CAE 465/526 Building Energy Conservation Technologies

Fall 2023

September 14, 2023

Project feedback, intro to building energy simulation, and OpenStudio training

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ANNOUNCEMENTS

Announcements

- Assignment 2 is tomorrow (spent sufficient time on the assignment)
- Assignment 3 will be posted early next week
- Review the Q&A file regularly and please feel free to ask questions!

ASSIGNMENT 1 FEEDBACK

Assignment 1 Feedback

- Let's look at a few examples of what can be improved and a few good practices

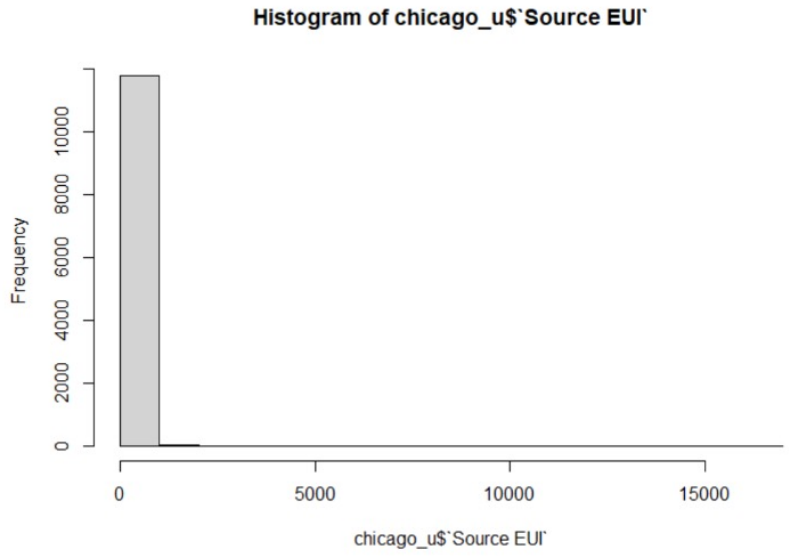
Assignment 1 Feedback

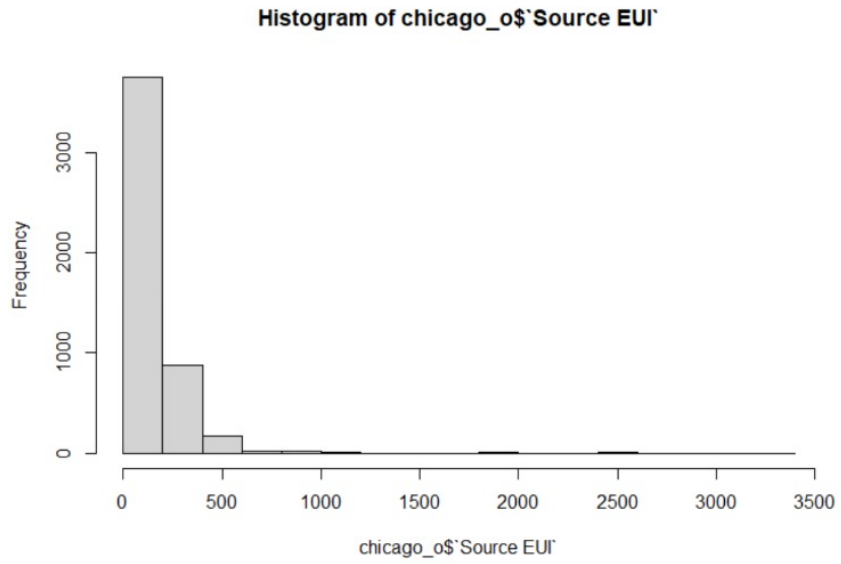
- Feedback: Common improvements

		Site EUI (kBtu/sq.ft.)	Source EUI (kBtu/sq.ft.)	Year Built	Floor Area (sq.ft.)
Chicago, IL	Areas Under 250,000 sq.ft.	Mean: 103.9 Median: 80 Max: 15634.5 Min: 0.1 SD: 294.9	Mean: 179.7 Median: 136.7 Max: 16485.4 Min: 0.2 SD: 335.9	Mean: 1960 Median: 1964 Max: 2020 Min: 1692 SD: 38.2	Mean: 110721 Median: 95310 Max: 249910 Min: 16333 SD: 52213.3
	Areas Over 250,000 sq.ft.	Mean: 90.88 Median: 78.20 Max: 3063.10 Min: 3.80 SD: 74.6	Mean: 175.2 Median: 148.1 Max: 3357.6 Min: 8.4 SD: 153.6	Mean: 1973 Median: 1976 Max: 2020 Min: 1845 SD: 32.5	Mean: 658460 Median: 445564 Max: 9245333 Min: 250000 SD: 656661.6
Washington, D.C.	Areas Under 250,000 sq.ft.	Mean: 96.33 Median: 61.50 Max: 124660.1 Min: 0 SD: 1567.1	Mean: 194.85 Median: 131.20 Max: 151010 Min: 0 SD: 2312.6	Mean: 1963 Median: 1964 Max: 2020 Min: 1727 SD: 33.47	Mean: 105670 Median: 89609 Max: 249965 Min: 714 SD: 60800.4
	Areas Over 250,000 sq.ft.	Mean: 81.37 Median: 57.20 Max: 100 Min: 0 SD: 26.82	Mean: 201 Median: 144 Max: 168490 Min: 0 SD: 65	Mean: 1982 Median: 1986 Max: 2022 Min: 1789 SD: 52.2	Mean: 481535 Median: 360200 Max: 5634890 Min: 250000 SD: 512116.9

Assignment 1 Feedback

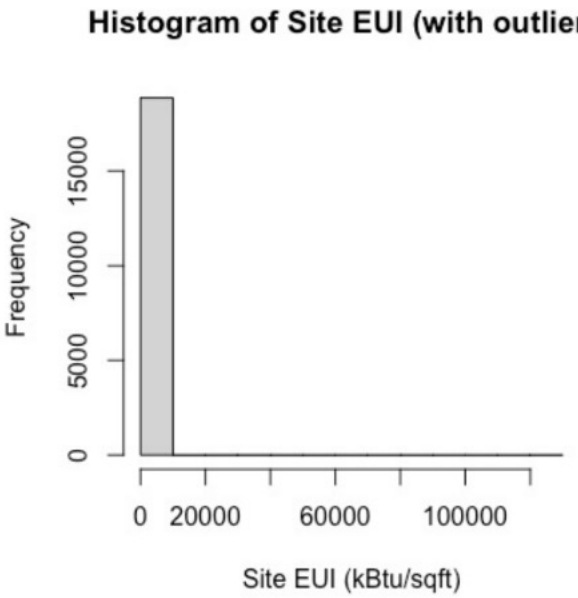
- Feedback: Common improvements

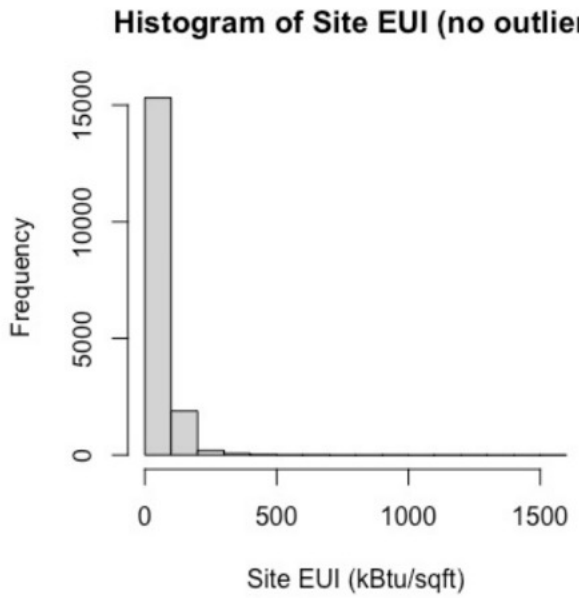




Assignment 1 Feedback

- Feedback: Common improvements



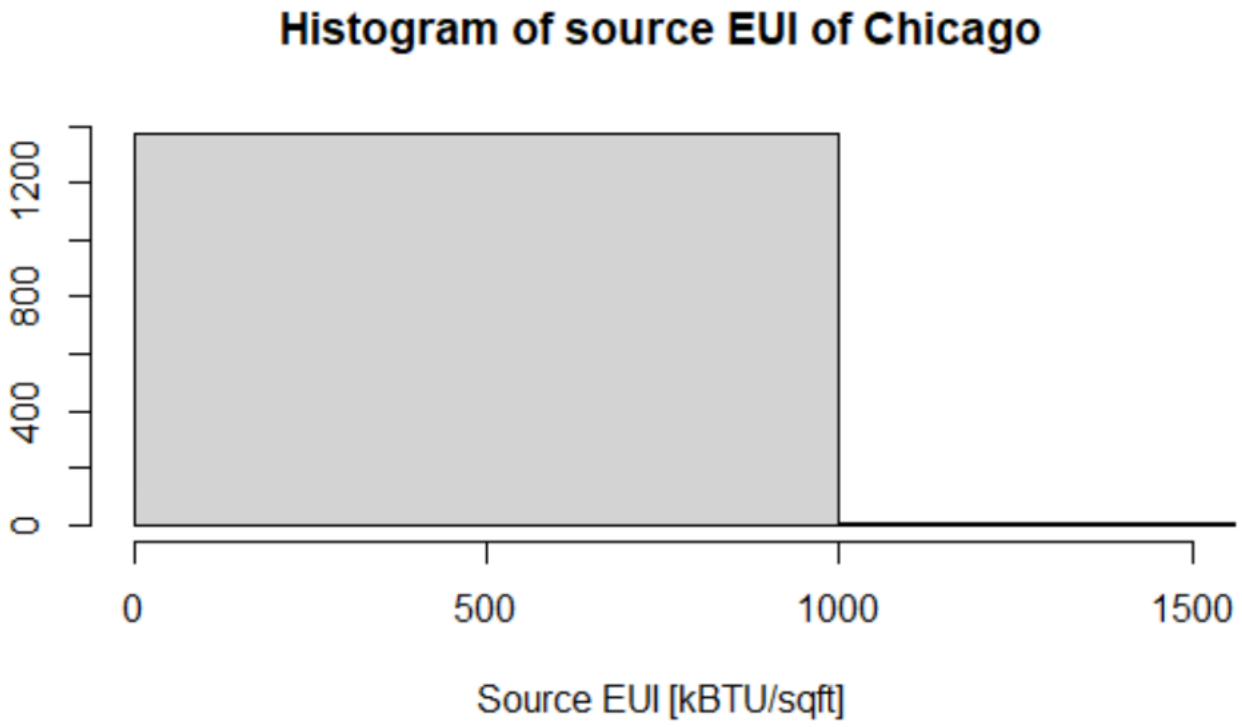


Summary without NA Data

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
0.0	42.40	59.60	92.18	79.30	124660.10

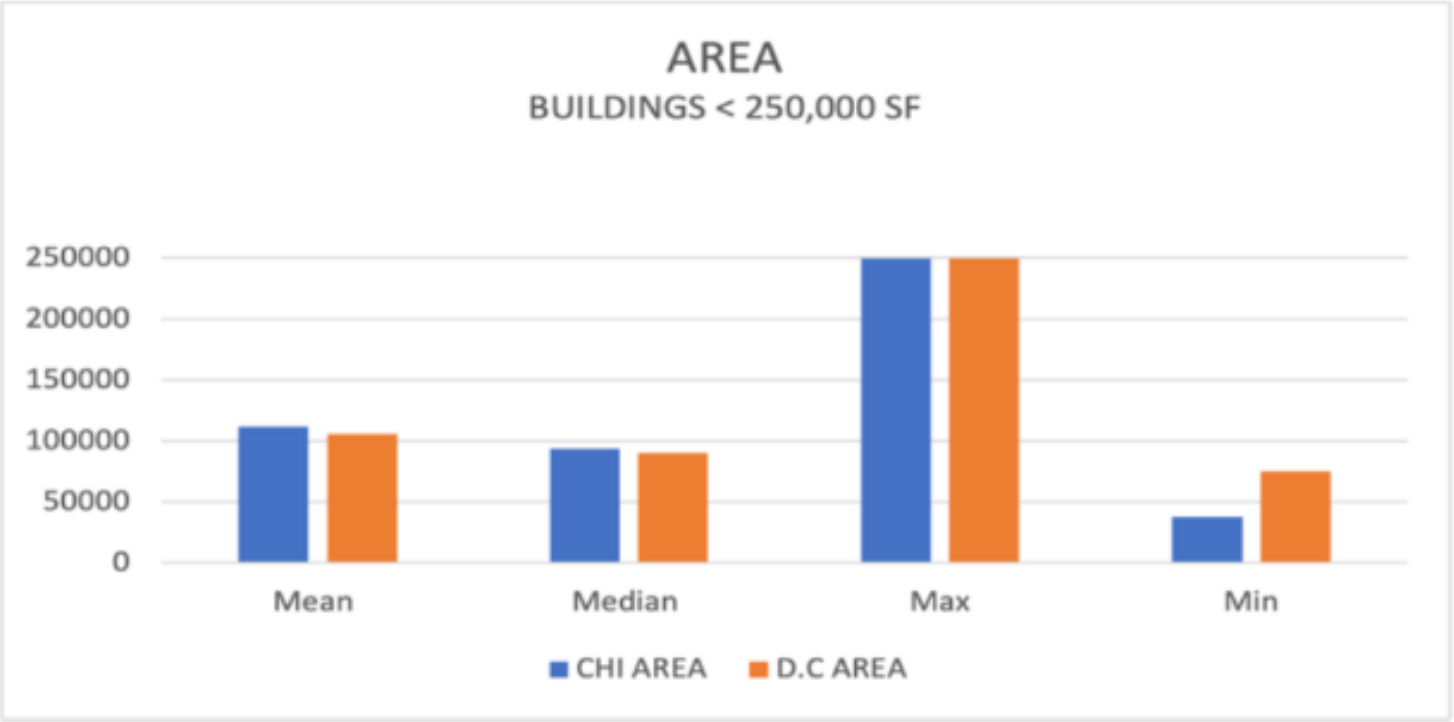
Assignment 1 Feedback

- Feedback: Common improvements



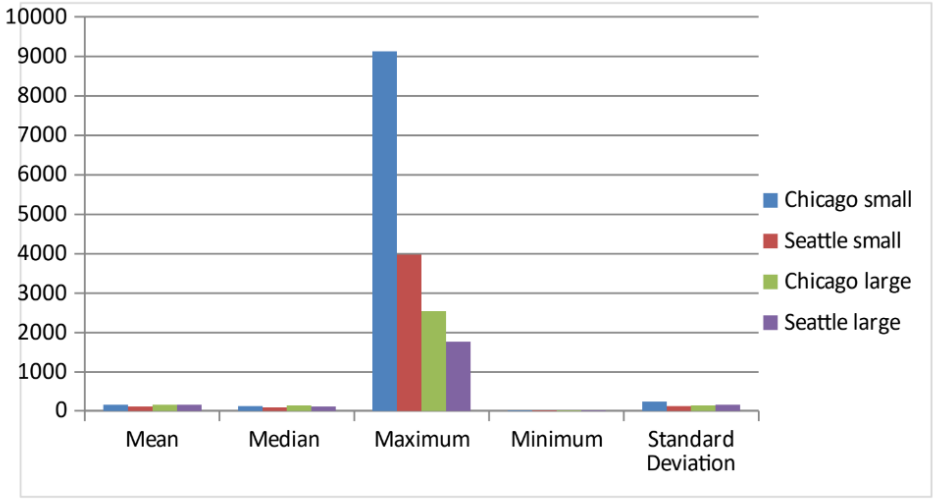
Assignment 1 Feedback

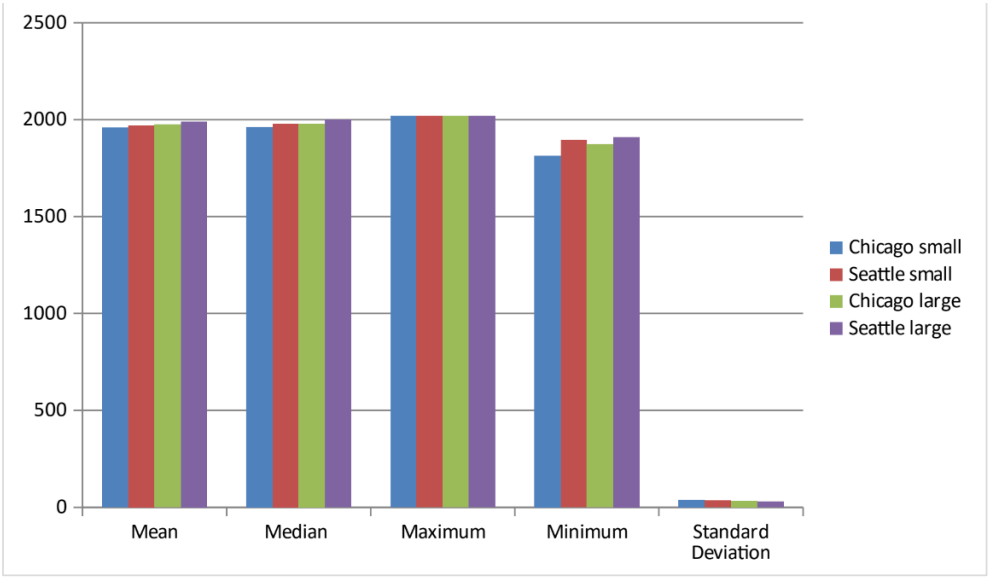
- Feedback: Common improvements



Assignment 1 Feedback

- Feedback: Common improvements





Assignment 1 Feedback

- Feedback: Common improvements

1.1 Buildings smaller than 250,000 ft2

sumtable {vtable} Summary Statistics

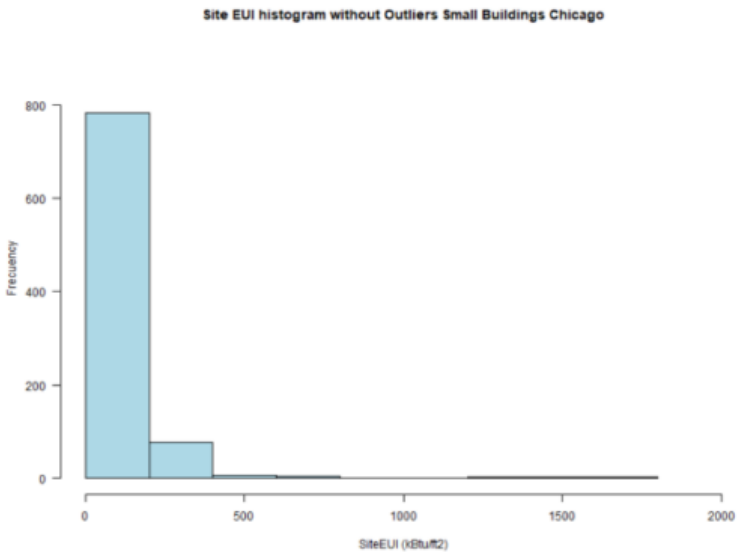
Summary Statistics of Small Buildings in Chicago

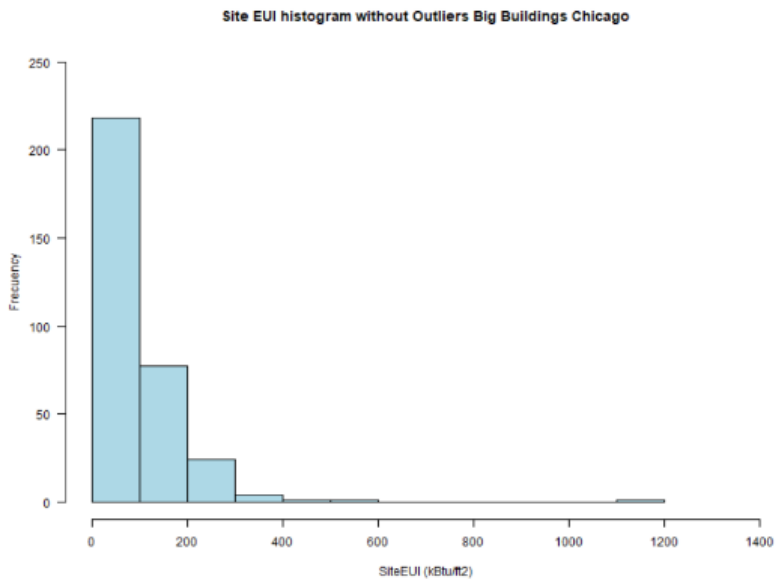
Variable	Mean	Median	Maximum	Minimum	Standard deviation
SiteEUI	113	88	1648	0.2	118
SourceEUI	192	144	1788	0.4	172
YearBuilt	1963	1968	2018	1692	38
Area	112058	94053	249600	38000	54247

sumtable {vtable} Summary Statistics

Assignment 1 Feedback

- Feedback: Common improvements





Assignment 1 Feedback

- Feedback: Good practice / Improvements

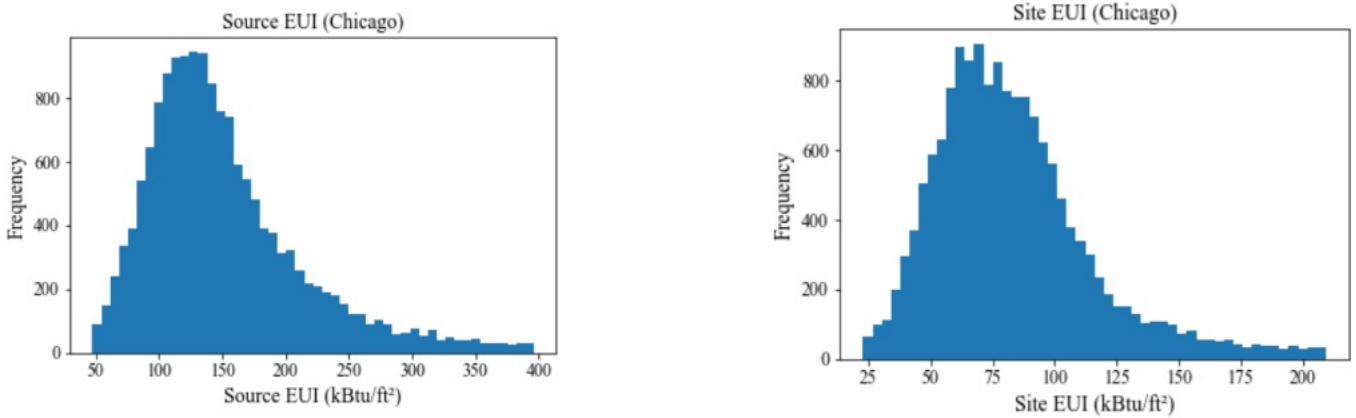


Fig.1: Histogram of site and source EUI for the city of Chicago

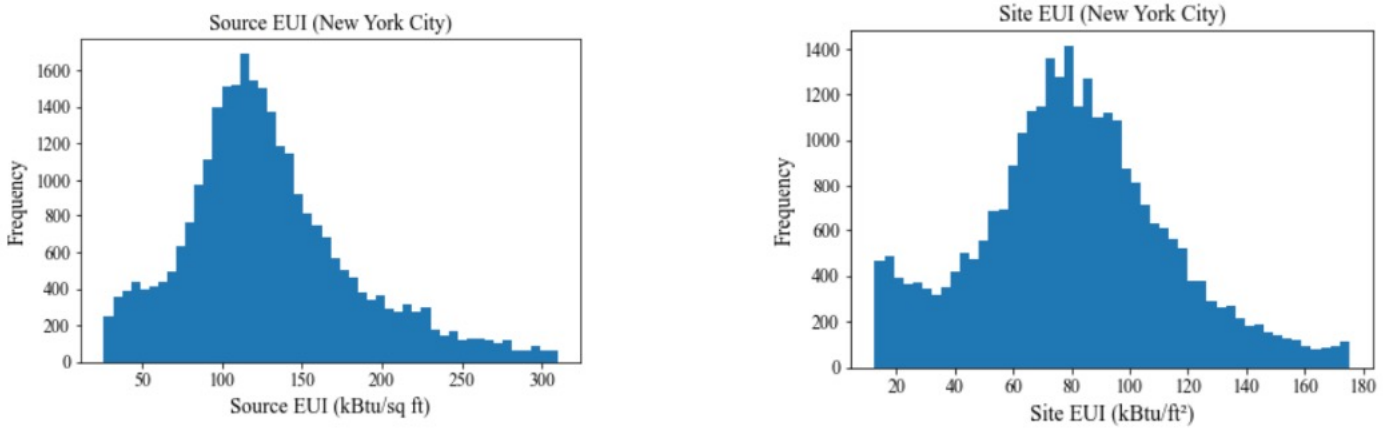


Fig.2: Histogram of site and source EUI for the city of New York

Assignment 1 Feedback

- Feedback: Good practice / Improvements

		Without Outliers				With Outliers			
		Area < 250000(ft^2)		Area > 250000(ft^2)		Area < 250000(ft^2)		Area > 250000(ft^2)	
		Chicago	NYC	Chicago	NYC	Chicago	NYC	Chicago	NYC
Area (ft^2)	Mean	104,898	69,346	554,102	475,315	110,795	75,870	664,125	560,765
	Median	92,454	59,989	435,118	394,913	95,500	61,750	449,107	404,293
	Maximum	218,875	180,166	1,687,710	1,357,968	249,910	249,978	9,245,333	8,942,176
	Minimum	50,060	12,960	252,504	253,376	16,333	1	250,200	250,044
	Stand. Dev.	44,629	37,420	313,717	234,446	52,114	48,400	670,022	523,843
Year Built	Mean	1956	1941	1971	1957	1959	1944	1973	1959
	Median	1962	1931	1974	1962	1964	1931	1977	1963
	Maximum	2012	2007	2013	2008	2020	2021	2020	2017
	Minimum	1889	1896	1893	1896	1692	1051	1,845	1,600
	Stand. Dev.	35.8	27.36	30.5	27.6	38.2	32.5	32.6	31.6
Source EUI ($kBtu/ft^2$)	Mean	148.7	124.48	148.7	152.18	179.7	354.6	175.4	11,565
	Median	78.3	118.6	76.7	142.8	79.8	120.9	78.3	146.3
	Maximum	406.6	306.7	377.1	385.6	16,485	2,219,625	3,357	28,942,940
	Minimum	32.3	6.6	50.4	0.6	0.2	0.0	8.4	0.0
	Stand. Dev.	65.54	54.67	65.5	68.2	335.8	14,795	335.8	567,744
Site EUI ($kBtu/ft^2$)	Mean	83.7	78	80.9	81.75	104.2	234.9	91.4	9,568
	Median	78.3	78.5	76.7	79.45	79.8	80.0	78.3	80.3
	Maximum	212.9	173.7	201.7	211.3	15,634	1,340,295	3,063	24,058,060
	Minimum	14.6	2.8	24.6	1.3	0.1	0.0	3.8	0.0
	Stand. Dev.	33.7	34.87	29.3	35.7	301.5	8,897	76.4	471,927

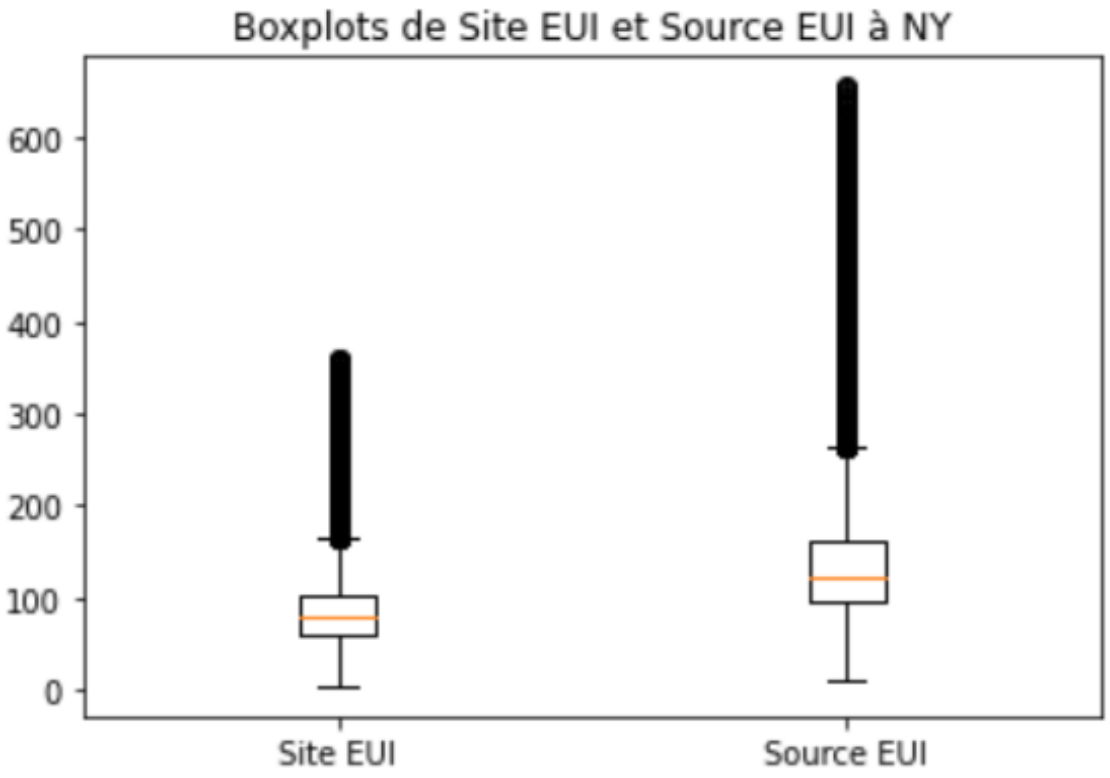
Assignment 1 Feedback

- Feedback: Good practice / Improvements

Table 2. Buildings in Chicago equal or bigger than 250000 sqft					
Variables	**MEAN**	**MEDIAN**	**MAXIMUM**	**MINIMUM**	**STANDARD DEVIATION**
SITE EUI	119,03	80,95	14680,60	0,20	552,46
SOURCE EUI	NA	NA	NA	NA	NA
YEAR BUILT	1976	1981	2019	1873	31,93
AREA	659007,40	455855	9245333	250000	647822

Assignment 1 Feedback

- Feedback: Good practice / Improvements



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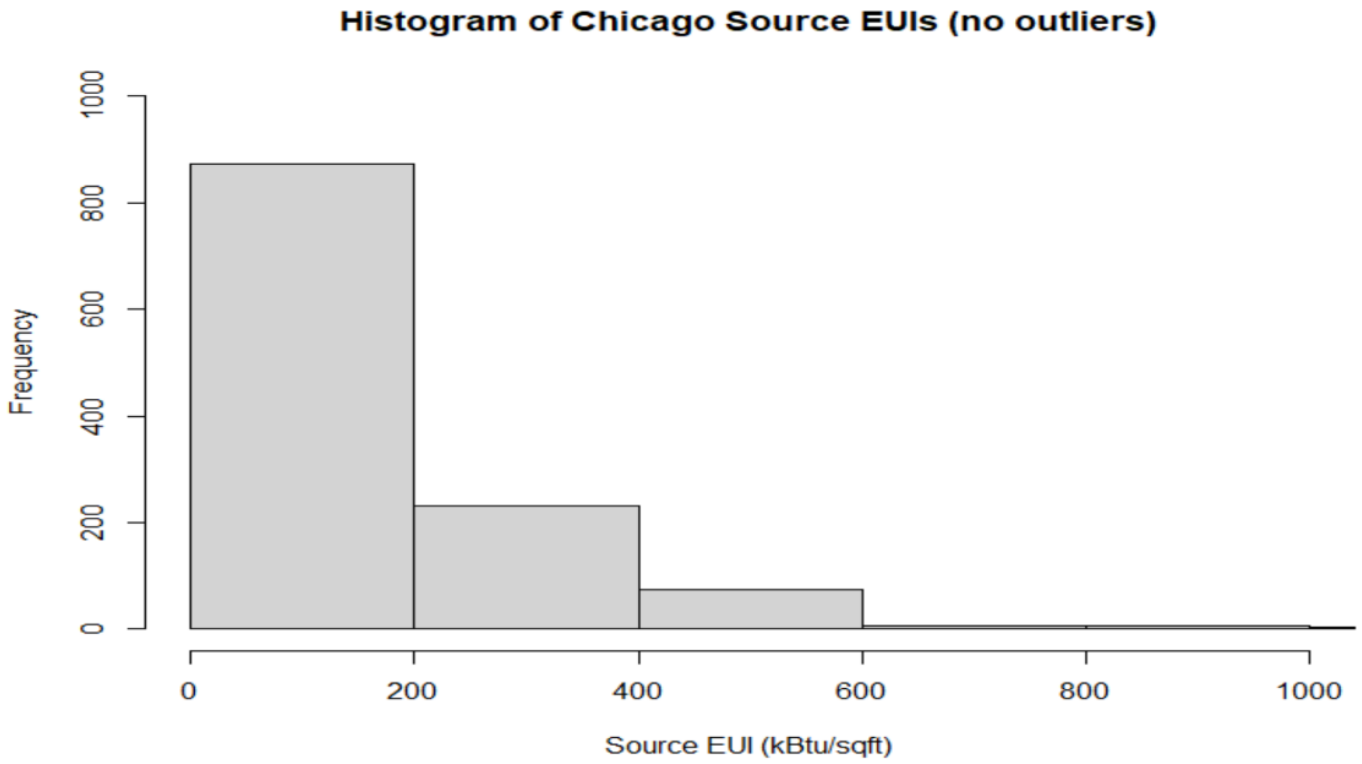

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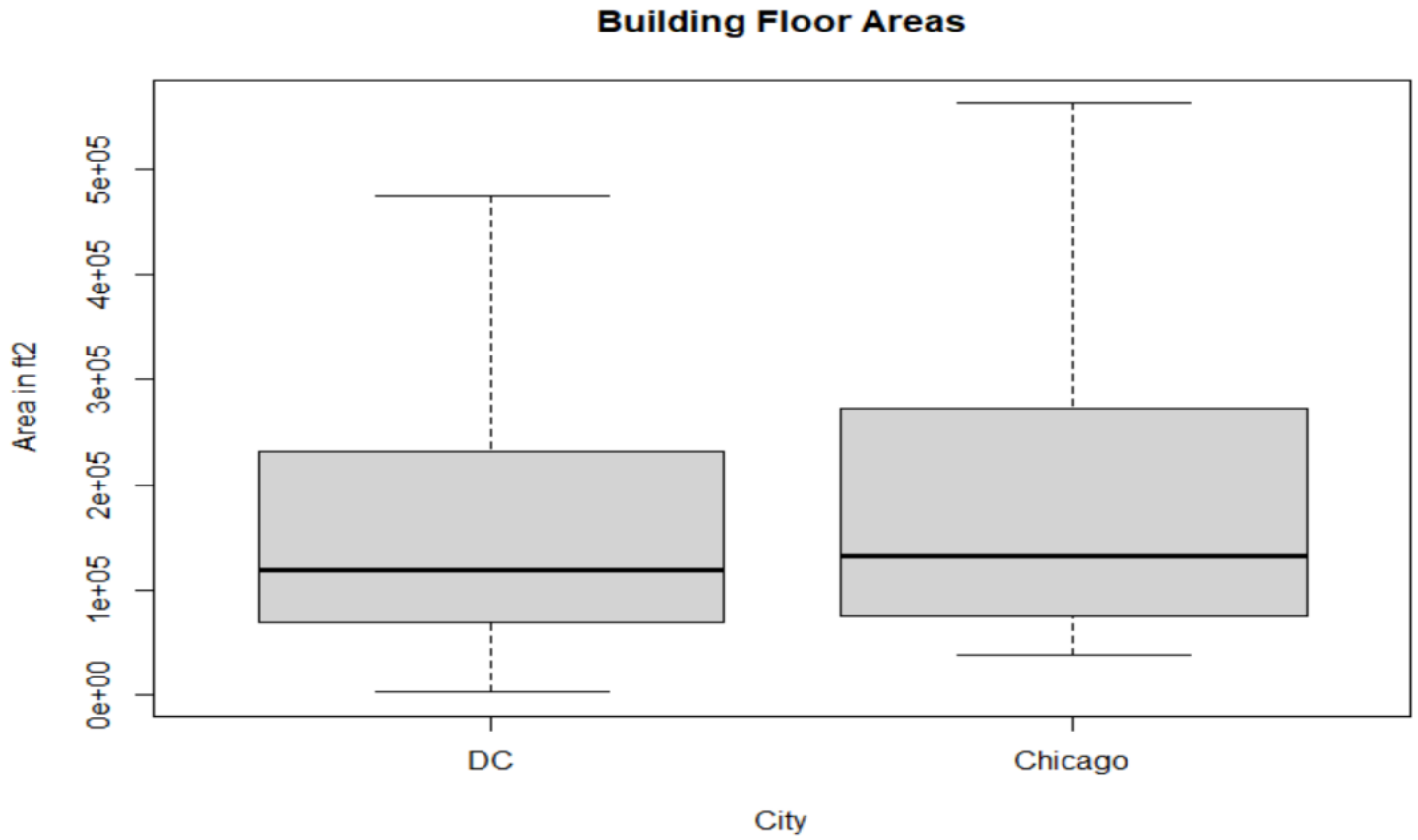

