

CAE 464/517 HVAC Systems Design

Spring 2023

January 26, 2023

OpenStudio Training (Heating and Cooling Load)

Built
Environment
Research

@ IIT



*Advancing energy, environmental, and
sustainability research within the built environment*

www.built-envi.com

Dr. Mohammad Heidarinejad, Ph.D., P.E.
Civil, Architectural and Environmental Engineering
Illinois Institute of Technology

muh182@iit.edu

OPENSTUDIO INSTALLATION

OpenStudio Installation

- Download Version 1.4.0 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
 OpenStudioApplication-1.4.0+e0fb8f854d-macOS12.1-arm64.dmg	444 MB
 OpenStudioApplication-1.4.0+e0fb8f854d-Ubuntu20.04.deb	429 MB
 OpenStudioApplication-1.4.0+e0fb8f854d-Ubuntu20.04.tar.gz	429 MB
 OpenStudioApplication-1.4.0+e0fb8f854d-Windows.exe	261 MB
 OpenStudioApplication-1.4.0+e0fb8f854d-Windows.zip	347 MB
 Source code (zip)	
 Source code (tar.gz)	

<https://github.com/openstudiocoalition/OpenStudioApplication/releases/tag/v1.4.0>

OpenStudio Installation

- Install it on your computer (You can access it via Apporto or the 218 Computer Lab too)

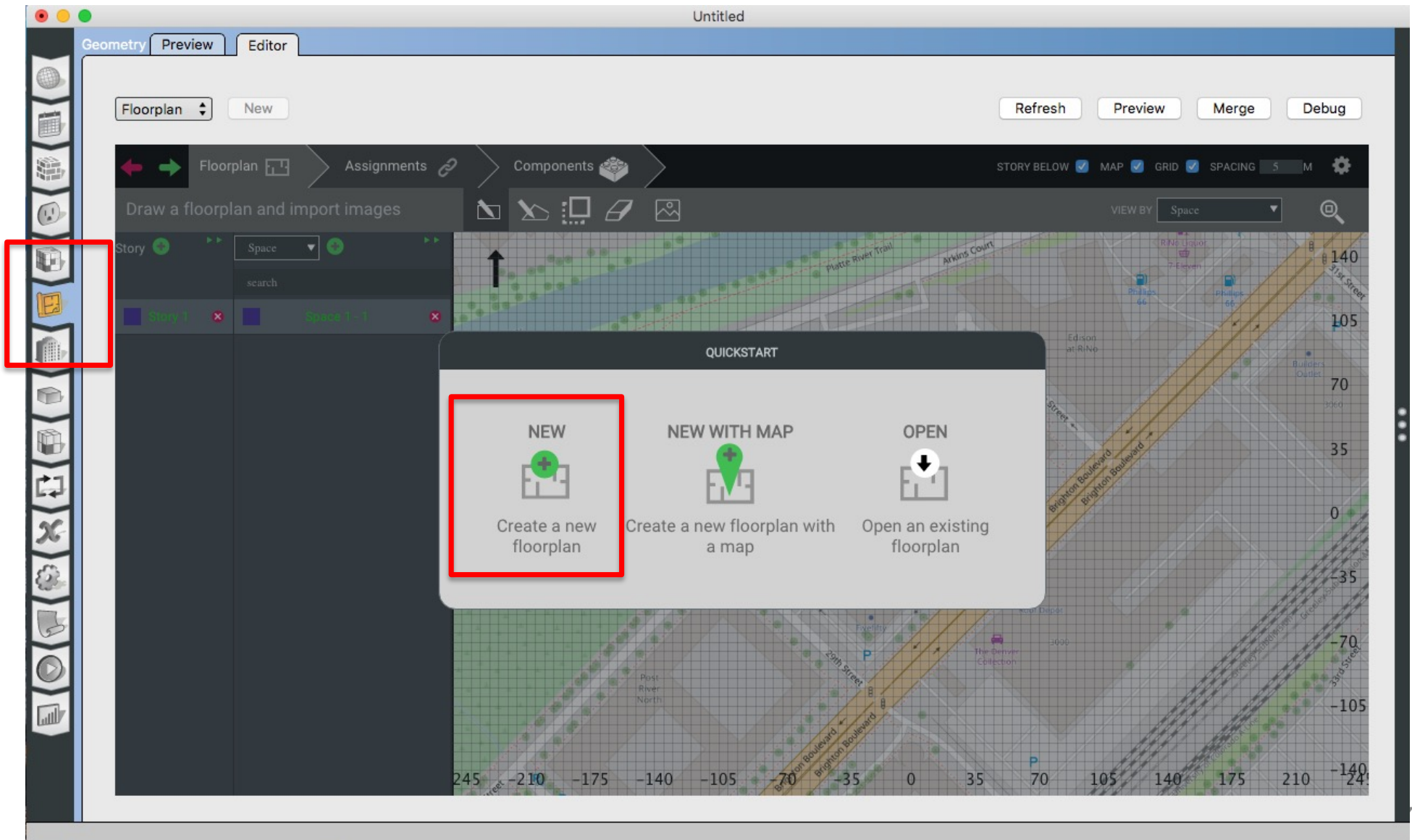
OpenStudio Installation

- Download Weather Data files from one of these sites:
 - ❑ <https://energyplus.net/weather>
 - ❑ <https://www.ladybug.tools/epwmap/>
 - ❑ <https://climate.onebuilding.org/>

