

ARCH 4150/5550 • Whole Building Analysis

Envisioning the Sustainable Campus

towards zero: integrating carbon, energy, water and ecological impacts

Exercise 1: Creating a Shoebox Model and establishing a Baseline Case

Exercise 1 Part B Due Date

Tues. Oct. 4, 2011, 12:30 PM

Upload to Exercise 1b assignment drop box on course Moodle site

Phase Grade weighting: This is an extra credit assignment worth up to 5% of the total grade (50 points); individual grade

OBJECTIVES

- To learn to create a pre-design phase rudimentary building energy model.
- To establish a baseline performance model for your project including loads and energy use.
- To identify the performance metrics, tools and related performance goals for your project.
- To begin to establish an holistic approach to integrated whole building analysis

Introduction

This exercise guides you in continuing to work with your “shoebox” model, as a preliminary energy model for your project. The shoebox energy model allows for optimizing design requirements before the building design has been determined, and can be used to inform early design decisions, e.g., to optimize building envelope materials and specifications. In this exercise several key building performance metrics (e.g., energy use, average monthly heating and cooling loads, utility costs, energy use intensity (KBtu/sf, etc.) will be measured and a performance baseline that corresponds to ASHRAE 90.1 2004 will be established. This Baseline will be used for comparison to evaluate the relative effectiveness of a variety of design strategies and energy conservation measures (ECMs). The results of this series of studies will also be used to establish specific performance goals for the key performance metrics under consideration. Students will work in teams of 2 or 3 and will divide up the responsibilities for evaluating the various ECM's under consideration, but will combine the results to reach a consensus on the findings and conclusion. Each individual will be responsible for turning in their own IES VE model for Exercise 1B.

Before you begin this phase of the Shoebox Analysis, review the steps you performed in Exercise 1A. Verify that the floor area, no. of stories, wall area and orientation are accurate based on the initial project you chose for your study. If you are matching a specific Window to Floor Area Ratio (WFAR) in your base project, you should adjust the sizes and orientation of the windows accordingly. This is not critical at this step, because you will have ample opportunity to visit this again later. Make any needed corrections to your shoebox and re-run the IES room identification tool. Check the *Building Properties Settings* and make sure that the location is Mpls./St. Paul and the building type is set according to your project type. Check the *default building construction settings* to see if they are as you set them previously. If not, reset them now and save them. *Save* the Building Settings and select *Room Properties*. If your model requests you to define them again, do so now. You can click either no or yes depending on whether you have assigned room names to your model. If you have, then click “Yes.” Make sure that all of the rooms are properly identified. Clean up the geometry in your model as needed to accomplish

this. Check to see that any surrounding structures, exterior shading devices, trees or other non-room geometry are properly designated as shading using the *Select Groups* tool. After you have done this, proceed to the next set of steps. You are encouraged to attempt this assignment even if you do not successfully complete it. The experience gained in going through the process will help familiarize you with methods, terms and performance metrics that will help in other graded portions of the course.

As you perform the following steps, note that:

- ☞ This symbol is your prompt to take an action in Google Sketchup.
- ☐ This symbol is your prompt to take an action in IES <VE>.

REMEMBER TO SAVE OFTEN!

Exercise One - Part B: steps for creating an ASHRAE 90.1 Performance Baseline:

STEP 1: ☞ Select the *Room Properties tool* and rename your rooms, e.g., “Classroom” or “Dining” or “Lounge” or “Lab.” These settings should help when you are matching your rooms up to the ASHRAE 90.1 templates later.

STEP 2: ☞ Click on the *Launch VE tool*. This is the red and green button with “VE” written on it. This will launch VE and export your model.

STEP 3: ☐ Set up your views. When the VE screen opens you should see a plan view of your model. In the model navigation toolbar at the top there is a view selection pull-down menu. Click on the “v” and select Axonometric. Check the Axonometric view and make sure that the geometry imported correctly. Make sure that all the floors and rooms are visible in the axon view of your model. Next, select the “View” menu at the top of the screen to see that the Browser view is turned on (checked). If necessary select “Browser” to turn on that view. If desired, you can set up multiple viewports for viewing your model. This may not be a good idea unless you have a large monitor screen.

