

Case Study #3

“Sustainable Design”

For this case study assignment, you will use energy modeling to review design decisions and their impact on CO2 emissions.

Your case study will consist of six parts.

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| 1 | Introduction – include the names of your group members | 0 pts. |
| 2 | Site and climate analysis – Question A | 2 pts. |
| 3 | Envelope analysis- Question A | 4 pts. |
| 4 | Systems analysis- Question B | 4 pts. |
| 5 | Building use analysis- Question B | 4 pts. |
| 6 | Embodied Carbon and net zero report – Question C | 6 pts. |

Investigative questions:

- How much CO2e emissions can be saved by adapting to site and exterior elements in the climate zone?
- How much CO2e emissions can be saved at a reasonable financial cost when adapting the envelop and systems to the climate zone.
- From the original to code model to the fully upgraded design, what were the CO2e emissions saved and at what financial cost? Is it worth it?

Introduction.

- 1- Download [BeOpt](#)
- 2- Make sure to review MEEB Chapter 2 Environmental Resources and Green Studio Handbook pages 31-64, 131-146, 211-234
- 3- Your TA will assign your group a Climate Zone. As described on the [Chapter 3 of The International Energy Conservation Code \(IECC\)](#).
- 4- If needed, find weather files [here](#)
- 5- Review the [IECC 2018](#) Insulation requirements.
- 6- The point is to explore the relationship between design, cost y carbon emissions (both embodied and operational)
- 7- Start by using climate consultant and a weather file appropriate to your assigned location to review the effectiveness of the following design strategies:
 - Sun Shading of Windows
 - Natural ventilation Cooling
 - Passive Solar
 - Humidification
 - Dehumidification

Climate Zone	City and State
1A Very Hot-Humid	Miami, FL
2A Hot-Humid	Houston, TX
2B Hot-Dry	Phoenix, AZ
3A Warm-Humid	Memphis, TN
3B Warm-Dry	El Paso, TX
3C Warm-Marine	San Francisco, CA
4A Mixed-Humid	Baltimore, MD
4B Mixed-Dry	Albuquerque, NM
4C Mixed-Marine	Salem, OR
5A Cool-Humid	Chicago, IL
5B Cool-Dry	Boise
6A Cold-Humid	Burlington, VT
6B Cold-Dry	Helena, MT
7 Very Cold	Duluth, MN
8 Sub Artic	Fairbanks, AK

- 1- We will use BEopt Optimization analysis for four different parts of the design. The first one is Site:
 - A. Start by deleting the cases that do not apply to you and re-saving the file as Part 1
 - B. On the Options screen choose the “to code” options for Wood Stud, Unfinished Attic, Crawlspace (use ceiling), and Windows according to the table on Section R402 of the 2018 IECC.
 - C. For Orientation, Neighbors, choose 3 options each.
 - D. For Eaves choose 3 options (including none). Do the same for Overhangs.
 - E. Run the simulation.
 - F. Looking at the Output page, from the Energy Related Costs, Annualized axis, identify the simulated option with the lowest cost per year and what selections were used for it. Identify the option with the largest percentage of source energy savings. Compare them and explain in your opinion how and what makes them different. Make sure to screenshot the results so that you can include that step in your presentation.
 - G. Using the Save As option, save the file after clearing the results and updating the Options screen to only include the options that gave you the highest percentage of source energy savings. Call it Part 2.

- 2- Using the updated Part 2 BEopt model you will now look at the Envelope design and its effects on CO₂e emissions. You will choose options for Different insulations, and windows. For this part you may not choose “None”.
 - A- For Wood Stud, Wall Sheathing, Unfinished Attic, Crawlspace, and Windows options select 3 options for each, the first option you click on must be the existing to code option. The other 2 options will outperform the code requirement.
 - B- For Air tightness leaving the already selected option in place add the 1ACH50 option.