CREATE GEOMETRY

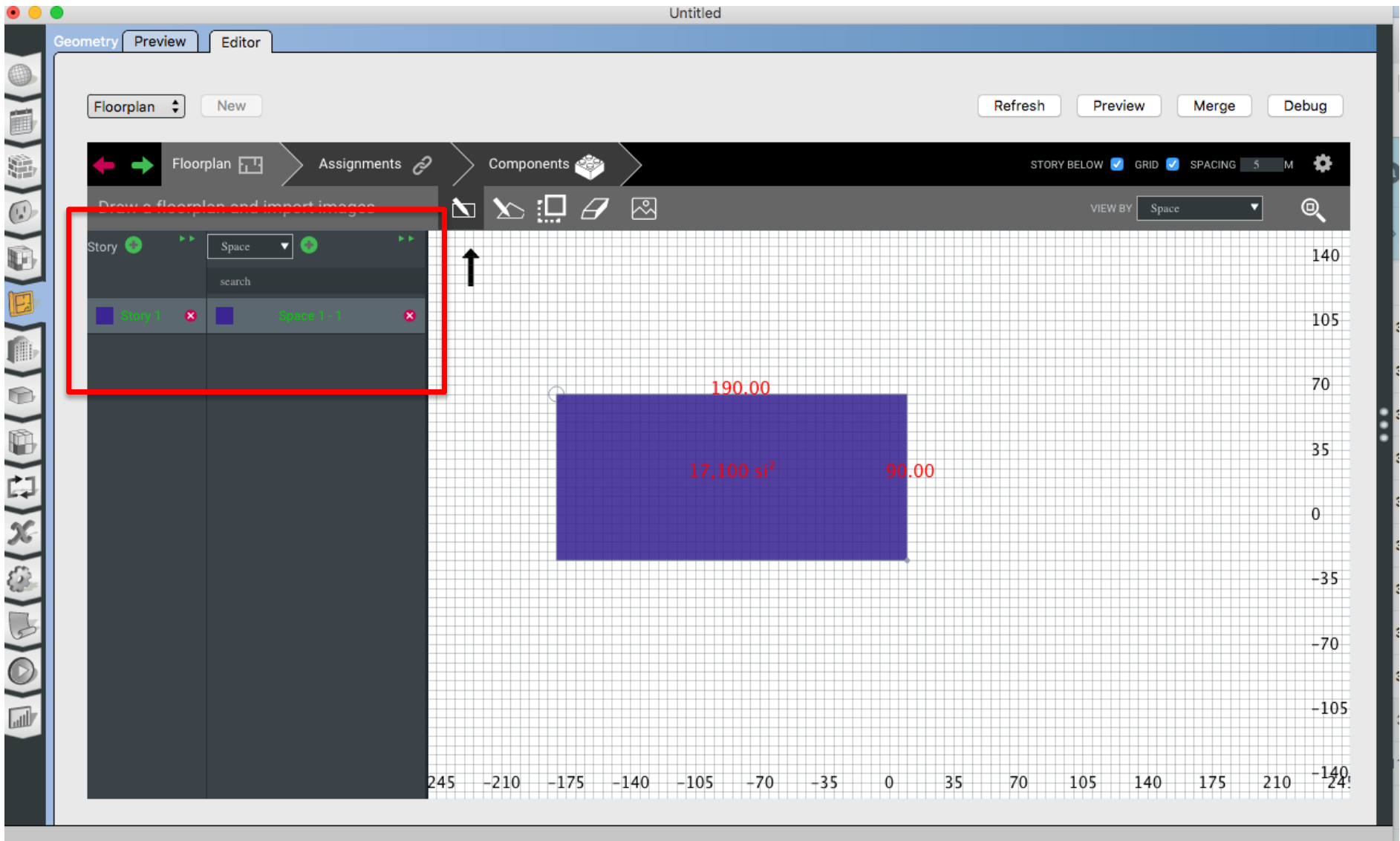
OpenStudio Training

- Step 1: Create or Import Floor Plan



OpenStudio Training

- Step 2: Add Spaces and Stories



OpenStudio Training

- Step 3: Add the height

The screenshot displays the OpenStudio software interface. The top panel shows the 'Space 1 - 1' configuration table, with the 'Below Floor Plenum Height', 'Floor to Ceiling Height', and 'Above Ceiling Plenum Height' columns highlighted by a red box. The values in these columns are all set to 0. Below the table is a 2D grid view showing a blue rectangular space labeled 'Space 1 - 1' on a coordinate system. The x-axis ranges from -285 to 135, and the y-axis ranges from -30 to 60. A red box highlights the 'Draw a floor plan and import images' button in the top toolbar.

Name	Story	Building Unit	Thermal Zone	Space Type	Construction Set	Below Floor Plenum Height	Floor to Ceiling Height	Above Ceiling Plenum Height	Floor Offset
Space 1 - 1	Story 1	(none)	(none)	(none)	(none)	0	0	0	0

OpenStudio Training

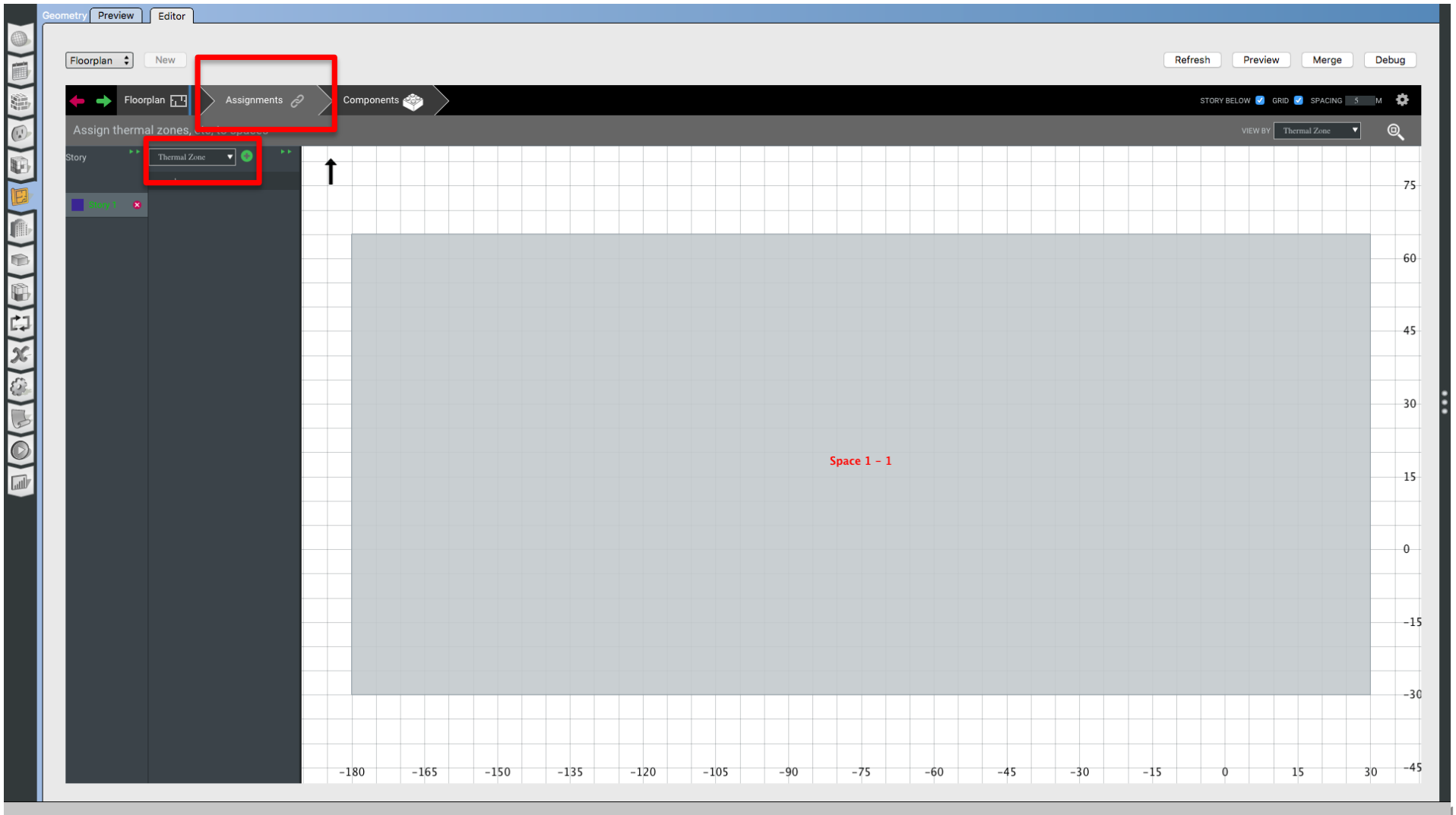
- Step 3: Add the height

The screenshot displays the OpenStudio software interface. The top panel shows the 'Space' properties for a selected space. The 'Height' field is highlighted with a red box and contains the value '3'. Other fields in the 'Height' section include 'Below Floor Plenum Height' (0), 'Above Ceiling Plenum Height' (0), and 'Floor Offset' (0). The 'Open To Below' dropdown is set to 'False'.