STEP 4: ☐ Open the ASHRAE 90.1 App. G – PRM Navigator:

In the upper left hand corner there are two tabs - click on the “Navigators” tab and directly below it there is a Tool pull-down menu. Click on the “v”. Scroll down to the “Compliance” category and select “ASHRAE 90.1 App. G – PRM.” This will open the workflow for this tool. The first time you go through the workflow it is a good idea to click on the “?” next to the various steps to learn about that step and determine whether there is a necessary action. Follow the workflow in order from the top to the bottom. When you see a circle with a + sign click on it to expand that group of steps. As you go through these steps, check the box once you have completed the item so that you can proceed to the next step.

STEP 5: ☐ Next Complete the ASHRAE 90.1 Workflow, step by step. The following steps are the ones that require action on your part and must be visited or in some cases “no action required” may be indicated. First complete **Preliminary Data Setup**:

- A. Prototype Data (ASHRAE baseline): When you click on this you should see a file named “90_1_2007_IP.mit”. Open it and click OK. Check the box to show that step is completed.
- B. Building Geometry:
 - a. Inner Volumes. Click on this and select “Add Inner Volumes.” Click OK. Check the box to show that step is completed.

- b. Adjacency separation Distance: This does not require any action, however it is a good idea to check your model to make sure all of the rooms and openings are found. See the instructions for this step by clicking on the “?”.
- C. Input Options: This should not require any action.
- D. Site Obstructions and Shading: This should not require any action unless you wish to add shading to your model. If you assigned shading objects in Sketchup 8 Pro, they should have transferred to your VE model. Otherwise read the instructions and add them at this time using the *ModelIt* tool while running the navigator. (See the *Help* page for this step.)
- E. Building Orientation: No action required, but check to make sure that the North Arrow is pointing in the correct direction. You can rotate your model at this time if necessary, but you shouldn't need to do this if your model was correctly oriented in Sketchup. Check the box to show that step is completed.
- F. Room/Zone Group Assignment: This is a critical step and care must be taken to perform this step correctly. After reading the instructions for this step, follow these steps.
 - a. Open the instructions and follow them.
 - b. Upon opening the first screen you should select “Word search grouping” at the bottom Right.
 - c. When the next screen opens select “Extract” from buttons on the right.
 - d. Then click on “Apply” at the bottom. Save the schemes.
 - e. At the bottom of your screen is the *Model Browser*. In the Browser Menu select “90.1 Building Area Method (IP).” Scroll down through the list of Building area types to see if your building type is now checked.
 - f. Then select “90.1 Building Space by space method (IP).” Scroll down through the list of Space area types to see if your room types are checked. In parenthesis after each checked room type should be the number of rooms of that type. If your rooms are not assigned to any group, it means the default for all rooms is the Building Area type. You can leave it that way or you can assign specific room types to certain rooms if you wish for a more accurate result. (See next paragraph)
 - g. If your rooms did not populate these lists, follow these directions:
 - i. Expand the Model to show a list of all rooms. Select each room one by one and assign it to an *ASHRAE 90.1 Room Group* by selecting the room and then clicking on the “Assign Room Group” tool to the right of the Room ICON (with 9 squares). In the “Assign Room Group” dialog box, select “90.1 Space by space method (IP) in the first pull-down menu and select the appropriate group for that space in the second pull-down menu. E.g., for a classroom – select “SPACE: Classroom/Lecture/Training” or for a Lab select “SPACE: Laboratory.” Complete this assignment for each space listed.
 - ii. Alternatively, you could go back to your Sketchup model and assign room names that correspond more closely to the *90.1 Space by Space Method* room types. In this case you will have to start over at the beginning of these instructions.
 - h. Once you feel you have assigned Room groups to all of your spaces, check the box to show that this step is completed.
- G. Solar shading calculations: If your model does not contain any shading elements this requires no action. If it does then click on this and run the shading calculations. Save the results. Check the box to show that step is completed.

You have now completed The **Preliminary Data Setup.

