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2021 Fall ENGR333 Poster, Section A

Gerald Darkey

Jonathan Jansma

Chris Singh

Ryan Whitney

Adam Brunsting

See next page for additional authors

Authors

Gerald Darkey, Jonathan Jansma, Chris Singh, Ryan Whitney, Adam Brunsting, Adam Tjoelker, Jack Van Der Molen, Cornelius van Liere, Derrick Bittner, William Terpstra, Matthew Winkle, Kelsey Yen, Kasen Anderson, Jack Cahalane, Samantha Krupa, James Kulaga, Chukwudubem Nweke, Nathan Holwerda, Jacob Meulink, John Stehouwer, Isaac Spackman, and Moses Yang

Low-Carbon Housing Project

Habitat for Humanity and Calvin's ENGR-333-A – Thermal Systems Design

Introduction

Habitat for Humanity (HFH) built a low-carbon home at 726 London Street SW. Mark Ogland-hand, a representative of HFH, connected with Professor Matthew Heun to begin a carbon study of this new home with the goals of understanding the carbon footprints of a traditional HFH home, the London home, and future improvements feasible for HFH to make in reducing the carbon emissions of their houses.

Organization

Carbon emission calculations were split into 5 teams:

Embodied: Evaluated carbon emissions from the manufacturing and fabrication of materials used in the houses (i.e. cement production, lumber milling, insulation fabrication)

Onsite/Transportation: Evaluated carbon emissions from transporting materials to the build site (i.e. lumber, insulation) as well as emissions related to labor processes (i.e. running generators, using electric saws)

Heating: Analyzed the energy required to heat the home during winter season for 25 years and converted the heat required to carbon emissions for both natural gas heating (Stolpe) and an electric heat pump (London)

General Appliances: Analyzed the electricity used to power appliances such as stoves, refrigerators, TVs, water heaters, etc. in the home.

Design: Used estimations from the other 4 teams to generate alternatives for the house builds to reduce carbon emissions by 20%

Figure 1. ENGR-333-A students

Acknowledgements

We would like to thank H4H representative Mark Ogland-Hand for answering our many questions and being excited about our work and Professor Matthew Heun for advising us when the project was not working as intended. We also want to thank the ENGR-333 students for dedicating long hours and hard work to help HFH reduce carbon emissions in their future builds and combat climate change.

Approach

To fully solve HFH's needs, we analyzed several different housing cases: 1) a theoretical "to-code" city of Grand Rapids minimum insulation required house, 2) a HFH-built, non-carbon conscious home (Stolpe), 3) the new, HFH low-carbon house (London), and 4) an "improved" house that utilizes 4 different design options to reduce the projected carbon emissions of the London home. Additionally, we looked at the effects of Consumers Energy's pledge to clean their power grid in the coming decades and the impact this would have on the London home's electricity consumption.

To perform estimates, the expected lifespan of the home was defined as 25 years, based on the length of time that the mortgage will last for the London home.

Over 12 weeks, each team worked individually on their assigned research and calculations while the executive team brought cohesion to the group and managed the exchange of information between the groups when necessary.

Design Options

Solar Panels: Adding solar panels to the roof of the house reduced the amount of electricity required from the grid, but also increased the embodied carbon.

Triple Pane Windows: These windows improve the insulation of the windows, significantly reducing the heat loss and therefore the carbon emissions related to heating

Pre-fabricated concrete foundation: using prefabricated concrete slabs reduced the amount of embodied carbon from the concrete.

Solar Water Heater: A solar water heater reduces the amount of energy required to run the water heater, reducing the carbon emissions caused by electricity consumption

Figure 2. London house during construction

Results

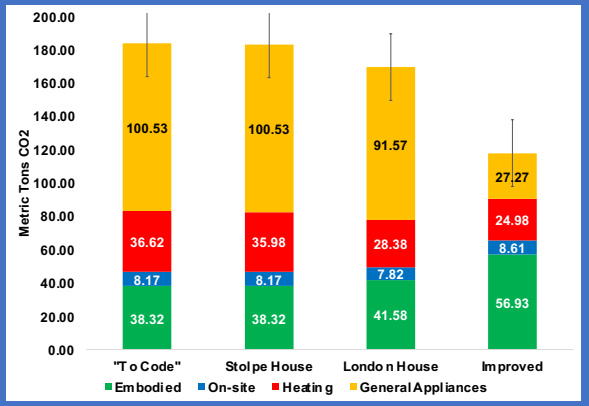

Figure 3. CO2 emissions breakdown for current electric grid

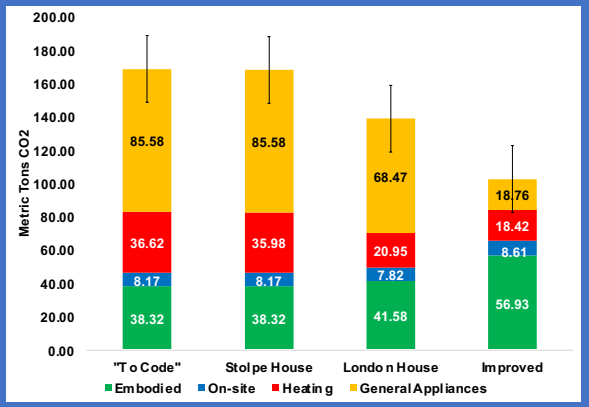

Figure 4. CO2 emissions breakdown for renewable electric grid

Conclusion

Results from the carbon emission calculations show that the changes made between the Stolpe and London home will reduce carbon emissions by 18%, from 183.00 to 169.35 tonnes CO2, if Consumers Energy follows through with their renewable pledge. Primary improvements in the London home included an ICF and Heat Pump.

The "improved" London house that includes all 4 design options would reduce carbon emissions by an estimated 30% when compared to the current London house. The biggest factor in this reduction was the solar panels, which single-handedly reduced the lifetime carbon emissions by 19% when considering the renewable grid option.