Exercise 1

Getting started with energy modelling

In this exercise, you will initiate your first EnergyPlus model using the OpenStudio application. EnergyPlus is an energy simulation engine. It can be used as standalone software with text editing tools and command-line prompts. However, it is often used with GUIs such as OpenStudio to enable visual editing of the EnergyPlus files. In this course, we will use OpenStudio for our energy simulation exercises. In this exercise, we will build a simple baseline model for a 3-unit apartment building (see exercise details).

Step 1: Installation

OpenStudio is distributed with EnergyPlus, so there is no need to install EnergyPlus separately.

1) Go to https://github.com/openstudiocoalition/OpenStudioApplication/releases
2) Under "Assets", select the installation file for your machine
    a. For Windows machines, this will be the .exe file
    b. For Mac machines (with Apple silicon), this will be the arm64.dmg file
    c. For Mac machines (with Intel silicon), this will be the x86_64.dmg file
3) Follow the installation instructions
4) Open OpenStudio to ensure the installation went smoothly

Another important tool to be able to visualise certain results from OpenStudio is Data Viewer (DView)

5) Go to https://www.nrel.gov/buildings/beopt.html?utm_medium=print&utm_source=buildings&utm_campaign=beopt
6) Scroll down to the DView header and download the appropriate file
    a. For Windows machines, this is the Windows file
    b. For Mac machines, this is the Darwin file

Step 2: Load OpenStudio libraries

Our modeling exercise will involve a small apartment building with older construction set in Italy. OpenStudio relies on libraries for space types, construction sets, and schedules to assist in creating the energy model.

1) Create a new model.

2) **Load libraries.** Go to File -> Load Library and select "DOE_Ref_1980_2004.osm". This library includes data for the US Department of Energy's reference buildings for older construction.

3) **Space types**. Navigate to the Space Types tab 

   a. On the right-hand panel on the page, select the Library tab and open the Space Types dropdown box.
   b. Scroll to find MidriseApartment Apartment and MidriseApartment Corridor and drag each of these to where it says Drop Space Type in the middle of the page.

4) **Construction sets.** Navigate to the Constructions Sets tab 
   a. On the right-hand side of the page, select the Library tab and open the Construction Sets dropdown box.
   b. Scroll to find DOE Ref 1980-2004 - MidApt - ASHRAE 169-2013-4A and drag it to where it says Drag From Library.

5) **Schedules.** Navigate to the Schedules tab 
   a. Ensure that the Apartment Schedule Set and the Corridor Schedule Set appear under Schedule Sets. These were automatically populated when you added those space types to the model.

Step 3: Create building geometry

Once we have added the proper libraries to the model, we can create a building geometry and assign space types, construction sets, and thermal zones to the different spaces we create. Building geometry can be created in OpenStudio in multiple ways. A built-in program called FloorplanJS can be used to model buildings with simple geometries. For more complex modelling, OpenStudio can also be integrated with SketchUp directly. In this exercise, we will be using FloorplanJS.

1) Under Preferences -> Units, ensure Metric (SI) is selected.

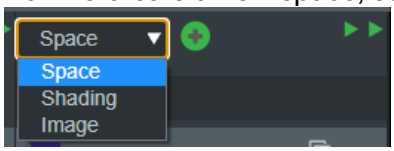
2) Navigate to the Geometry tab  and select the Editor tab at the top of the page.
   a. Click New to create a new FloorplanJS geometry.
   b. Click Create a new floorplan on the popup menu.
   c. On the top right, change the spacing to 0.05 m.
   

3) Import template image
   a. Rename Story 1 as “Ground Floor” and set floor to ceiling height to 2.7
   

   b. Import the floorplan name “Exercise-template floor 0” on Moodle as a template
   
   c. Rescale and centre the image. Do this by clicking the expand button and setting width to 13, height to 13, x to 6.5, y to 6.5.
   

4) Geometries are built in FloorplanJS using spaces as the building block. Spaces are drawn as rectangles in plan view.

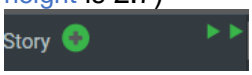
a. In Ground Floor select Space and create the spaces for this floor. When you want to create a new space, select the + button next to the Space selection.



b. Click the expand button (right side of the image above) to rename the spaces. Rename them using the following convention:
[floor]-[space].[detail (if needed)]. For example, “0-H” indicates “ground floor, hall” while “0-A1.LK” indicates “ground floor, apartment 1, living room and kitchen”.
c. With the box expanded, use the drop-down menu to assign space types. Add the apartment space type for the apartment units and the corridor space type for the halls.
d. With the box still expanded, use the drop-down menu to assign construction sets. For all spaces, select the construction set you imported (there is only one).

5) Once you have created all the spaces for the Ground Floor add a new story and import the corresponding template image

a. Create a new story (Story 2) and rename it “First Floor” (be sure floor to ceiling height is 2.7)



b. Repeat the procedure in point **3)** for the First Floor by importing “Exercise-template floor 1”.

6) Now create all the spaces for the First Floor by repeating all the steps in point **4)**. Be sure to rename the spaces and ensure all the space types and construction sets are correct for the second story.

7) Click Merge with Current OSM at the top right of the page. Then, select the 3D View tab to view your geometry and ensure it looks correct.

Step 4: Change orientation

Once we have created the building geometry, we can define the orientation of the building to match the one indicated on the floor plan.