The bottom panel shows a 2D floor plan view on a grid. A blue rectangular area is labeled 'Space 1 - 1' in red text. The grid axes are labeled with numerical values: X-axis from -285 to 135, and Y-axis from -30 to 60.

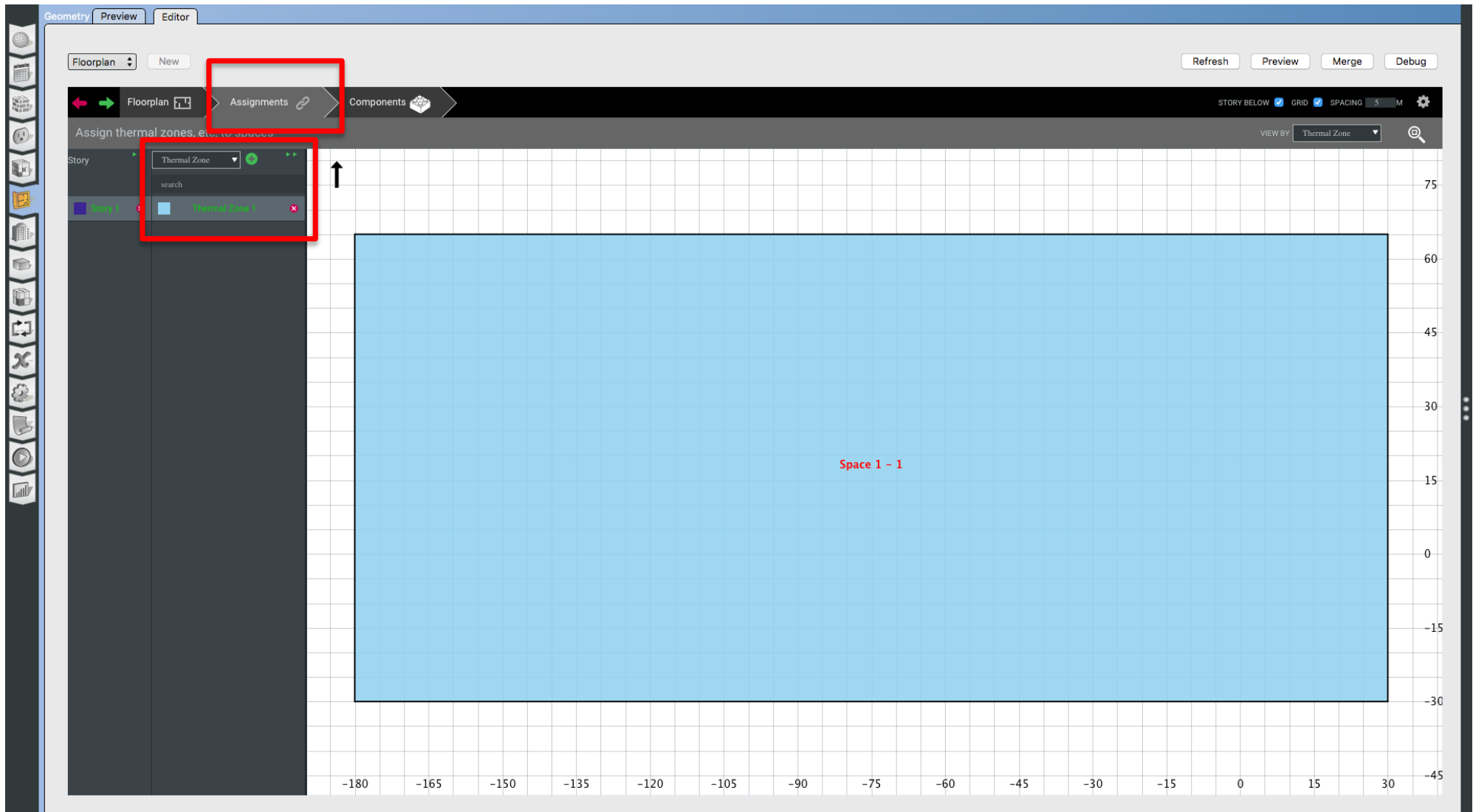
OpenStudio Training

- Step 4: Add Thermal Zone(s)