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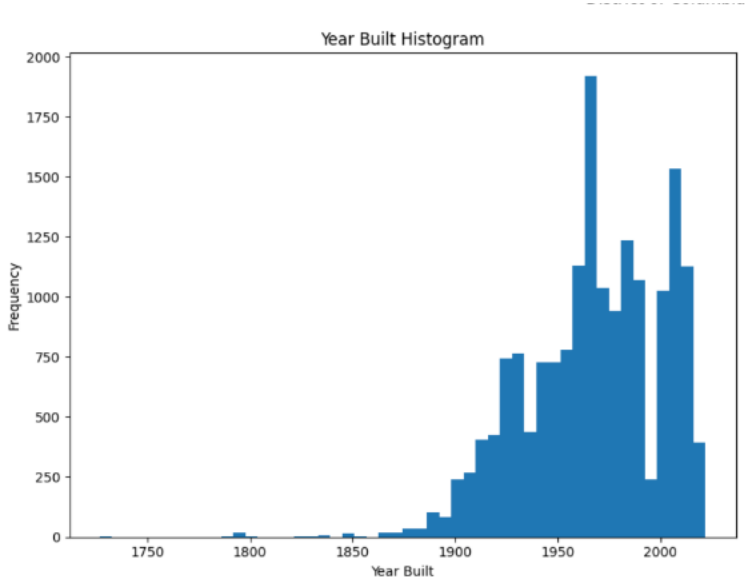

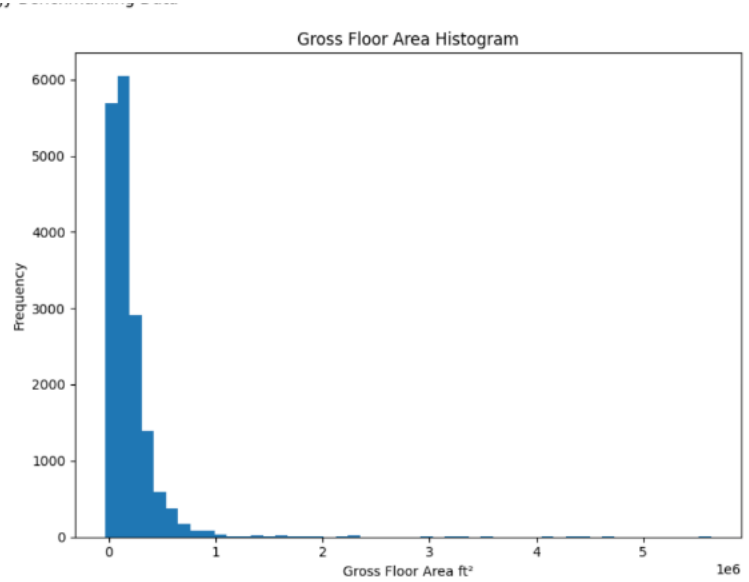

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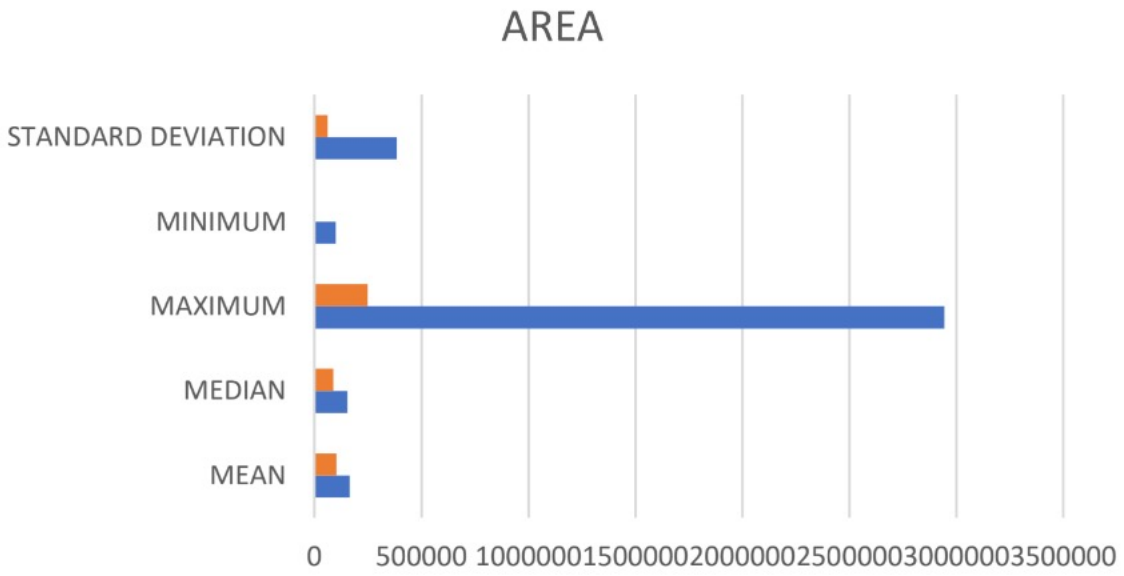
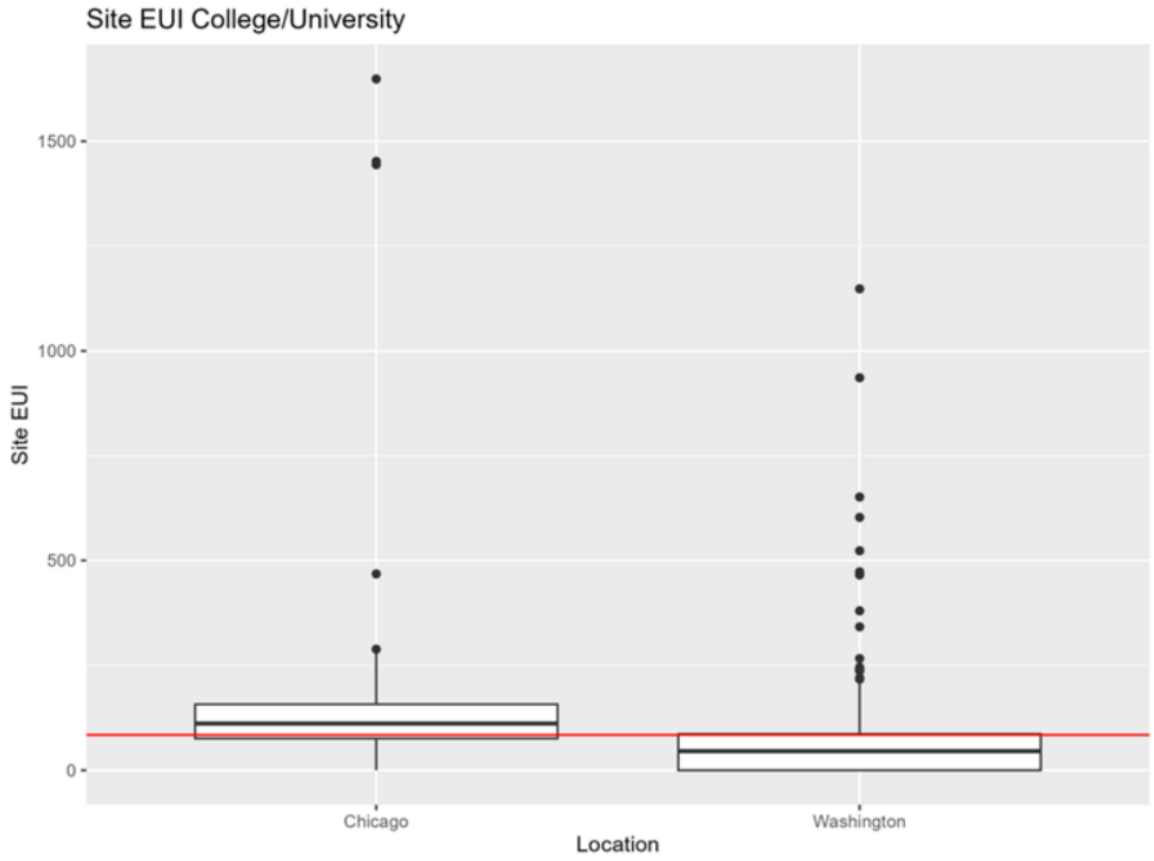


	MEAN	MEDIAN	MAXIMUM	MINIMUM	STANDARD DEVIATION
DISTRIC OF COLUMBIA	103575	88373	249965	0	62489
CHICAGO	165712	154113	2944091	100000	386059

Assignment 1 Feedback

- Feedback: Good practice / Improvements



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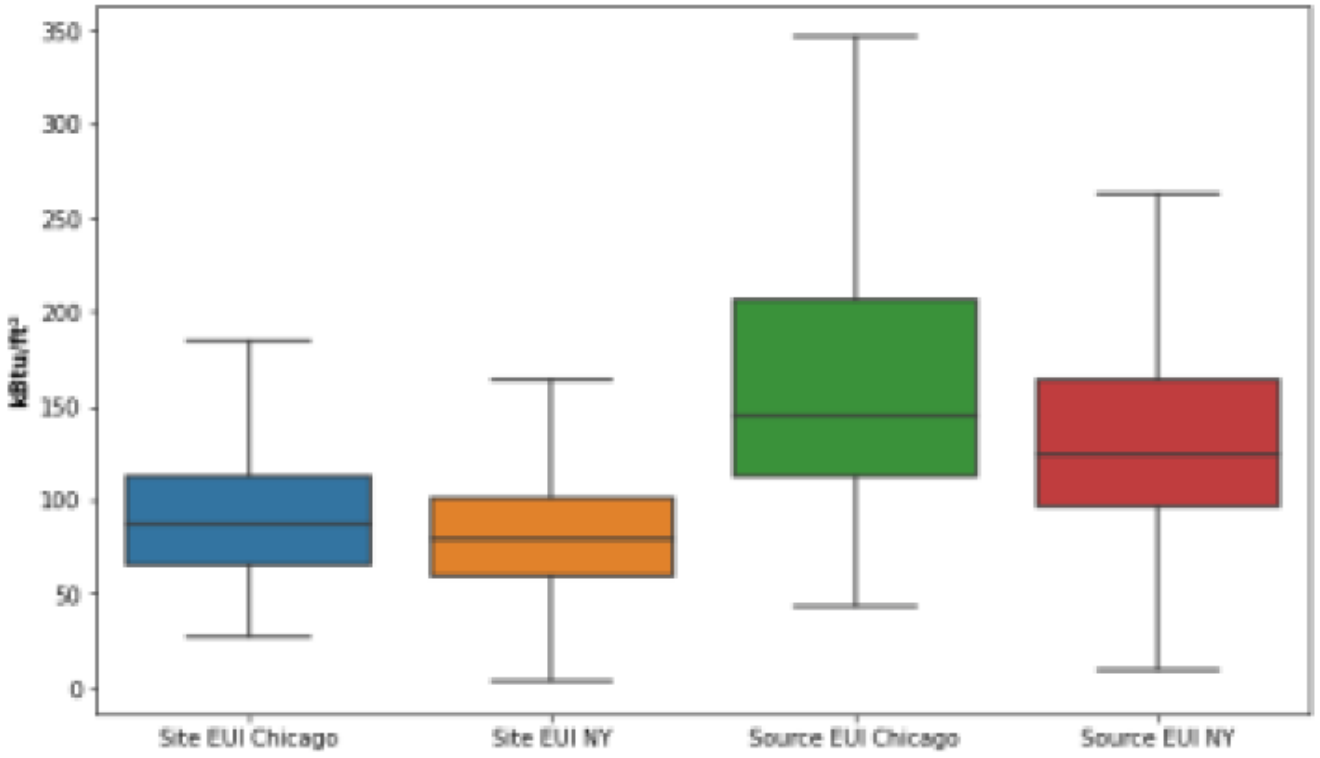

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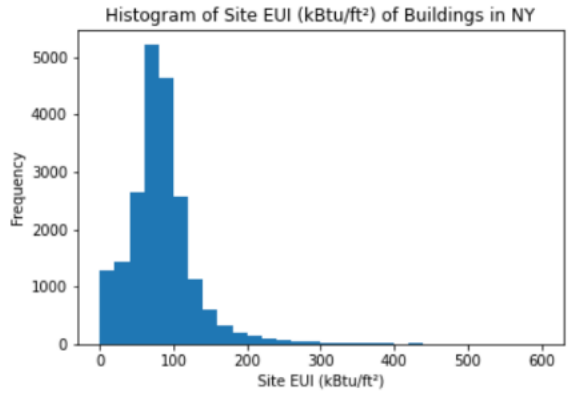

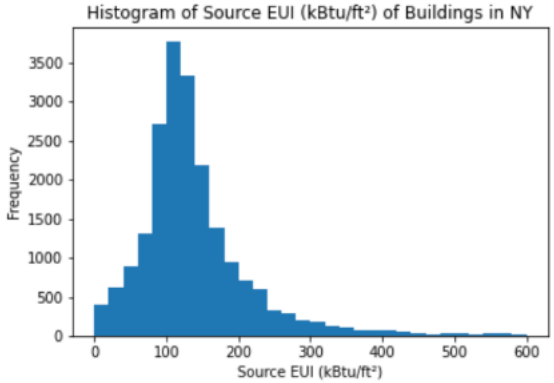

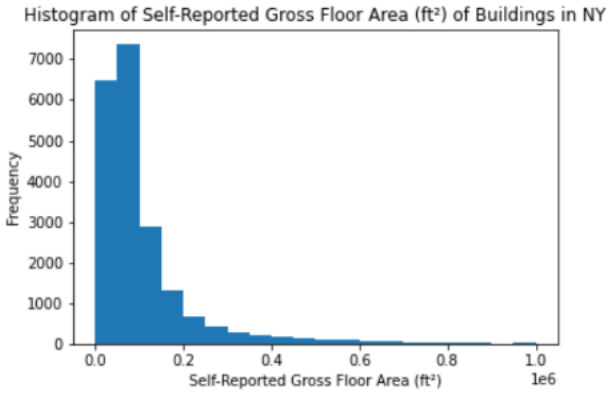

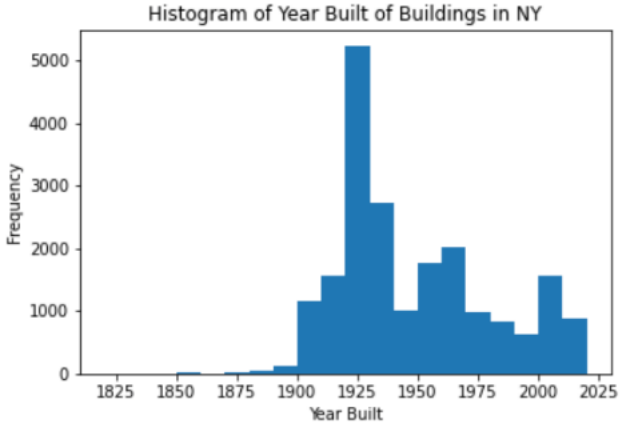

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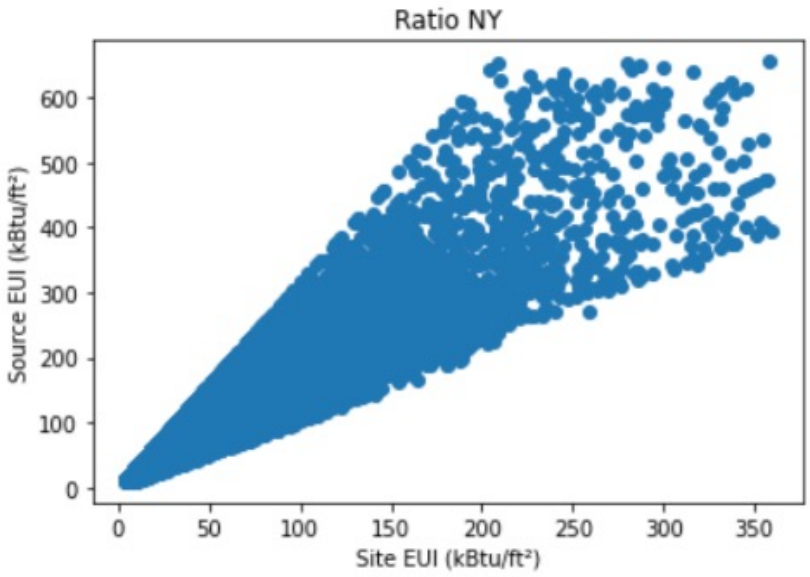

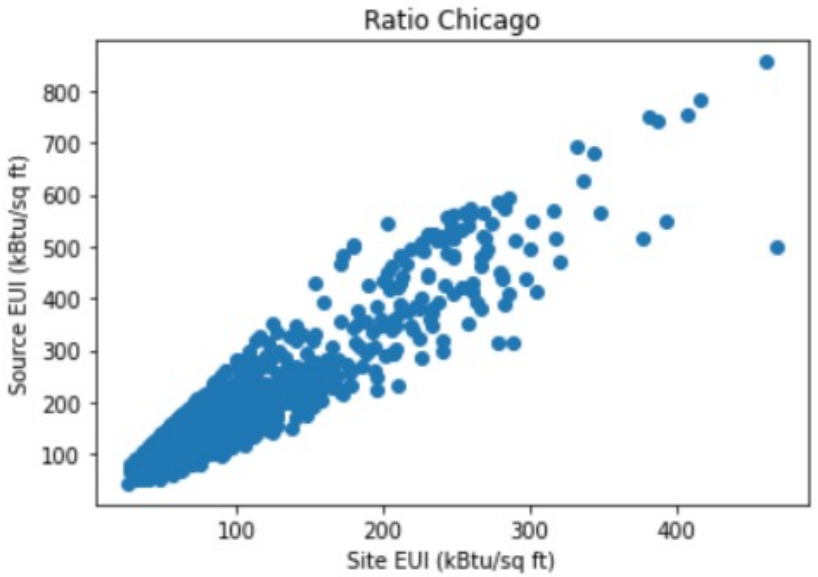

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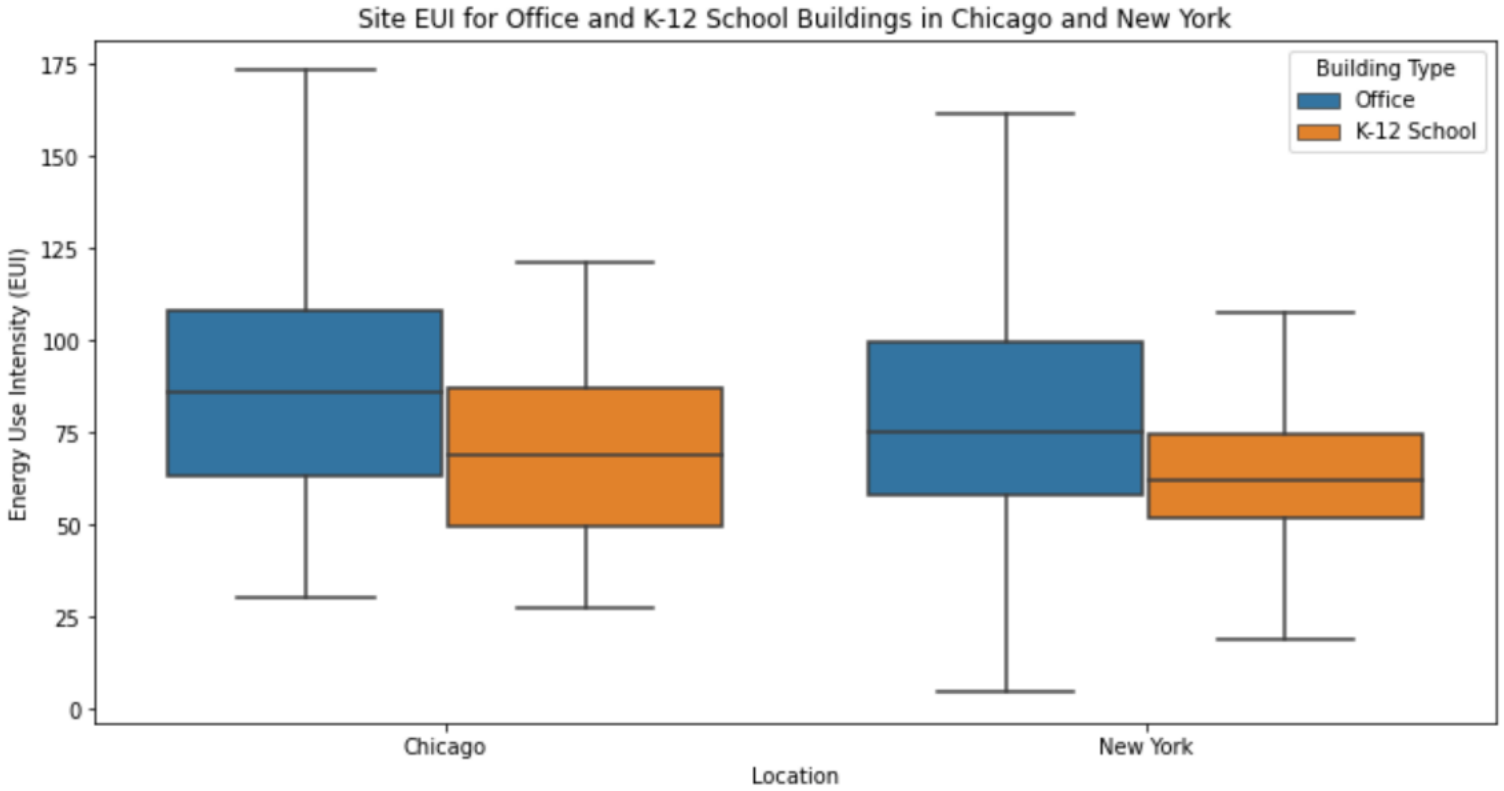


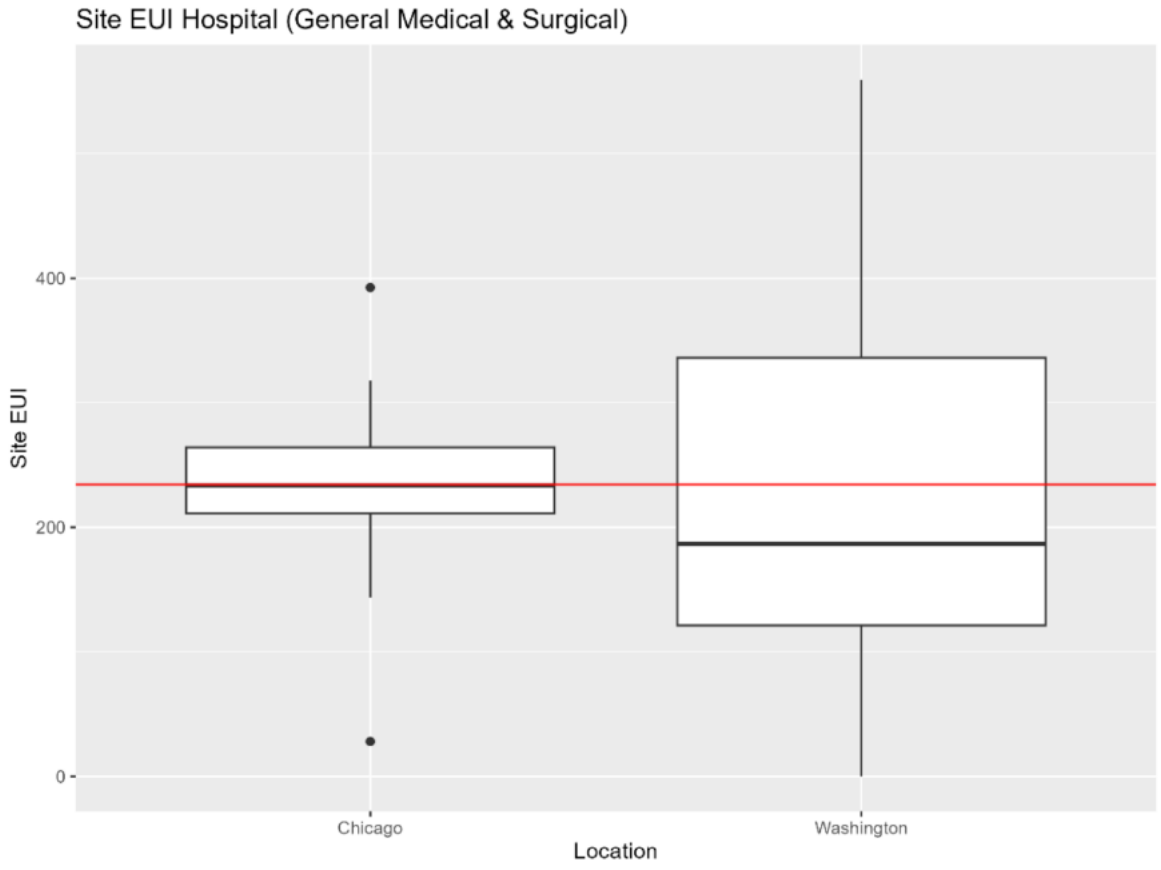
Assignment 1 Feedback

- Feedback: Good practice

Property Type	Mean Source EUI Chicago (kBtu/ft^2)	Mean Source EUI Washington (kBtu/ft^2)	CBECS Site EUI (kBtu/ft^2)
Adult Education	249.6	158.9	110.4
Bank Branch	130.7	162.8	209.9
College/University	562.4	120.8	180.6
Convention Center	221.0	164.8	109.6
Courthouse	165.6	249.7	211.4
Enclosed Mall	285.5	168.5	170.7
Financial Office	227.8	188.3	116.4
Fitness Center/Health Club/Gym	306.0	222.4	112.0
Hospital (General Medical & Surgical)	393.6	396.7	426.9
Hotel	403.2	489.4	146.7
Indoor Arena	316.0	197.9	
K-12 School	113.4	360.4	104.4
Laboratory	553.5	368.4	318.2
Library	228.8	247.8	143.6
Medical Office	263.3	219.6	121.7
Mixed Use Property	206.5	265.7	89.3
Movie Theater	347.5	262.4	112.0
Multifamily Housing	126.8	127.9	118.1
Museum	520.6	268.1	112.0
Office	189.5	187.6	116.4
Other	141.0	245.4	
Other - Education	375.0	105.0	110.4
Other - Entertainment/Public Assembly	173.7	249.2	
Other - Lodging/Residential	170.0	135.9	143.6
Other - Mall	316.8	42.5	225.3
Other - Public Services	393.8	184.6	89.3
Other - Recreation	185.6	215.4	112.0
Other - Specialty Hospital	370.7	292.9	433.9

Assignment 1 Feedback

- Feedback: Good practice



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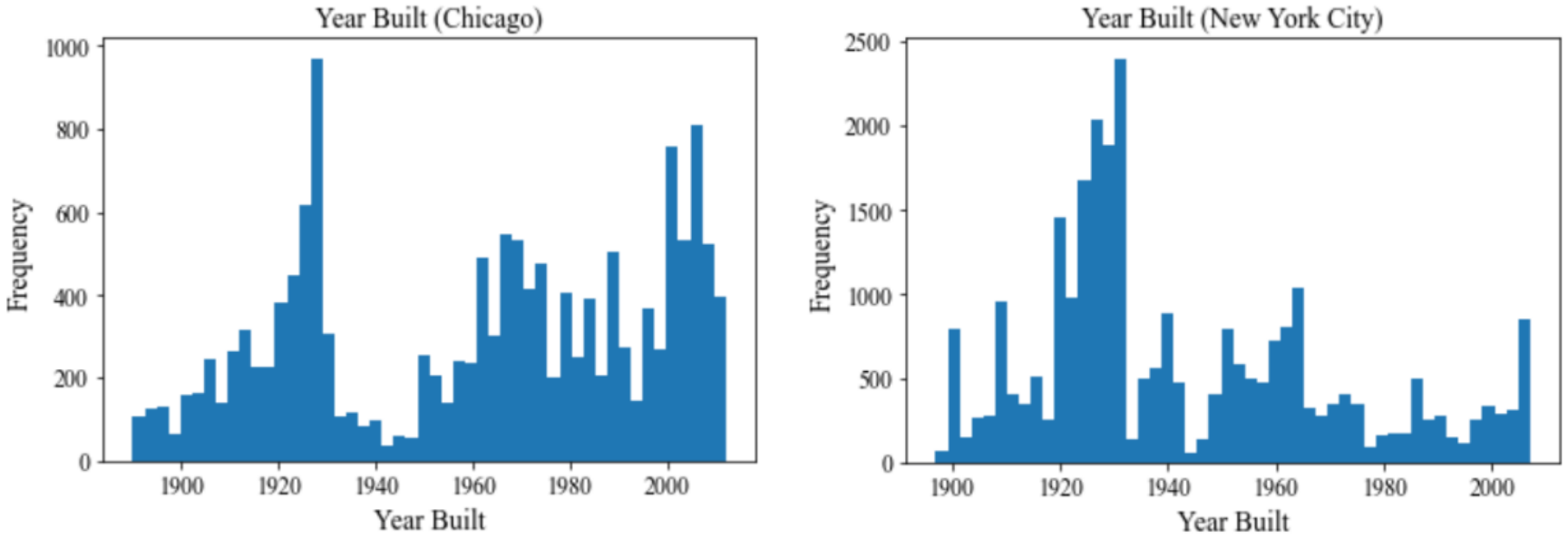


Fig.4: Histogram of year built for the city of Chicago and New York

Assignment 1 Feedback

- Feedback: Good practice

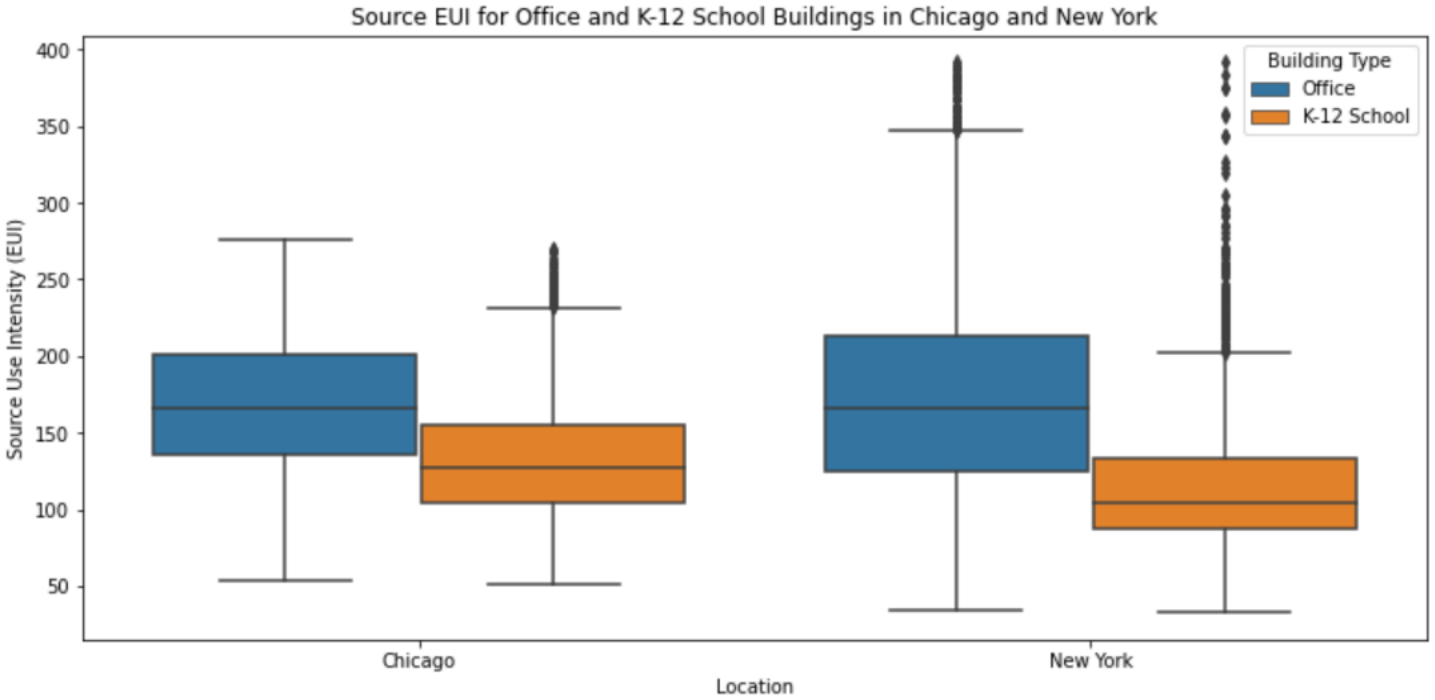
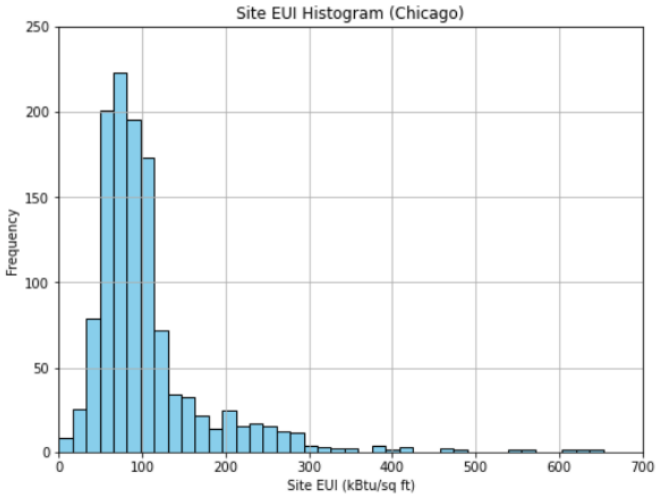
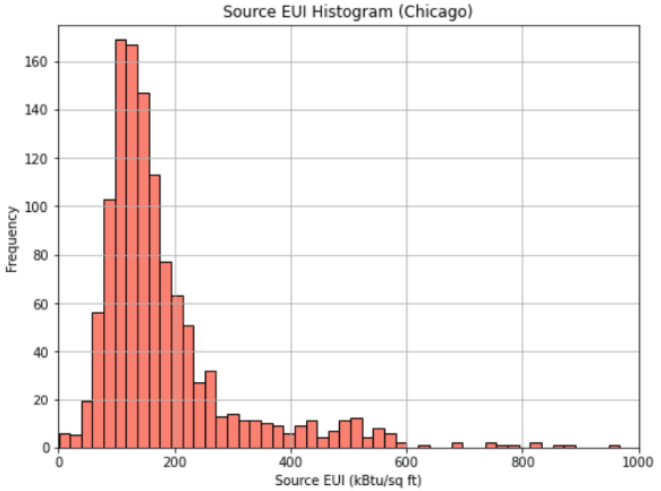


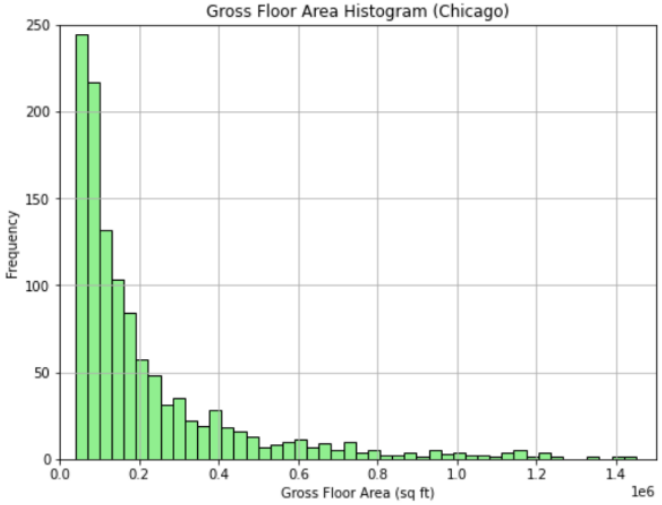
Fig.9: Box plot of Year built for buildings in New York and Chicago

