

4.464 Environmental Technologies in Buildings – Assignment 7

Instructor: Christoph Reinhart

Due Date: Friday of week 9

Type: This is a group assignment.

Energy Explorations

Now that you have a well daylit, visually comfortable building with an electric lighting design in place, we are turning our attention towards evaluating and improving the energy performance of your design. In this assignment you will first create a baseline energy model of your building and then explore various energy updates.

Task 1: Baseline Energy Use

Develop a simple thermal massing model of your final daylighting design from Assignment 6 assuming construction and usage practices for a typical medium sized office building as per the US Department of Energy [Commercial Reference Buildings](#). The zone properties for Chicago, Houston and Seattle are stored within the Grasshopper Definition that comes with this assignment.

Build a simple massing model of your design with at least one thermal zone per floor. Figure 1 shows an example of a daylighting (left) and a thermal (right) model of a "typical New England House."

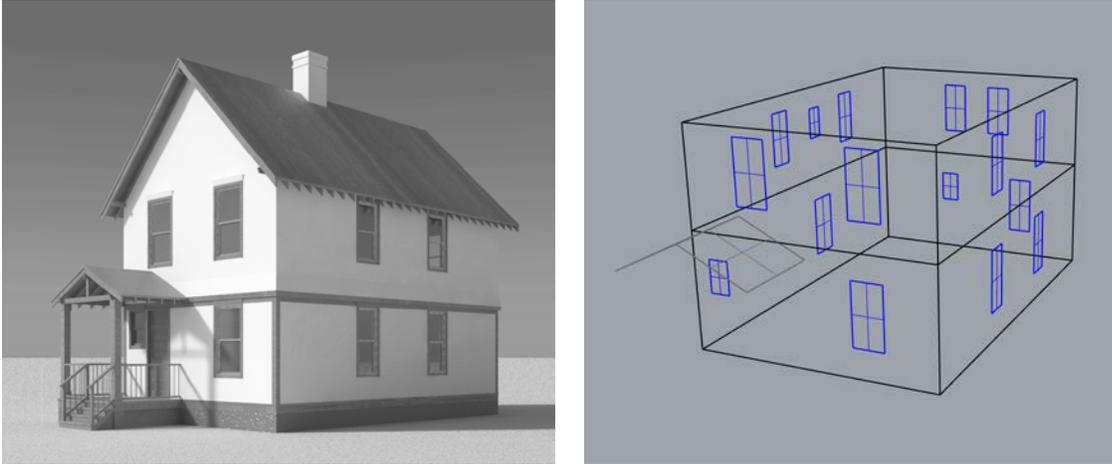
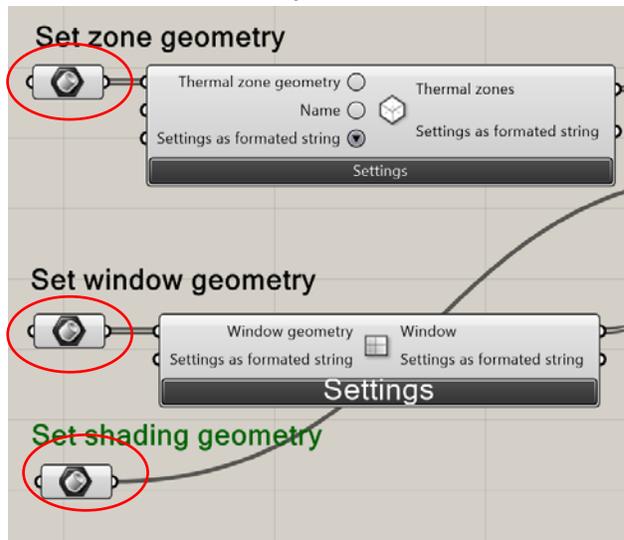


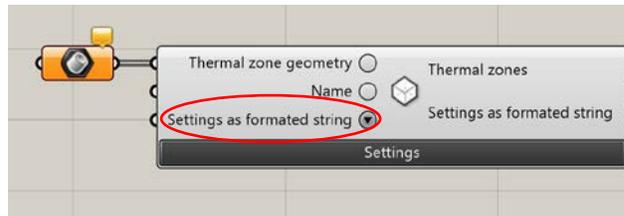
Figure 1: Daylighting (left) and two-zone thermal model of a residential house. The thermal model consists of breps for the two stories, individual surfaces for the windows that are co-planar with the walls and two surfaces that represent that porch roof.

Conduct the following steps to setup and run your thermal model:

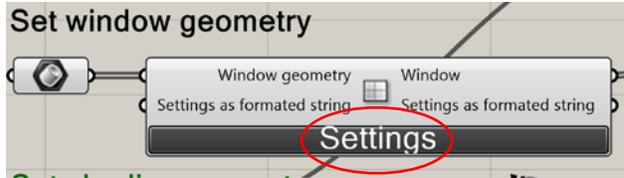
1. Set geometry: Select the breps and surfaces for the thermal zones, windows and shading surfaces. In case you do not have any external shading surfaces you need to delete the *shading geometry* brep in Grasshopper.