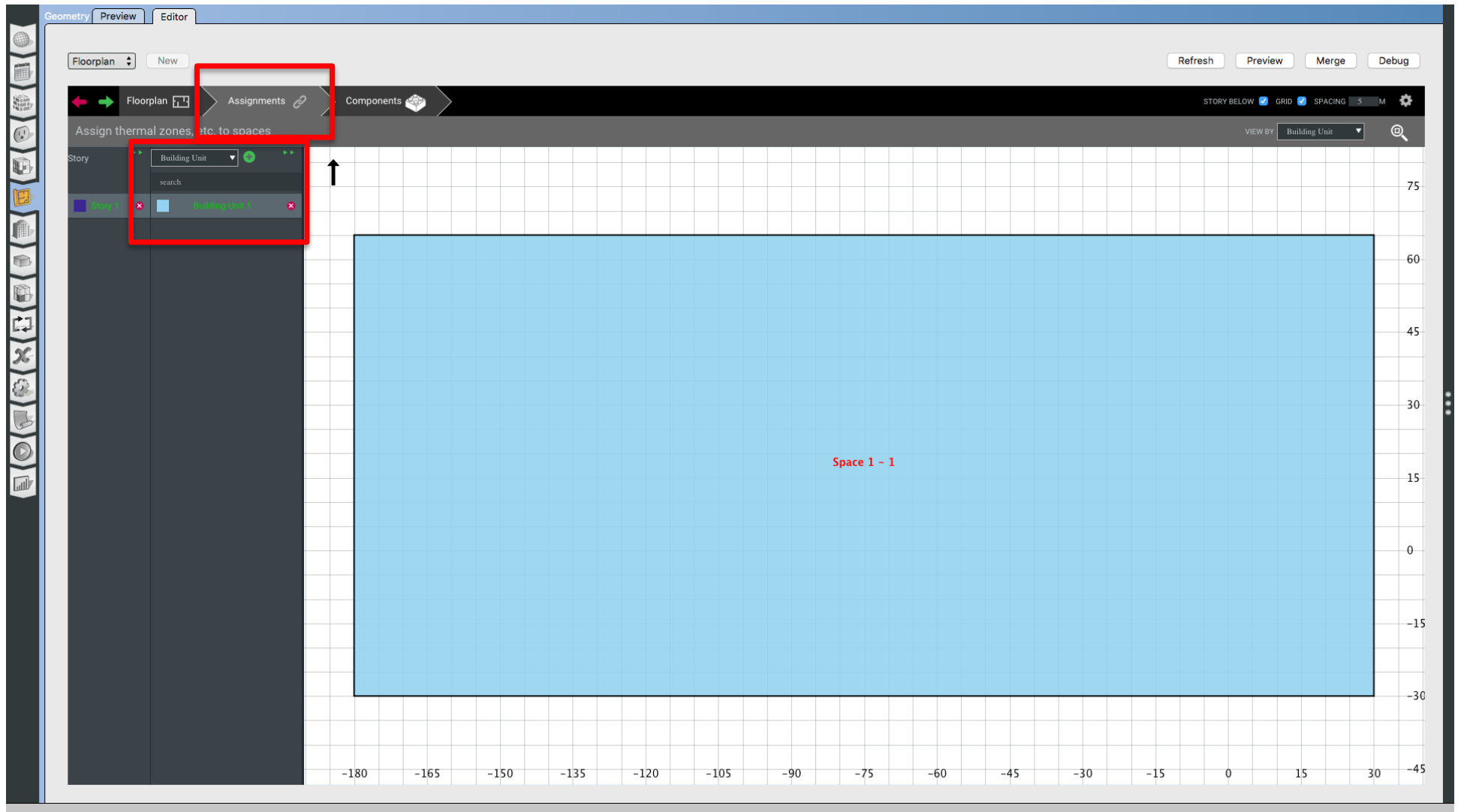
OpenStudio Training

- Step 4: Add Thermal Zone(s)



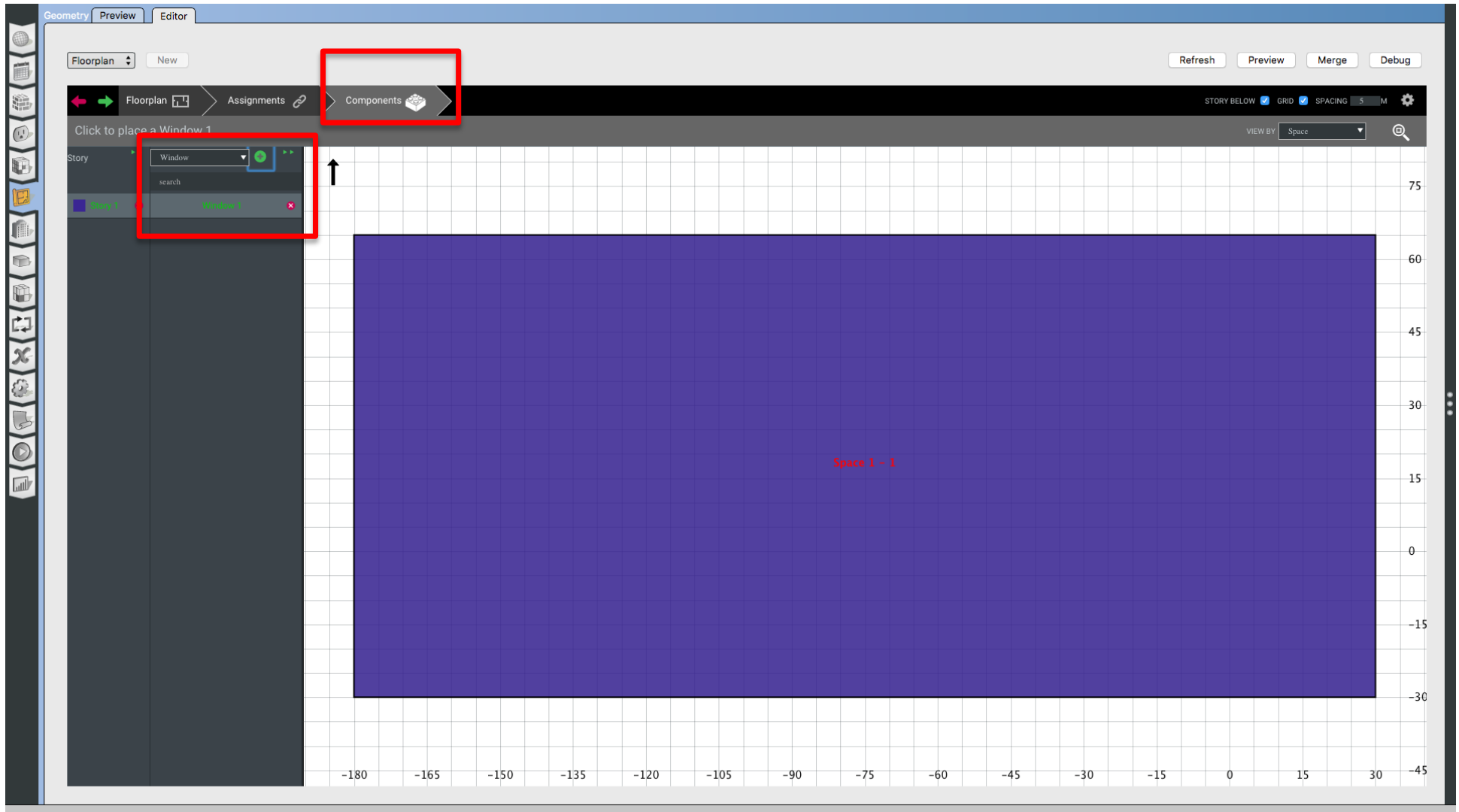
OpenStudio Training

- Step 5: Add Building Unit



OpenStudio Training

- Step 6: Add Windows (WWR or Individual)



OpenStudio Training

- Step 6: Add Windows (WWR or Individual)

The screenshot displays the OpenStudio software interface. The top navigation bar includes 'Geometry', 'Preview', and 'Editor' tabs. Below this, the 'Floorplan' view is active, showing a 'Components' panel with a 'Window' component selected. The 'Window to Wall ratio' is set to 0.4. The main workspace shows a grid view of a window component, with a blue rectangle representing the window on a white grid. The grid axes are labeled with coordinates: X-axis from -285 to 135, and Y-axis from -30 to 60.

Name	Mode	Window to Wall ratio	Height	Width	Sill Height	Spacing	Window Type	Overhang Projection Factor	Fin Projection Factor
Window 1	Window to Wall Ratio	0.4	{none}	{none}	0.9144000000000001	{none}	Fixed	{none}	{none}