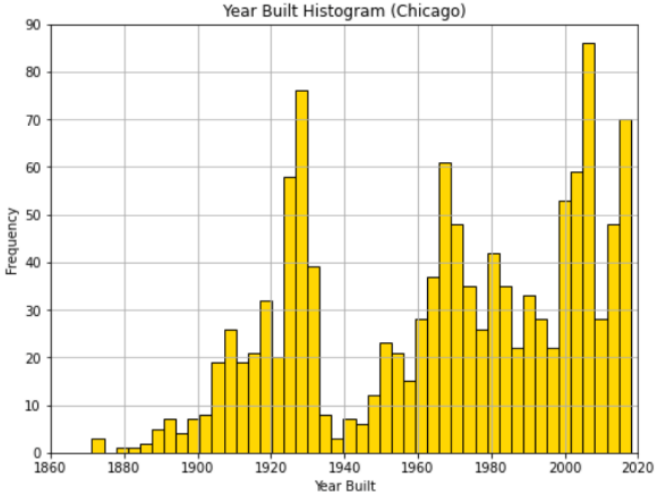
Assignment 1 Feedback

- Feedback: Good practice









Assignment 1 Feedback

- Feedback: Good practice

Table 2: Energy Efficiency (Buildings < 250,000 ft²)

	City of Chicago	City of Seattle
Site EUI in kBtu/sf (Mean / Median)	136.8 / 88.1	53.8 / 37.8
Source EUI in kBtu/sf (Mean / Median)	217.3 / 144.0	116.9 / 85.1

Table 3: Energy Efficiency (Buildings > 250,000 ft²)

	City of Chicago	City of Seattle
Site EUI in kBtu/sf (Mean / Median)	105.0 / 86.0	147.7 / 47.9
Source EUI in kBtu/sf (Mean / Median)	191.1 / 148.2	249.7 / 118.4

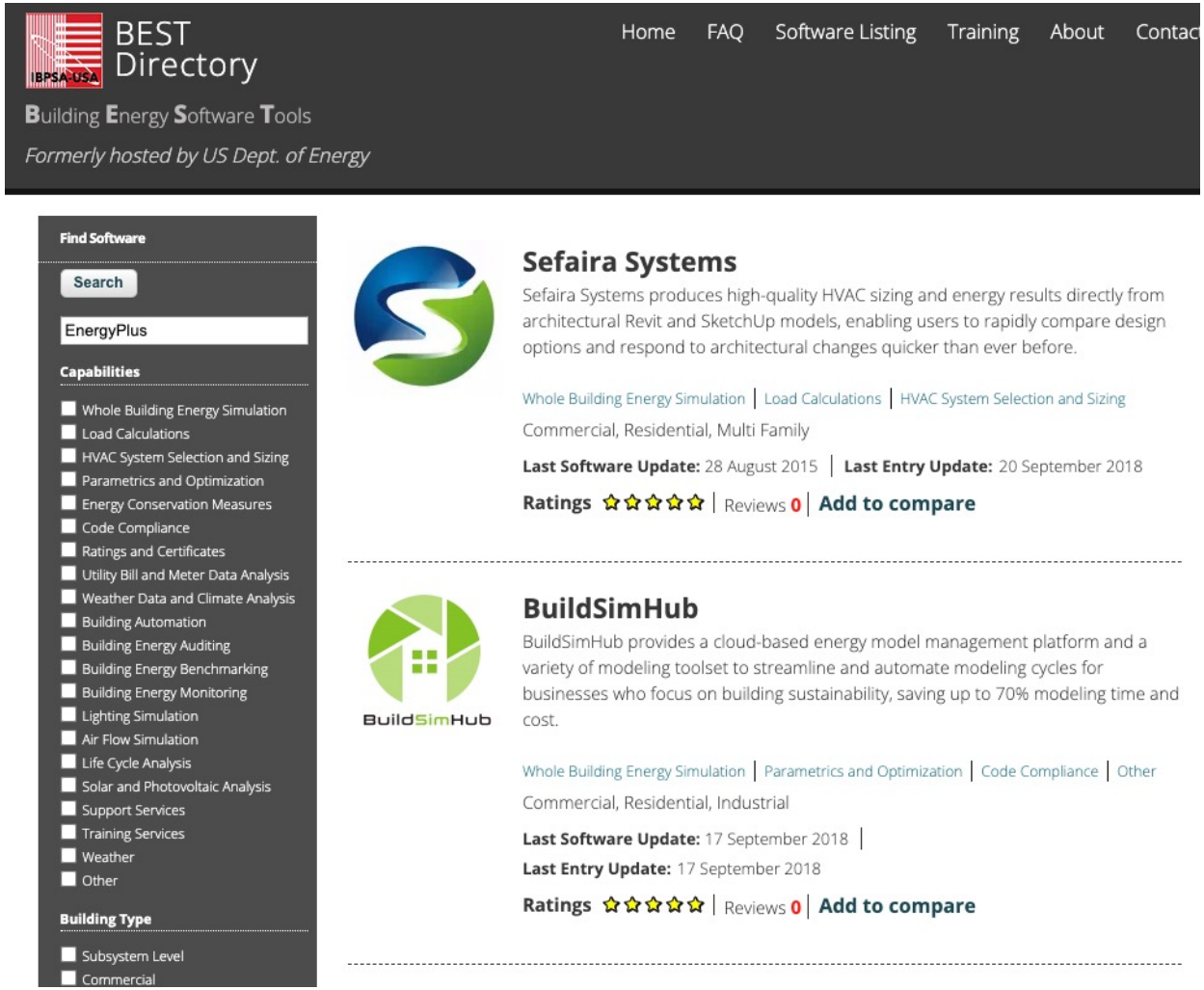
Assignment 1 Feedback

- Feedback: Common improvements
  - ❑ Do not forget about adding comments to your code!
  - ❑ Comment on your numbers

INTRO TO BUILDING ENERGY SIMULATIONS

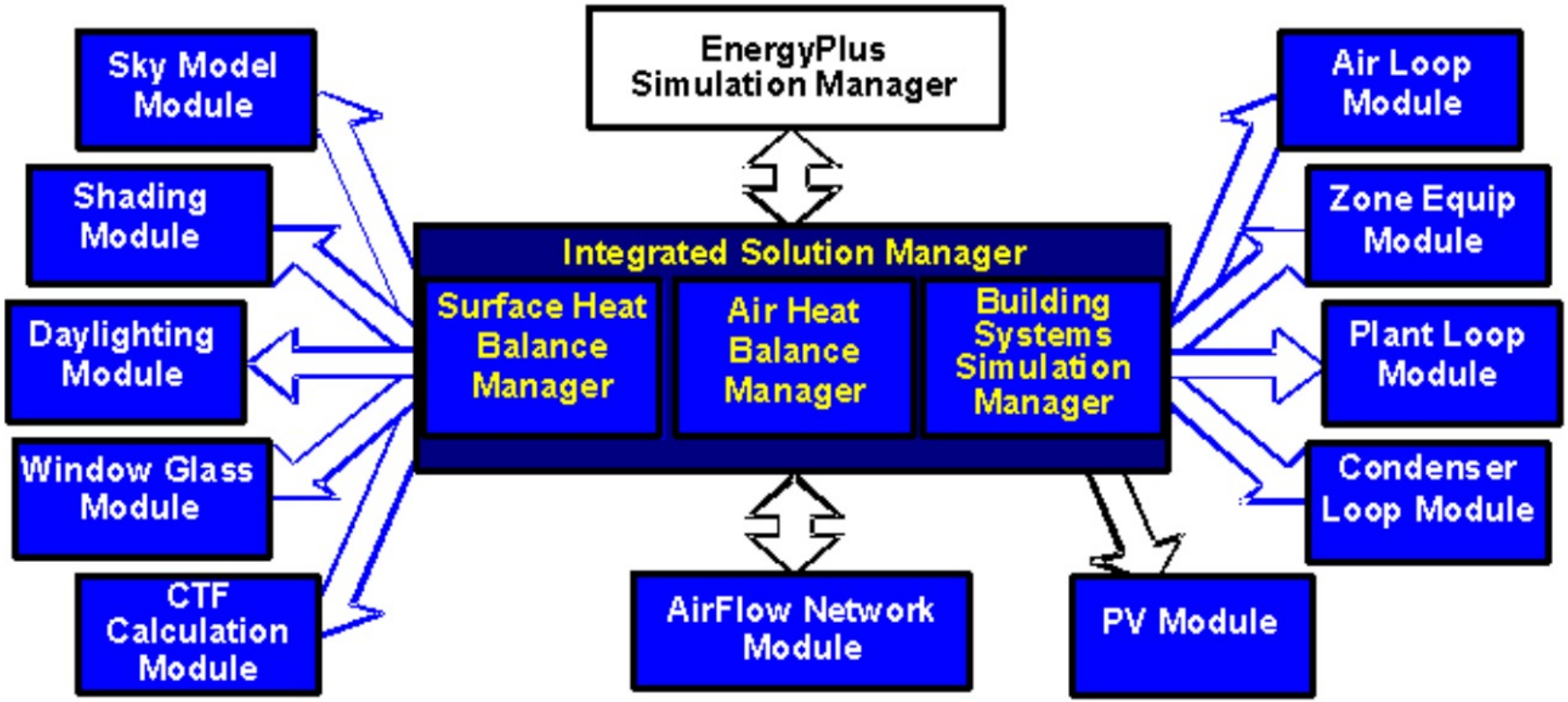
Building Energy Simulation

- There are several graphical interface for EnergyPlus:



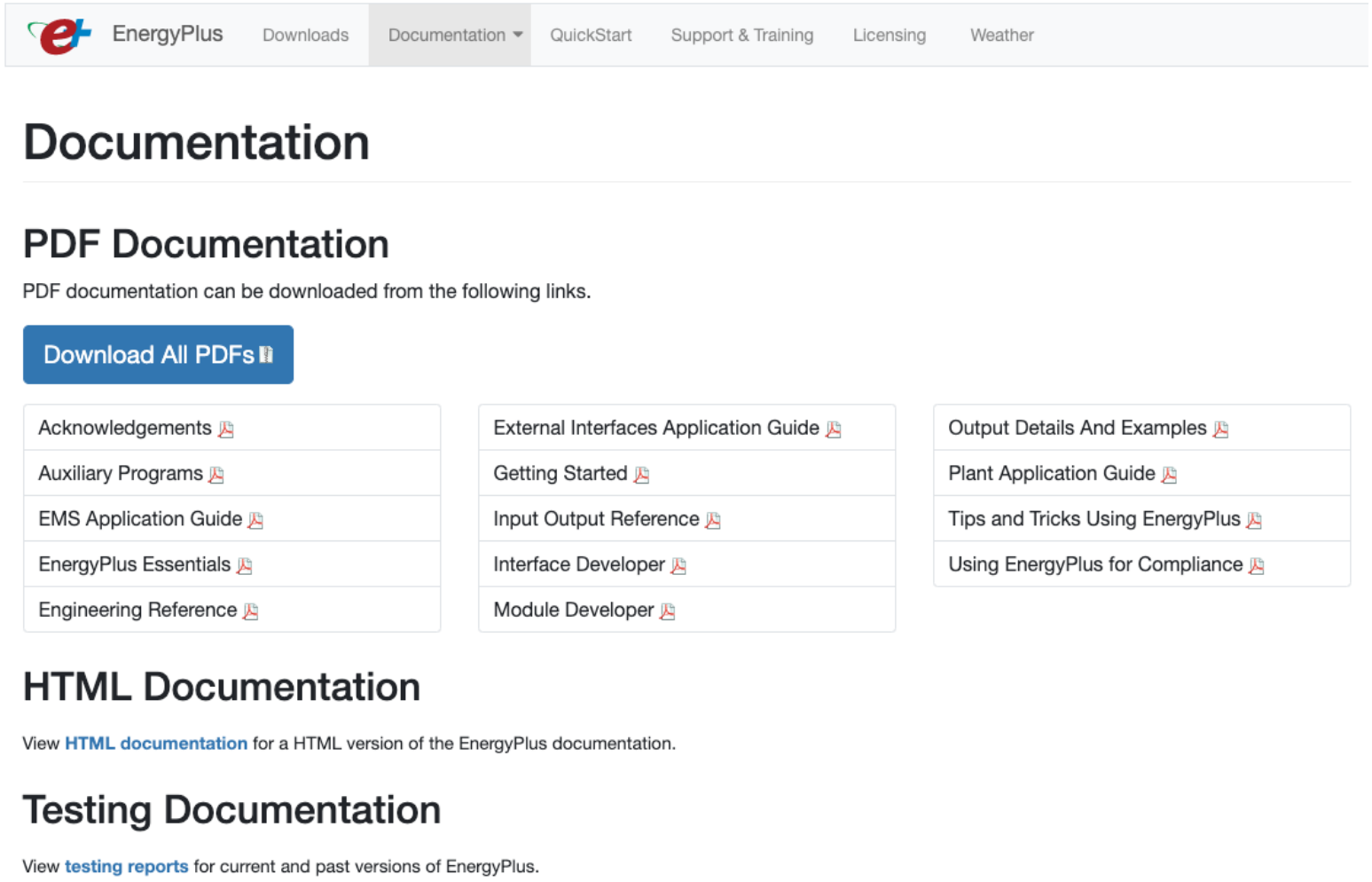
Building Energy Simulation

- EnergyPlus:



Building Energy Simulation

- EnergyPlus:

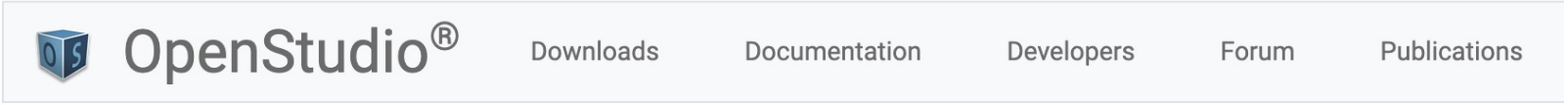


https://energyplus.net/documentation

OPENSTUDIO

OpenStudio

- OpenStudio as a BEM operating system



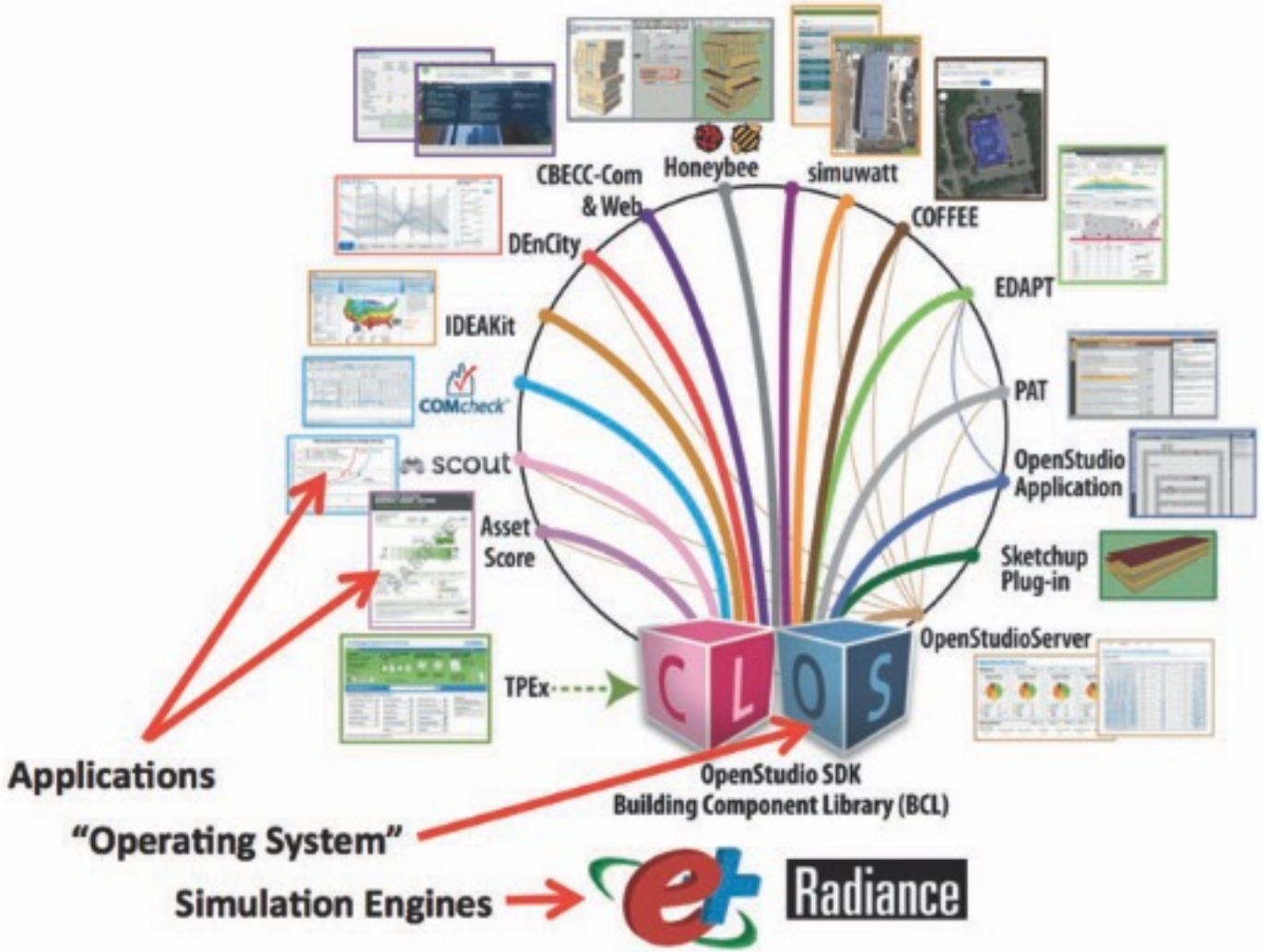
OpenStudio® is a cross-platform (Windows, Mac, and Linux) collection of software tools to support whole building energy modeling using EnergyPlus and advanced daylight analysis using Radiance. OpenStudio is an open source project to facilitate community development, extension, and private sector adoption.

OpenStudio SDK is both a Software Development Kit (SDK) and a Command Line Interface (CLI). Conceptually, OpenStudio SDK provides an Application Programming Interface (API) to access the EnergyPlus modeling engine. This interface provides many benefits such as a stable, version-controlled interface, space typology abstractions that make it easier for end-users to model buildings, and language bindings in Ruby, Python and C-Sharp to make it more accessible to users familiar with these languages. The CLI is a powerful, cross-platform tool that allows users to run OpenStudio based workflows on supported architectures such as Linux, Windows and Mac.

The graphical applications include the OpenStudio SketchUp Plug-in, OpenStudio Application, and the Parametric Analysis Tool. The SketchUp Plug-in and the Openstudio Application are maintained by the OpenStudio Coalition, which was founded to maintain and develop these graphical applications for the building energy modeling community. The SketchUp Plug-in is an extension to Trimble's popular SketchUp 3D modeling tool that allows users to quickly create geometry needed for EnergyPlus. Additionally, OpenStudio supports import of gbXML and IFC for geometry creation. The OpenStudio Application is a fully featured graphical interface to OpenStudio models including envelope, loads, schedules, and HVAC. ResultsViewer enables browsing, plotting, and comparing simulation output data, especially time series. The Parametric Analysis Tool enables studying the impact of applying multiple combinations of OpenStudio Measures to a base model as well as export of the analysis results for EDAPT submission.

https://openstudio.net/

OpenStudio


CBECC-Com & Web
Honeybee
simuwatt
COFFEE
DEnCity
EDAPT
IDEAKit
COMcheck
PAT
scout
OpenStudio Application
Asset Score
Sketchup Plug-in
OpenStudioServer
TPEx
C L O S
Applications
OpenStudio SDK
Building Component Library (BCL)
"Operating System"
Simulation Engines
Radiance

OpenStudio

- We will create the model in a few different ways:
  - ❑ OpenStudio Application
  - ❑ Rhino + Grasshopper + LBT
  - ❑ SketchUp + OpenStudio
  - ❑ Application Programming Interface (API)

OPENSTUDIO INSTALLATION

OpenStudio Installation

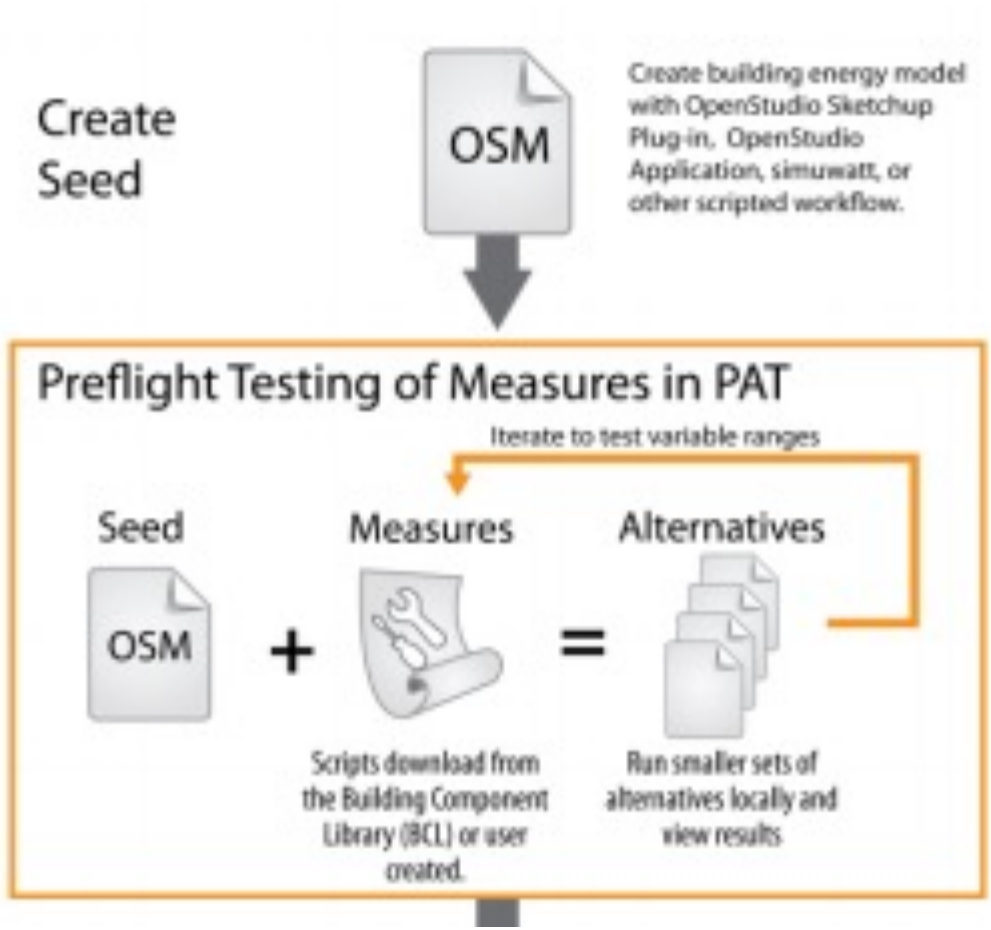
- OpenStudio Page: https://nrel.github.io/OpenStudio-user-documentation/

- OpenStudio videos (The SketchUP part now is using FloorSpaceJS): https://www.youtube.com/user/NRELOpenStudio/videos?flow=grid&sort=dd&view=0

- See existing questions or ask questions on unmethours: https://unmethours.com/questions/

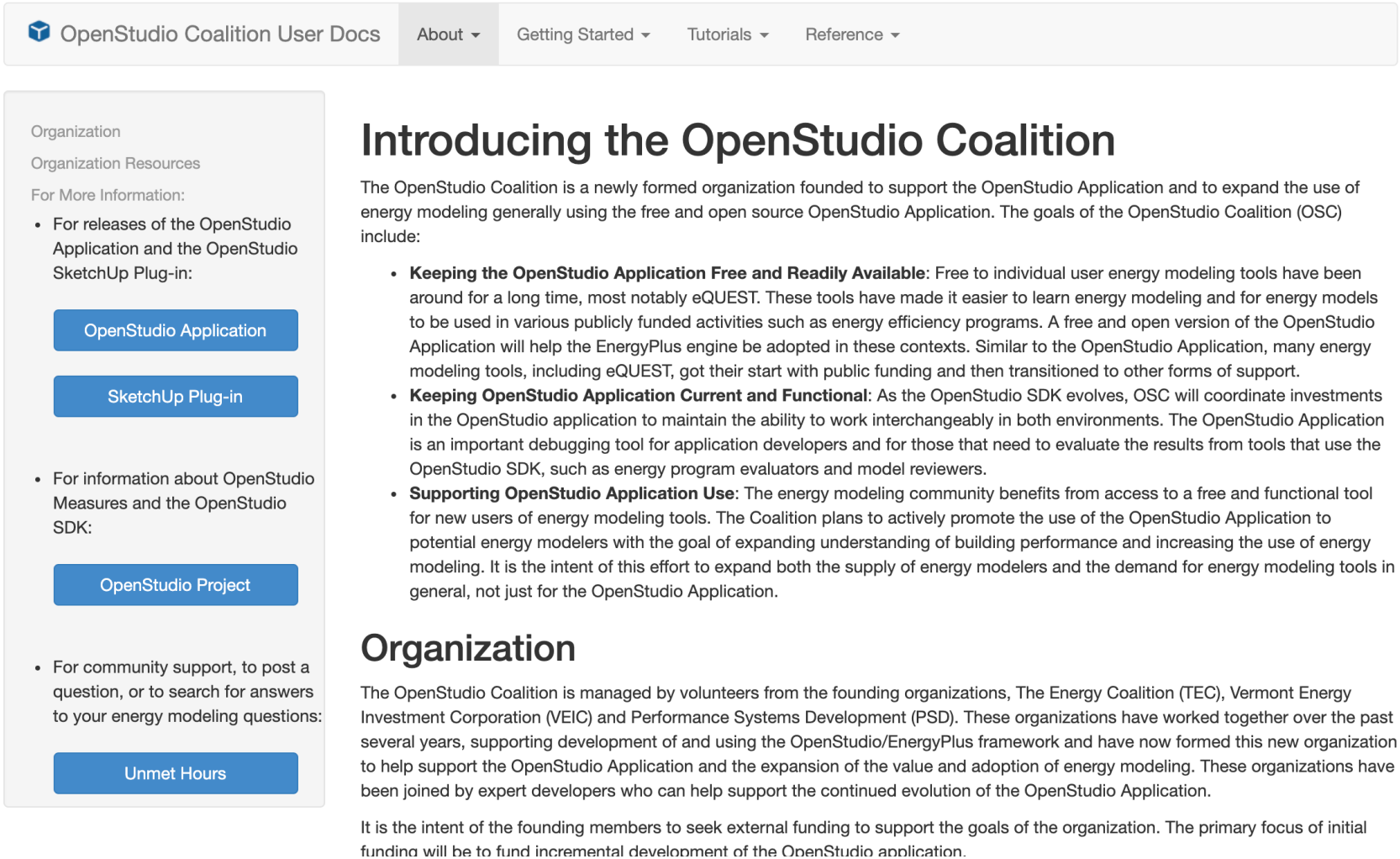
OpenStudio Installation

- Parametric Analysis Tool (PAT) allows installing different measures



https://nrel.github.io/OpenStudio-user-documentation/img/pdfs/graphical-tool-cloud-based.pdf

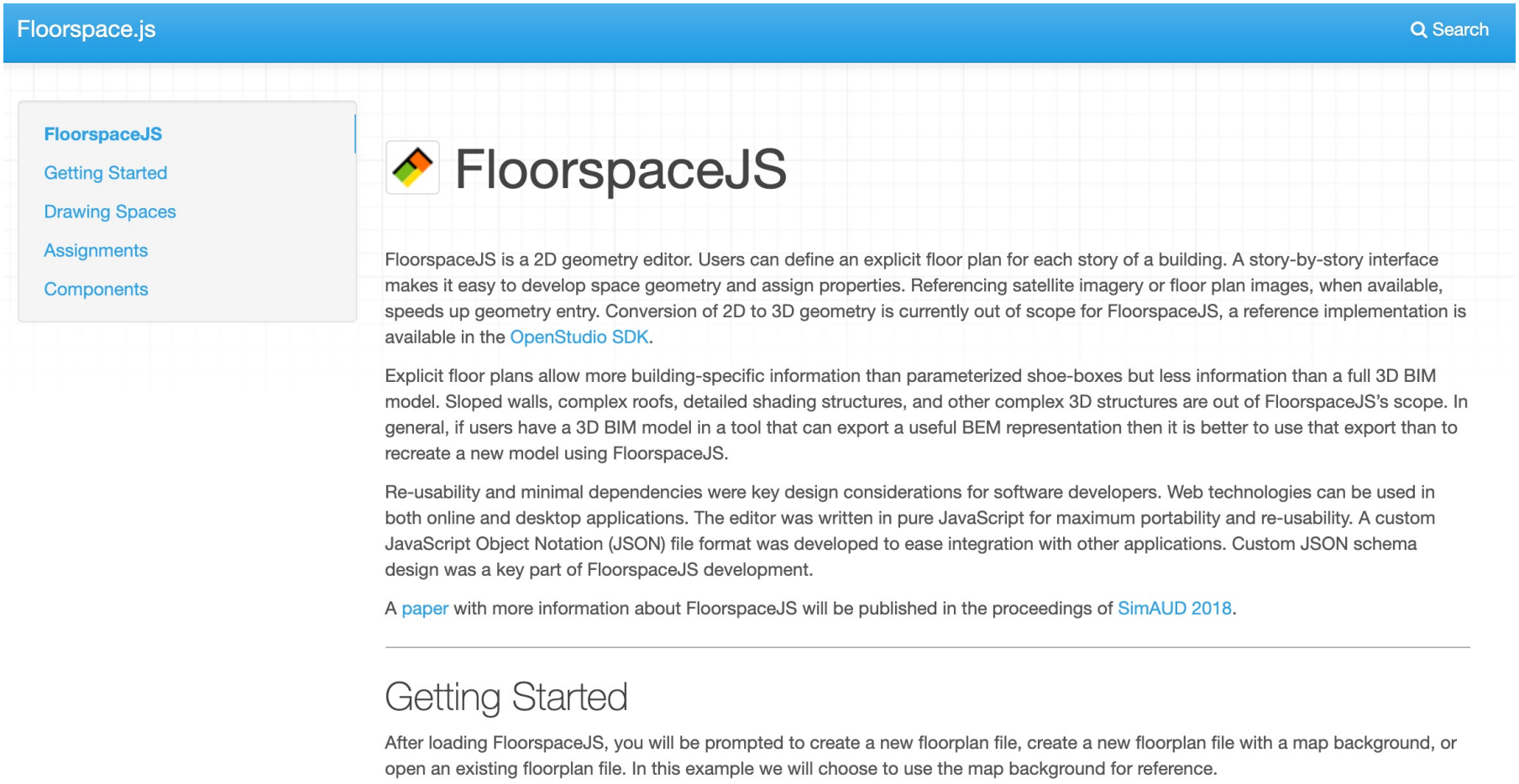
OpenStudio Installation



https://openstudiocoalition.org/about/openstudio_coalition/

OpenStudio Installation

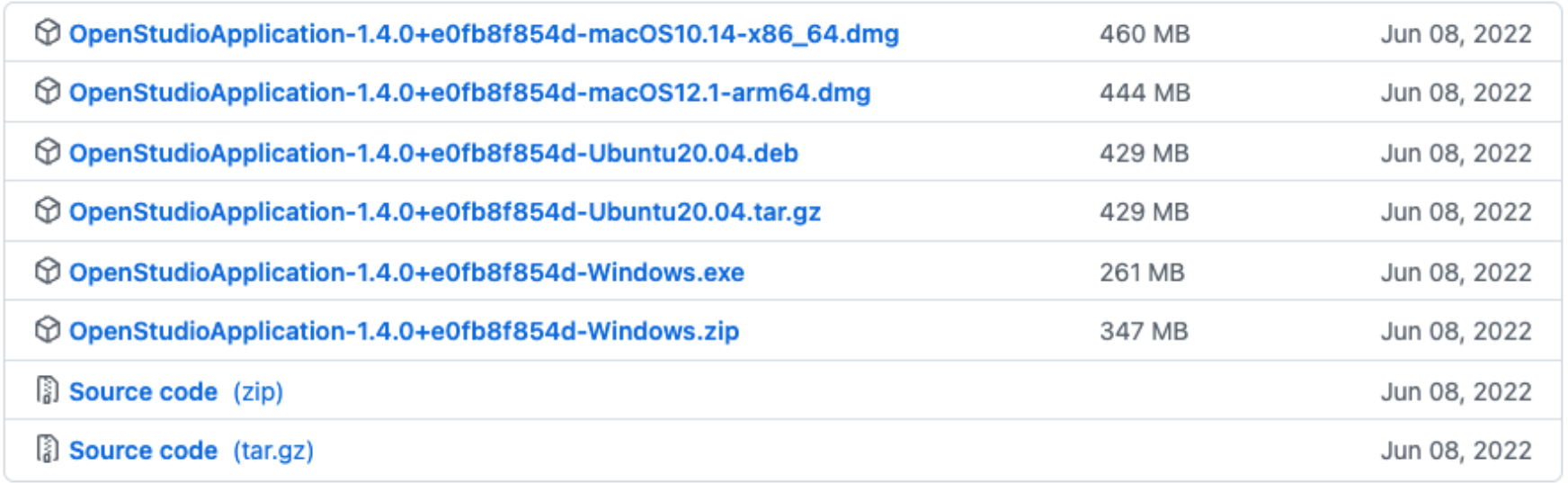
- Model creation using FloorSpaceJS:



https://nrel.github.io/floorspace.js/docs/

OpenStudio Installation

- Download Version 1.6.0 from this link (If you have the new version, that's fine, but you cannot use your model in the computer lab) :