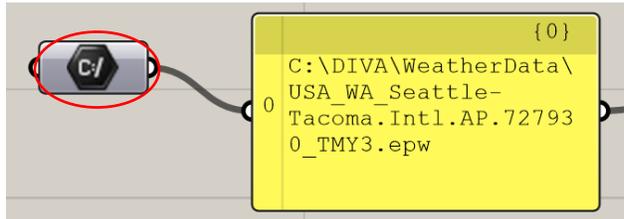
2. Zone settings: Go to the *Thermal Zone* component and under "Settings as formatted string" select your city, i.e. 4c_Seattle. ("4c" is the ASHRAE climate zone for Seattle)



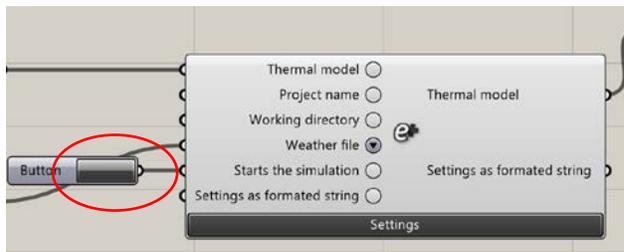
3. Window settings: Go to the *Window* component. Under Settings>> Glazing Construction select the window for your ASHRAE climate zone.



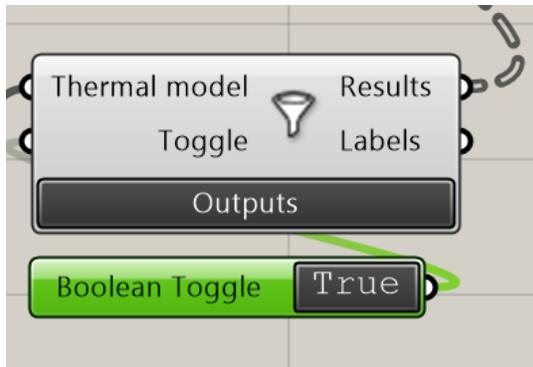
4. Climate file settings: Go to the *File Path* component and select the *.epw file for your city.



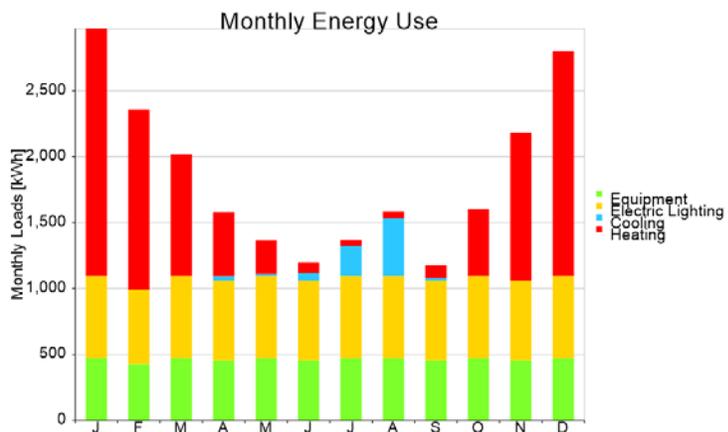
5. Run the Simulations: Go to the *Simulation Engine* component and start the thermal simulation. A black DOS window should appear and run for 15 seconds or more, depending on the number of zones in your model.



6. Select the simulation output: Go to the *Load Results File* component and select all zones in your model under Outputs.



7. Analyze results: Investigate the monthly loads of your building design for heating, cooling, equipment and lighting. Note down the annual energy uses for the base variant for your building. An example Excel template is provided with the assignment (Figure 2).



Task 2: Explore Energy Upgrades

Try to reduce the energy use of your building. As a first step set the lighting power density in your building to the level that you calculated in Assignment 6 (*Thermal Zone* component under the *Load* Tab). You may then add continuous dimming controls and other upgrades to your building. Note that once you selected various zone upgrades you have to save your settings within the *Thermal Zone* component under "Save as template." You then need to select your new zone type as described above under step 2. Report annual energy uses for at least two sets of building upgrades which may include changes to the building geometry and/or other zone properties.

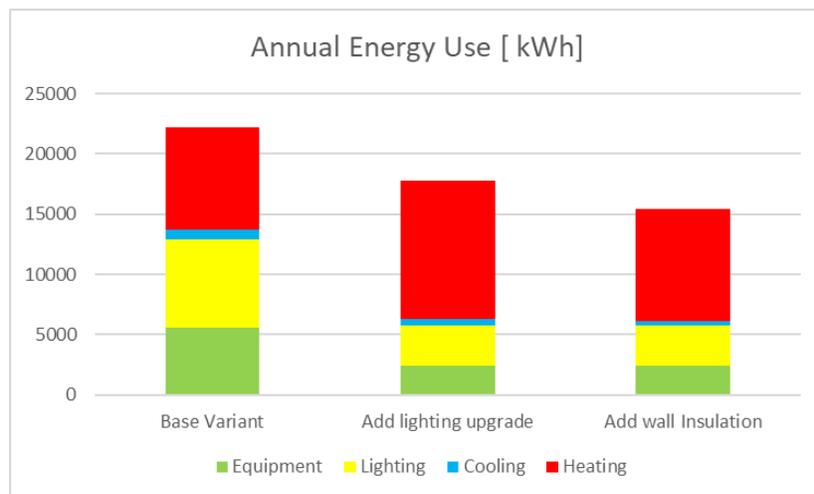


Figure 2: Annual energy use for the baseline energy use and two upgrades

Table: Thermal Simulation Checklist.

Before you start	Did you decide which daylighting performance metrics to simulate and how to interpret the results?
	Do you have a general idea of what the results should look like? E.g. a mean daylight factor in a standard sidelit space should lie between 2% and 5%; interior illuminance should lie between 100 lux and 3000 lux and daylight autonomies should range from 60% to 90% throughout the space.
	Have you verified that the simulation program that you intend to use has been validated for the purpose that you intend to use it for, i.e. that the simulation engine produces reliable results <i>and</i> that the program supports the sky models related to your performance metric of choice? (An example would be the old CIE overcast sky for daylight factor calculations.)
	Have you secured credible climate data for your building site? (This is only required for climate-based daylighting performance metrics.)

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