OpenStudio Training

- Step 7: Merge & Preview

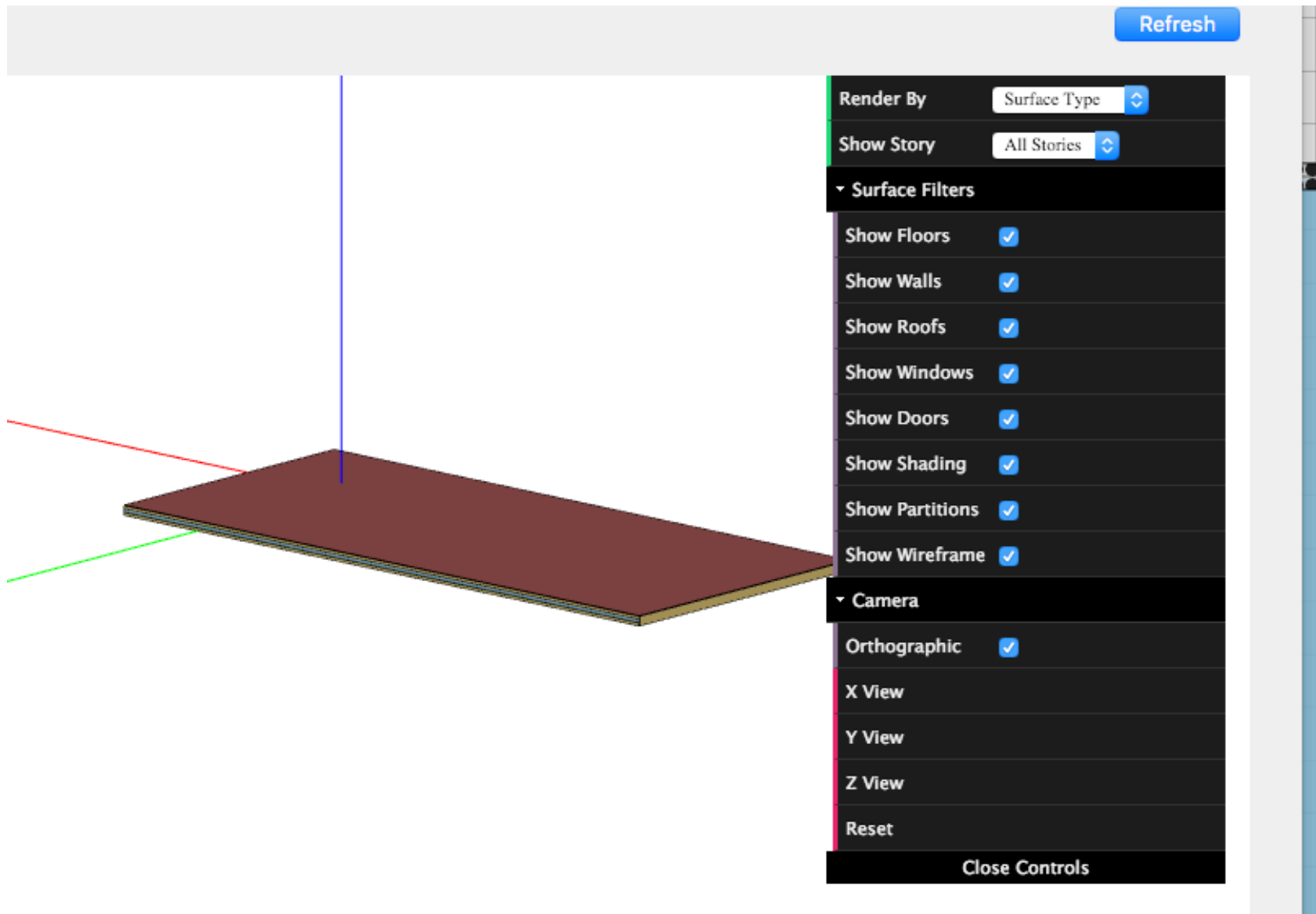
The screenshot shows the OpenStudio software interface. At the top, there are tabs for 'Geometry', 'Preview', and 'Editor'. Below these, there are buttons for 'Floorplan', 'New', and a search bar. A red box highlights the 'Refresh', 'Preview', 'Merge', and 'Debug' buttons in the top right corner. The main workspace is divided into a top panel for 'Window' properties and a bottom panel for the floorplan view. The 'Window' panel includes a search bar and a table of properties for 'Window 1'.

Name	Mode	Window to Wall ratio	Height	Width	Sill Height	Spacing	Window Type	Overhang Projection Factor	Fin Projection Factor
Window 1	Window to Wall Ratio	0.4	(none)	(none)	0.9144000000000001	(none)	Fixed	(none)	(none)

The floorplan view shows a grid with a blue rectangular window element. The grid has x and y axes ranging from -285 to 135 and -30 to 60, respectively. A red arrow points to the 'Window 1' entry in the table.

OpenStudio Training

- Step 7: Merge & Preview



**ADD DEFAULT VALUES TO TEST THE
MODEL**

OpenStudio Training

- Step 8: Add Default Values

The screenshot displays the OpenStudio software interface. The main window is titled 'Building' and contains several input fields and controls. A red box highlights the 'Standards Building Type' dropdown menu. Another red box highlights the 'Standards Number of Stories' input field. A third red box highlights the 'Standards Number of Living Units' input field. The sidebar on the right contains a 'Library' tab, which is also highlighted with a red box. Below the 'Library' tab, there is a list of 'Construction Sets' with the first item, '189.1-2009 - CZ1 - Office', highlighted with a red box. Other items in the list include '189.1-2009 - CZ2 - Office', '189.1-2009 - CZ3 - Office', '189.1-2009 - CZ4 - Office', '189.1-2009 - CZ5 - Office', '189.1-2009 - CZ6 - Office', and '189.1-2009 - CZ7-8 - Office'. Below the 'Construction Sets' list, there are sections for 'Schedule Sets', 'Design Specification Outdoor Air', 'Space Infiltration Effective Leakage Areas', 'Space Infiltration Design Flow Rates', 'People Definitions', 'Lights Definitions', 'Luminaire Definitions', 'Electric Equipment Definitions', 'Gas Equipment Definitions', and 'Water Use Equipment Definitions'.

OpenStudio Training

- Step 8: Add Default Values

The screenshot displays the OpenStudio software interface. The main window is titled 'Building' and contains several configuration sections:

- Name:** A text field containing 'Building 1'.
- Measure Tags (Optional):**
 - Standards Building Type:** A dropdown menu.
 - Relocatable:** A checkbox labeled 'false'.
 - Nominal Floor to Ceiling Height:** A text field with 'm' as a unit.
 - Nominal Floor to Floor Height:** A text field with 'm' as a unit.
 - Standards Number of Stories:** A text field.
 - Standards Number of Above Ground Stories:** A text field.
 - Standards Number of Living Units:** A text field.
- North Axis:** A text field containing '0.000000' with 'deg' as a unit.
- Space Type:** A dashed box containing the text 'Drag From Library'.
- Default Construction Set:** A dashed box containing a selection of '189.1-2001 - CZ2 - Office' with a close button (X).
- Default Schedule Set:** A dashed box containing the text 'Drag From Library'.

On the right side of the interface, there is a vertical panel titled 'Space Types' with a dropdown arrow. This panel lists various space types, each with a small icon and a label. The first item, '189.1-2009 - Office - BreakRoom - CZ1-3', is highlighted with a red box. Other items include 'BreakRoom - CZ4-8', '189.1-2009 - Office - ClosedOffice - CZ1-3', '189.1-2009 - Office - ClosedOffice - CZ4-8', '189.1-2009 - Office - Conference - CZ1-3', '189.1-2009 - Office - Conference - CZ4-8', '189.1-2009 - Office - Corridor - CZ1-3', '189.1-2009 - Office - Corridor - CZ4-8', '189.1-2009 - Office - Elec/MechRoom - CZ1-3', '189.1-2009 - Office - Elec/MechRoom - CZ4-8', '189.1-2009 - Office - IT_Room - CZ1-3', '189.1-2009 - Office - IT_Room - CZ4-8', '189.1-2009 - Office - Lobby - CZ1-3', '189.1-2009 - Office - Lobby - CZ4-8', '189.1-2009 - Office - OpenOffice - CZ1-3', and '189.1-2009 - Office - OpenOffice - CZ4-8'.