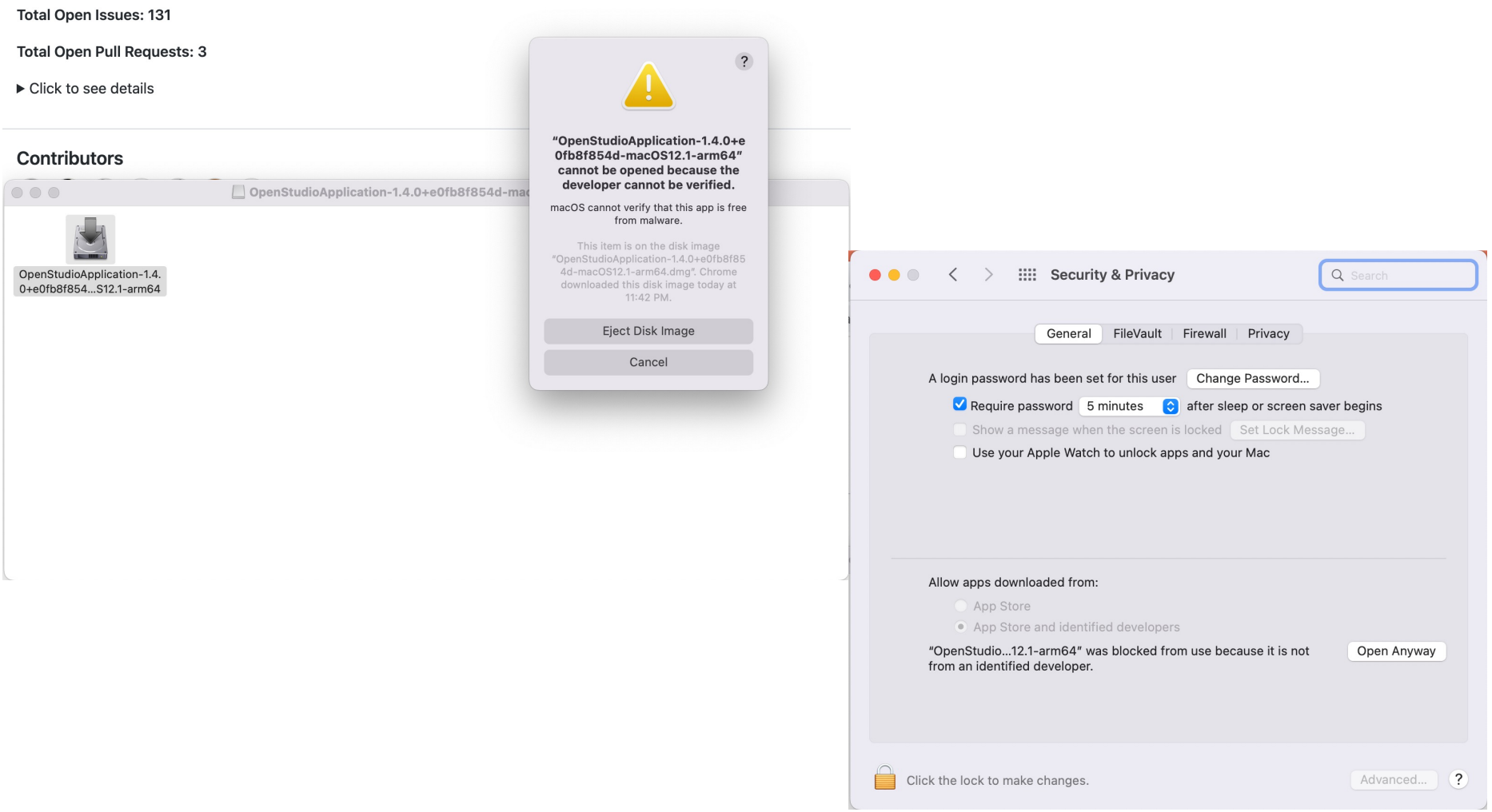


OpenStudioApplication-1.4.0+e0fb8f854d-macOS10.14-x86_64.dmg	460 MB	Jun 08, 2022
OpenStudioApplication-1.4.0+e0fb8f854d-macOS12.1-arm64.dmg	444 MB	Jun 08, 2022
OpenStudioApplication-1.4.0+e0fb8f854d-Ubuntu20.04.deb	429 MB	Jun 08, 2022
OpenStudioApplication-1.4.0+e0fb8f854d-Ubuntu20.04.tar.gz	429 MB	Jun 08, 2022
OpenStudioApplication-1.4.0+e0fb8f854d-Windows.exe	261 MB	Jun 08, 2022
OpenStudioApplication-1.4.0+e0fb8f854d-Windows.zip	347 MB	Jun 08, 2022
Source code (zip)		Jun 08, 2022
Source code (tar.gz)		Jun 08, 2022

https://github.com/openstudiocoalition/OpenStudioApplication/releases/tag/v1.6.0

OpenStudio Installation

- In case you are using Mac, you might see this message when you click on the installer:



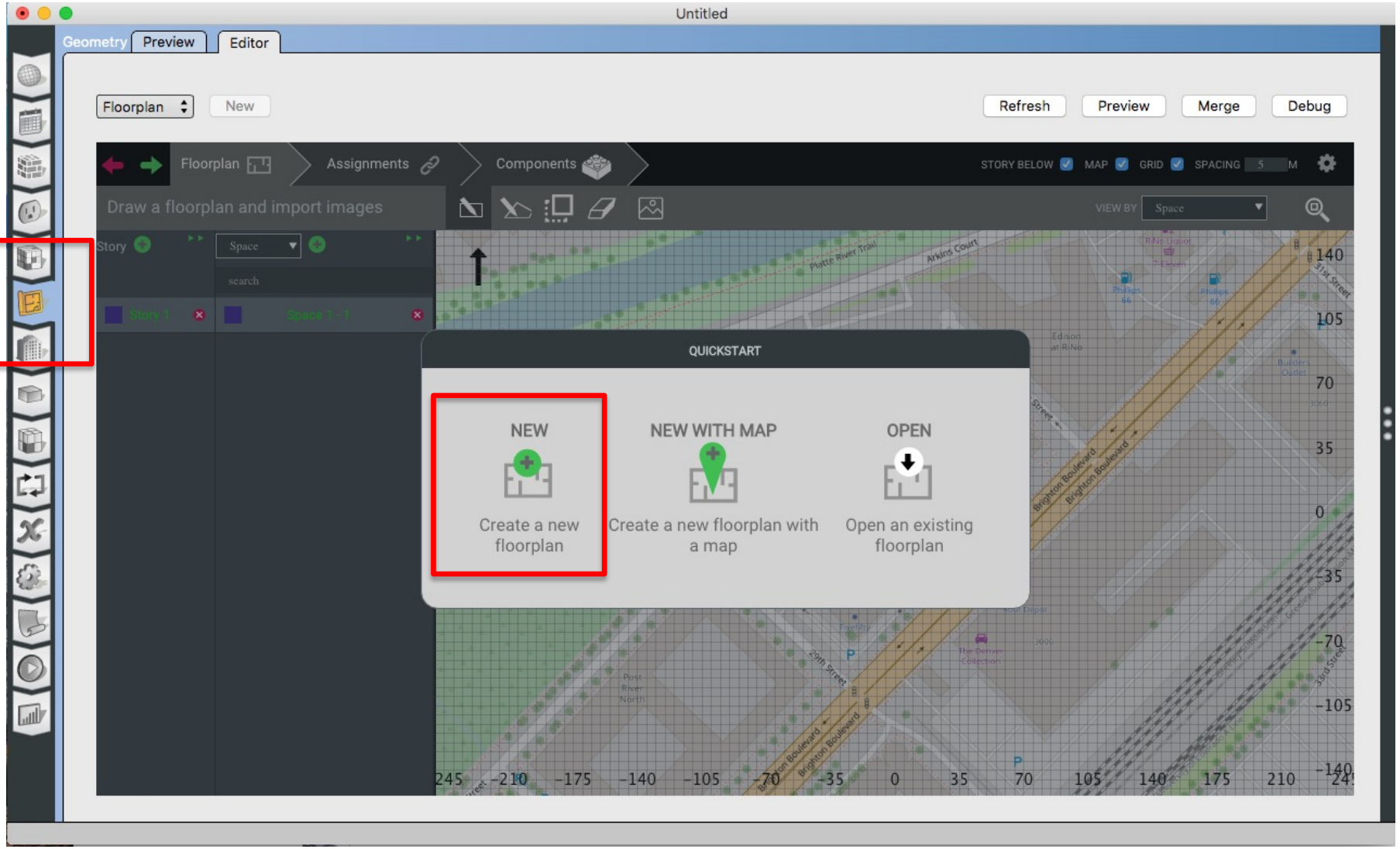
OpenStudio Installation

- Download weather data files
  - ❑ Download files from:
    1. EnergyPlus: https://energyplus.net/weather
    2. One Building: http://climate.onebuilding.org/WMO_Region_4_North_and_Central_America/USA_United_States_of_America/index.html
    3. Ladybug Tools: https://www.ladybug.tools/epwmap/

CREATE GEOMETRY

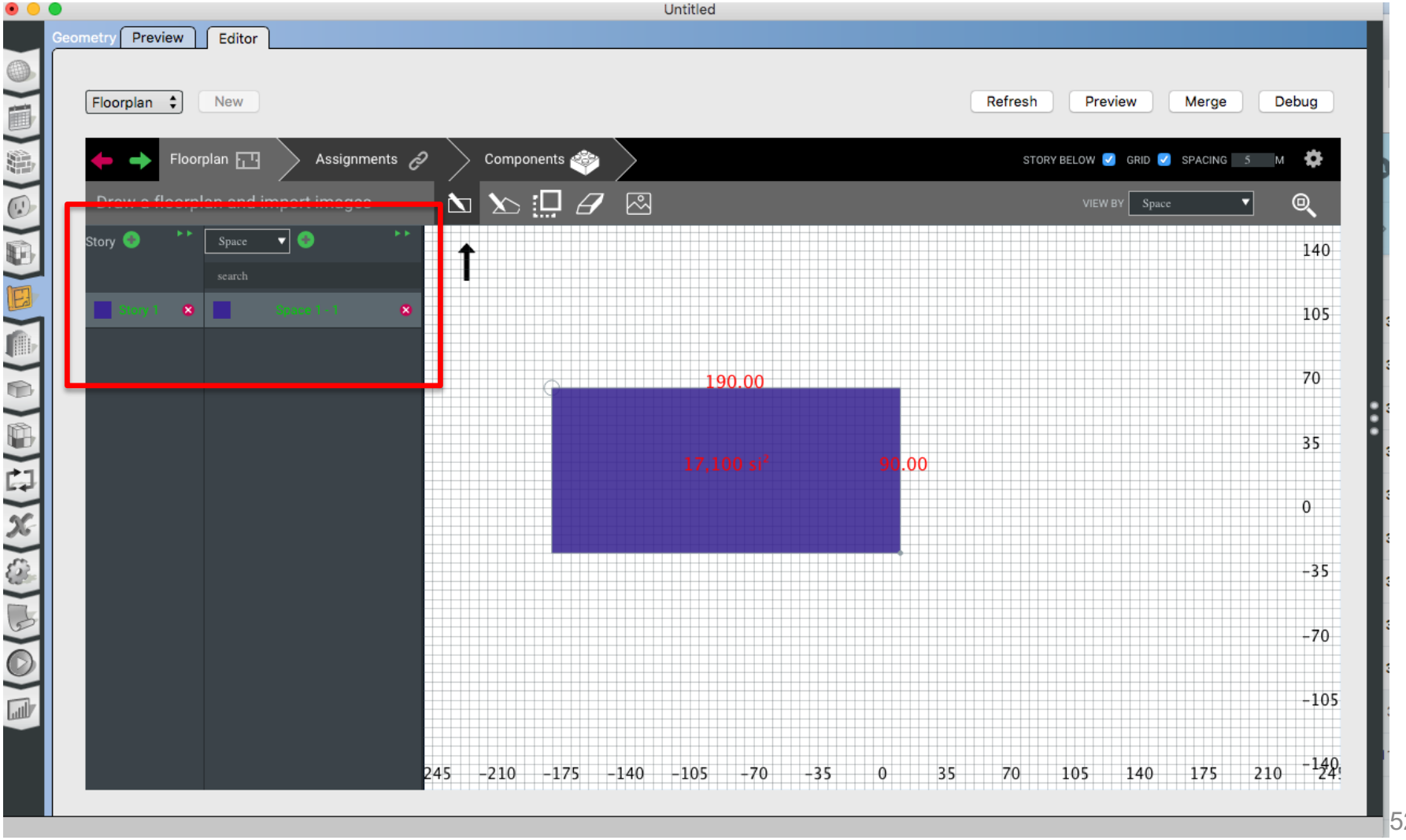
OpenStudio Training

- Step 1: Create or Import Floor Plan



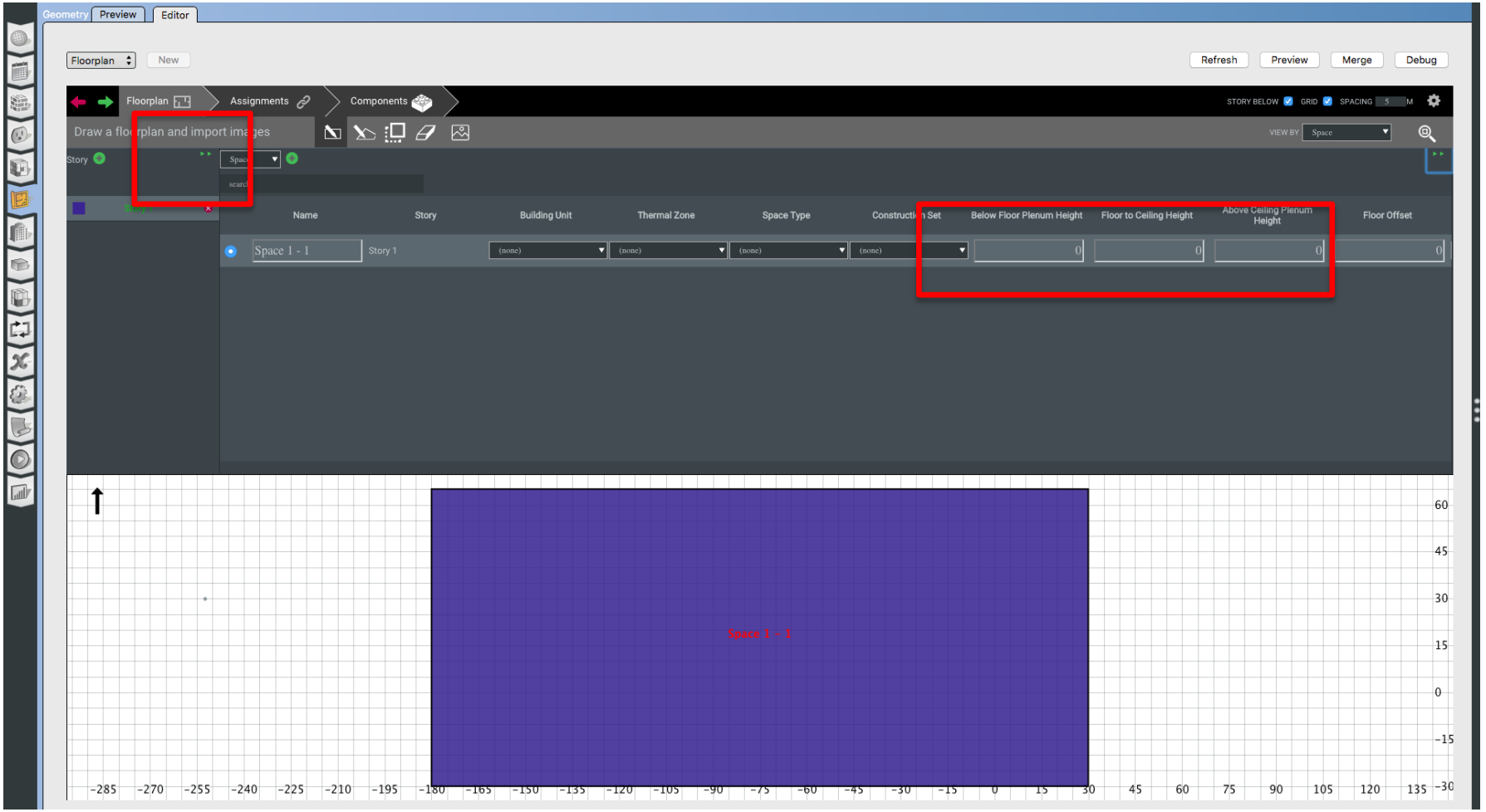
OpenStudio Training

- Step 2: Add Spaces and Stories



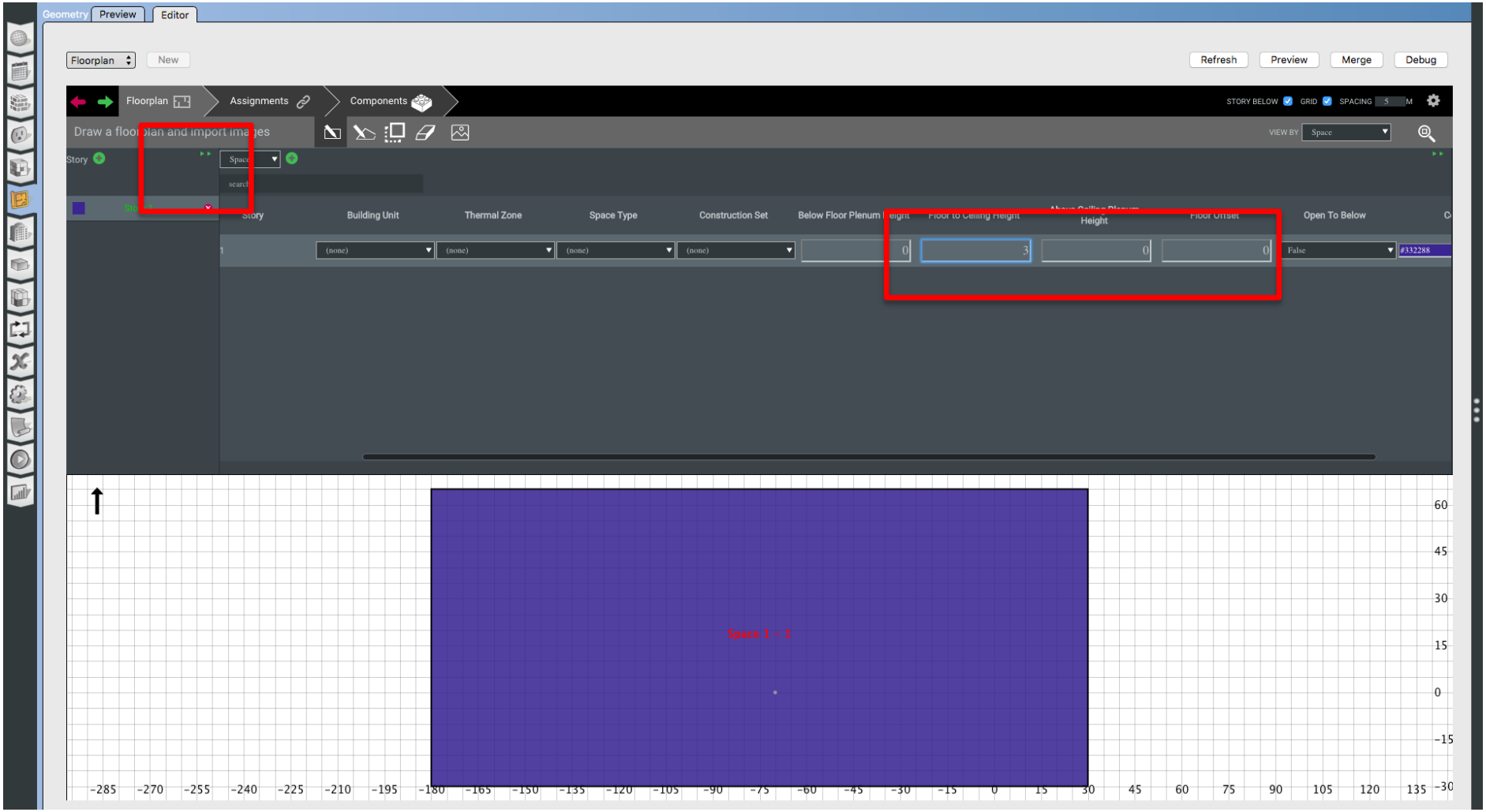
OpenStudio Training

- Step 3: Add the height



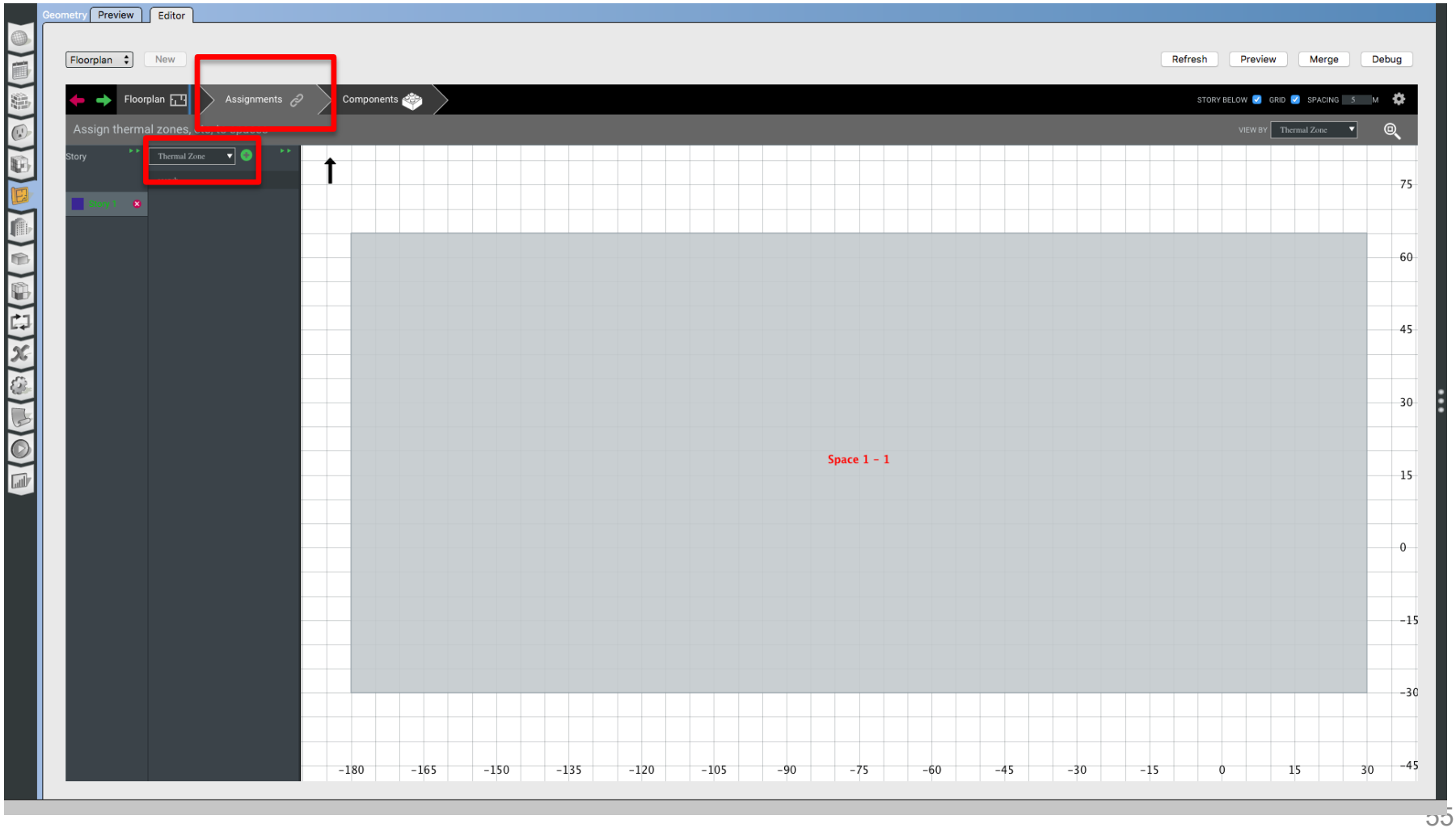
OpenStudio Training

- Step 3: Add the height



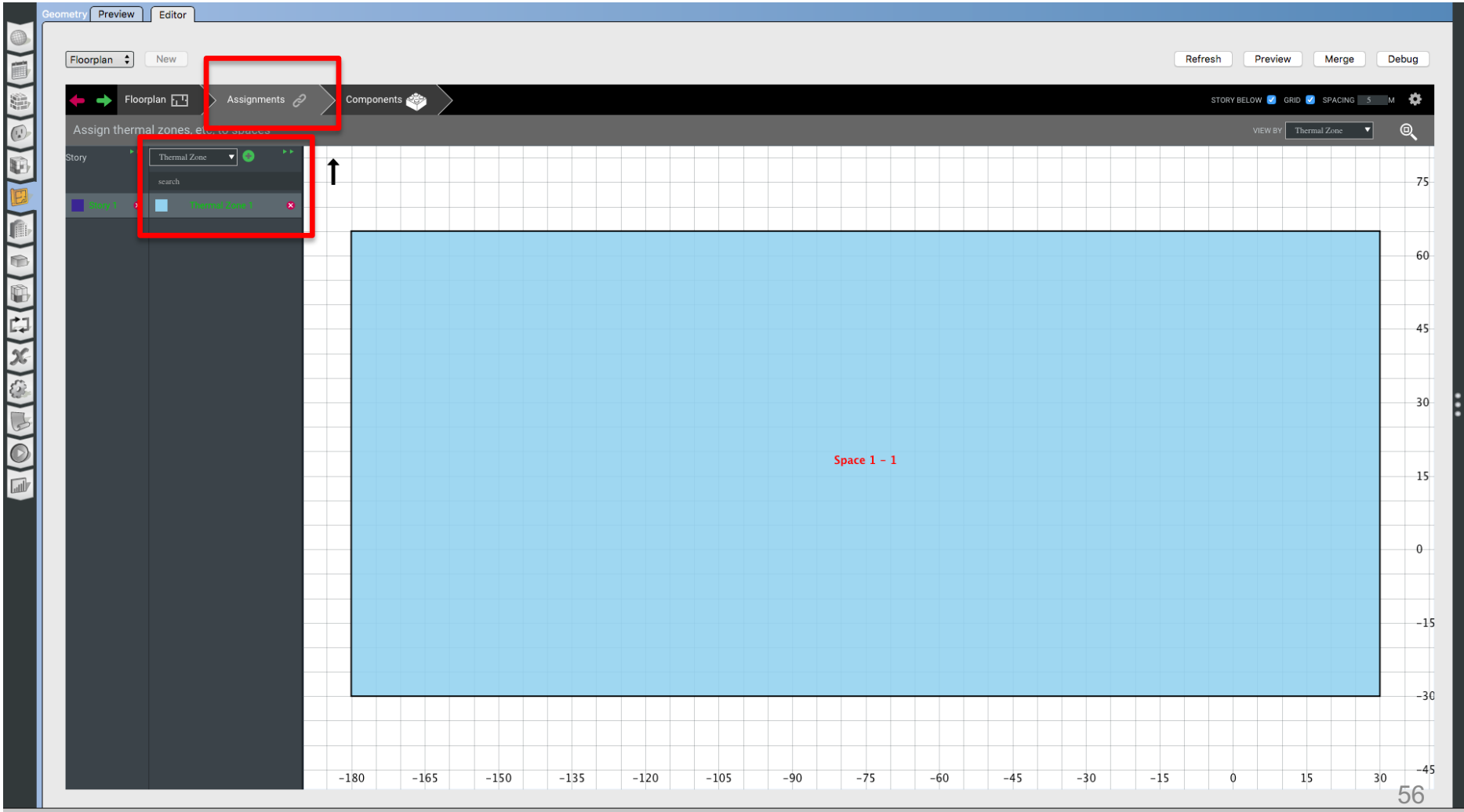
OpenStudio Training

- Step 4: Add Thermal Zone(s)



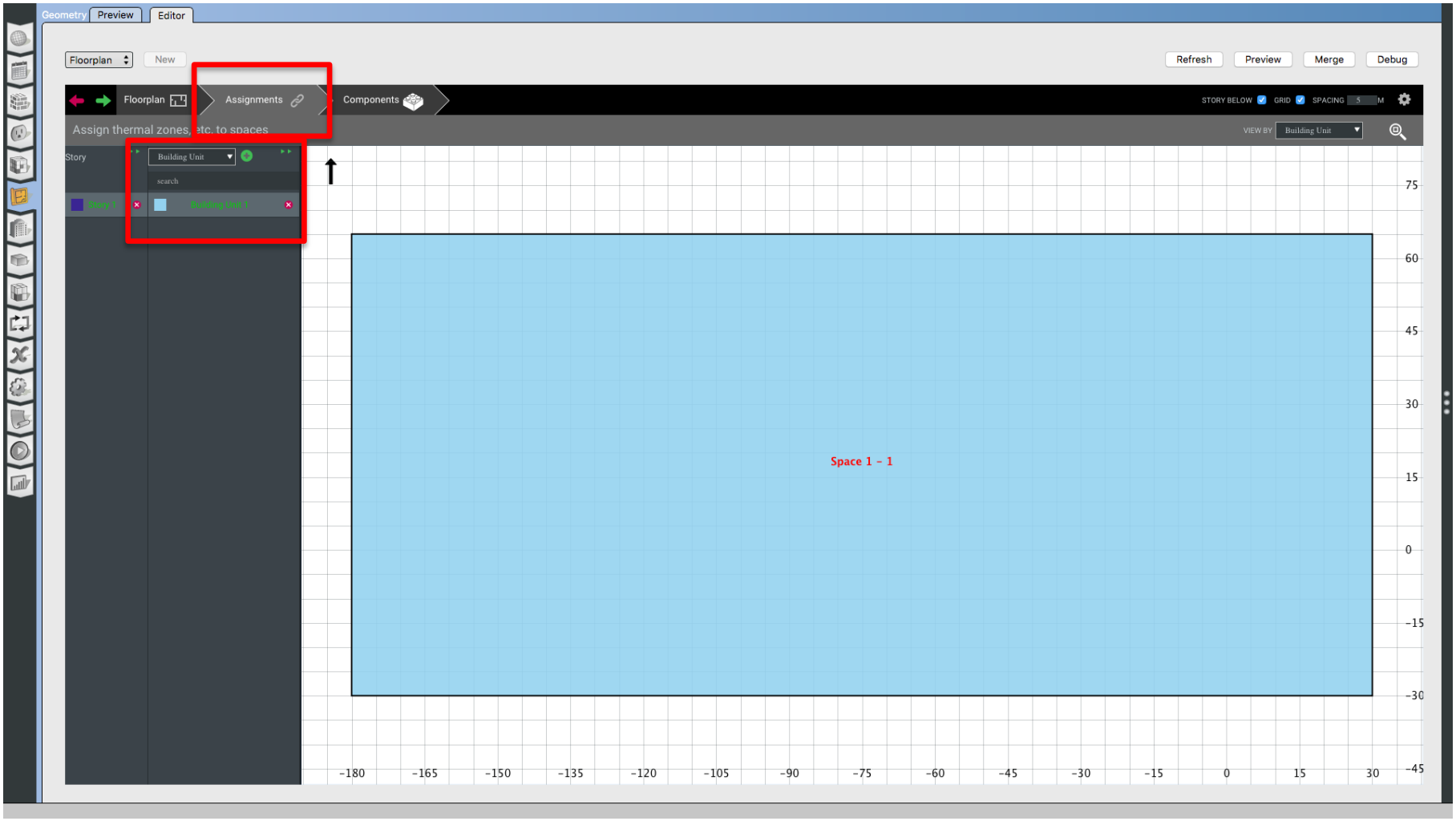
OpenStudio Training

- Step 4: Add Thermal Zone(s)



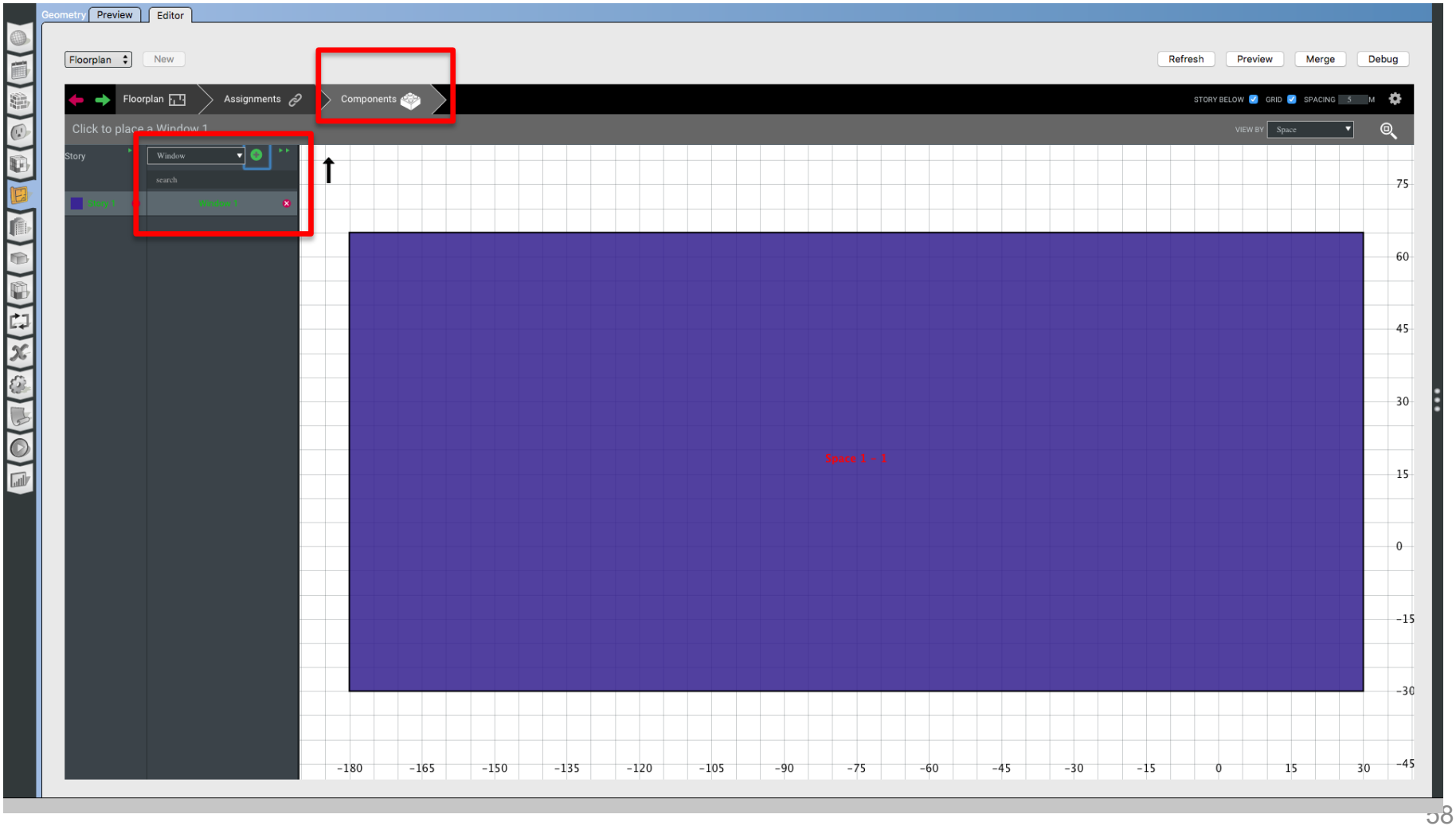
OpenStudio Training

- Step 5: Add Building Unit



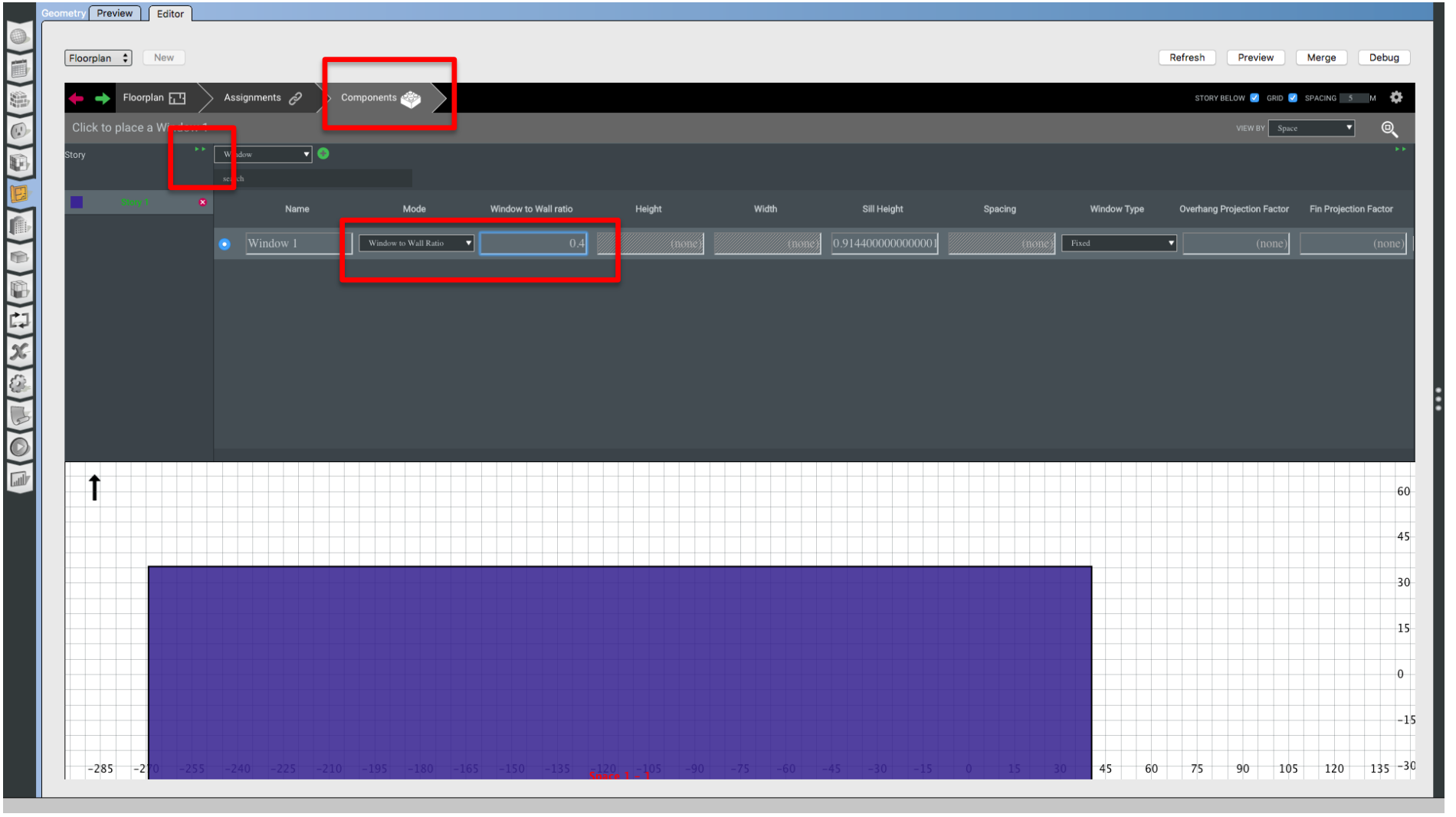
OpenStudio Training

- Step 6: Add Windows (WWR or Individual)