STEP 6: □ Establish the Envelope and systems settings:

H. Expand **Envelope Thermo-physical Properties**.

- a. ASHRAE Baseline Constructions: Click on this and Save your model. If your building type is not residential, leave the default settings and click OK. If it is residential (e.g., a dormitory or apartment building) select “Residential” for Building type and click OK. It should then import the required building construction types into your baseline model. Check the box to show that step is completed.
- b. Proposed Building Constructions. No action is required, but you may wish to click on “Custom Construction Type” to make sure that your desired construction types imported from your Sketchup model. If they are correct, check the box to show that step is completed.
- c. Surface assignment: No action required.

I. Expand **Room/Zone Thermal template Data**:

- a. Space Classification: Read instructions and then click on this item. Click “Yes” to assign thermal templates. Check the box to show that step is completed.
- b. Internal Heat Gains: this requires no action.
 - a. ASHRAE 62.1 Parameters: Click on this – wait for the screen to come up – click OK – it should update GAIA inputs. Check the box to show that step is completed.
 - b. Air Exchange: No action required.
 - c. Other End Uses: No action required (unless you wish to add exterior lighting loads, since there are none in the baseline model.)

J. Expand **HVAC Systems**.

- a. Space Classification: This brings up the instructions for this series of steps.
- b. System Schedules: No action required.
- c. Baseline system: Click on “Edit current baseline.”
 - i. Select a system and click on “Import.” In the next view, click on “Edit Mutiplex.”
 - ii. Here you should select “Add room groups” to your system. When you select a group it will ask if you wish to create more layers. Click “yes.”
 - iii. When you are done assigning all room groups to your system, check the box to show that step is completed. Check to make sure that you have all rooms assigned and none assigned more than once. You can change a room assignment at this stage by double clicking on the Room and selecting the desired space from the menu. Or you can select a room and delete it from the list to prevent duplication.
 - iv. You will be asked if you wish to save your data, click “yes.”
- d. Proposed System:
 - i. Improve Upon Baseline: Click on this and select “Yes” to set the proposed HVAC system to be the same as the Baseline. You may wish to come back later and evaluate other alternatives, but for now no other action is required. Check the box to show that step is completed.

K. **Other Input Data**: No action required for this category at this time.

L. Expand **Generate Baseline**: Click on “Generate the Baseline Model” – Once the baseline model is generated in the model window, check the box to show that step is completed.

M. Expand **Sizing Runs**:

- a. Click on “Room Load Calculations” - click on “Calculate” at the bottom. When the simulation is complete check the box to show that step is completed.

- b. Access Loads Data Spreadsheets. There should be spreadsheets for 4 *Baseline* buildings and a *Proposed* building. Read the instructions to learn about the 4 different baseline simulations. Check the box to show that step is completed.
- c. Assign Room Sizing Data: Before running these simulations, be sure that you have closed any of the loads spreadsheets you may have opened earlier. Click on “Assign Room Sizing Data” and click “OK.” Check the box to show that step is completed.
- d. System Loads Calculations: This will open the Apache Loads Window a second time. Click on “Calculate” at the bottom. When the simulation is complete check the box to show that step is completed.
- e. Update fan and coil sizing: This will bring up the Apache simulation dialog box a third and final time. Click on “Calculate” at the bottom. When the simulation is complete check the box to show that step is completed.

Congratulations! Now you are ready to run your full building simulations.

STEP 7: Run your building simulations and view the results:

- N. Expand **Simulations** and run desired building simulations.
 - a. If you want to run the Proposed design as well as *all four* of the baseline models, skip the first two choices and proceed directly to “*Full PRM Simulation.*”
 - i. Click on “*Full PRM Simulation*” to open the Simulation Window
 - ii. You do not need to change the default results file setting.
 - iii. Check the box “ApacheHVAC link?” and select the “Proposed.asp” file in the menu to the right.
 - iv. Auxiliary ventilation air exchange and Natural Ventilation air exchange are not necessary at this stage, but if you know that your building has operable windows you can select the latter.
 - v. On the right hand side under Simulation, set the simulation dates:
From: 1 January
To: 31 December
 - vi. Click on the “*Simulate*” button.
 - vii. This may take a while to run depending on your processor speed.
 - b. Alternatively you can run just the *Proposed Model Simulation* or *0° Baseline Model Simulation* separately:
 - i. Click on “*Proposed Model Simulation*” to open the Simulation Window
 - ii. You do not need to change the default results file setting.
 - iii. Check the box “Apache HVAC link?” and select the “Proposed.asp” file in the menu to the right.
 - iv. On the right hand side under Simulation, set the dates:
From: 1 January
To: 31 December
 - v. When you click on “*0° Baseline Model Simulation*” it will immediately begin running the baseline simulations based on your previous selections.
 - c. Save Project.