OpenStudio Training

- Step 8: Add Default Values

The screenshot displays the OpenStudio software interface for configuring a space type. The main window is titled 'Building 1' and shows various configuration options. The 'Name' field is set to 'Building 1'. Under 'Measure Tags (Optional)', the 'Standards Building Type' is set to a dropdown menu, and the 'Relocatable' checkbox is checked. The 'Nominal Floor to Ceiling Height' and 'Nominal Floor to Floor Height' are both set to 0 m. The 'Standards Number of Stories' and 'Standards Number of Above Ground Stories' are both set to 1. The 'Standards Number of Living Units' is set to 1. The 'North Axis' is set to 0.000000 deg. The 'Space Type' dropdown is set to '189.1-2009 - Office - ClosedOffice'. The 'Default Construction Set' is set to '189.1-2009 - CZ2 - Office'. The 'Default Schedule Set' is set to '189.1-2009 - Office - BreakRoom - CZ1-3 Schedule Set'. The right sidebar shows a list of available schedule sets, with the selected one highlighted in red.

Facility | Building | Stories | Shading | Exterior Equipment

Name:
Building 1

Measure Tags (Optional):
Standards Building Type: [dropdown] Relocatable: false
Nominal Floor to Ceiling Height: [input] m Nominal Floor to Floor Height: [input] m
Standards Number of Stories: [input] Standards Number of Above Ground Stories: [input]
Standards Number of Living Units: [input]

North Axis: 0.000000 deg

Space Type: 189.1-2009 - Office - ClosedOffice

Default Construction Set: 189.1-2009 - CZ2 - Office

Default Schedule Set: 189.1-2009 - Office - BreakRoom - CZ1-3 Schedule Set

My Model | Library | Edit

Space Types

Construction Sets

Schedule Sets

- 189.1-2009 - Office - BreakRoom - CZ1-3 Schedule Set
- 189.1-2009 - Office - BreakRoom - CZ4-8 Schedule Set
- 189.1-2009 - Office - ClosedOffice - CZ1-3 Schedule Set
- 189.1-2009 - Office - ClosedOffice - CZ4-8 Schedule Set
- 189.1-2009 - Office - Conference - CZ1-3 Schedule Set
- 189.1-2009 - Office - Conference - CZ4-8 Schedule Set
- 189.1-2009 - Office - Corridor - CZ1-3 Schedule Set
- 189.1-2009 - Office - Corridor - CZ4-8 Schedule Set
- 189.1-2009 - Office - Elec/ MechRoom - CZ1-3 Schedule Set
- 189.1-2009 - Office - Elec/ MechRoom - CZ4-8 Schedule Set
- 189.1-2009 - Office - IT_Room - CZ1-3 Schedule Set
- 189.1-2009 - Office - IT_Room - CZ4-8 Schedule Set
- 189.1-2009 - Office - Lobby - CZ1-3 Schedule Set
- 189.1-2009 - Office - Lobby - CZ4-8 Schedule Set
- 189.1-2009 - Office - OpenOffice - CZ1-3 Schedule Set

TEST MODEL WITH IDEAL AIR LOOP

OpenStudio Training

- Step 9: Run Ideal Air Loop

Thermal Zones

HVAC Systems Cooling Sizing Parameters Heating Sizing Parameters Custom

Name	All	Turn On Ideal Air Loads	Air Loop Name	Zone Equipment	Cooling Thermostat Schedule	Heating Thermostat Schedule	Humidifying Setpoint Schedule	Dehumidifying Setpoint Schedule	Multiplier
Thermal Zone 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	None	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	1

My Model Library Edit

Schedule Rulesets

Compact Schedules

Zone Ventilation Design Flow Rate

Unit Ventilator

Unit Heater

High Temp Radiant

Low Temp Radiant Electric

Low Temp Radiant Variable Flow

Low Temp Radiant Constant Flow

PTAC

Water To Air HP

PTHP

Water Heater - Heat Pump - Wrapped Condenser

Water Heater - Heat Pump

Fan Zone Exhaust

Four Pipe Fan Coil

ERV

Dehumidifier - DX

Baseboard Radiant Convective Water

Baseboard Radiant Convective Electric

Baseboard Convective Water

ADD WEATHER DATA

OpenStudio Training

- Step 10: Add Weather Data Files

The screenshot shows the OpenStudio interface with the 'Weather File & Design Days' tab selected. The 'Weather File' section is highlighted with a red box, showing the following information:

- Name: Chicago O'hare Intl Ap
- Latitude: 41.98
- Longitude: -87.92
- Elevation: 201
- Time Zone: -6
- Download weather files at www.energypplus.net/weather

The 'Design Days' section is also highlighted with a red box, showing the following information:

- ASHRAE Climate Zone: [Dropdown]
- CEC Climate Zone: [Dropdown]
- Design Days: Import From DDY