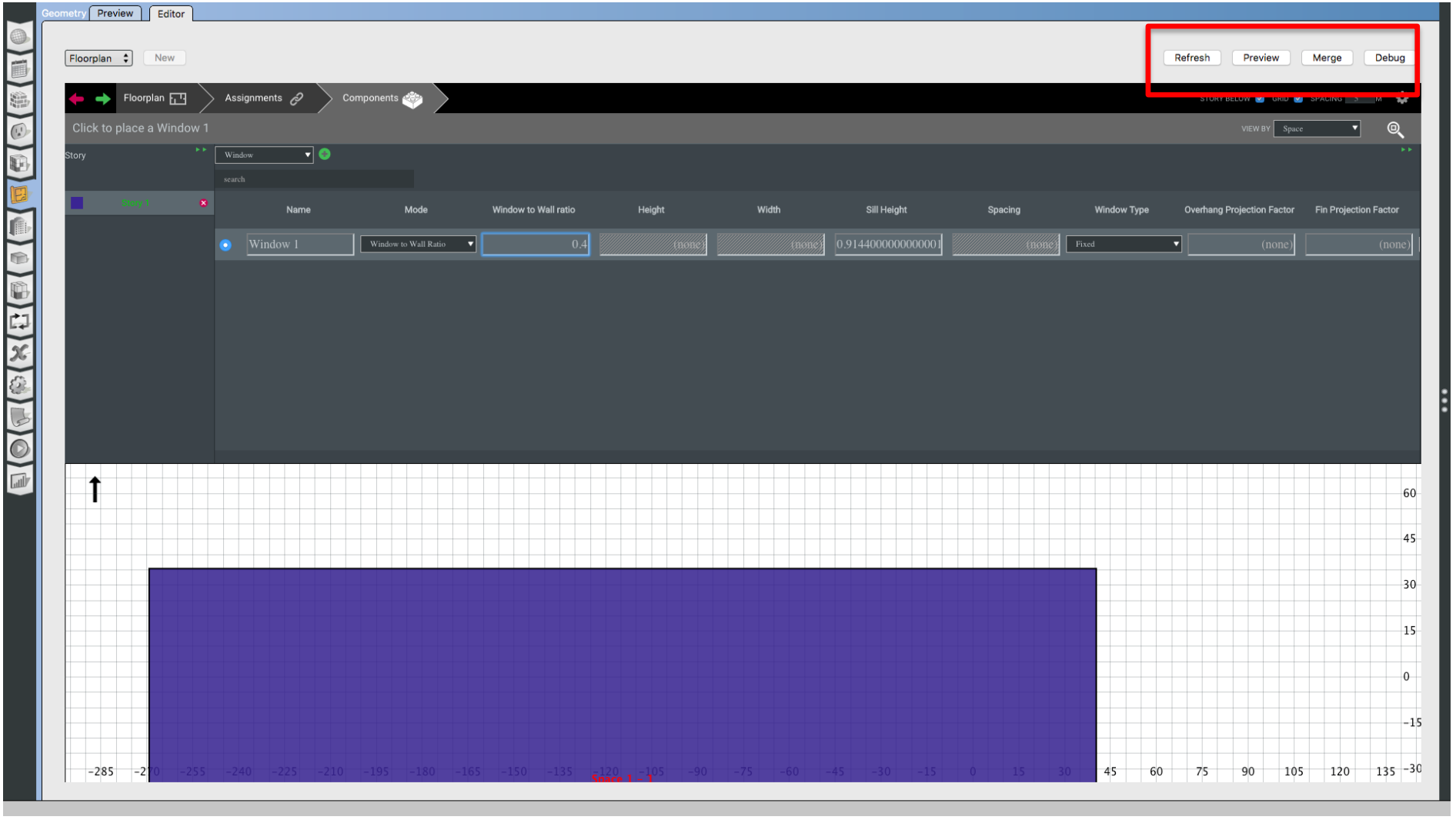
OpenStudio Training

- Step 6: Add Windows (WWR or Individual)