O. Expand **Cost** and Set *Utility Tariff Data*

- a. Expand *Simple option*

- b. Enter the utility rates as follows:
 - i. Currency: USD (\$)
 - ii. Electricity: 0.08 \$/KWh
 - iii. Gas: 0.50 \$/Therm
 - iv. Save and check that you completed “Set flat rate” and “Set currency.”
 - v. Close the “Cost” category
- P. Expand **Results** and select the reports you wish to create.
 - a. Expand **BPRM Report** and click on User Details.
 - b. Enter the Names of your team and under Company enter “School of Architecture, University of Minnesota.” Leave the remaining default information.
 - c. Generate various *ASHRAE 90.1. PRM Compliance* reports to view simulation results. Select from the following options (the Full Report is recommended as a minimum.)
 - i. Cost Savings Summary – Table 1.8.2 (b)
 1. Copy and paste entire report into an Excel Worksheet. To do this select Copy in the Edit Menu in the toolbar at the top of the page. This will copy the entire table. Open an Excel Workbook to store all the results of your simulations and paste into cell **A1** of a blank worksheet. Title the Worksheet “Table 1.8.2 EnergySavings.”
 2. Print to PDF. Click on the Print icon and set the printer as Adobe PDF or any other PDF writer that you have installed.
 - ii. Energy Savings Summary – Table 1.8.2
 1. Repeat 1 and 2 from above. Title the Excel Worksheet “Table 1.8.2 EnergyCost.”
 - iii. Baseline Energy - Table 1.8.1
 1. Repeat 1 and 2 from above. Title the Excel Worksheet “Table 1.8.2 EnergyCost.”
 - iv. Full Report
 1. Repeat 1 and 2 from above. Title the Excel Worksheet “Summary Report” Save
 - d. Expand *Detailed Simulation Reports* and select one to view.
 - e. Expand *ASHRAE 62.1 Reports* and select one to view.

STEP 8: Conclusions. In your own words summarize the results of the ASHRAE 90.1 Compliance simulations. Include a short narrative (roughly 30-50 words) and at least 4 general conclusions that can be drawn. E.g., you might address the following questions:

1. How much energy does the **ASHRAE 90.1. Baseline** consume and what is the estimated energy cost?
2. Compare the Proposed building to the baseline. How does the proposed design compare to the ASHRAE 90.1. baseline building? Is it better or worse? How much better or worse?
3. What would be the consequences of rotating the Baseline Building 90, 180 or 270 degrees from its initial orientation?
4. What energy uses in the building are the largest loads (consume the most energy) in the baseline? Is the proposed building similar or different?
5. What kinds of strategies would you recommend exploring to reduce energy use or energy cost in the proposed design relative to the Baseline?

Step 9: Deliverables: Upload the following deliverables to the *Exercise 1B Drop Box* on the course Moodle Website:

1. Summary and Conclusions in .pdf or .doc file format Include your name, date, course and exercise no.
2. Submit 2-3 *ASHRAE 90.1. PRM Compliance* reports in .pdf format. Including the Full Summary Report (from item C-iv. above) as one of the submitted documents.
3. Submit your Excel Workbook with all of the report data pasted into various worksheets. Include your Name and Project. Be sure that the text size and color is appropriate and that all columns are formatted and any graphics are positioned in the worksheets so that the data can be read.
4. Submit a 3D (axonometric) graphic representation of your Proposed Shoebox Building with the south facing orientation in view.

GRADING CRITERIA - Exercise 1B: This assignment is for Extra Credit – up to 50 points (5% total of grade) will be given based on the following criteria:

- Completeness of deliverables submitted
- Depth of analysis and complexity of project (shoebox.)
- Clarity and accuracy of quantitative analysis charts and graphics
- Clarity and accuracy of conclusions drawn