown in Table 2 (on page 34). Figure 3 (to the right) indicates a significant increase in active cooling energy between the current day ECM scenario and the future ECM scenario. This highlights the importance of retrofitting with resiliency in mind as buildings change from being heating dominated to requiring considerable cooling. Fan energy is also seen to increase between the baseline and proposed ECM scenarios due to the installation of a fan coil/heat pump system in the proposed ECM. The system will operate as the primary source of heating and cooling and will address unmet cooling hours in the summer. Weather neutral ECMs, such as regenerative elevator motors and low flow fixtures, achieve identical savings in both current and future weather scenarios.

Overall, for all measures, there is a reduction in effectiveness for future conditions with the proposed future weather scenario saving a total of 34 per cent energy compared to the future weather baseline, while the proposed current weather scenario saves 48 per cent energy compared to the current weather baseline. This reduction is attributed to lower space heating demand intensity, and higher cooling load for future warmer climate.





We must keep in mind that this is one study done in isolation and similar investigations should be conducted to gain a better understanding of the effectiveness of current strategies for future climates. However, this study does show that we can still unlock significant savings, now and in the future, by committing to envelope and HVAC upgrades. What we lose in heating savings, due to the warming climate, we gain in cooling savings. Finally, these ECMs increase low carbon resiliency by mitigating GHG emissions while simultaneously helping buildings adapt to the future climate.

Hassan Bokhary, E.I.T., CEM, CPHD, LEED®Green Associate, is a designer on RJC Engineer's Building Performance team. He specializes in building energy simulations and analyzing energy conservation measures (ECMs) for high performance buildings in major sectors to achieve performance based on various green certifications including LEED®, Green Globes, TGS, Step Code and code-based compliance. His simulation work has been primarily delivered using eQUEST, EE4, IES, and RETScreen Expert, but he also has experience using Trace 700, HAP and other building energy modelling software. Hassan's broader consulting expertise extends to existing building energy and water audits, financial life cycle assessments, building energy benchmarking, and energy performance incentive based applications.

TOP

Figure 2. The annual end use breakdown for Year 2019 and Year 2080 to 2099.

BOTTOM

Figure 3. The annual energy consumption for different end uses for existing and proposed buildings using current and future weather data.