- C- Run the simulation.
 - D- Looking at the Output page, from the Energy Related Costs, Annualized axis, identify the simulated option with the lowest cost per year and what selections were used for it. Identify the option with the largest percentage of source energy savings. Compare them and explain in your opinion how and what makes them different. Make sure to screenshot the results so that you can include that step in your presentation.
 - E- This time choose an option You believe is the right course of action. Explain why. Save the file, and then clear the results and update the options to match the results you chose. Save as Part 3.
- 3- Using the updated Part 3 file you will now look at how to better reduce the CO₂e emissions by changing appliances and adding some strategies. Not all options will be appropriate to your climate zone. Use common sense, intuition, and the climate consultant to guide you. BEopt can not simulate more than one heating or cooling system simultaneously, meaning for example that you can not have a Furnace and Electric Baseboards as options at the same time.
- A- Is natural ventilation an option you want to consider for your model? If so, choose a couple of options under Natural Ventilation, if not leave as none.
 - B- Choose 3 different options for Central air conditioning. None is not an option.
 - C- Choose at least 3 different options for Furnace. Make sure you include both Gas, and Electric. None is not an option.
 - D- Choose at least 3 options for a water heater. Make sure to include at one Gas and one heat pump (HPWH)
 - E- Run the simulation.
 - F- Looking at the Output page, from the Energy Related Costs, Annualized axis, identify the simulated option with the lowest cost per year and what selections were used for it. Identify the option with the largest percentage of source energy savings. Compare them and explain in your opinion how and what makes them different. Make sure to screenshot the results so that you can include that step in your presentation.
 - G- Choose an option You believe is the right course of action. Explain why. Save the file and then clear the results and update the options to match the results you chose. Save as Part 4.
- 4- Now you will look at the impacts of lifestyle. Using the update Part 4 model you will choose options for Temperature setbacks, stoves, fridges, dishwashers, washer, dryer. Make decisions you can back up.
- A- Choose 2 options for each. Some might be none.
 - B- Add an option under Extra Refrigerator in addition to the “none” option already there. Do the same to Pool or Hot Tub if it seems appropriate.
 - C- What else would you like to try to reduce the CO₂e emissions.
 - D- Run the simulation.
 - E- Looking at the Output page, from the Energy Related Costs, Annualized axis, identify the simulated option with the lowest cost per year and what selections were used for it. Identify the option with the largest percentage of source energy savings. Compare them and explain in your opinion how and what makes them different. How did a second

- refrigerator or pool impact CO₂e emissions? Make sure to screenshot the results so that you can include that step in your presentation.
- F- Choose an option You believe is the right course of action. Explain why. Save the file and then clear the results and update the options to match the results you chose. Save as Part 5

Phase II

- 5- For this part we will calculate the GWP of the selected insulation and add them to the CO₂e emissions of the life of the building. Then review the model to ensure that it lines up with expectations and rerun the simulation now attempting to reach Net Zero Carbon (at least for the use and insulation) by adding a photovoltaic system. Use the “Calculator” sheet on the Excel “GWP of insulation calculator” file.
 - A- Enter the R-values and select the “Insulation Type” used in your Part 5 BeOpt Model, into the GWP calculator.
 - B- Using the Calculator and considering the results of your energy models, investigate if there are better combinations of insulation type that you can use to achieve the same performance, but reduce the CO₂e. Enter that option into BeOpt file Part 5. You should only have two options for any materials you wish to review. The one you chose on the previous simulation (click on first) and the new one to compare to it.
 - C- Run the Simulation.
 - D- Review the results and compare them to the previous simulation. How are they different? Annualized cost? Source energy? Monthly bills? Etc. What is the CO₂e in metric tons?
 - E- Choose an option you believe is the right course of action. Explain why. Save the file and then clear the results and update the options to match the results you chose. Save as Part 6
- 6- Using the total CO₂e you will now use in-site energy production to offset the total CO₂e.
 - A- Because GWP represents lifecycle, divide the Insulation GWP by 30 (assumed life years of the house). Combine it with the yearly CO₂e operational. This will be our total embodied CO₂ e.
 - B- Using the latest BeOpt file, add a photovoltaic system. Add options under PV system, PV azimuth, and PV tilt. The goal is to match the yearly total CO₂e calculated on the previous step. Be aware that the largest system available to you will be 12 kW. You might have to run the simulation and fine tune your options to arrive at the perfect design.
 - C- Analyze your results, including the financial costs.