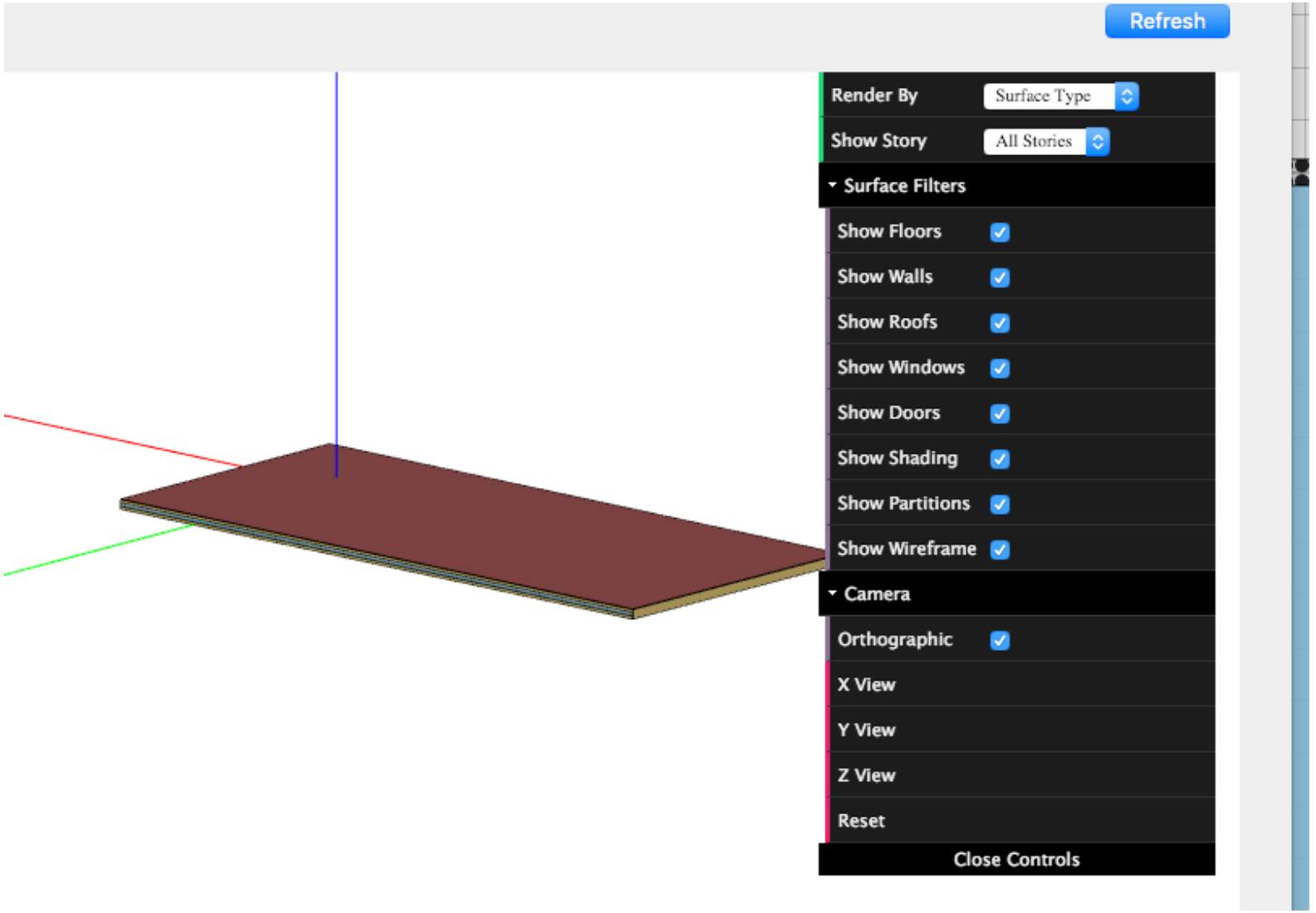
OpenStudio Training

- Step 7: Merge & Preview



OpenStudio Training

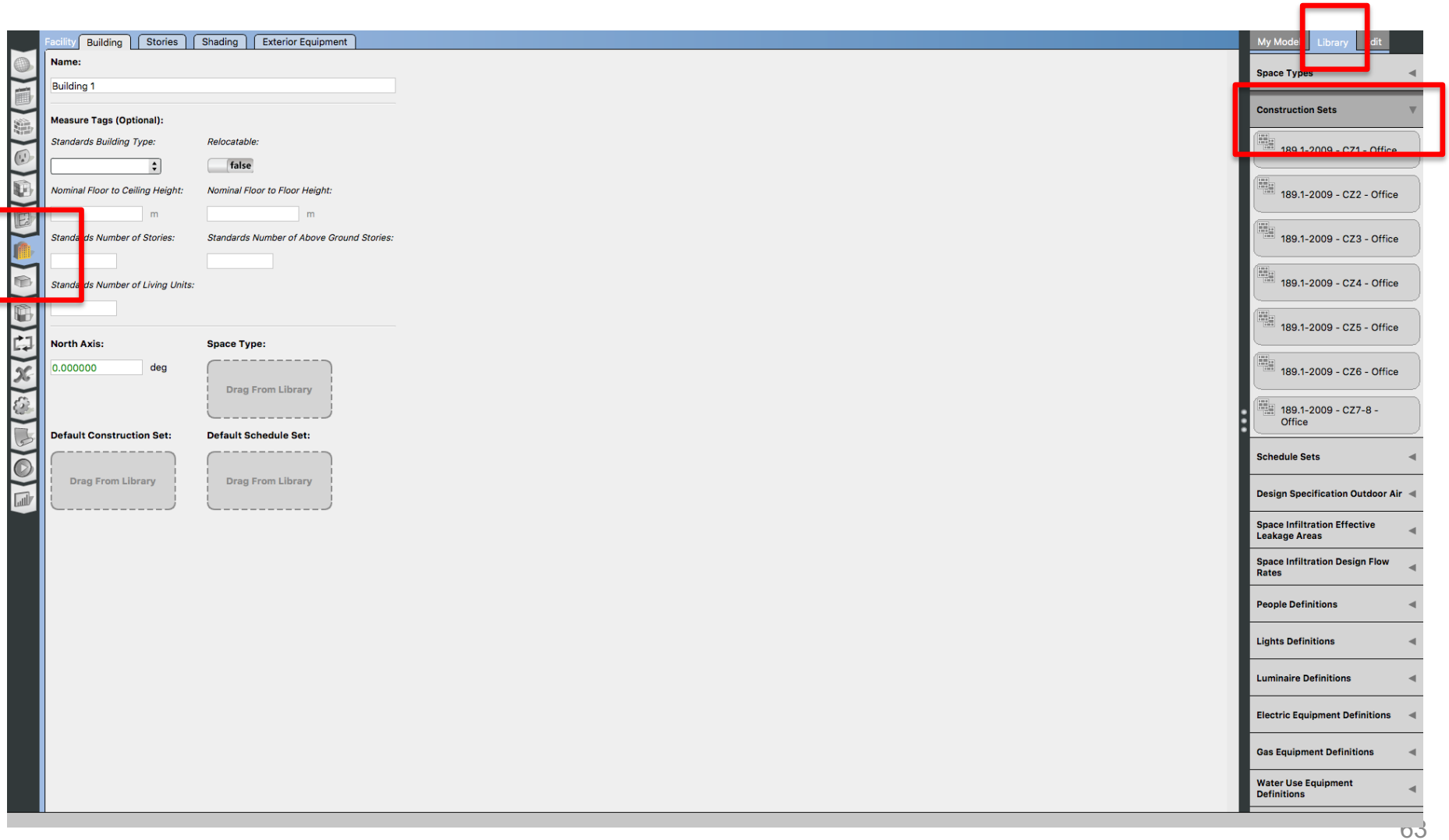
- Step 7: Merge & Preview



ADD DEFAULT VALUES TO TEST THE MODEL

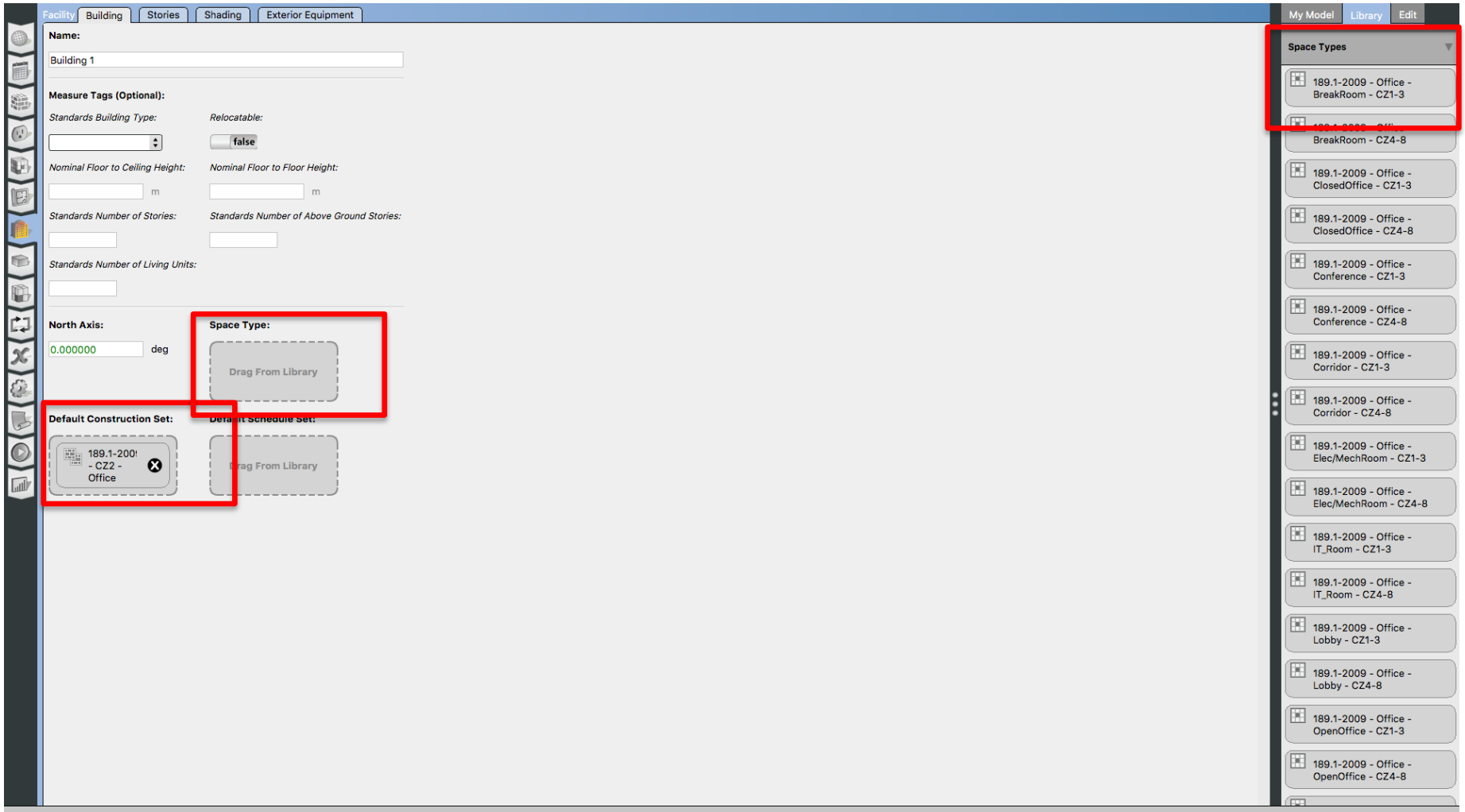
OpenStudio Training

- Step 8: Add Default Values



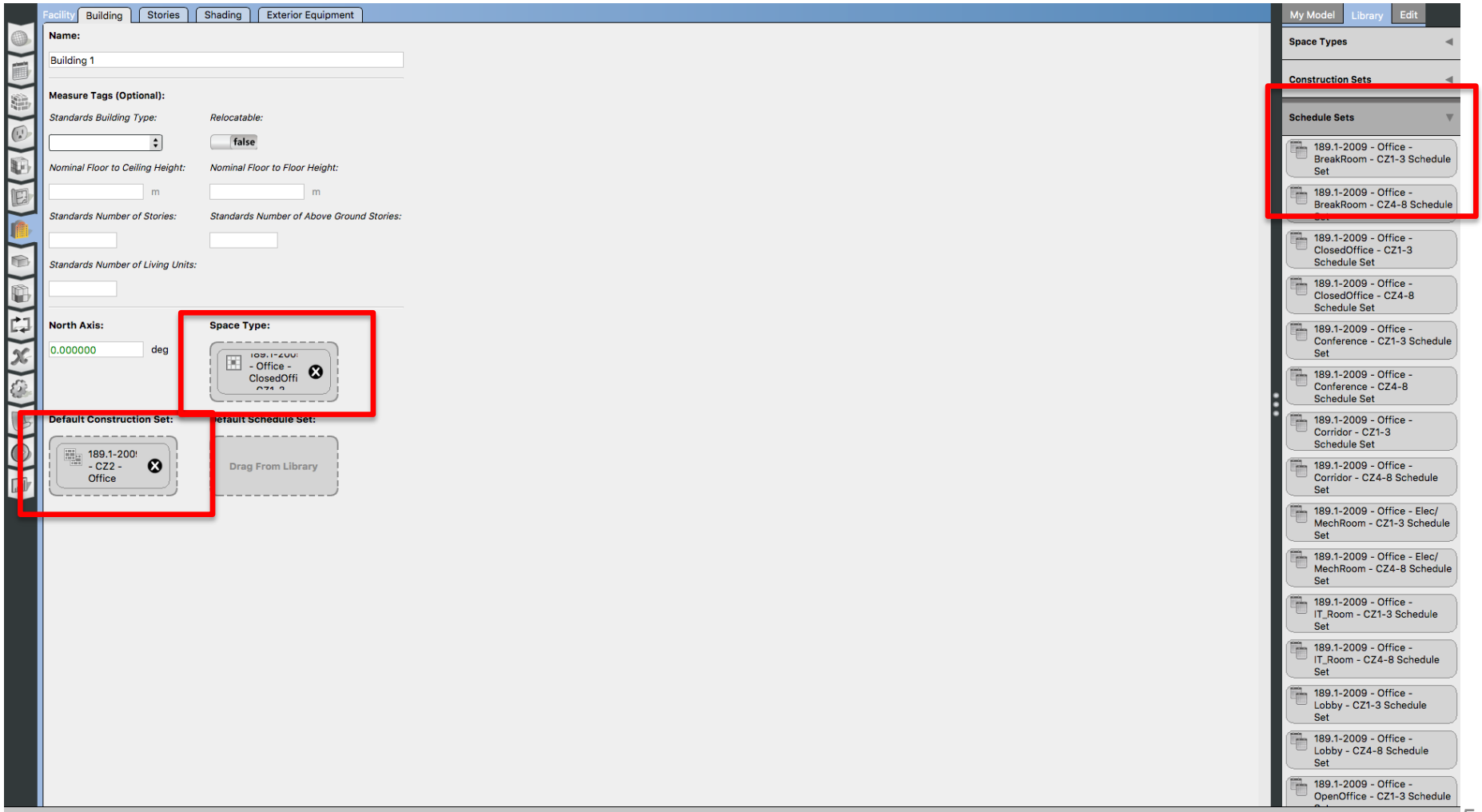
OpenStudio Training

- Step 8: Add Default Values



OpenStudio Training

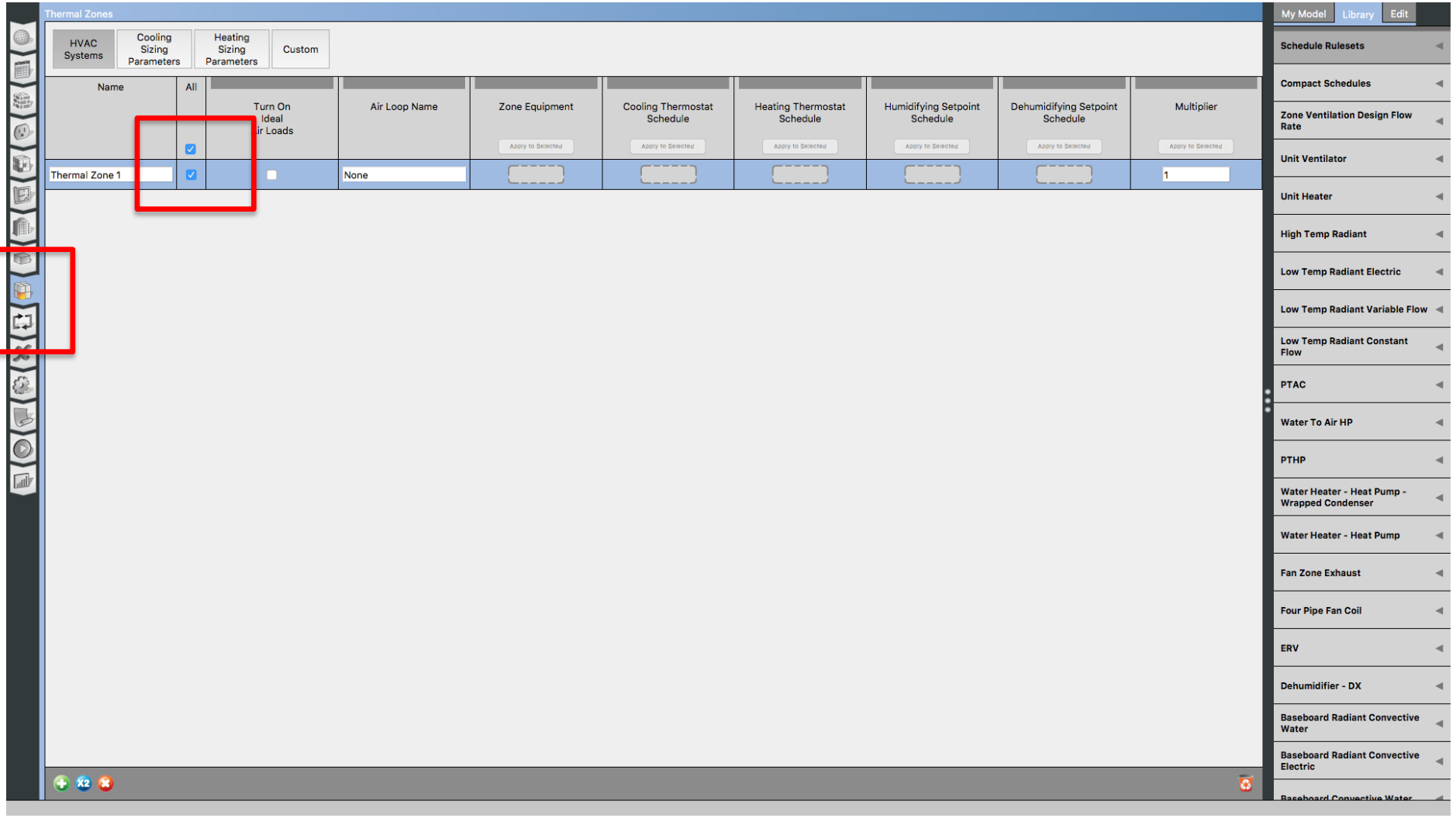
- Step 8: Add Default Values



TEST MODEL WITH IDEAL AIR LOOP

OpenStudio Training

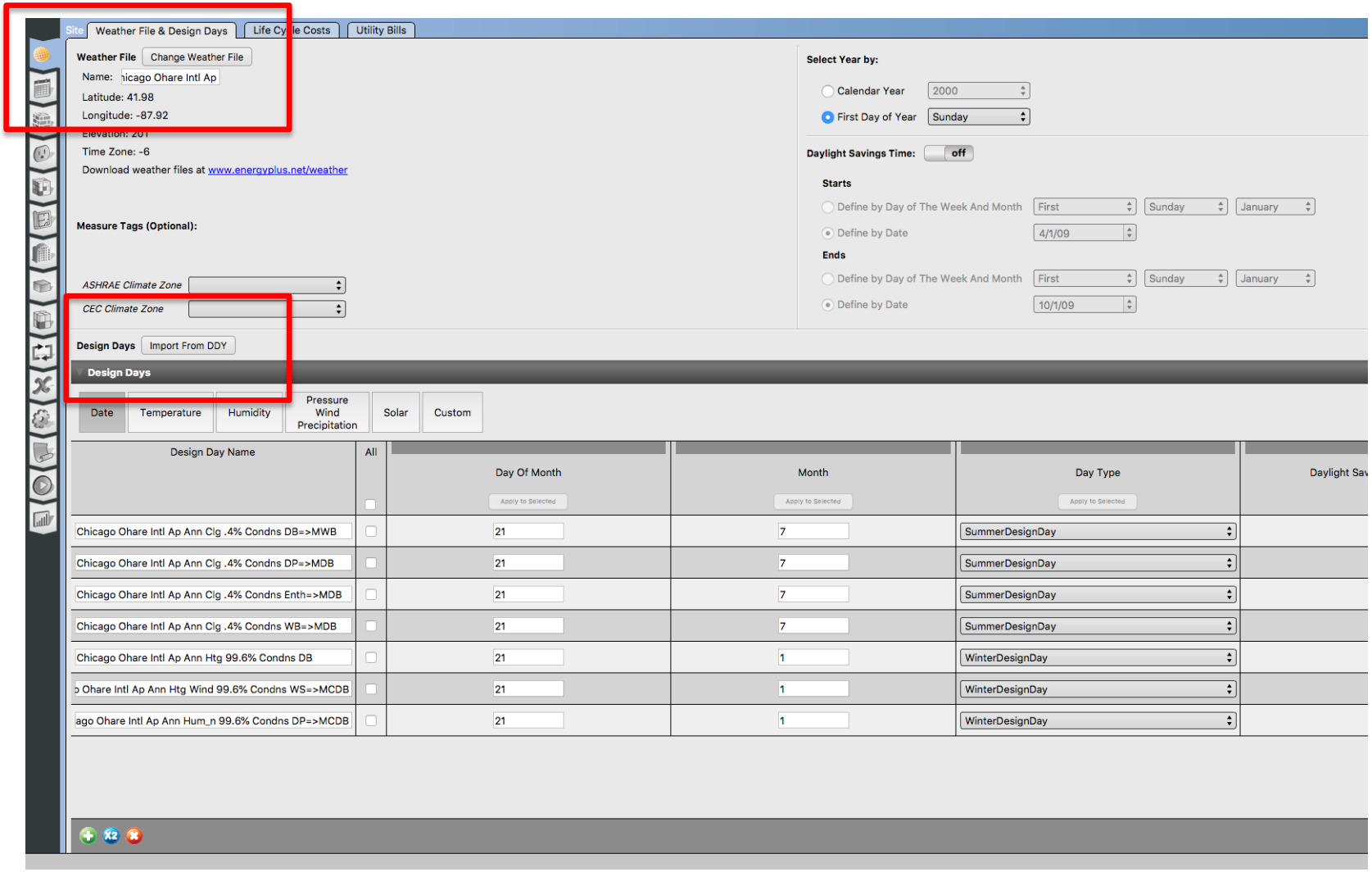
- Step 9: Run Ideal Air Loop



ADD WEATHER DATA

OpenStudio Training

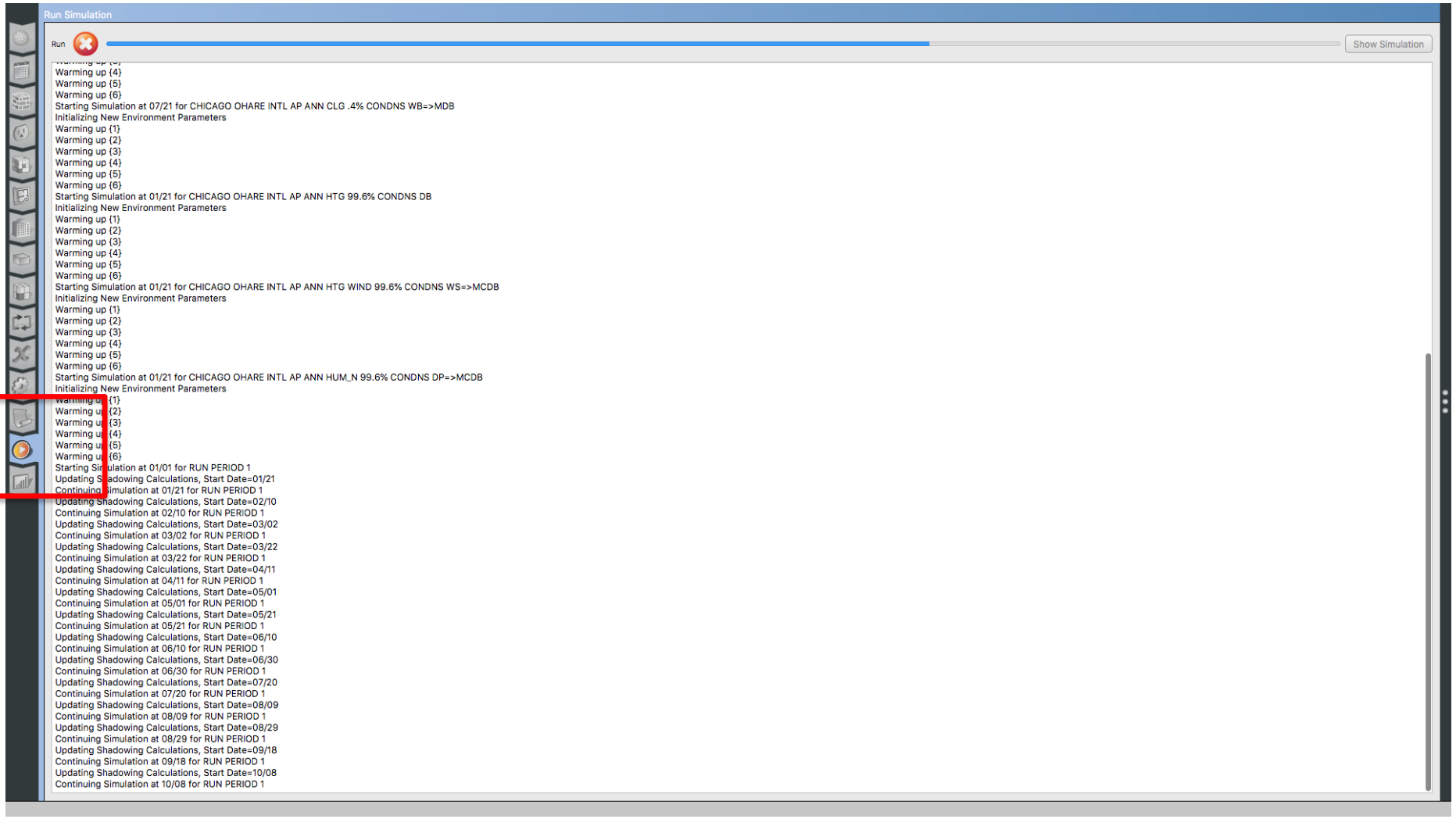
- Step 10: Add Weather Data Files



RUN MODEL

OpenStudio Training

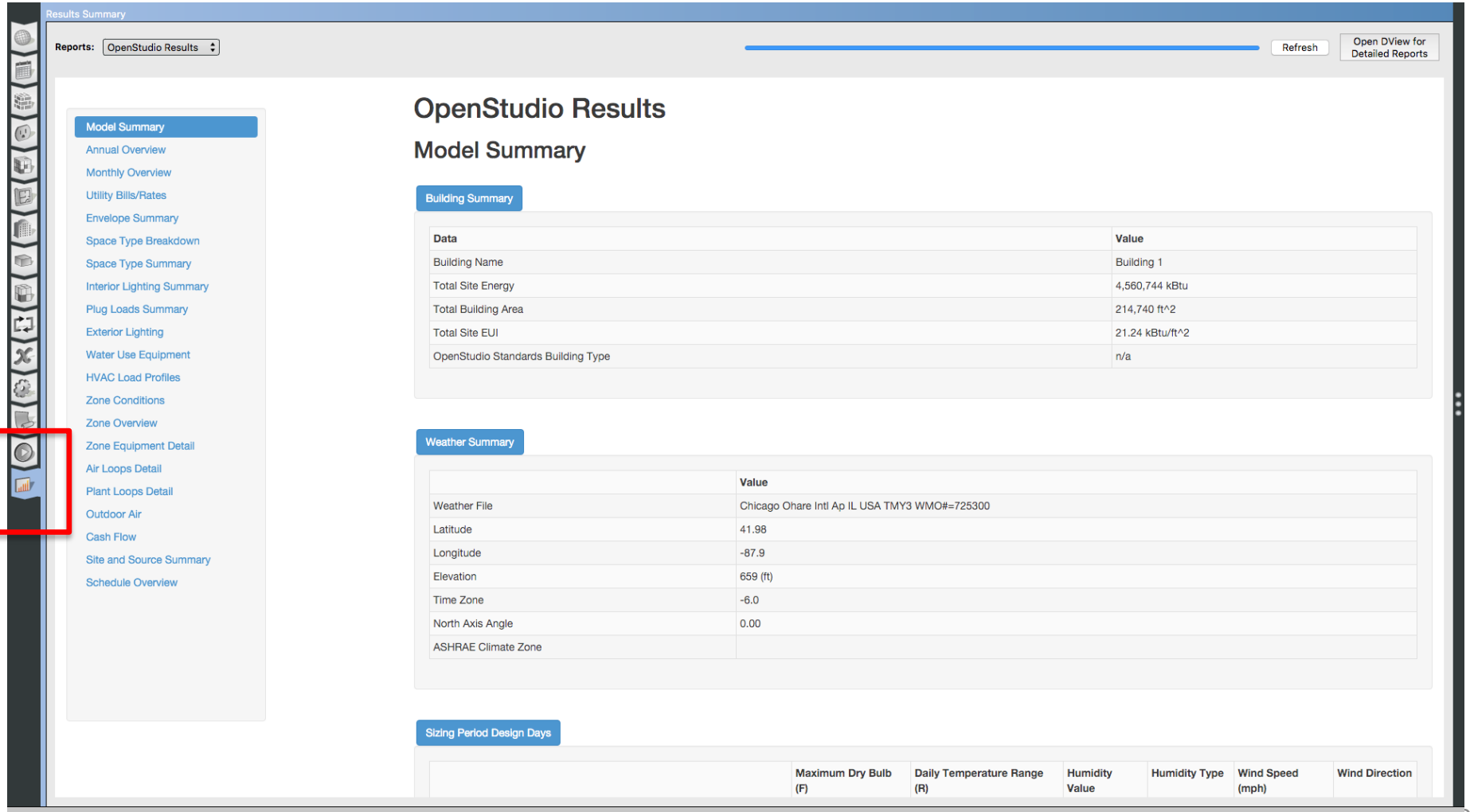
- Step 11: Run the Model



VISIT RESULTS

OpenStudio Training

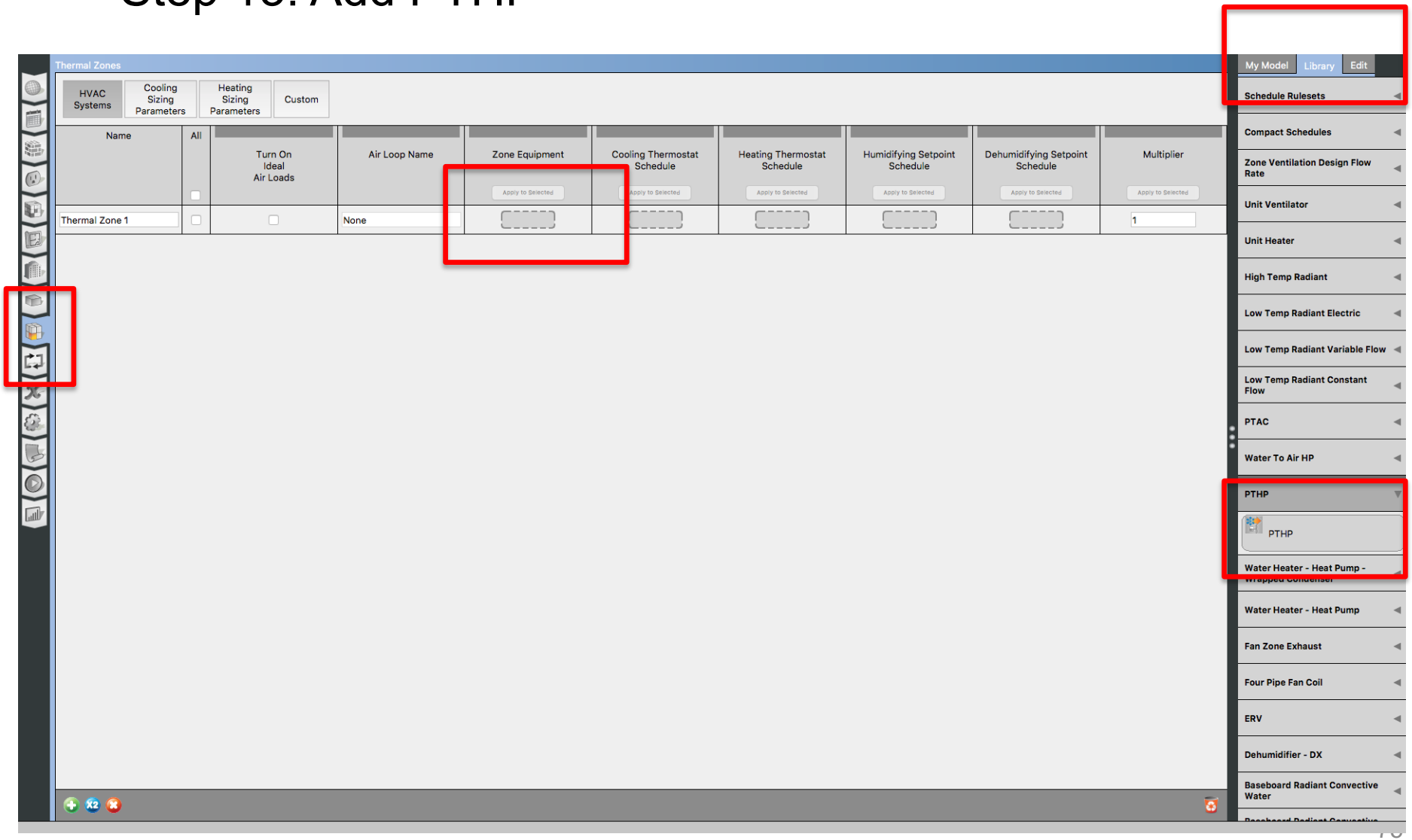
- Step 12: Visualize the Results



TEST A ZONE LEVEL HVAC SYSTEM

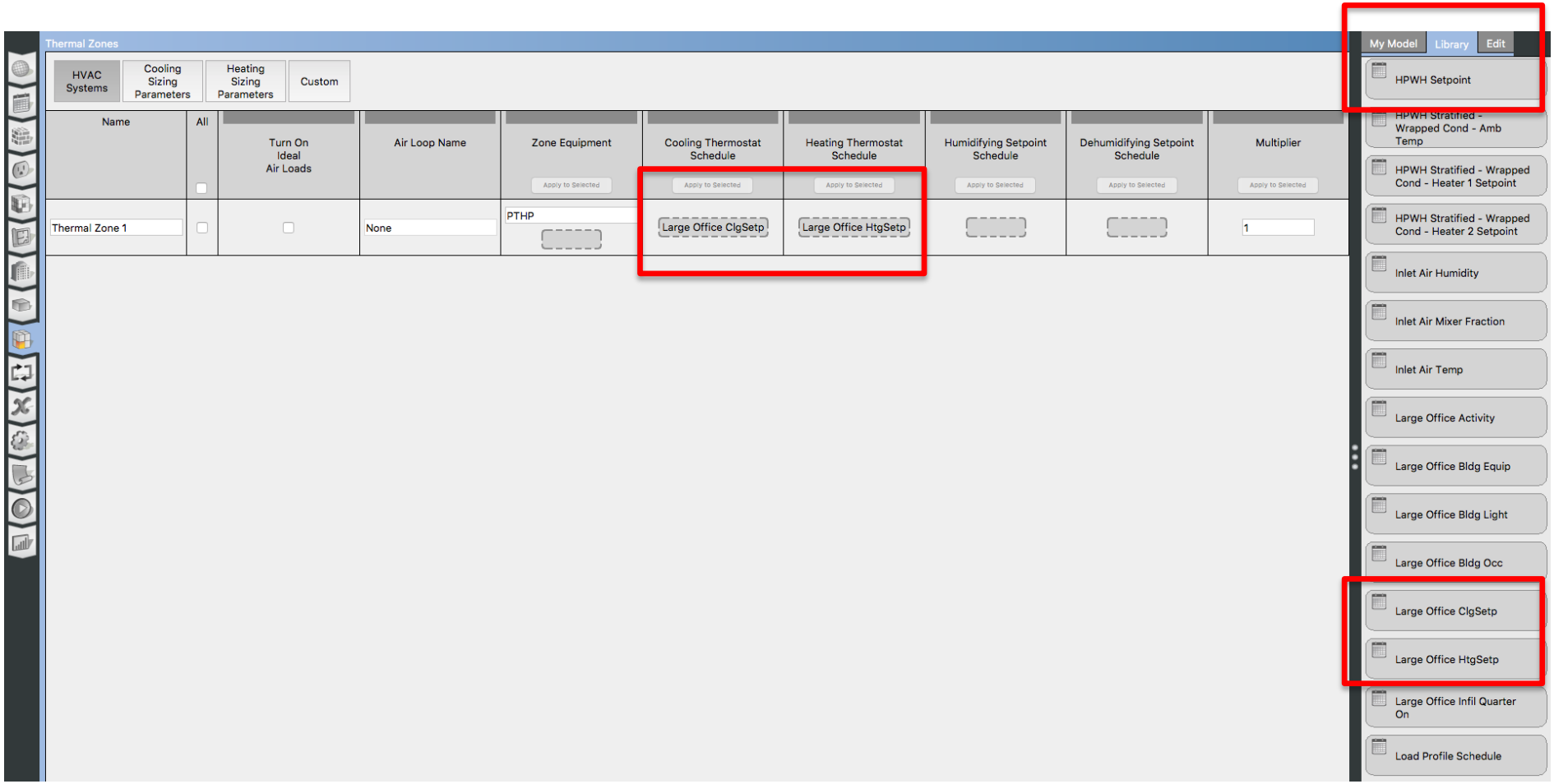
OpenStudio Training

- Step 13: Add PTHP



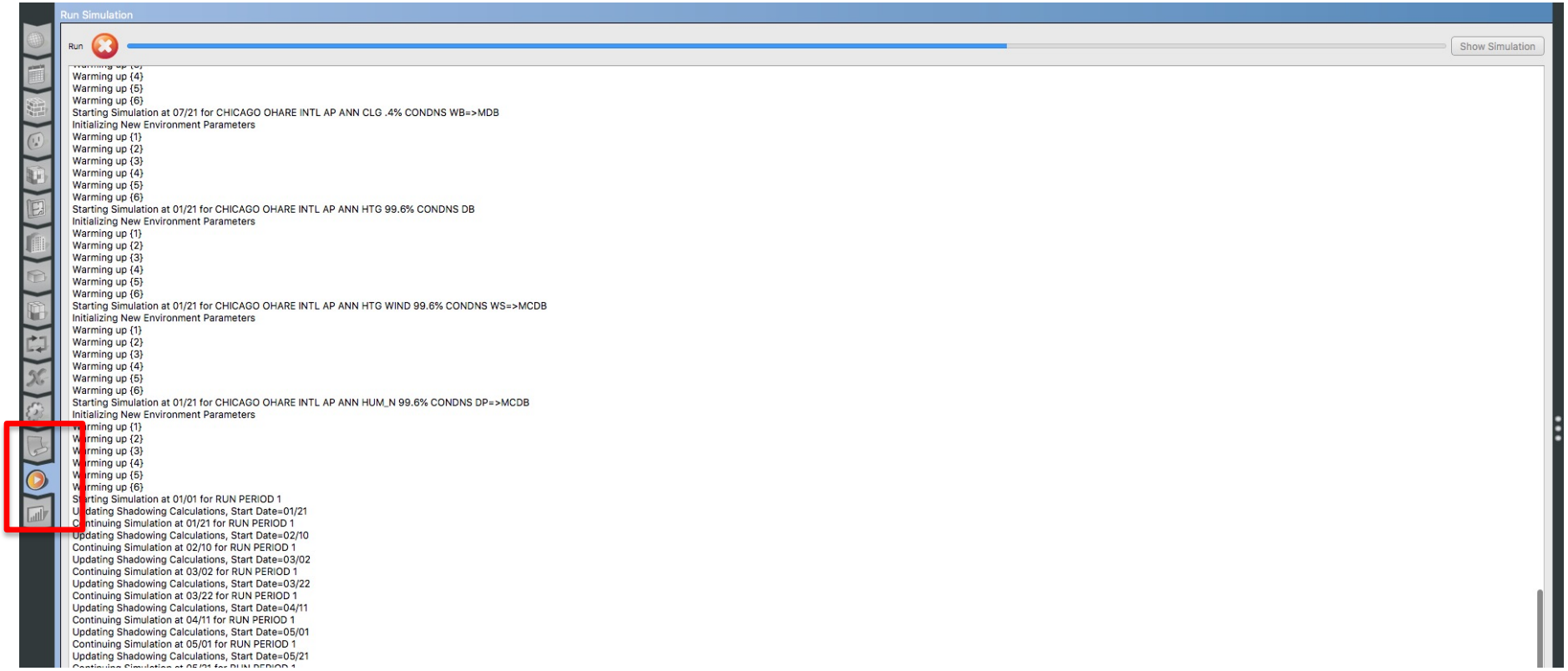
OpenStudio Training

- Step 13: Add heating and cooling setpoints



OpenStudio Training

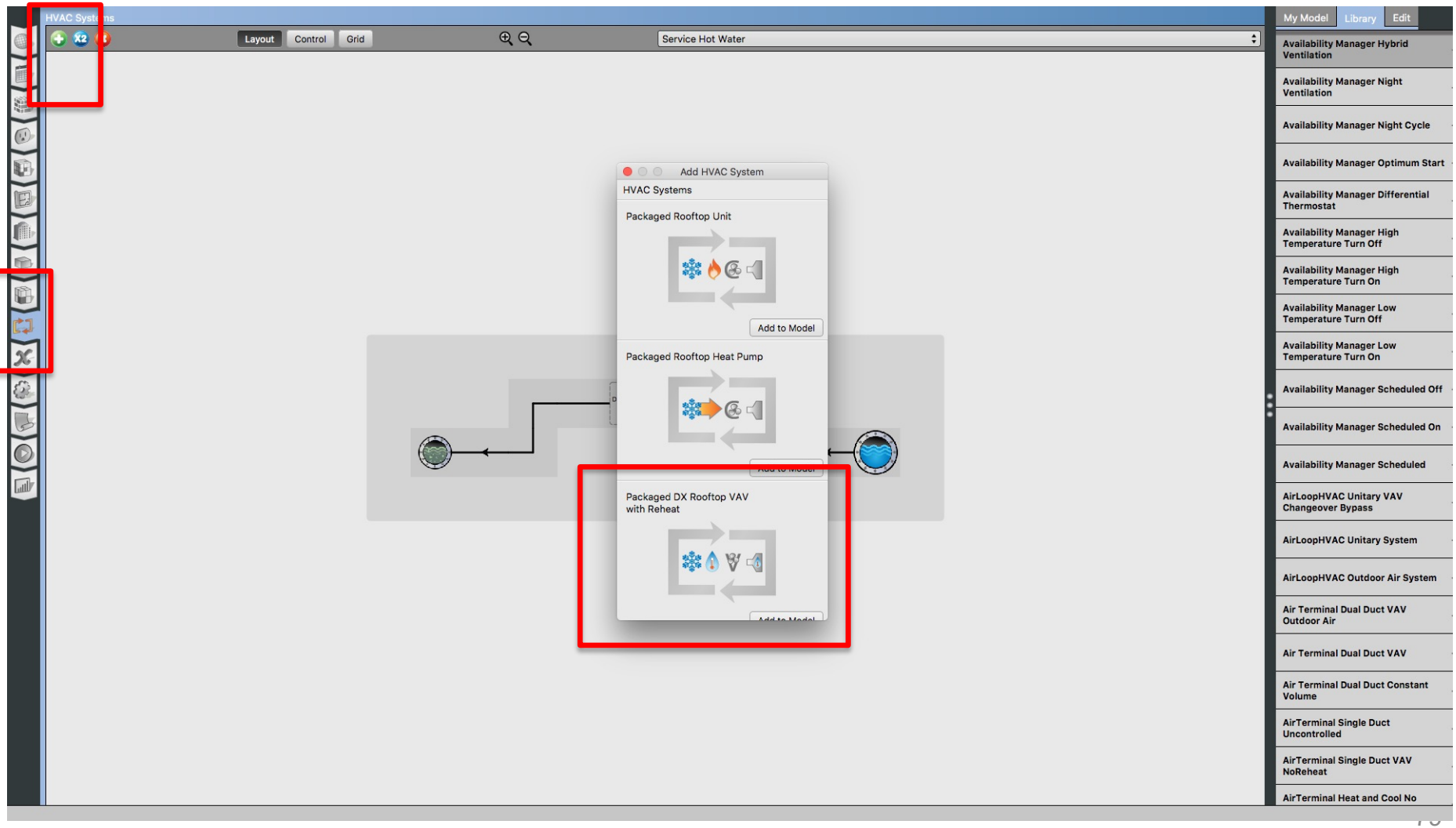
- Step 14: Run the Model



TEST A LOOP HVAC SYSTEM

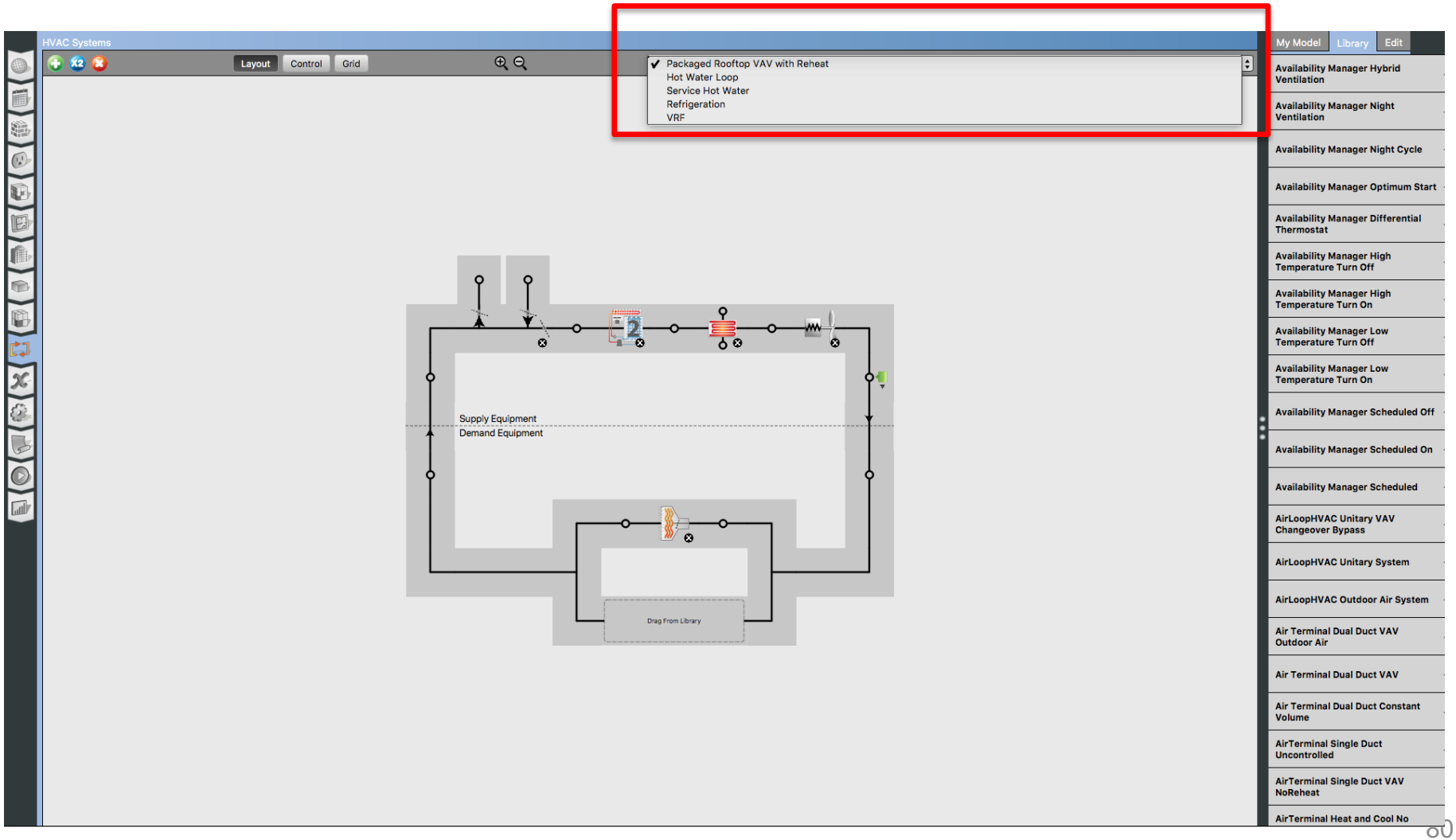
OpenStudio Training

- Step 15: Add System #5



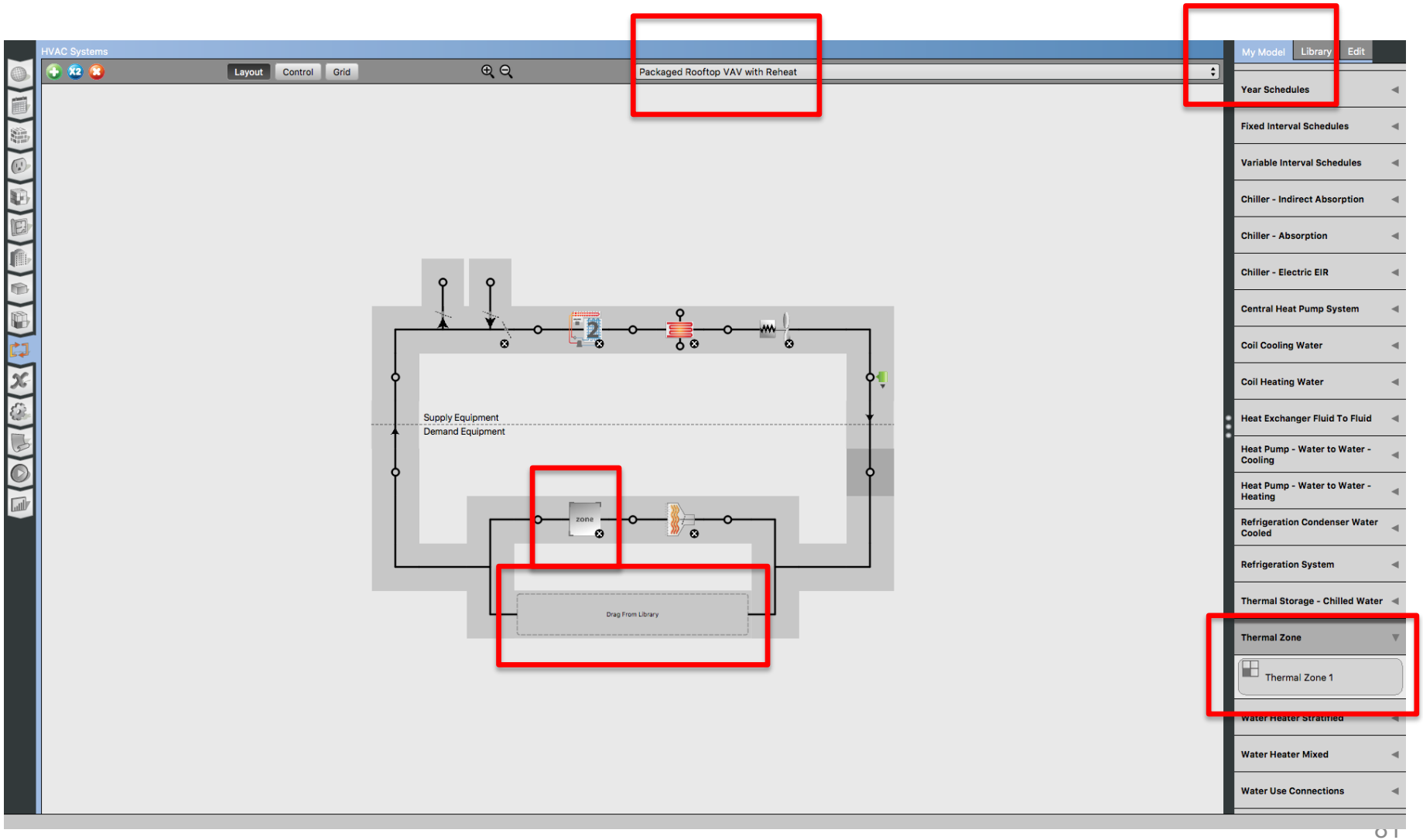
OpenStudio Training

- Step 15: Add System #5



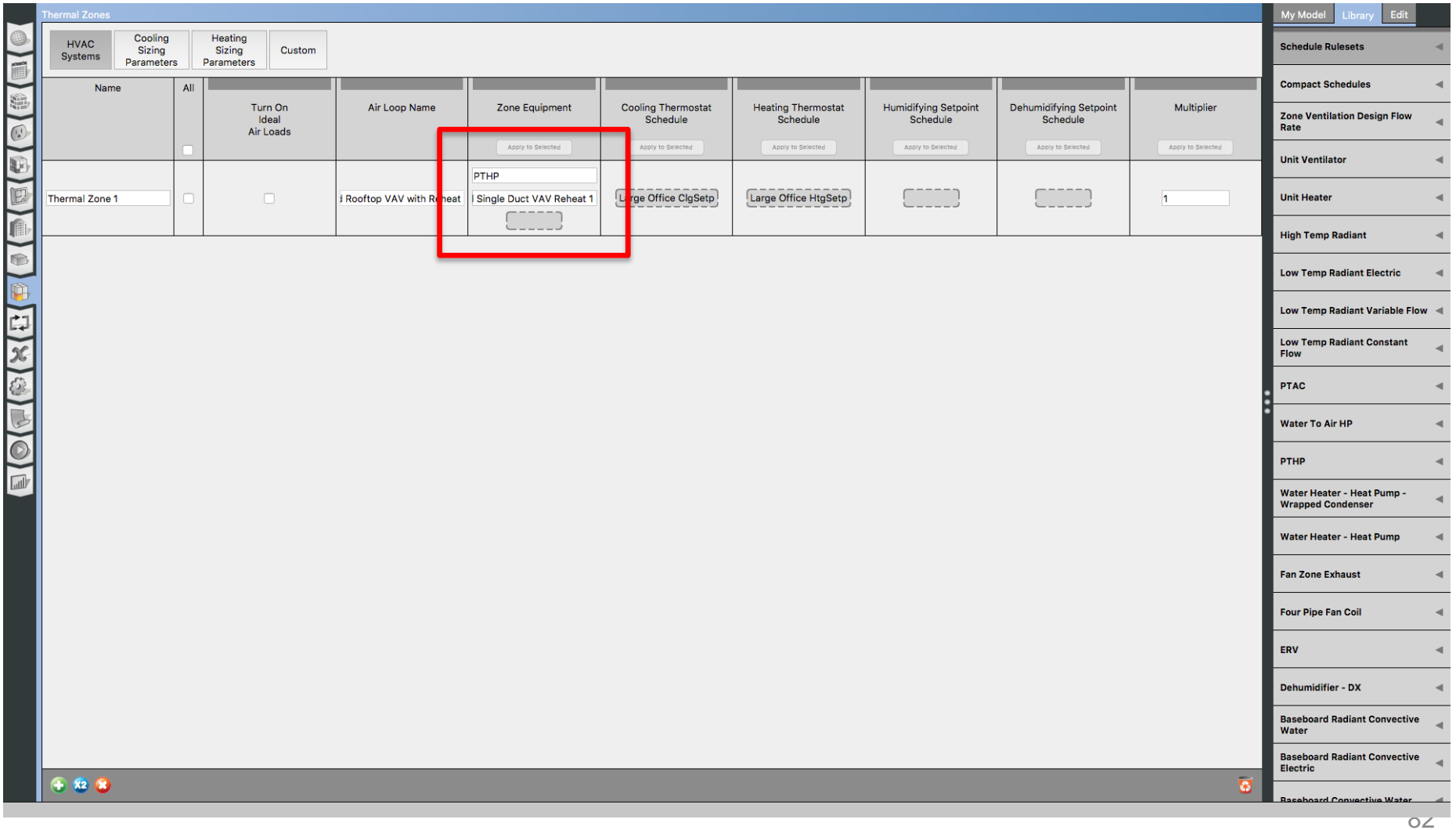
OpenStudio Training

- Step 16: Add a thermal zone to the air loop



OpenStudio Training

- Step 17: Automatically added to the zone level

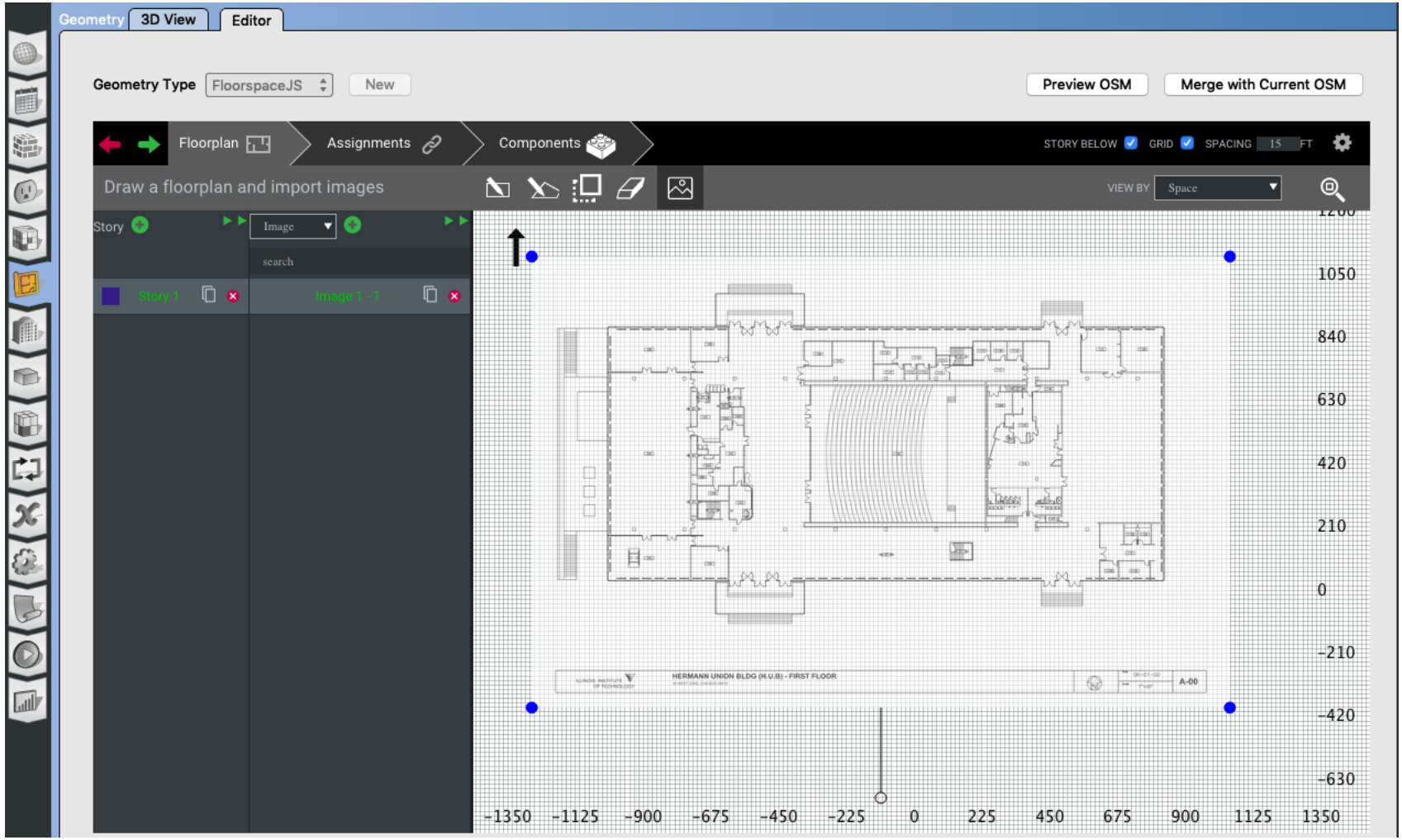


OPENSTUDIO TRAINING FROM EXISTING MODELS

GEOMETRY EDITOR

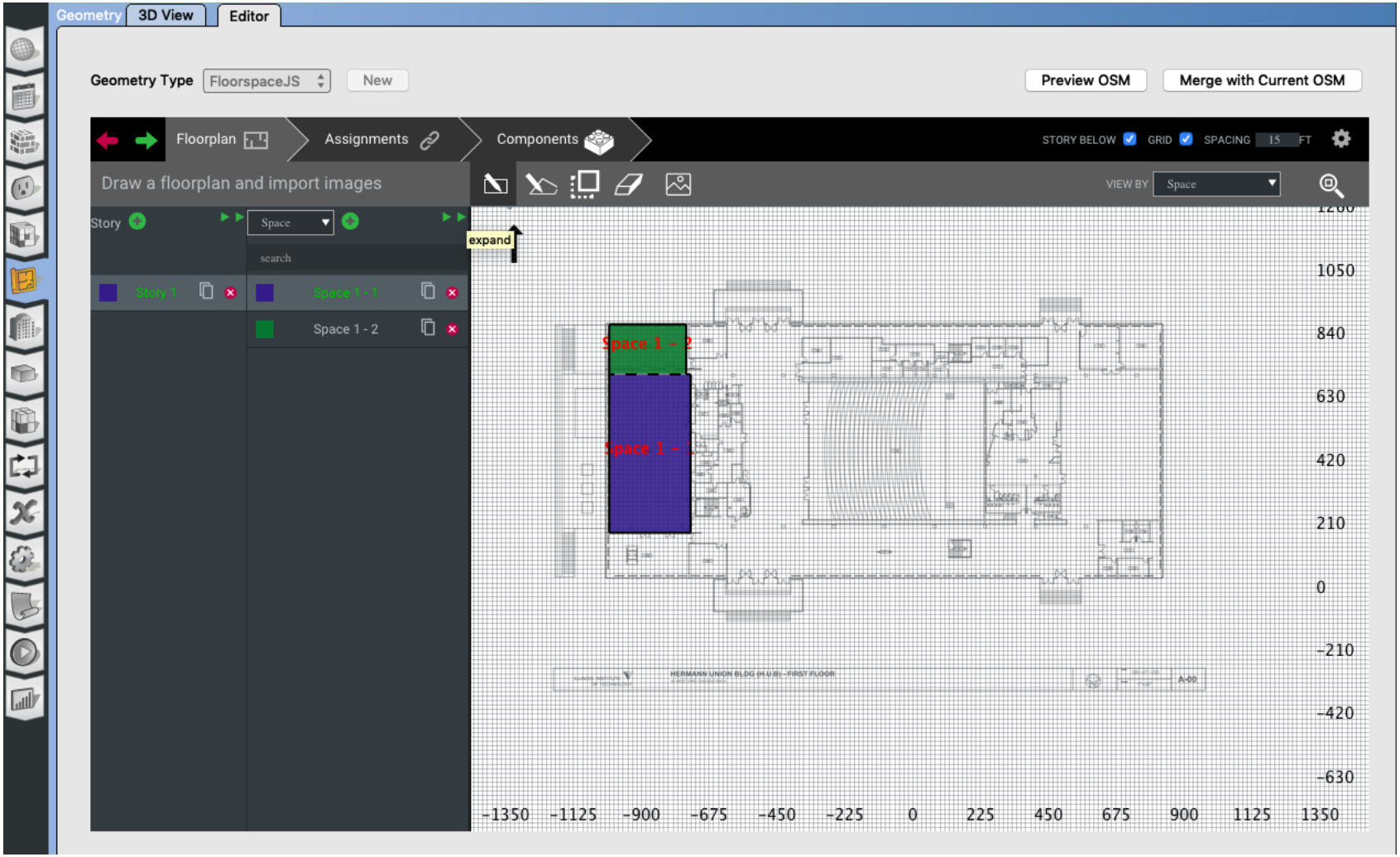
Draw From Floor Plan

- Import the floorplan using figure files



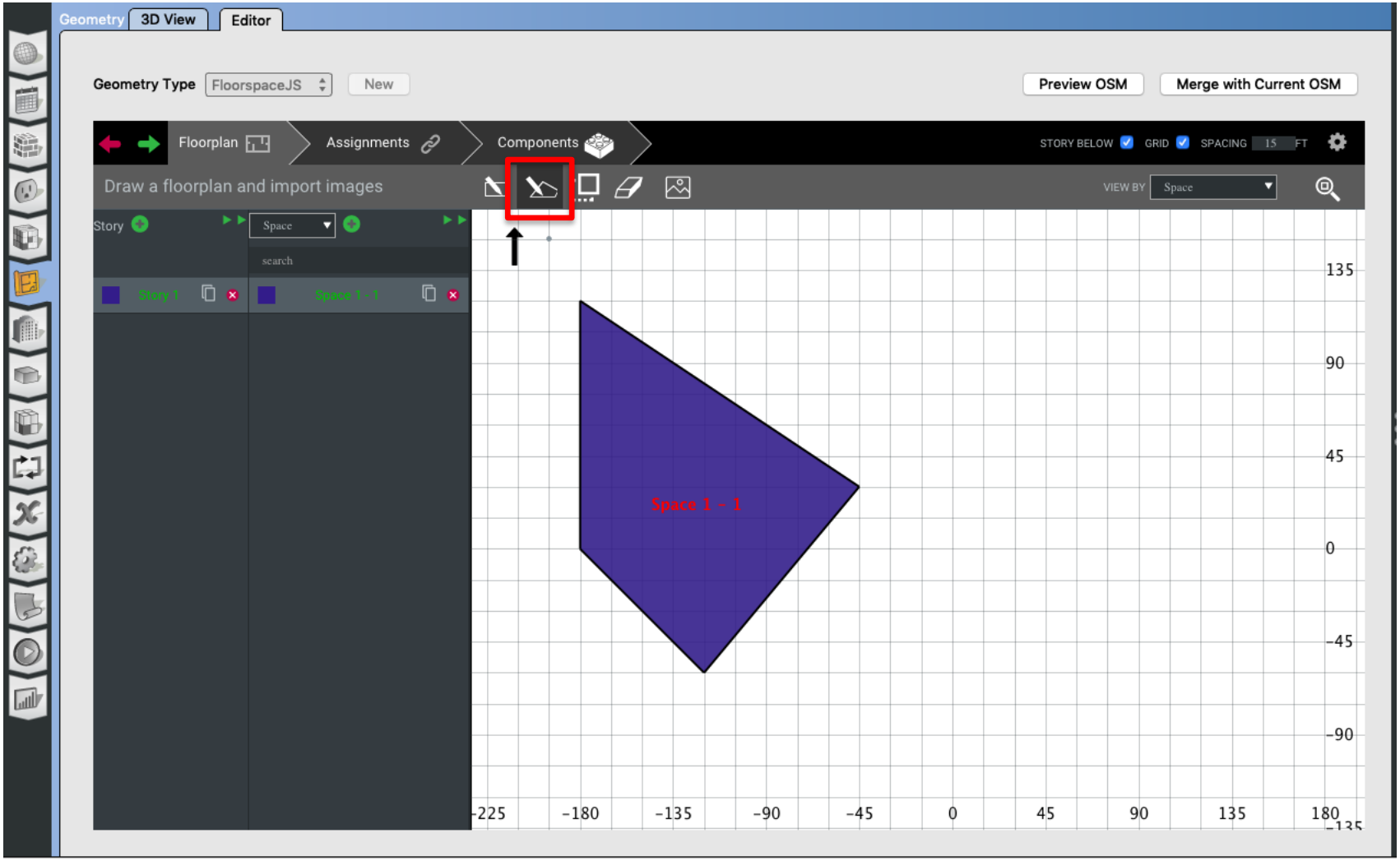
Draw From Floor Plan

- Build the spaces from the floorplan



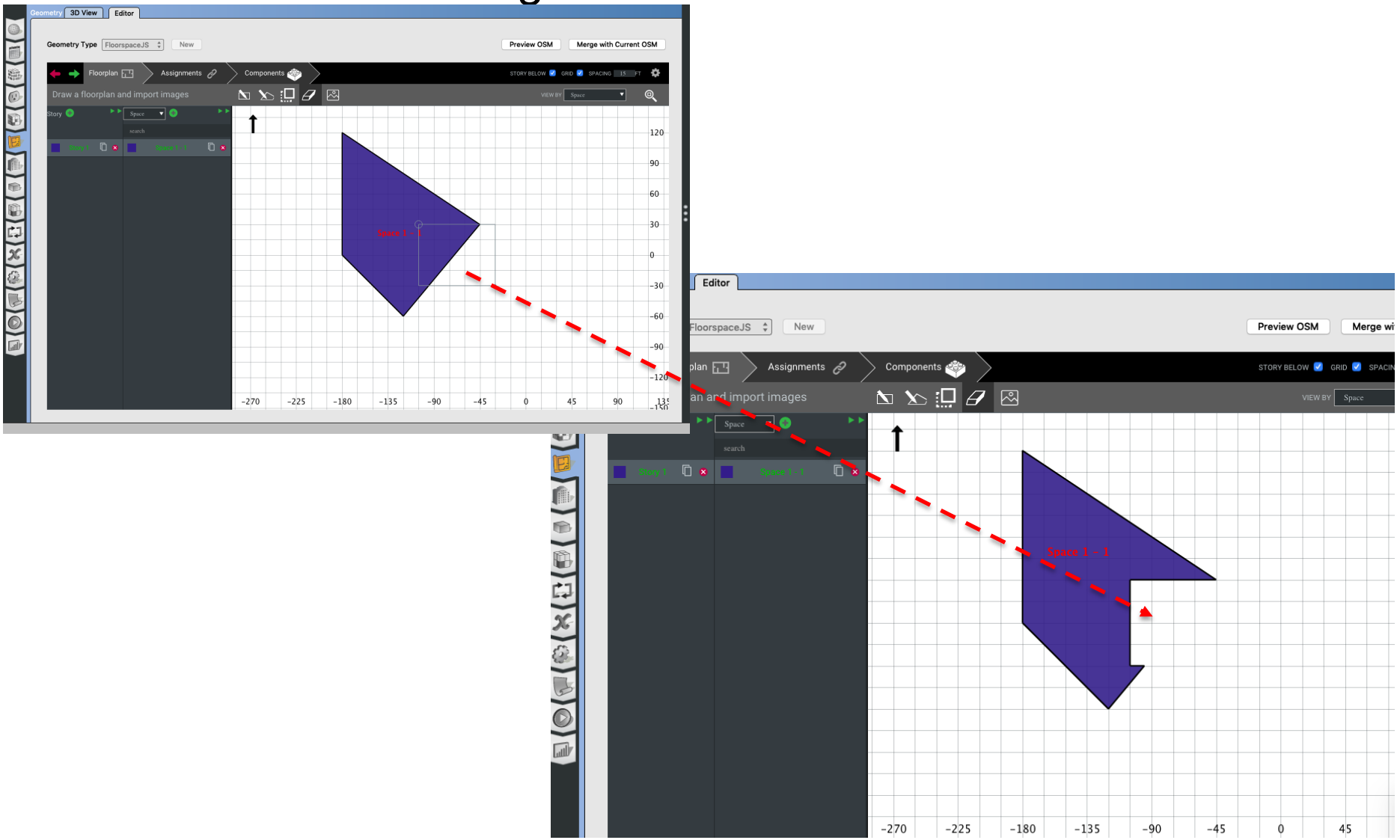
Draw Irregular Shapes

- Click on the irregular shape icon:



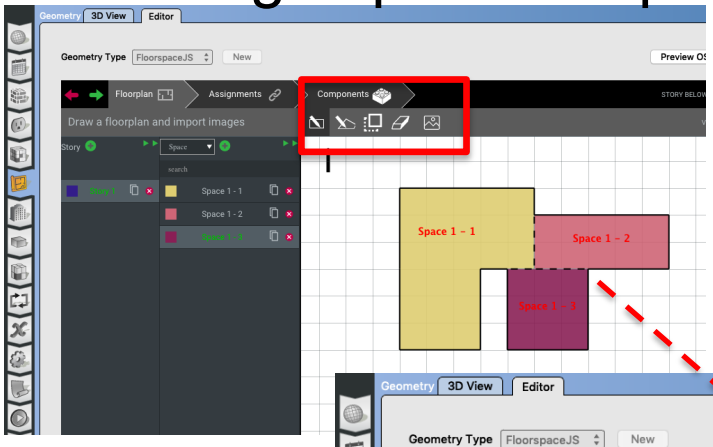
Cut Through the Space

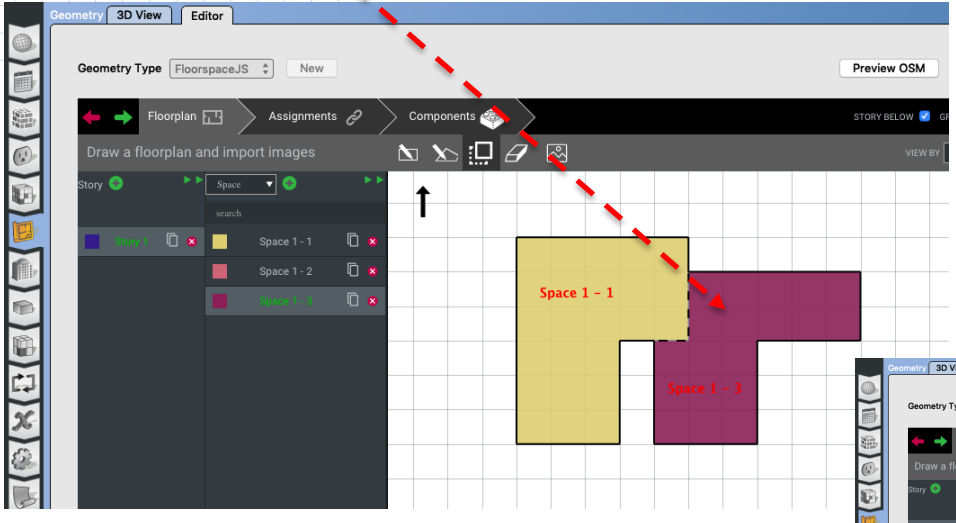
- Select the cut through section:

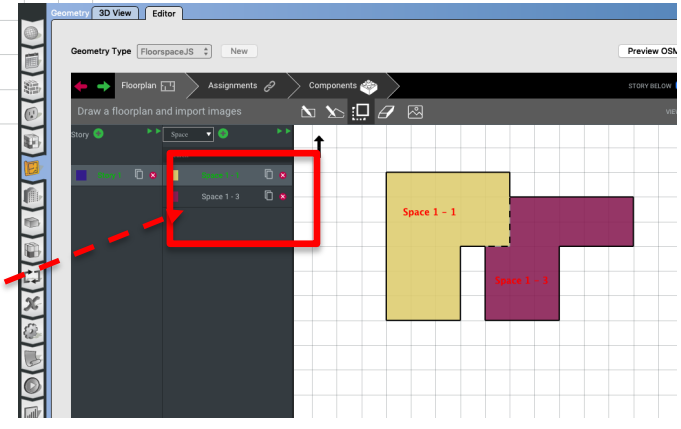


Merge Spaces

- Merge spaces requires careful consideration:



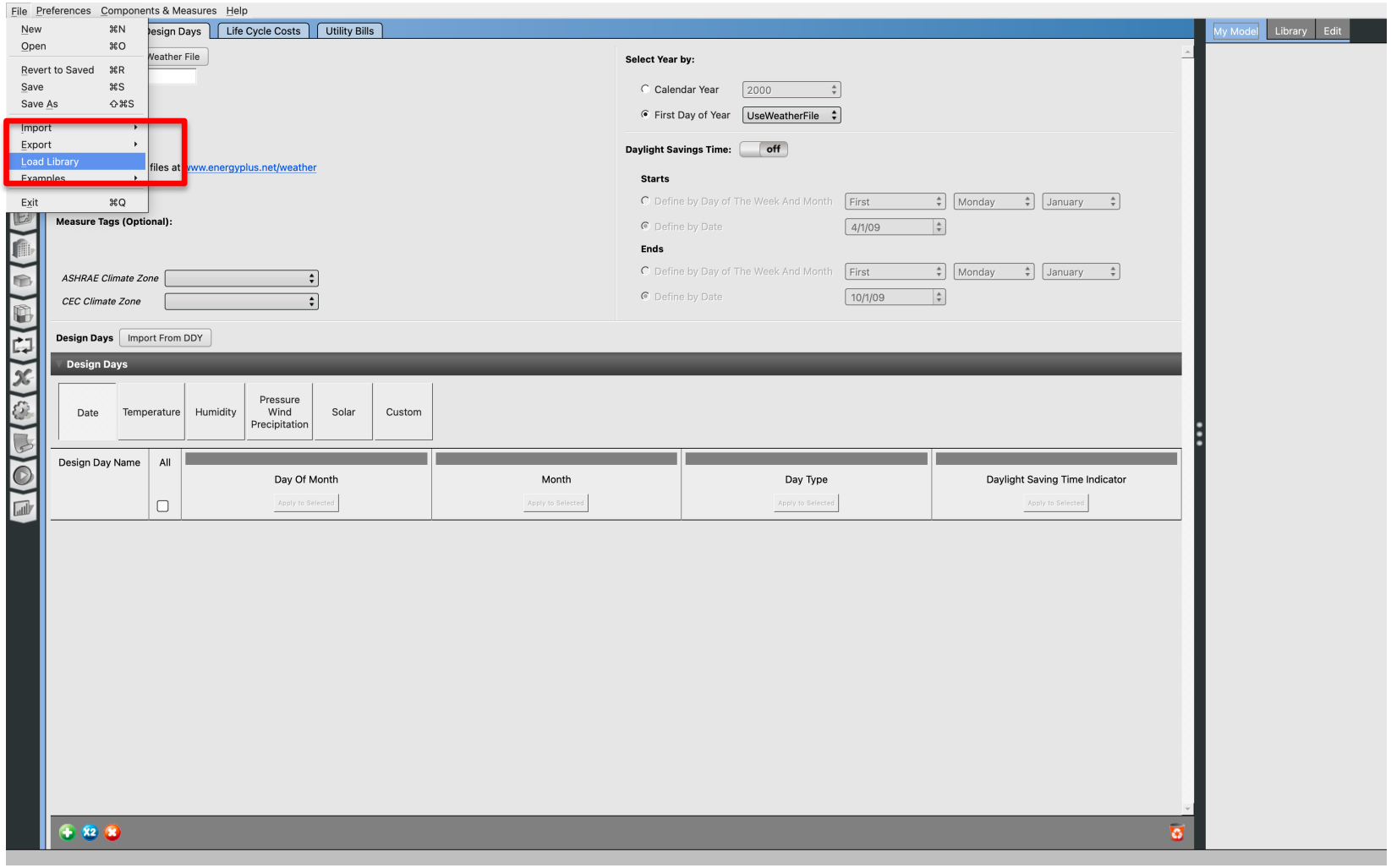




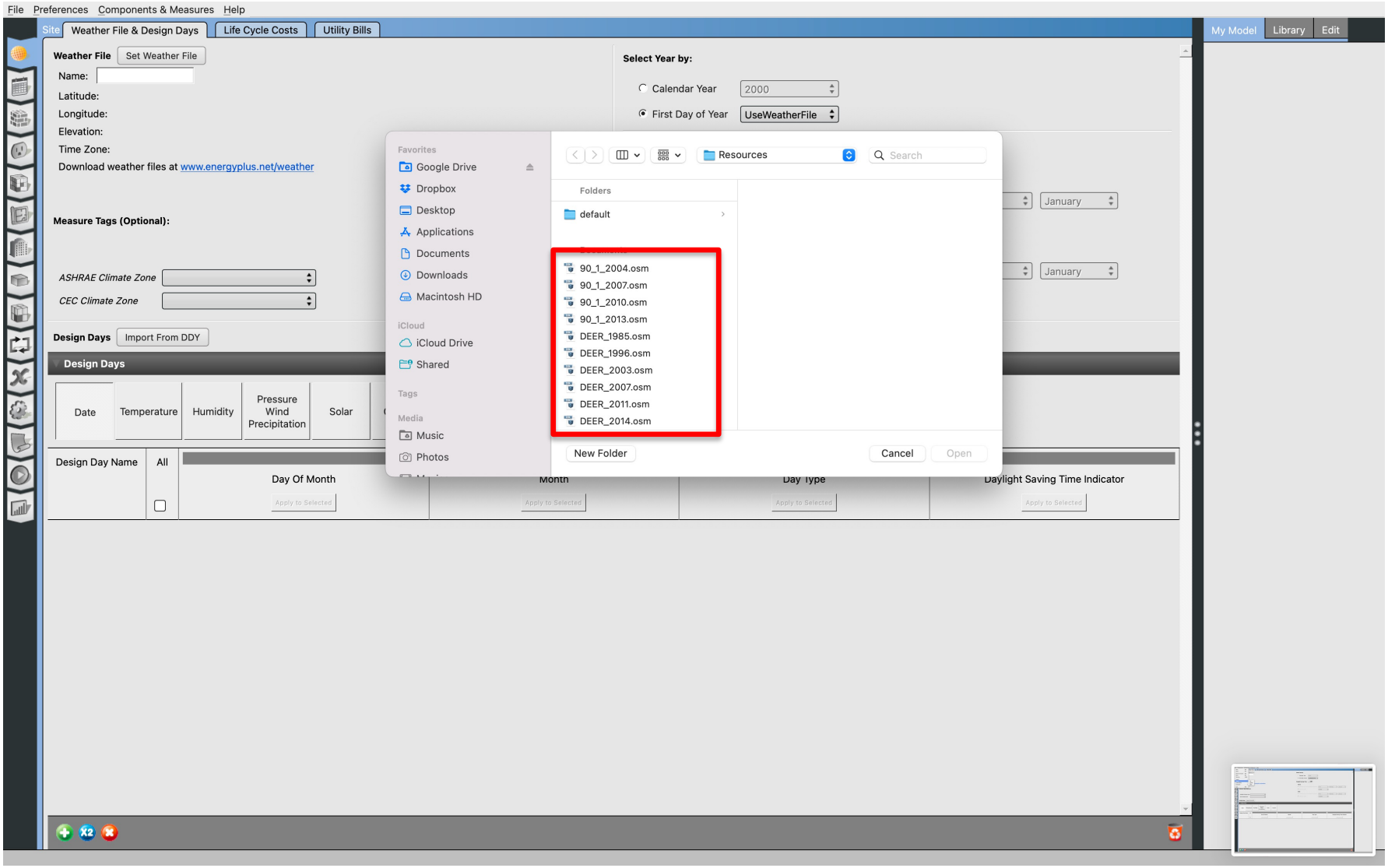
Make sure to remove the existing old space

TEMPLATES / LIBRARIES

Templates / Libraries



Templates / Libraries



Templates / Libraries

U.S. Department of Energy Commercial Reference Building Models of the National Building Stock

Michael Deru, Kristin Field, Daniel Studer,
Kyle Benne, Brent Griffith, and Paul Torcellini
National Renewable Energy Laboratory

Bing Liu, Mark Halverson, Dave Winiarski,
and Michael Rosenberg
Pacific Northwest National Laboratory

Mehry Yazdanian
Lawrence Berkeley National Laboratory

Joe Huang
Formerly of Lawrence Berkeley National Laboratory

Drury Crawley
Formerly of the U.S. Department of Energy

https://www.nrel.gov/docs/fy11osti/46861.pdf

OPENSTUDIO (SURFACE)

Construction Materials

- Two types of surfaces:
  - Exterior
  - Interior surfaces

- Constructions are composed of layers of materials

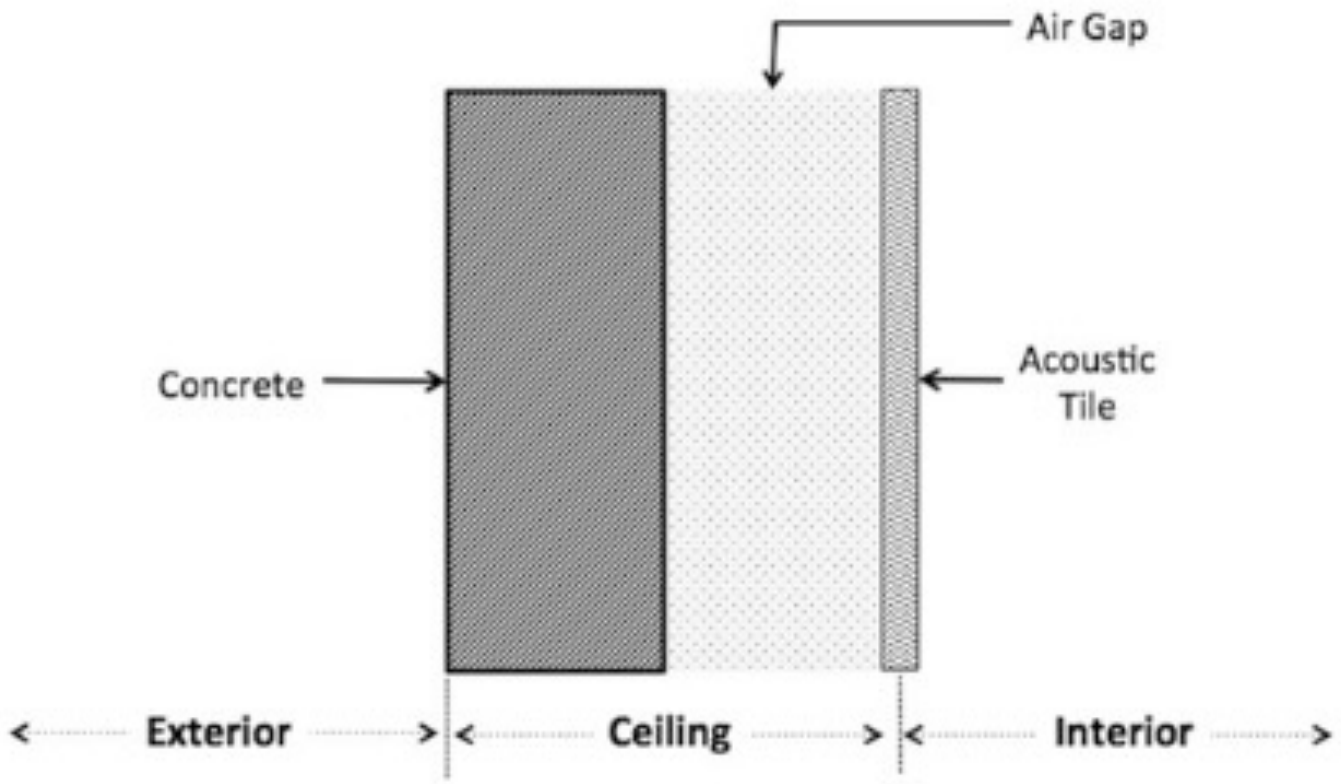
- Surfaces with same orientation/properties are lumped into one surface for a thermal zone
  - e.g. combine windows facing same direction

Construction Materials

- Two types of surfaces:
  - ❑ Exterior
  - ❑ Interior surfaces

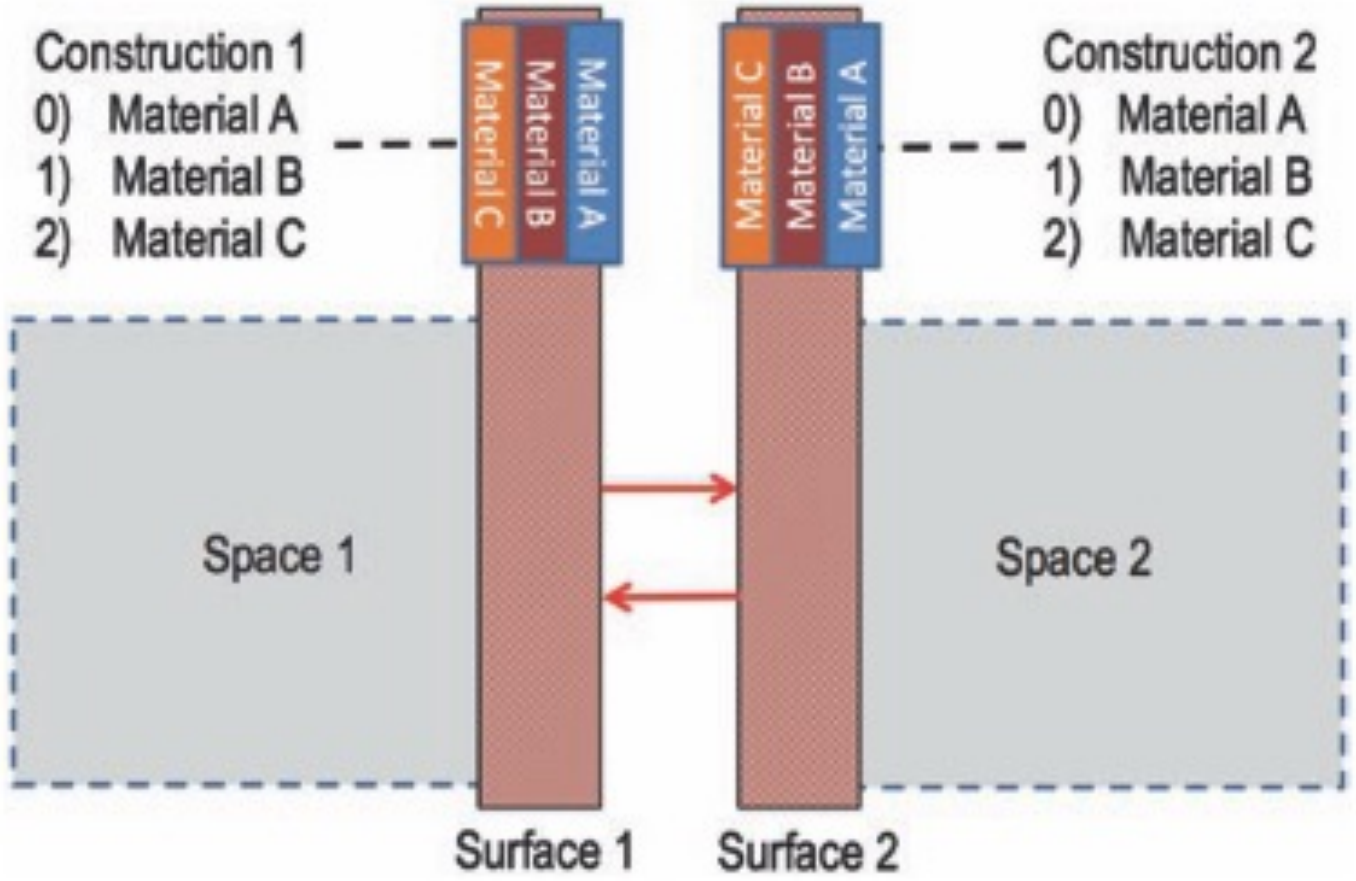
Constructions

- Constructions are composed of layers of materials



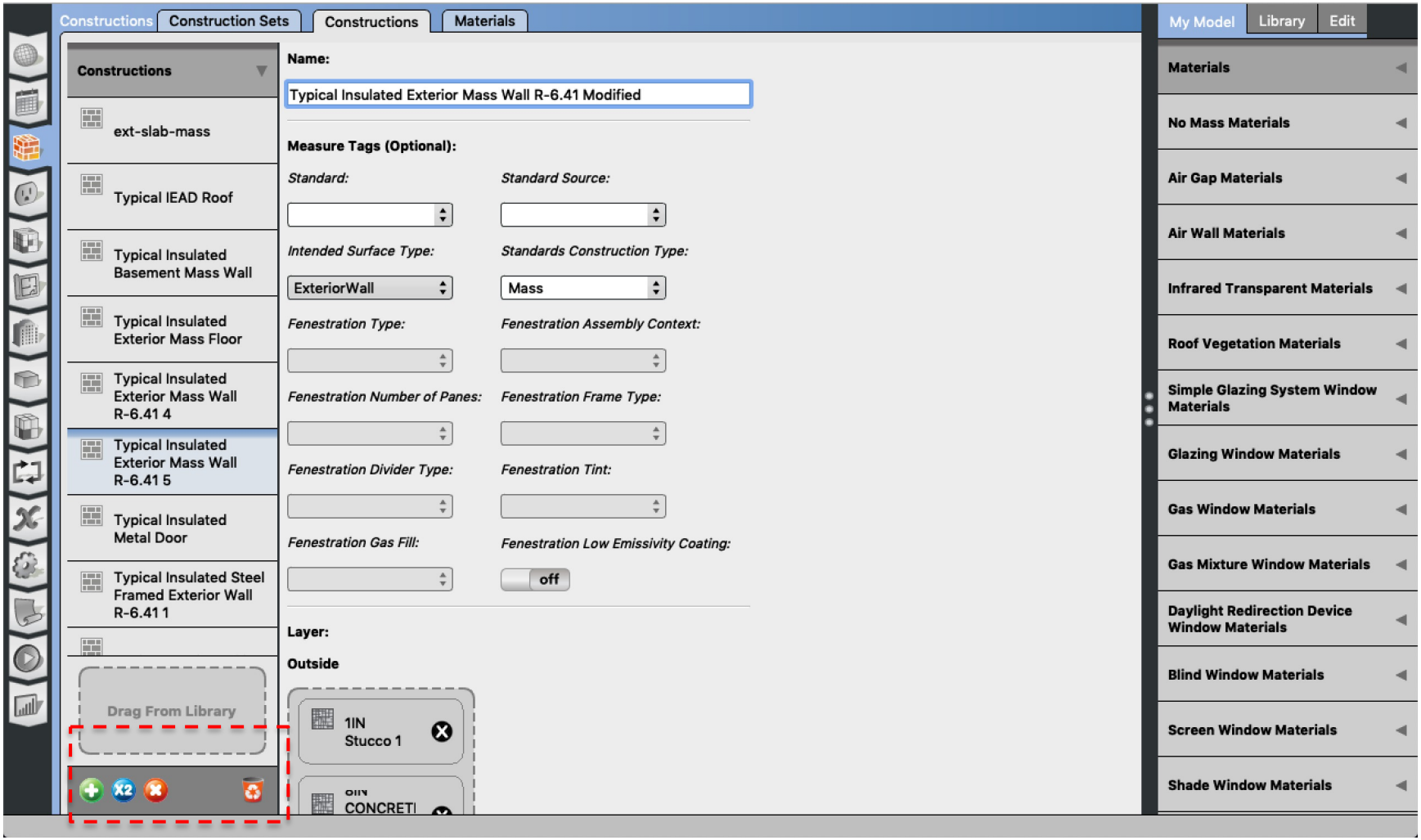
Constructions

- Constructions are composed of layers of materials



Add A New Material

- Add a new material



Construction Materials

- Constructions are composed of layers of materials (EnergyPlus)

An IDF example:

```
Material,A2 - 4 IN DENSE FACE BRICK,  ! Material Name
 Rough,  ! Roughness
  0.1014984    ,  ! Thickness {m}
   1.245296    ,   ! Conductivity {W/M*K}
   2082.400    ,   ! Density {Kg/M**3}
  920.4800     ,  ! Specific Heat {J/Kg*K}
  0.9000000    ,   ! Thermal Absorptance
  0.9300000    ,   ! Solar Absorptance
  0.9300000    ;   ! Visible Absorptance
```

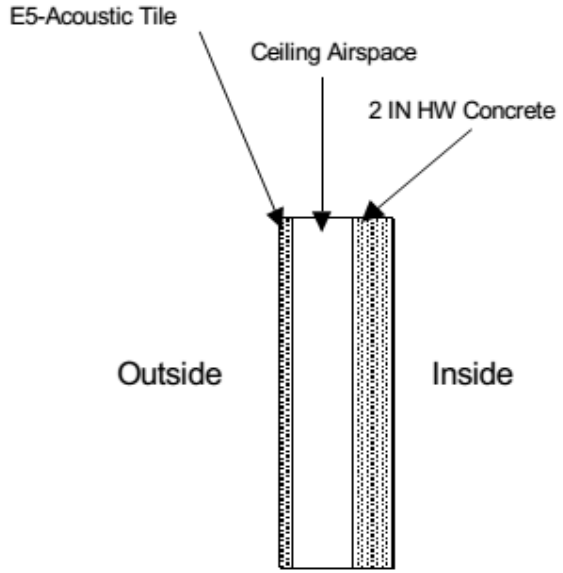


Figure 22. Example Floor Construction illustration.

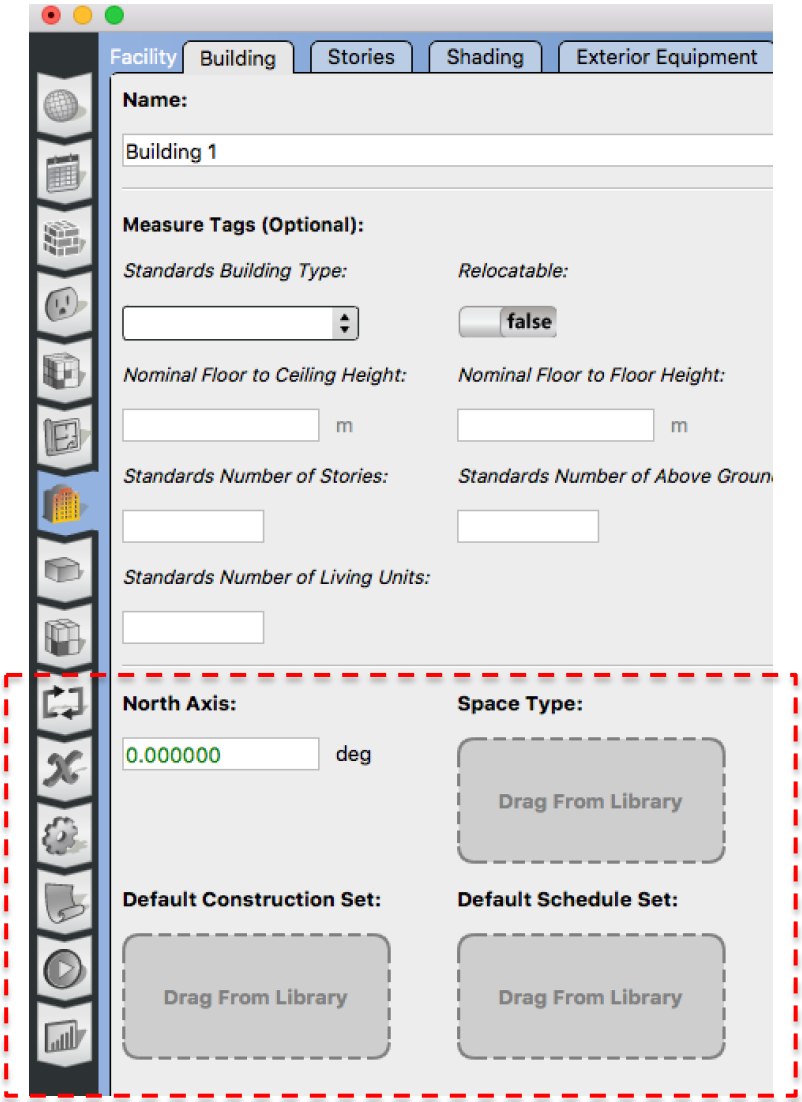
IDF Example (floor construction):

```
Construction, FLOOR38,  ! Material layer names follow:
      E5 - ACOUSTIC TILE,
      E4 - CEILING AIRSPACE,
      C12 - 2 IN HW CONCRETE;
```


EnergyPlus documentation

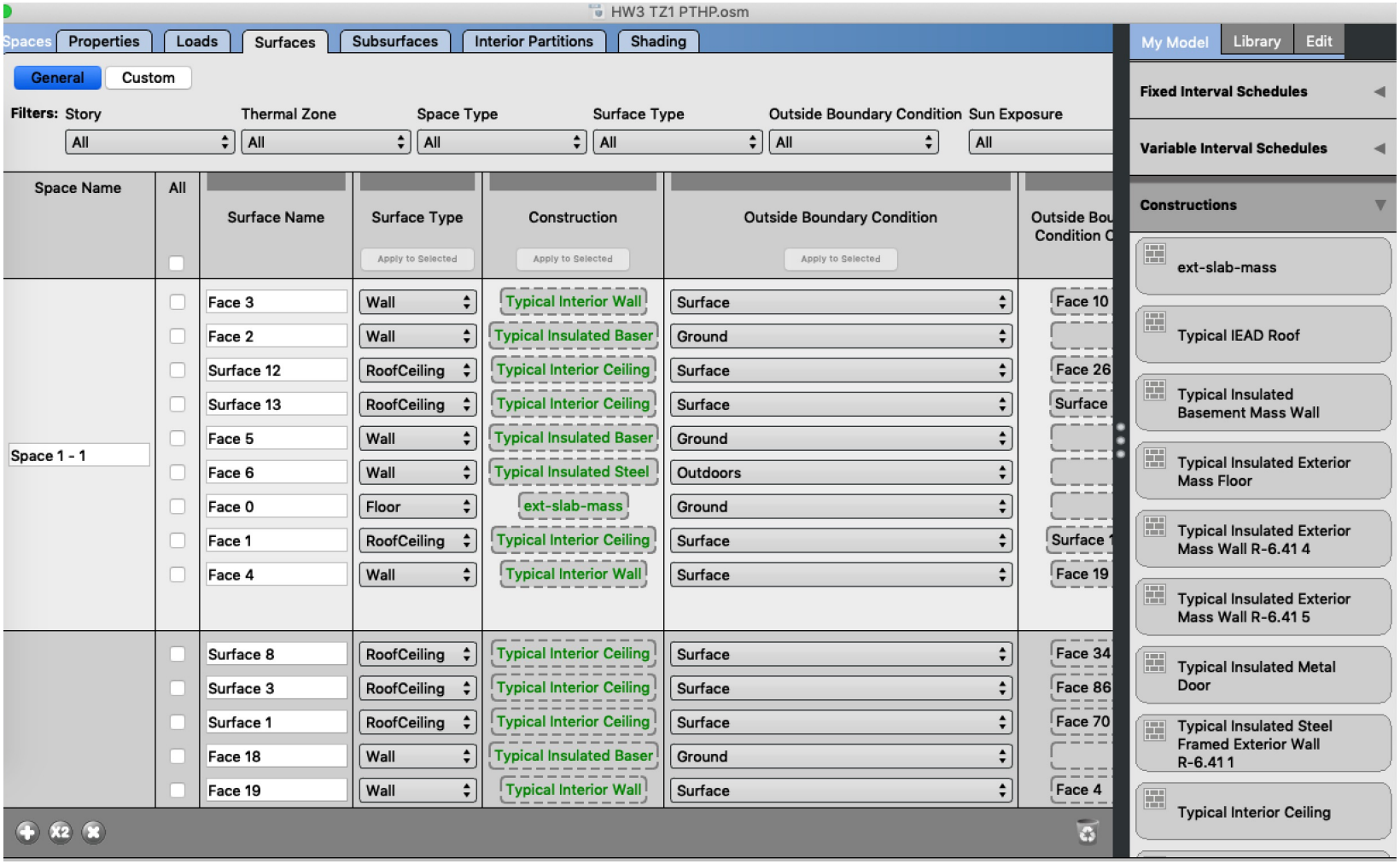
Inheritance

Priority	Level	Construction
1	Surface	Construction
2	Space	Default Construction Set
3	Story	Default Construction Set
4	Building	Default Construction Set



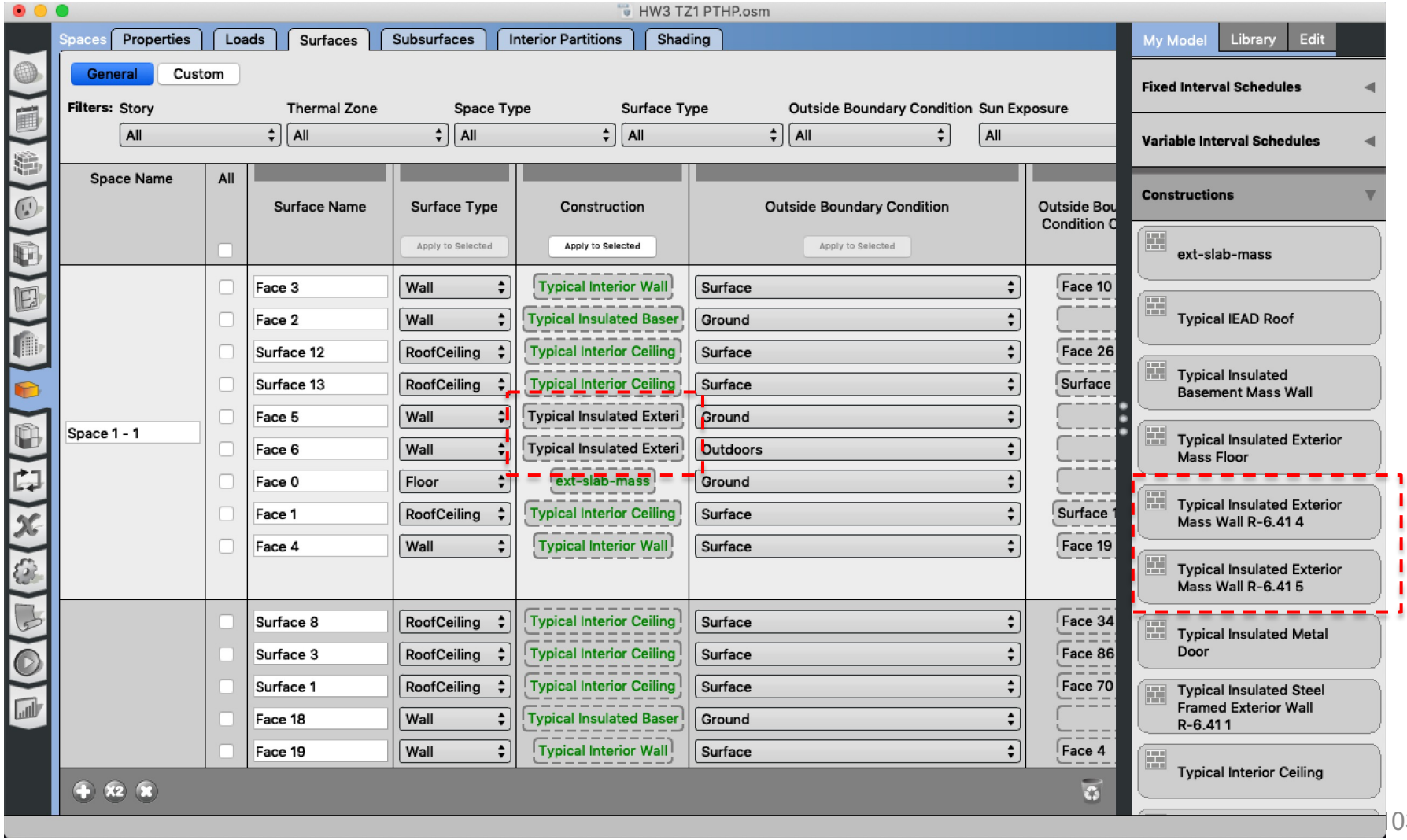
Inheritance

- Why do we see the “green color” text?