1) Navigate to the Facility tab 

a. In Name, rename the building (e.g., Two story apartment)
b. In North Axis, change the orientation to match the one indicated on the floor plan. In the 3D View, the orange line indicates the true north; However, this line is not visible because it is hidden under the green line (which indicates the building’s Y-axis). Positive values rotate the building clockwise from true north.

Step 5: Assign properties

First, we will create thermal zones for each space. This will tell the model that each space is controlled independently of the others.

1) Return to the Editor tab. Next to Floorplan, at the top of the page, select Assignments. Add a thermal zone for each space in each story. You can expand the thermal zones tab to duplicate and rename the thermal zones. Rename them using the following convention: TZ_ [floor]-[space].[detail (if needed)]. For example, “TZ_0-H” indicate “ground floor, hall” while “TZ_0-A1.LK” indicate “ground floor, apartment 1, living room and kitchen”.

2) Contract the thermal zones tab. To assign the thermal zones to the spaces, first select each thermal zone in the menu and then select the space you would like to assign the thermal zone to. Be sure to do this for both stories.

Next, we will add windows and doors to the model.

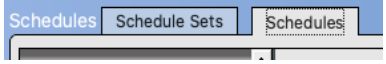
3) Next to Assignments at the top of the page, select Components. Here, you can add both windows and doors to the model. Use the expansion icon to be able to change the width and height (for both windows and doors) and sill height (for windows). For each window, select Operable (this will be important for later exercises). Once you have created a door or window, you can add it to your model by selecting that item and clicking in the appropriate place on the floorplan. Be careful to ensure you are placing the item on the correct story. Add the windows and doors according to the elevation drawings on Moodle. Note that window placement must be in the correct space. While it should be as close as possible to the drawings, the window’s location doesn’t need to be perfectly aligned – it is much more important for the energy modelling that they are in the correct space and have the correct size.

4) Once you have added all thermal zones, windows, and doors, merge your model again by clicking Merge with Current OSM.

Step 6: Creating a heating and cooling setpoint schedule

For a model to simulate heating and cooling behaviour, the model needs to know the proper setpoints for heating and cooling. In OpenStudio and EnergyPlus, we provide this information through schedules.

1) Navigate to the Schedules tab 

a. Navigate to Schedules (not Schedule Sets)


b. On the bottom left of the page, click the + to add a new schedule object.


c. Under Schedule Type, select Temperature.
d. Rename the schedule “Heating Setpoint”.
e. Change the setpoint. To do this, hover your mouse over the horizontal line at the top of the graph, type 20, and hit enter.

f. On the bottom left of the page, click the + to add a new schedule object. 
g. Under Schedule Type, select Temperature.
h. Rename the schedule "Cooling Setpoint".
i. Change the setpoint. To do this, hover your mouse over the horizontal line at the top of the graph, type 26, and hit enter.

2) Navigate to the Thermal Zones tab 

a. For all your thermal zones except the halls (i.e., "TZ_0-H" and "TZ_1-H"), select Turn On Ideal Air Loads
b. Select the My Model tab on the right-hand panel and navigate to the new heating setpoint schedule under Ruleset Schedules. Drag the schedule to the box labelled Heating Thermostat Schedule for each thermal zone.
c. Navigate to the new cooling setpoint schedule under Ruleset Schedules. Drag the schedule to the box labelled Cooling Thermostat Schedule for each thermal zone.

Step 7: Run your model

Here, we will be running the model just to confirm that the program runs smoothly. Before we can run the model, we need to supply it with a weather file so that EnergyPlus can compute the thermal demands for the building. We will also use a measure —a tool that helps us modify the OpenStudio program— to assist in reporting results.

1) Download the weather file for Milan from Moodle (or, more generally, at this link: https://energyplus.net/weather).

2) Navigate to the Site tab 
a. Click the Set Weather File button at the top of the page, and select your downloaded weather file (in .epw format).

3) Navigate to the Measures tab 
a. On the right-hand panel, click Find Measures on BCL near the bottom of the page.[1]
b. Search for "Openstudio results" (can also be found under Reporting -> QAQC, possibly on the second page). This measure is useful easily reading the results of the model.
c. Click Download.
d. Close the current window and return to the main OpenStudio window.
e. On the right-hand panel, find the OpenStudio Results measure you just downloaded (under Reporting -> QAQC), and drag the measure into Reporting Measures.

[1] Occasionally, the BCL website and API does not work. If you are having trouble accessing the BCL, you can find the measures on Moodle. To add the measures to your library, you need to download them and add the measure folders to your measure directory. The measure directory can be found by selecting Preferences -> Change My Measures Directory in the menu bar.

f. Click on the new measure. On the right-hand panel, switch the units from IP to SI.

4) Navigate to the Run Simulation tab  and click the green button next to Run.

5) After the model finishes running, navigate to the Results Summary tab 
   a. Navigate to the HVAC Load Profiles section. Which month required the greatest amount of heating energy, and what was the heating load?

6) **Don't forget to save your model.** We will be using it for future exercises.

7) For a more detailed visualisation of results, open the DView application. Using the application, open the results file. The results file can be found in the folder that was created in the directory containing your OpenStudio (.osm) file. The folder is named the same as the file. The file to open is as follows: [your file name]/run/eplusout.sql
   a. The Heat map tab provides useful information. You can select the DistrictHeating:Facility option to see the heating energy requirements. How would you describe the heating patterns over the months of the year and the hours of the day?