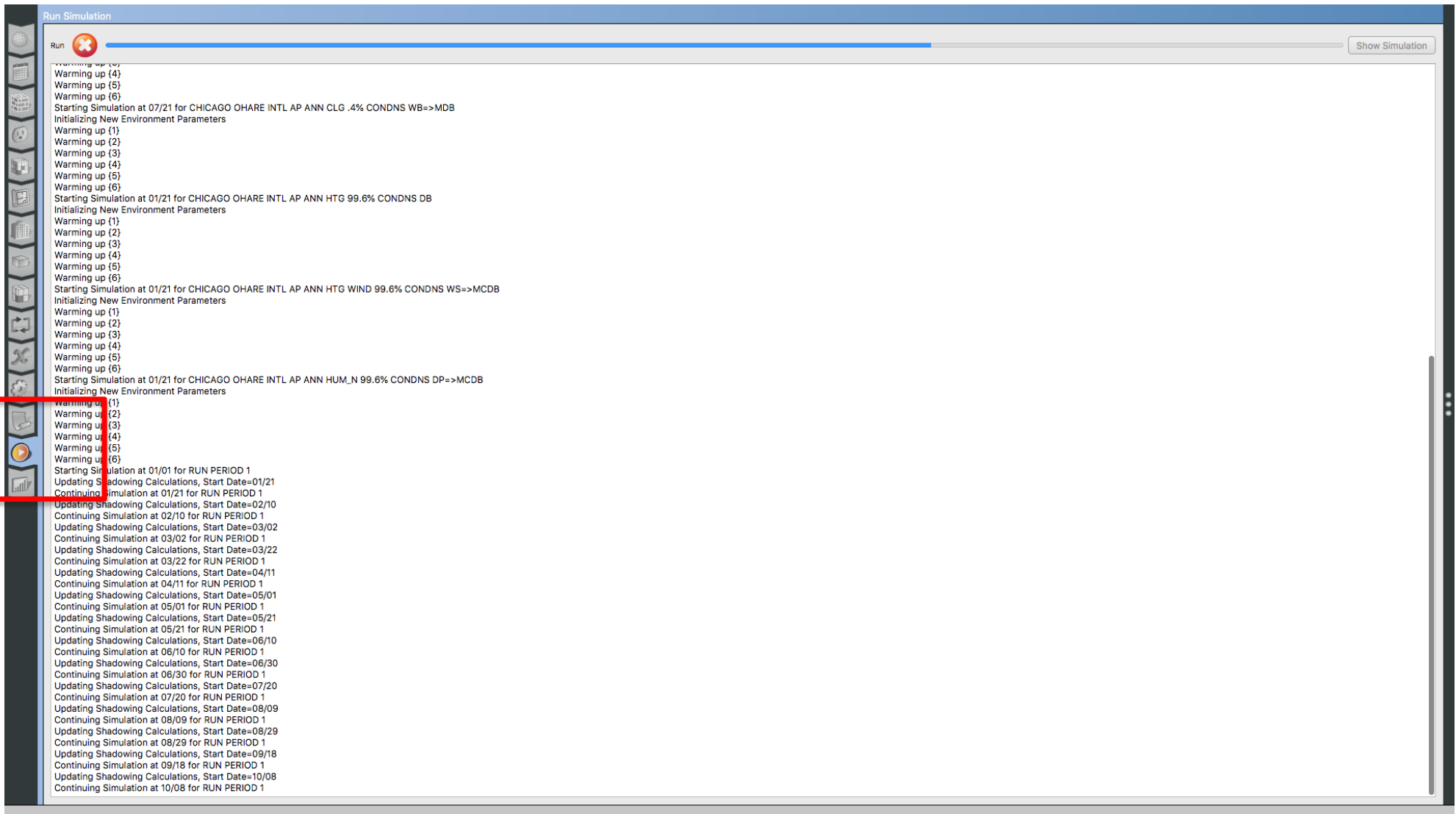
The 'Design Days' table is shown below, with columns for Date, Temperature, Humidity, Pressure Wind Precipitation, Solar, and Custom. The table lists several design days for Chicago O'hare Intl Ap, including summer and winter design days.

Design Day Name	All	Day Of Month	Month	Day Type	Daylight Sav
Chicago O'hare Intl Ap Ann Clg .4% Condns DB=>MWB	<input type="checkbox"/>	21	7	SummerDesignDay	
Chicago O'hare Intl Ap Ann Clg .4% Condns DP=>MDB	<input type="checkbox"/>	21	7	SummerDesignDay	
Chicago O'hare Intl Ap Ann Clg .4% Condns Enth=>MDB	<input type="checkbox"/>	21	7	SummerDesignDay	
Chicago O'hare Intl Ap Ann Clg .4% Condns WB=>MDB	<input type="checkbox"/>	21	7	SummerDesignDay	
Chicago O'hare Intl Ap Ann Htg 99.6% Condns DB	<input type="checkbox"/>	21	1	WinterDesignDay	
Chicago O'hare Intl Ap Ann Htg Wind 99.6% Condns WS=>MCDB	<input type="checkbox"/>	21	1	WinterDesignDay	
Chicago O'hare Intl Ap Ann Hum_n 99.6% Condns DP=>MCDB	<input type="checkbox"/>	21	1	WinterDesignDay	

RUN MODEL

OpenStudio Training

- Step 11: Run the Model



VISIT RESULTS

OpenStudio Training

- Step 12: Visualize the Results

Results Summary

Reports: OpenStudio Results

Refresh Open DView for Detailed Reports

OpenStudio Results

Model Summary

Model Summary

- Annual Overview
- Monthly Overview
- Utility Bills/Rates
- Envelope Summary
- Space Type Breakdown
- Space Type Summary
- Interior Lighting Summary
- Plug Loads Summary
- Exterior Lighting
- Water Use Equipment
- HVAC Load Profiles
- Zone Conditions
- Zone Overview
- Zone Equipment Detail
- Air Loops Detail
- Plant Loops Detail
- Outdoor Air
- Cash Flow
- Site and Source Summary
- Schedule Overview

Building Summary

Data	Value
Building Name	Building 1
Total Site Energy	4,560,744 kBtu
Total Building Area	214,740 ft ²
Total Site EUI	21.24 kBtu/ft ²
OpenStudio Standards Building Type	n/a

Weather Summary

	Value
Weather File	Chicago Ohare Intl Ap IL USA TMY3 WMO#=725300
Latitude	41.98
Longitude	-87.9
Elevation	659 (ft)
Time Zone	-6.0
North Axis Angle	0.00
ASHRAE Climate Zone	

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction

TEST A ZONE LEVEL HVAC SYSTEM

OpenStudio Training

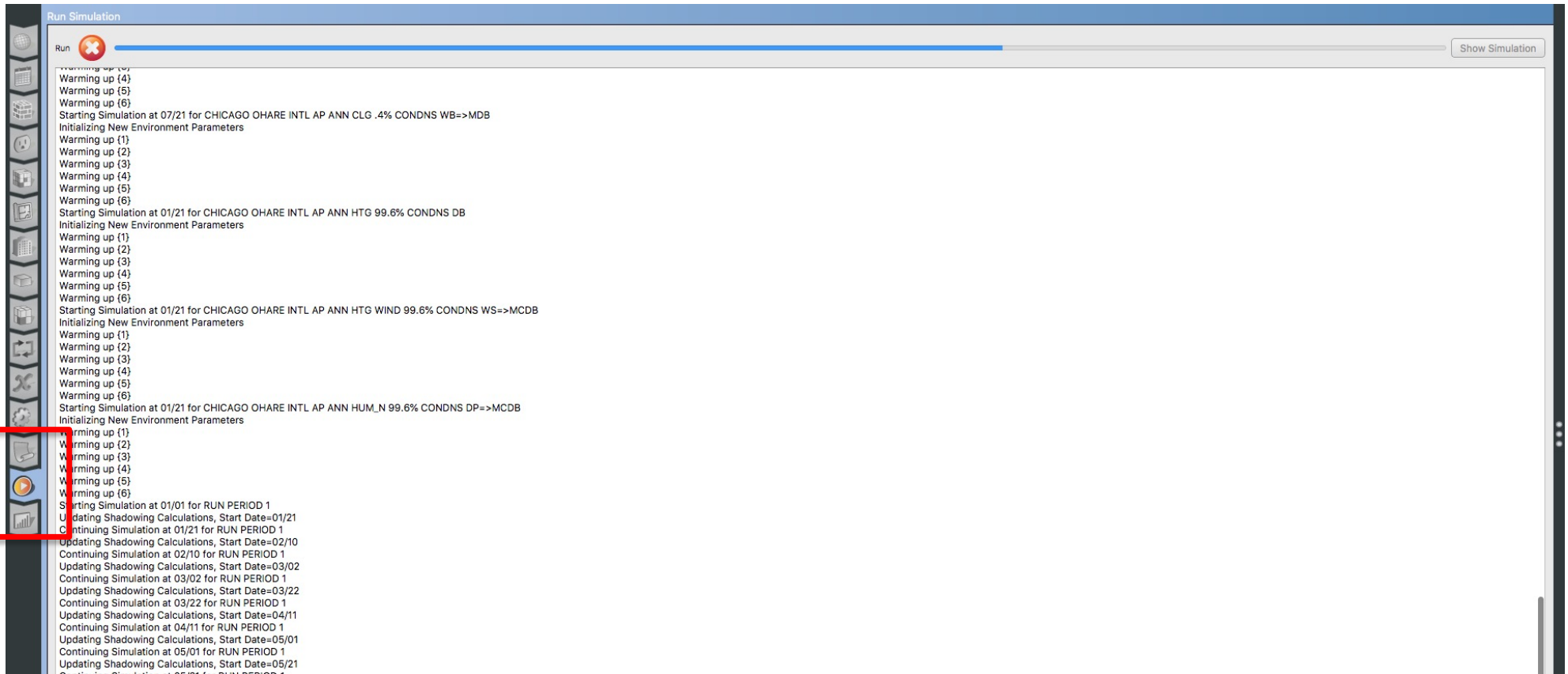
- Step 13: Add heating and cooling setpoints