Inheritance

- Replace the construction from “My Model”

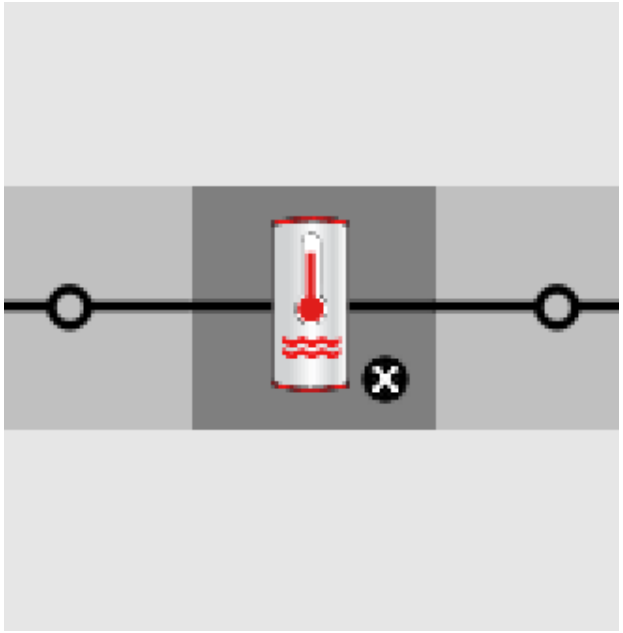


Other Inputs

- Plug Load Density, Schedule
- Occupancy Density, Schedule, Metabolic Rate
- Domestic Hot Water Rate, Schedule
- Lighting Level
- Temperature/Humidity Control, Schedule
- Ventilation

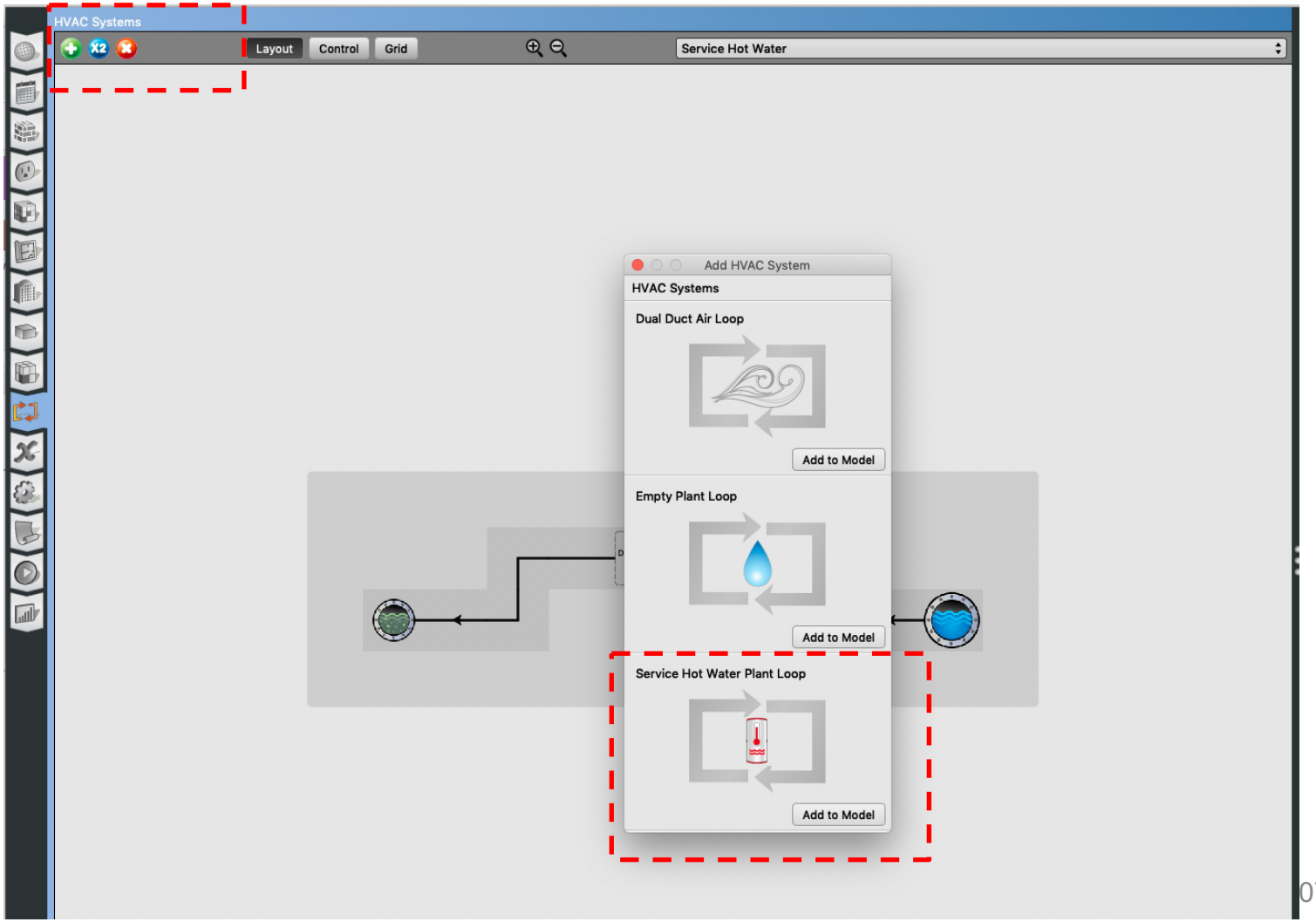
SERVICE HOT WATER

Service Hot Water



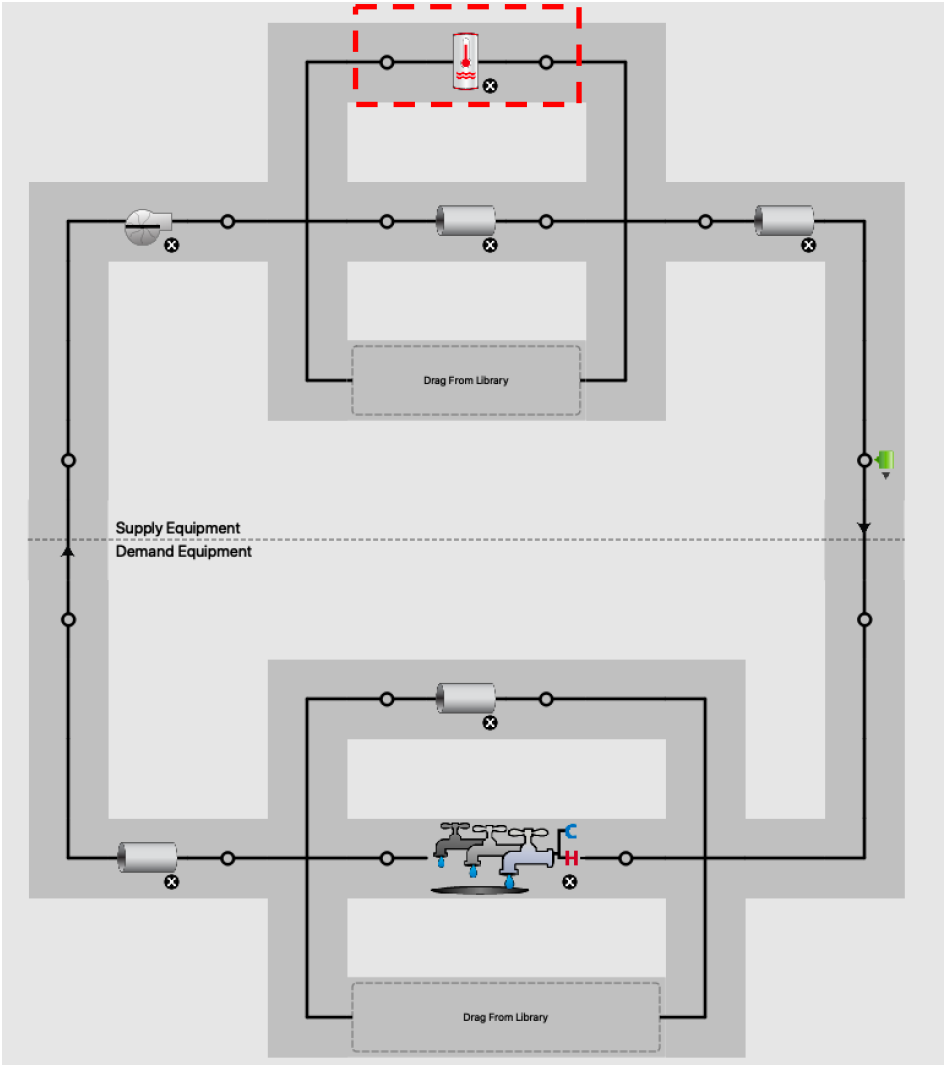
Service Hot Water

- Add a water heater tank to a plant loop:



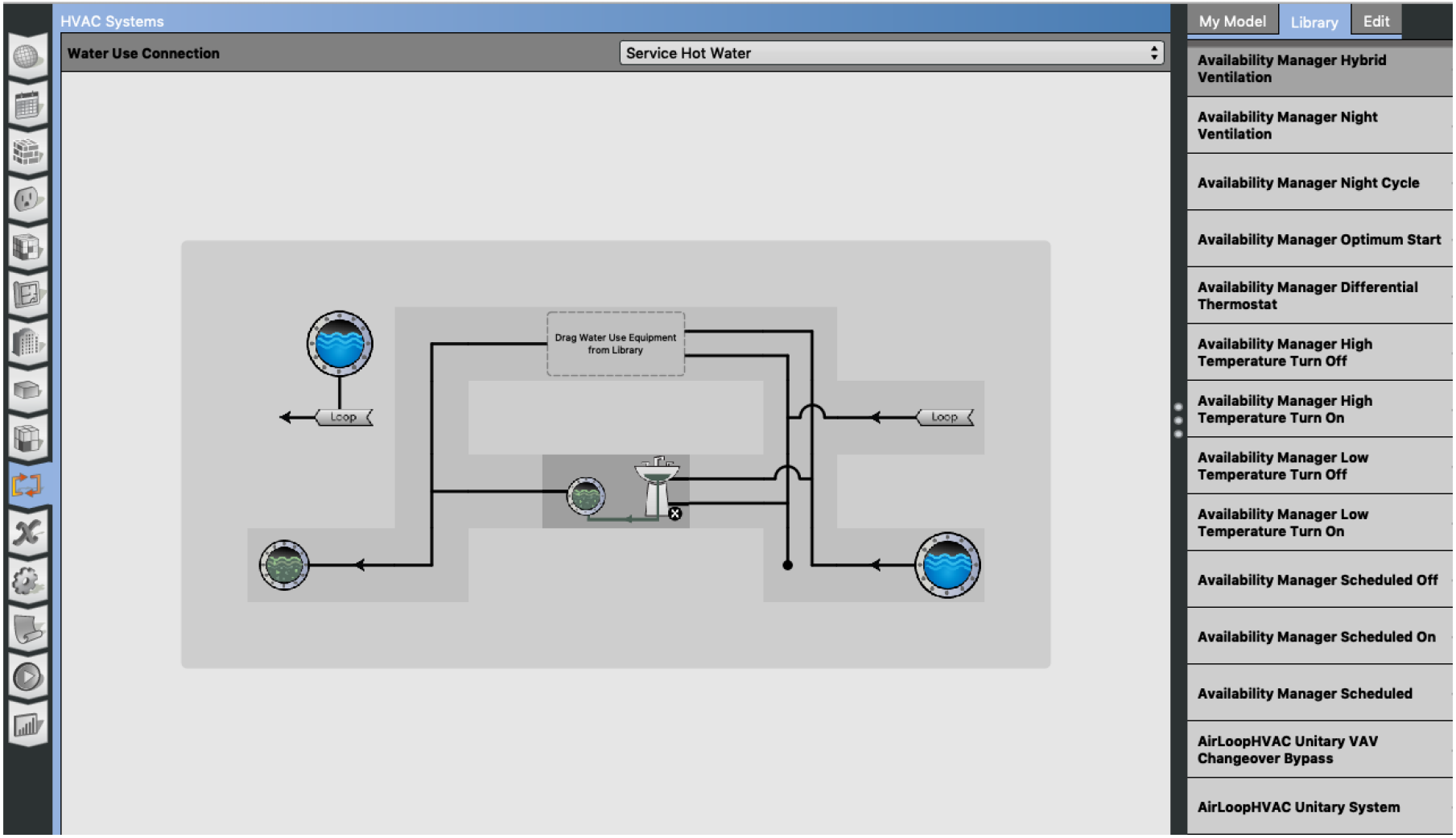
Service Hot Water

- Add service hot water plant loop:

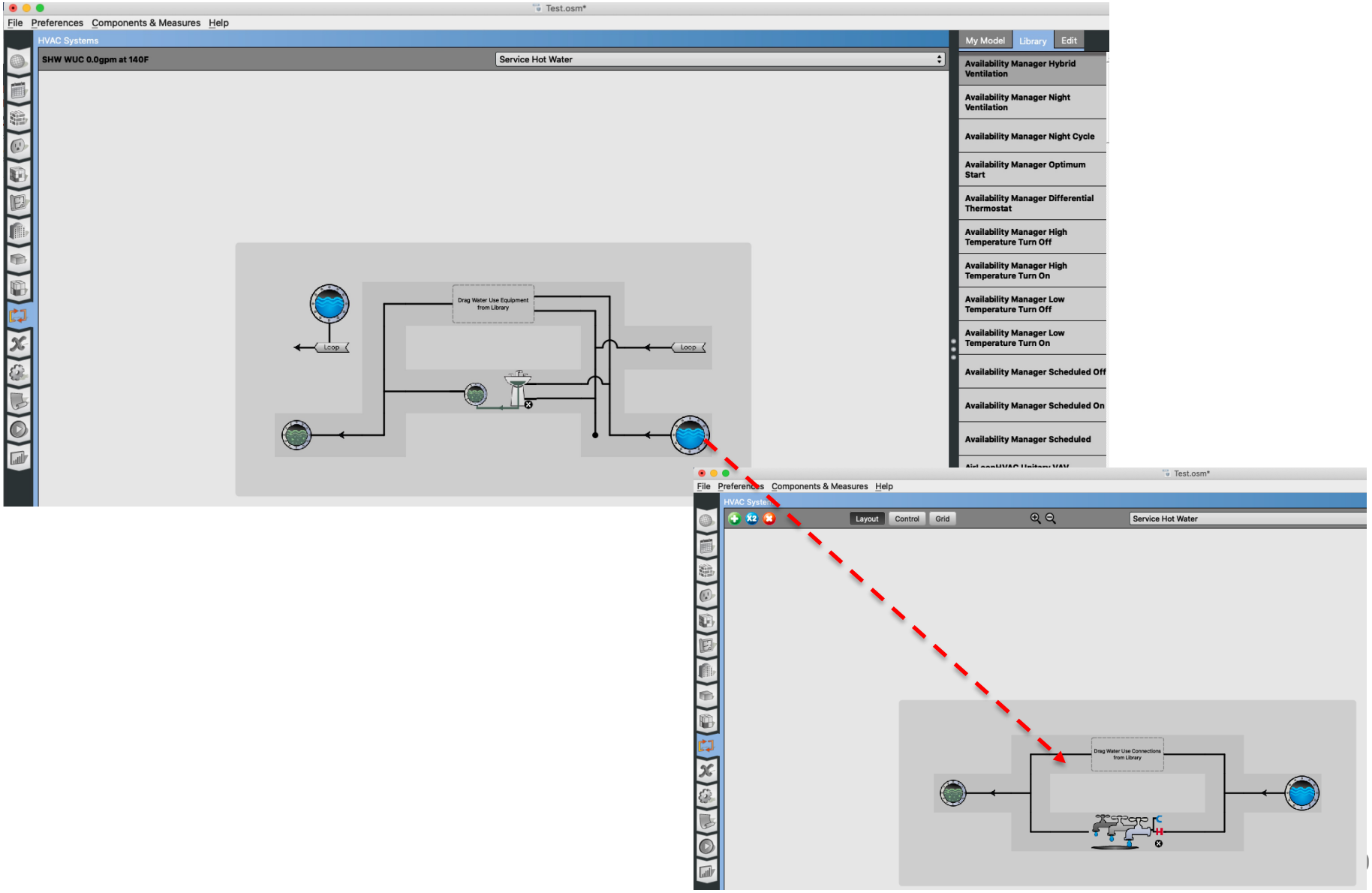


Service Hot Water

- Add a fixture:

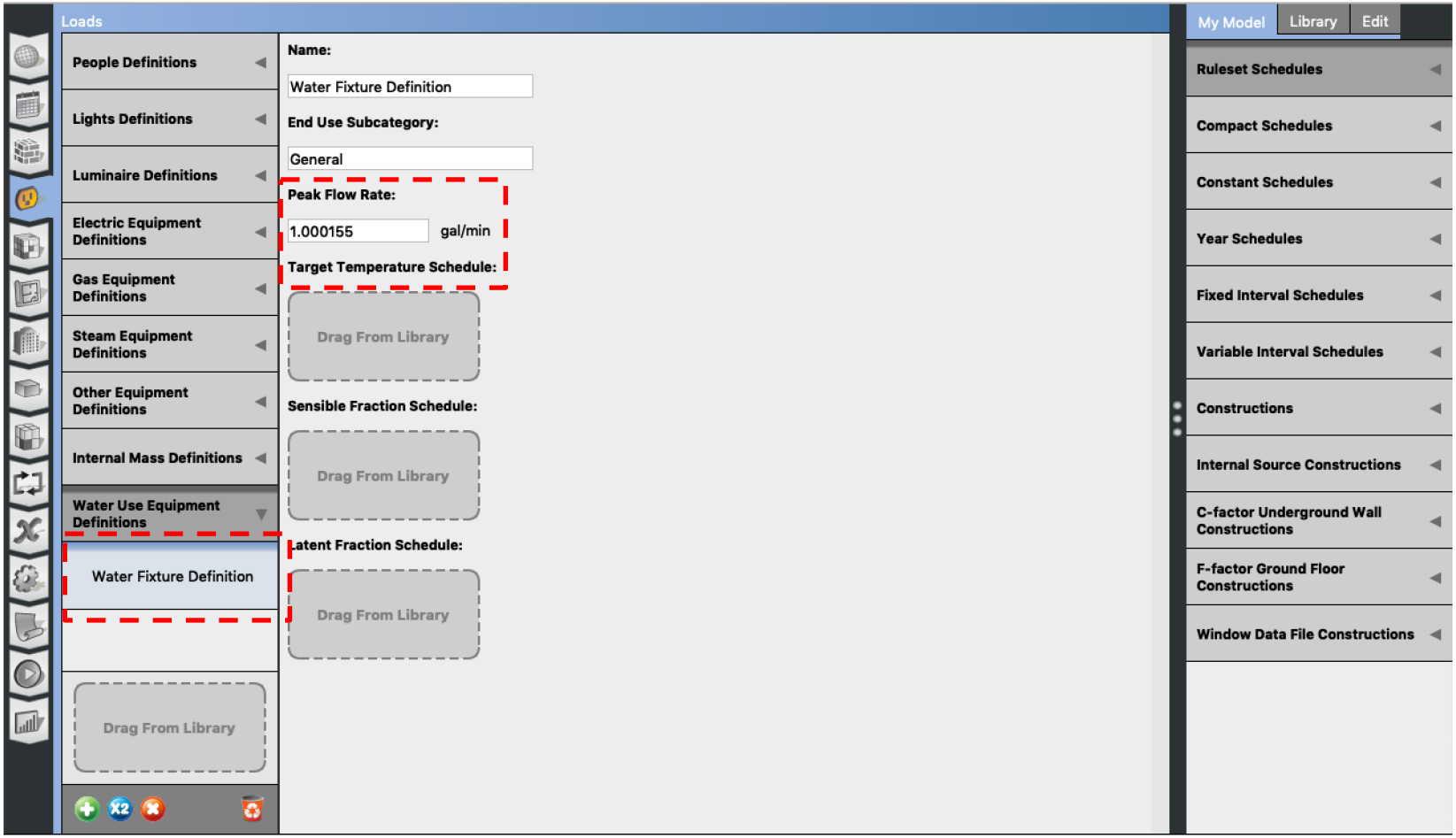


Service Hot Water



Service Hot Water

- Add service hot water definition



Service Hot Water

- DOE Reference Buildings
  - ❑ Section 5.1.6 Service Water Heater Demand

Table 11 Peak Service Hot Water Demand and Data Sources

Space Type	Use Rate		Temp. at Fixture		Data Sources
	gal/h	L/h	ºF	ºC	
Guest room (small hotel)	1.75	6.6	110	43	Jiang et al. 2008, ASHRAE 2007
Guest room (large hotel)	1.25	4.7	110	43	Jiang et al. 2008, ASHRAE 2007
Laundry (small hotel)	67.5	255.5	140	60	Jiang et al. 2008, ASHRAE 2007
Laundry (large hotel)	156.6	592.8	140	60	Jiang et al. 2008, ASHRAE 2007
Restrooms (primary school)	56.5	214.0	110	43	ASHRAE 2007
Restrooms (secondary school)	104.4	395.0	110	43	ASHRAE 2007
Gym (secondary school)	189.5	717.2	110	43	ASHRAE 2007
Small office	3.0	11.4	110	43	Jarnagin et al. 2006, ASHRAE 2007
Medium office (per floor)	9.9	37.5	110	43	Jarnagin et al. 2006, ASHRAE 2007
Large office (per floor)	21.3	80.6	110	43	Jarnagin et al. 2006, ASHRAE 2007
Apartment	3.5	13.2	110	43	Gowri et al. 2007
Outpatient healthcare	30.0	113.5	110	43	Doebber et al. 2009
Hospital					
ER waiting room	1.0	3.8	120	49	Engineering judgment
Operating/surgical cystoscopic	2.0	7.6	120	49	Engineering judgment
Laboratory	2.0	7.6	120	49	Engineering judgment
Patient room	1.0	3.8	120	49	Engineering judgment

https://www.nrel.gov/docs/fy11osti/46861.pdf

Service Hot Water

- Make reasonable assumptions for the water heater temperature:
  - Most households require about 120 ºF
  - Some manufacturers set water heater thermostats at 140 ºF, which also slows mineral buildup and corrosion in your water heater and pipes
  - Water heated at 140ºF also poses a safety hazard (scalding)

https://www.energy.gov/energysaver/heat-and-cool/water-heating
https://www.energy.gov/energysaver/services/do-it-yourself-energy-savings-projects/savings-project-lower-water-heating

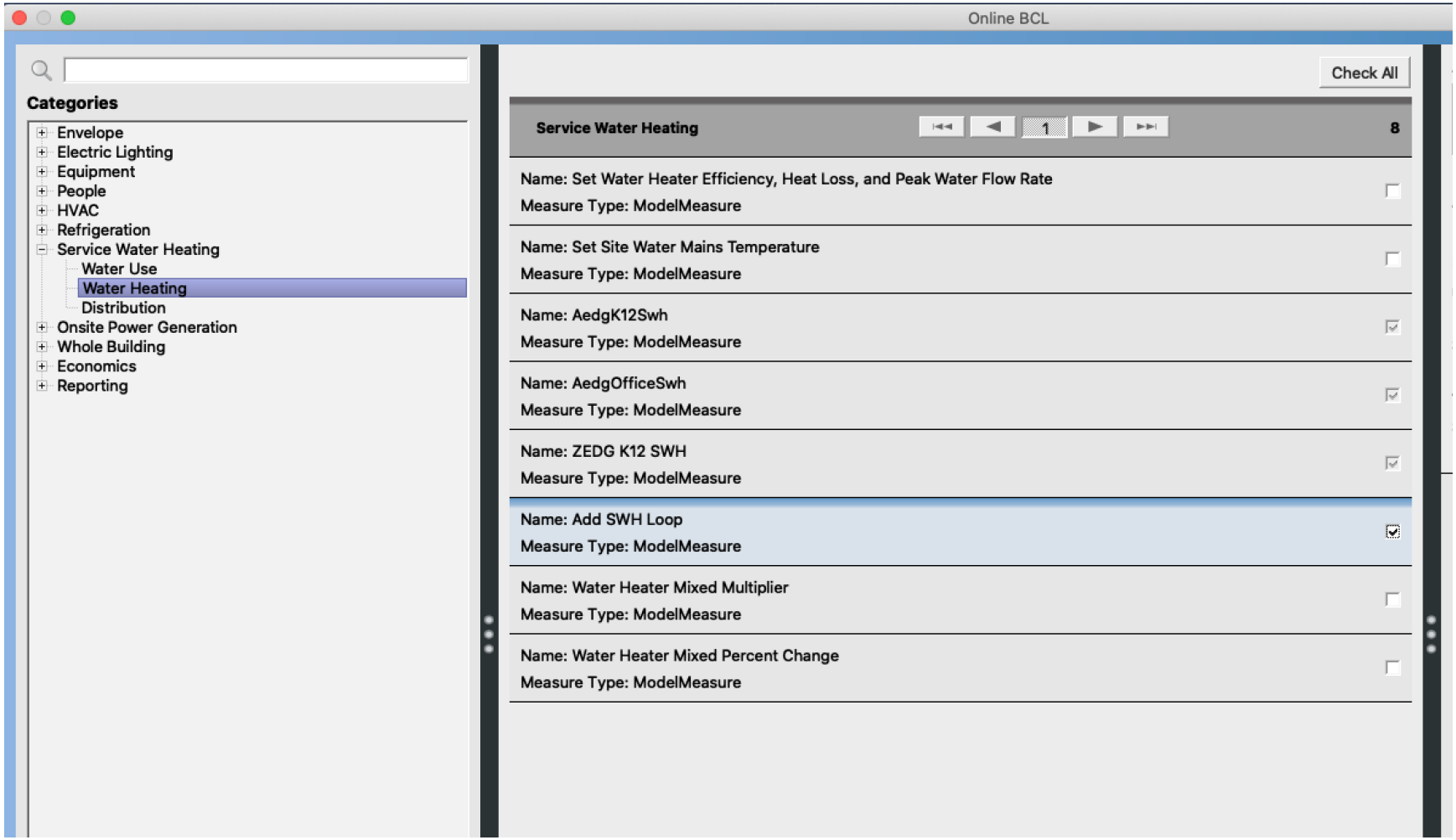
Service Hot Water

- Make reasonable assumptions for the flow rates and sizes. For example, for residential units:
  - Small size: A 50 to 60-gallon storage tank is usually sufficient for 1 to 3 people
  - Medium size: A 80-gallon storage tank works well for 3 to 4 people
  - Large size: A large tank is appropriate for four to six people

https://www.energy.gov/energysaver/heat-and-cool/water-heating
https://www.energy.gov/energysaver/services/do-it-yourself-energy-savings-projects/savings-project-lower-water-heating

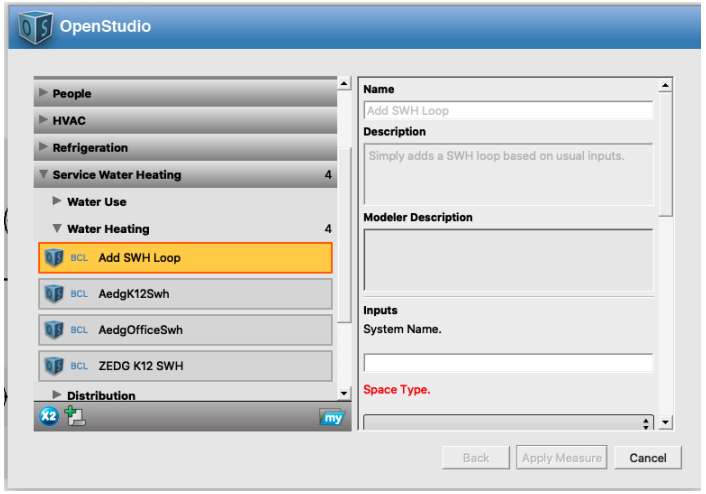
Service Hot Water

- You can use the OpenStudio measures:

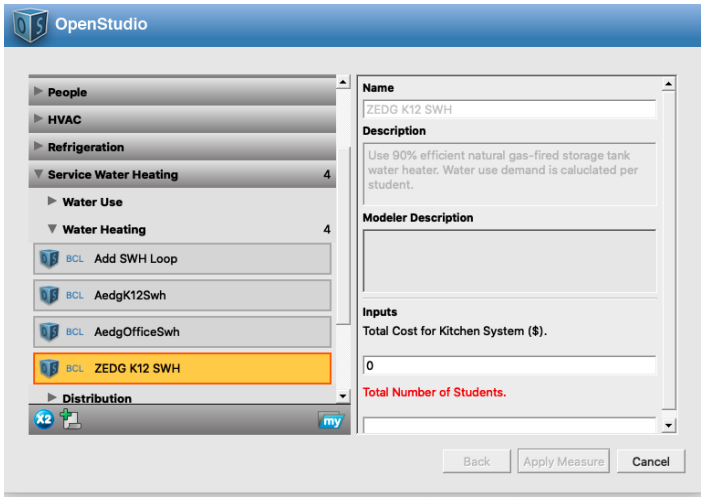


Service Hot Water

- You can use the OpenStudio measures:
  - First, use “Add SHW Loop”



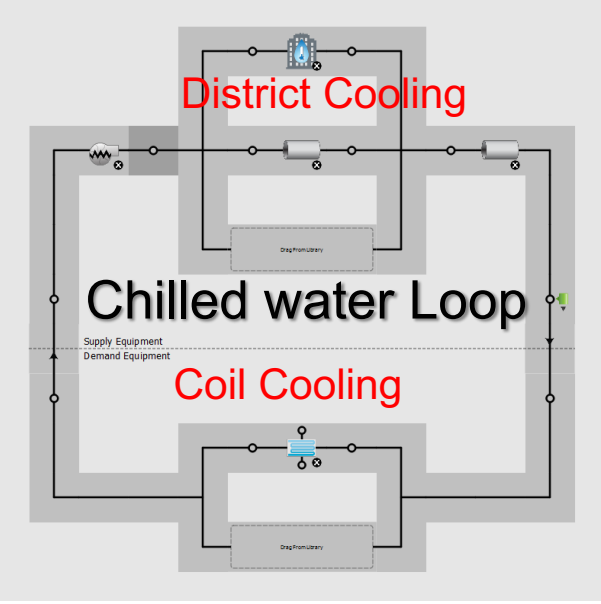
  - Second, use “ZEDG K12 SHW”

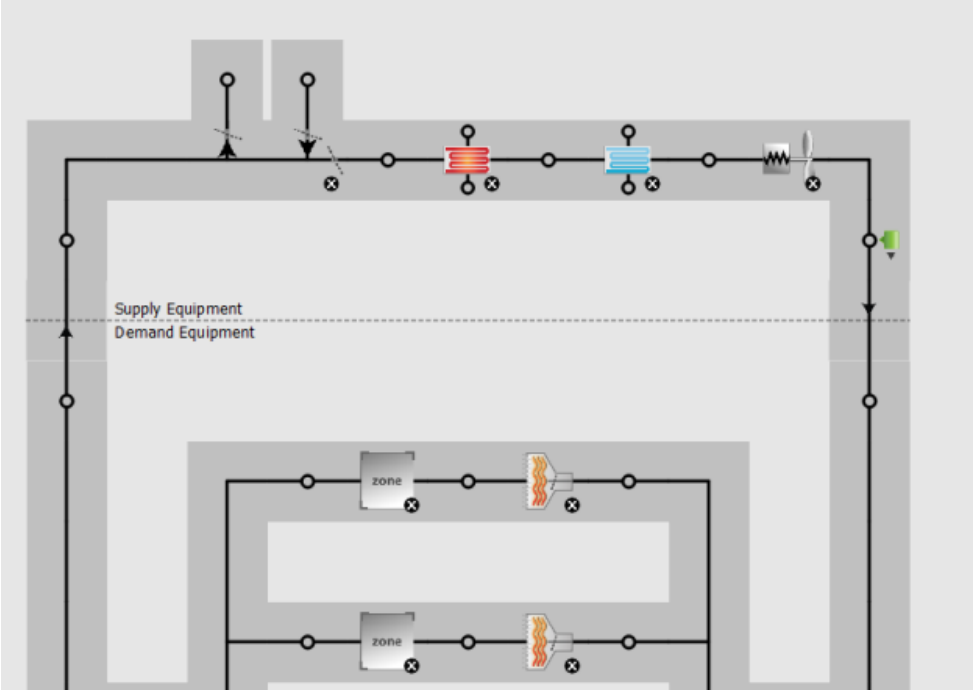


DISTRICT HEATING AND COOLING

District Heating and Cooling

- District heating and cooling:
  - ❑ No assumption required on:
    - ❑ Steam
    - ❑ Chilled water generation





Air Loop