



### INTRODUCTION

The aim of this research was to investigate the reduction of carbon dioxide (CO<sub>2</sub>) emissions that is achievable through changes in a building's control schedule and component retrofiting. In the United States, the building sector is responsible for approximately 41% of the nation's total power consumption. Of this amount, approximately 70% is used for heating, cooling, and lighting purposes, and 75% is supplied by the combustion of fossil fuels<sup>[1]</sup>. Therefore, strategies that reduce demand can be directly associated with fewer CO<sub>2</sub> emissions due to a reduced dependence on the electric grid and on-site fuel consumption.

### RESULTS/DISCUSSION

Results from each set of simulations are shown below. All figures use the following nomenclature: **V** – Ventilation, **C** – Cooling, **NGH** – Natural gas heating, **EH** – Electric heating, **L** – Interior lighting, **SE** – Site emissions, **GE** – Grid emissions.

### METHODS

For this research, a medium sized office building was simulated using the Department of Energy's EnergyPlus software and a TMY3 weather data file for the ASHRAE climate zone corresponding to Salt Lake City, UT<sup>[2]</sup>. The building was selected from the DOE's commercial reference building stock constructed before 1980<sup>[3]</sup>. The simulations focused on the following strategies:

- Automatic window shades and window construction
- Lighting intensity reductions
- Temperature setpoint adjustments

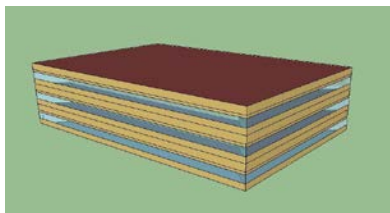


Figure 2: U.S. EnergyPlus medium sized office model

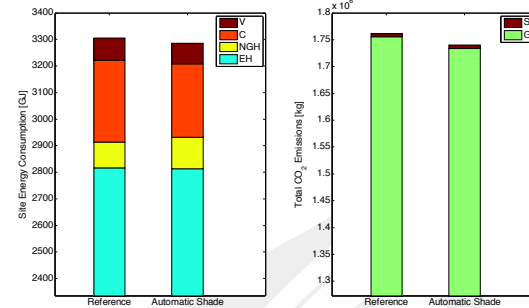


Figure 3: Energy and CO<sub>2</sub> reductions with an automatic window shade system

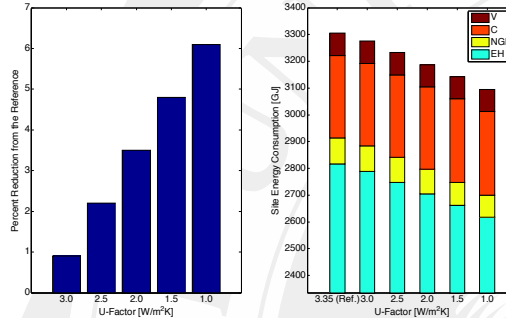


Figure 4: CO<sub>2</sub> and energy reductions associated with window construction

Each of the three strategies presented has the ability to reduce CO<sub>2</sub> emissions produced by the building sector. A reduction in the lighting intensity provided the greatest reduction, while the implementation of an automatic window shade was the least beneficial. The feasibility of the lighting intensity range and window construction U-factors were validated with values found in ASHRAE's Fundamentals Handbook and the 50% Advanced Energy Design Guides (AEDG) for small to medium sized office buildings<sup>[4]</sup>. The temperature setpoints are more subjective and may fall outside ASHRAE's comfort guidelines<sup>[1]</sup>. However, humans possess a remarkable ability to adapt to their surroundings. It is suggested that building inhabitants dress warmly during the winter and increase ventilation during the summer<sup>[5]</sup>.

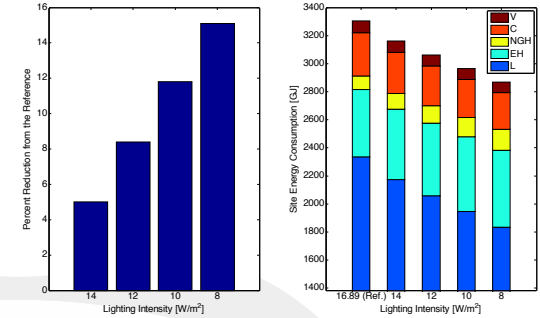


Figure 5: Effect of lighting intensity on CO<sub>2</sub> emissions and energy consumption

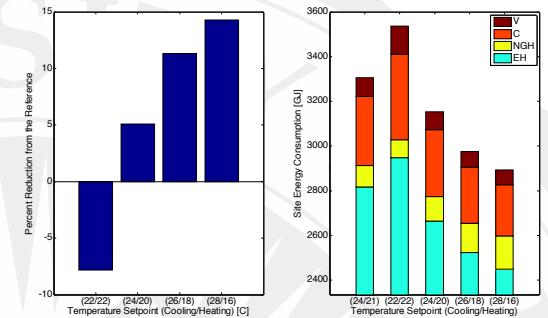


Figure 6: CO<sub>2</sub> and energy reductions associated with temperature setpoints

### CONCLUSIONS

Each of the three strategies introduced has the potential to reduce CO<sub>2</sub> emissions produced by the building sector in Salt Lake City. In order to move towards a more sustainable energy future, it is important that energy demand is reduced before focusing on adding renewable energy capacity to buildings. Future work will focus on incorporating renewable energy sources and storage into the model, as well as resource optimization, and the economics and culture surrounding sustainable design solutions.

### REFERENCES

1. "Chapter 1: Buildings Sector." *2011 Buildings Energy Data Book*. Jordan D. Kelso. United States Department of Energy, Mar. 2012.
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3. "Commercial Reference Buildings." *Office of Energy Efficiency and Renewable Energy. Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving 50% Energy Savings toward a Net Zero Energy Building*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2011. Web
4. "Commercial Reference Buildings." *Office of Energy Efficiency and Renewable Energy. Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving 50% Energy Savings toward a Net Zero Energy Building*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2011. Web
5. Tester, Jefferson W., Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, and William A. Peters. *Sustainable Energy: Choosing among Options*. Cambridge, MA: MIT, 2012. Print.