The screenshot displays the 'Thermal Zones' configuration window in OpenStudio. The interface is divided into several sections:

- Top Navigation:** 'My Model', 'Library', and 'Edit' tabs.
- Buttons:** 'HVAC Systems', 'Cooling Sizing Parameters', 'Heating Sizing Parameters', and 'Custom'.
- Table:** A table with columns for Name, All, Turn On Ideal Air Loads, Air Loop Name, Zone Equipment, Cooling Thermostat Schedule, Heating Thermostat Schedule, Humidifying Setpoint Schedule, Dehumidifying Setpoint Schedule, and Multiplier. The row for 'Thermal Zone 1' shows 'None' for Air Loop Name, 'PTHP' for Zone Equipment, and 'Large Office ClgSetp' for Cooling Thermostat Schedule and 'Large Office HtgSetp' for Heating Thermostat Schedule. These two schedule cells are highlighted with a red box.
- Right Sidebar:** A list of objects including 'HPWH Setpoint', 'HPWH Stratified - Wrapped Cond - Amb Temp', 'HPWH Stratified - Wrapped Cond - Heater 1 Setpoint', 'HPWH Stratified - Wrapped Cond - Heater 2 Setpoint', 'Inlet Air Humidity', 'Inlet Air Mixer Fraction', 'Inlet Air Temp', 'Large Office Activity', 'Large Office Bldg Equip', 'Large Office Bldg Light', 'Large Office Bldg Occ', 'Large Office ClgSetp', 'Large Office HtgSetp', 'Large Office Infil Quarter On', and 'Load Profile Schedule'. The 'Large Office ClgSetp' and 'Large Office HtgSetp' objects are highlighted with a red box.

OpenStudio Training

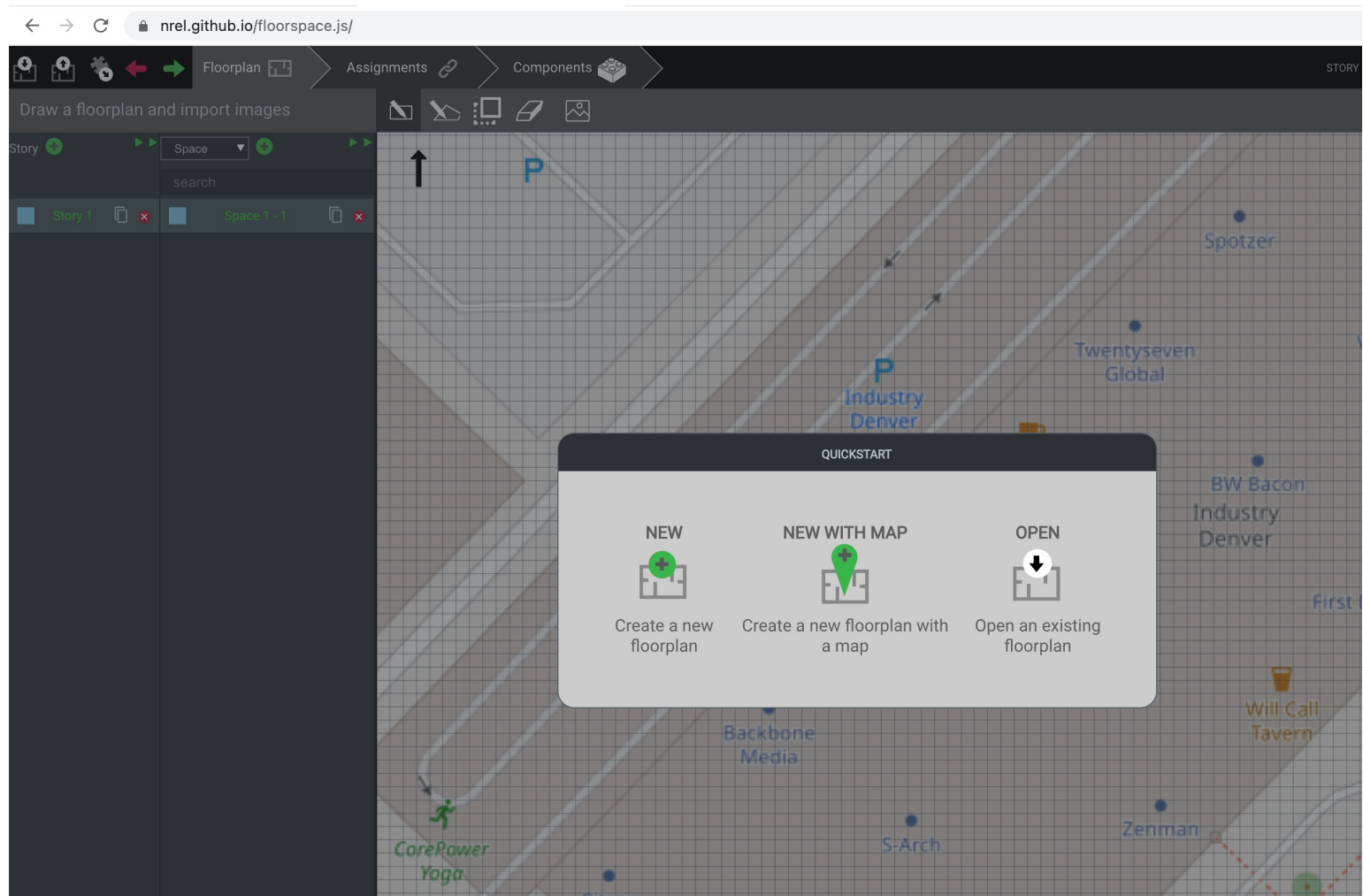
- Step 14: Run the Model



FLOORSPACEJS

FloorSpaceJS

- For those who have issues with the Geometry Tab, you can use the online geometry:



<https://nrel.github.io/floorspace.js/>

FloorSpaceJS

- Make sure to export the “json” file and place it in the folder with that comes with the OpenStudio model:

