

4.401/4.464

Environmental Technologies in Buildings

Lab 27.10.2022

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MIT SUSTAINABLE DESIGN LAB

Assignment Review

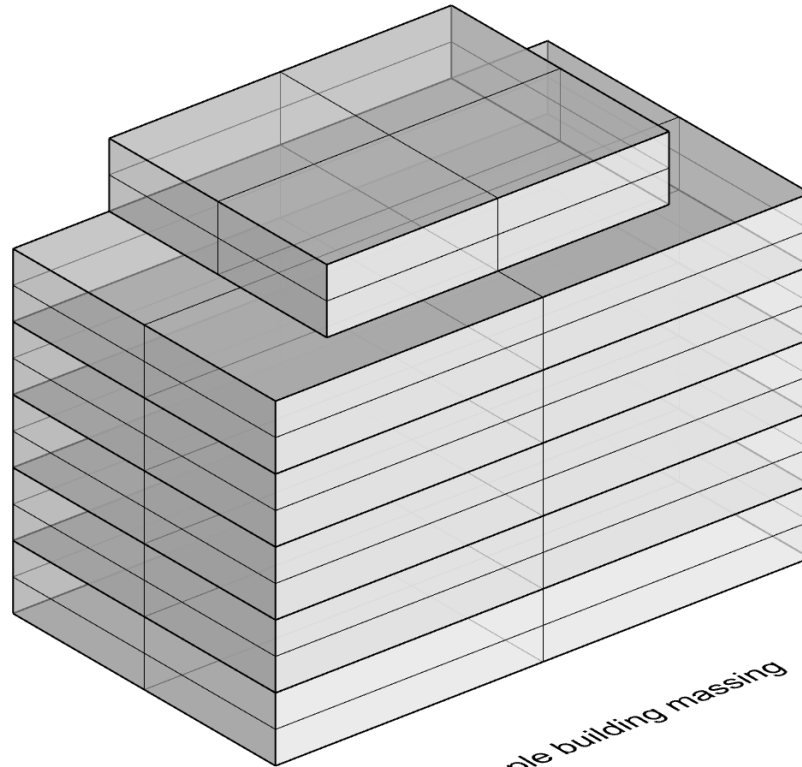
- **Questions?**

Assignment Review

- **Questions?**

TASK A
create the basic
geometry

Starting point

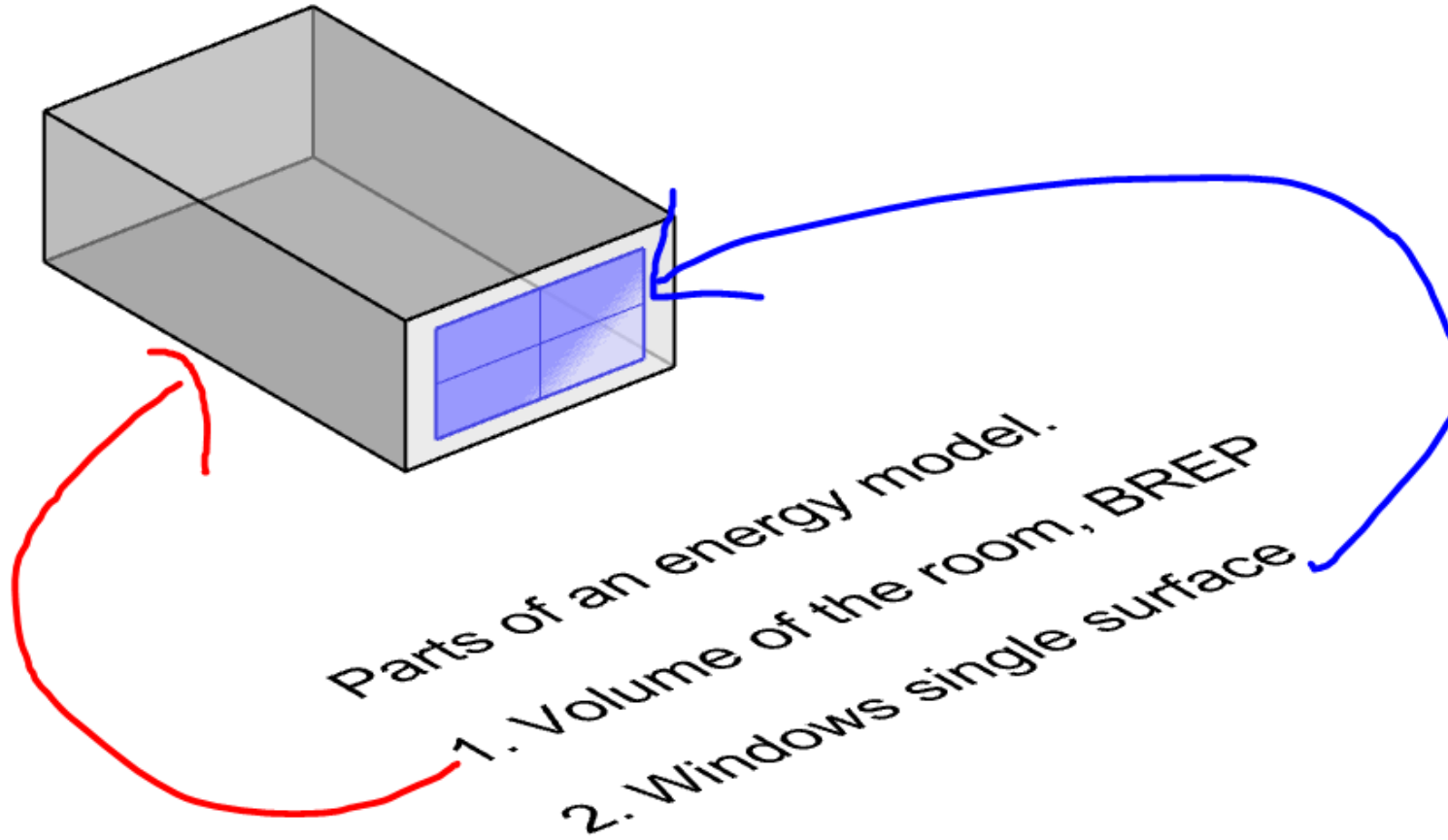


Model simple building massing

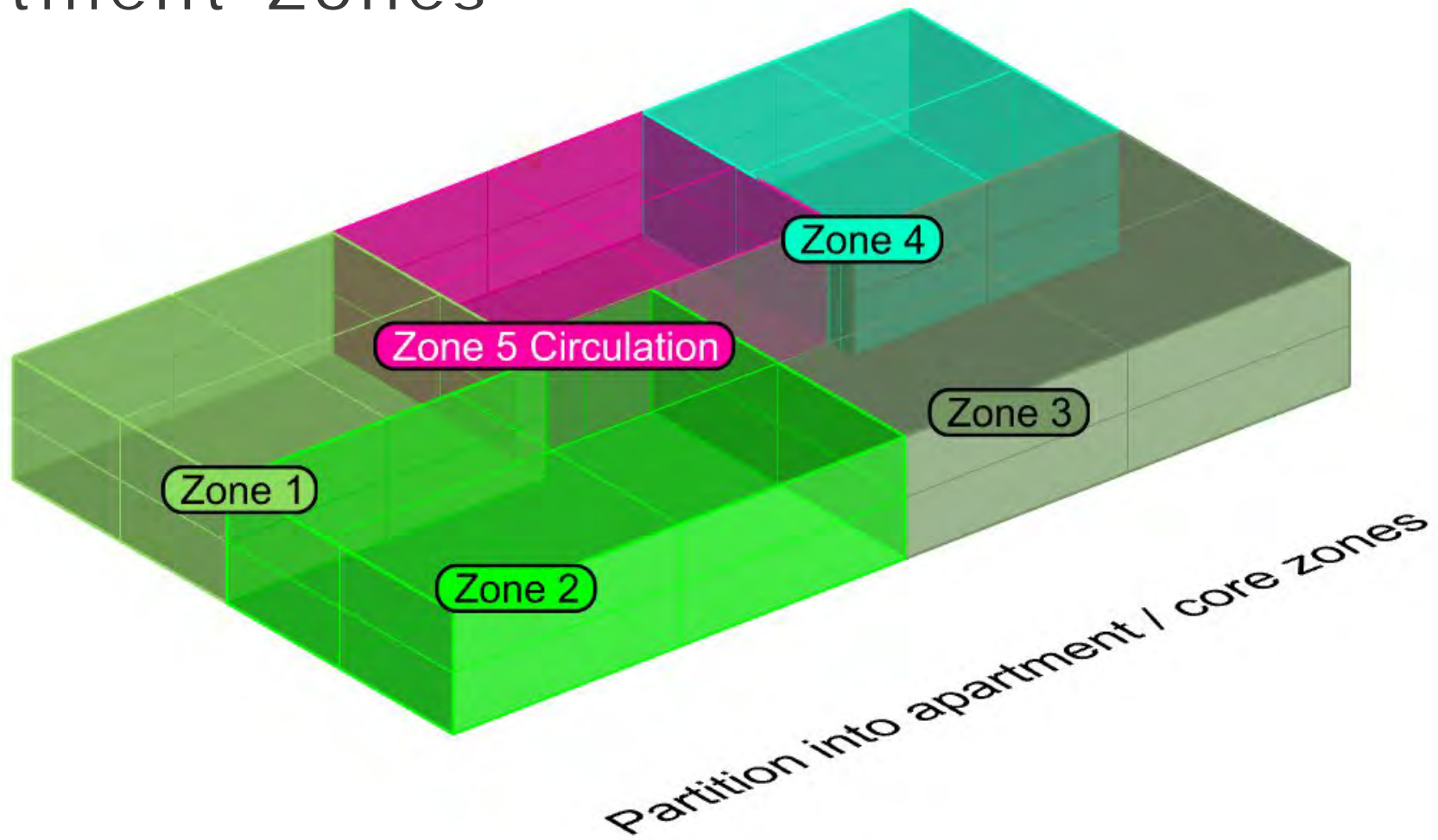
375 m² / floor

~ 2000 m² total floor area

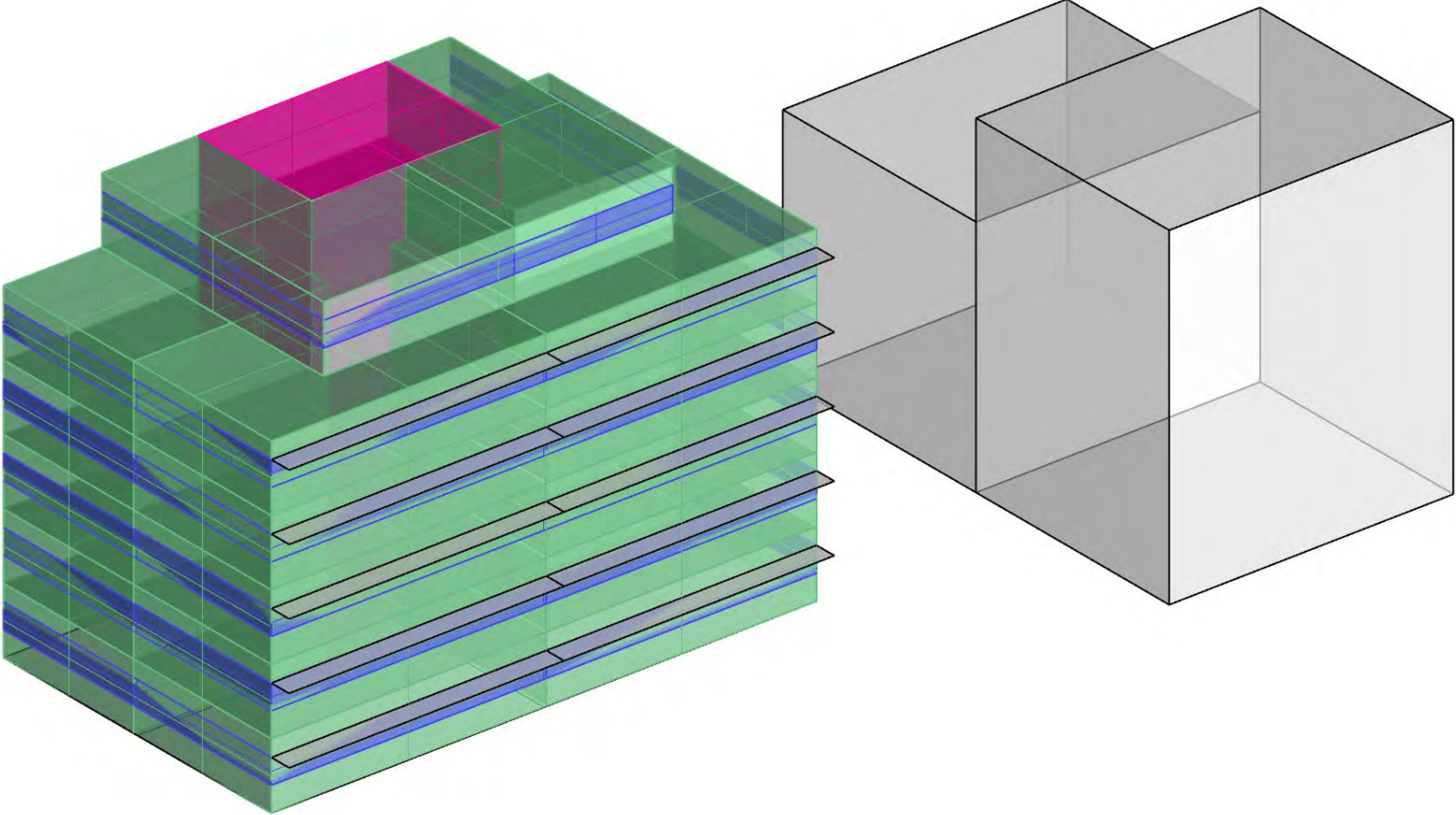
What is an energy model?



Apartment Zones



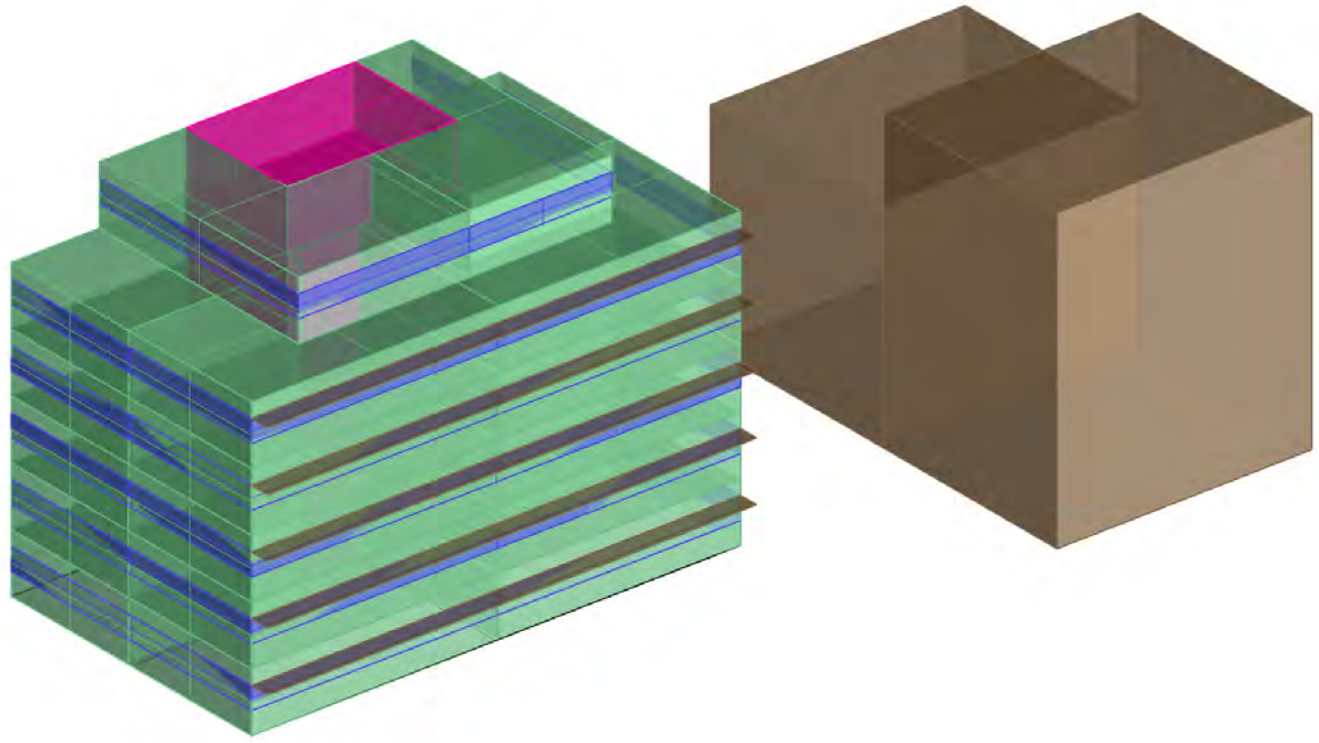
Assing parts to layers





iso_screenshot

Good Layers!!!



Layers

Layer	Mate...	Lin...	Print...
> Default	Lightbulb icon	Black square	Con... ◆ Defa...
Simulation Building	Lightbulb icon	Black square	Cont... ◆ Defa...
Zones Apartments	Lightbulb icon	Green square	Cont... ◆ Defa...
Zones Circulation	Lightbulb icon	Pink square	Cont... ◆ Defa...
Shading	Lightbulb icon	Brown square	Cont... ◆ Defa...
Windows	Lightbulb icon	Blue square	Cont... ◆ Defa...
Ground	Lightbulb icon	Black square	Cont... ◆ Defa...

Top iso_screenshot Front Right

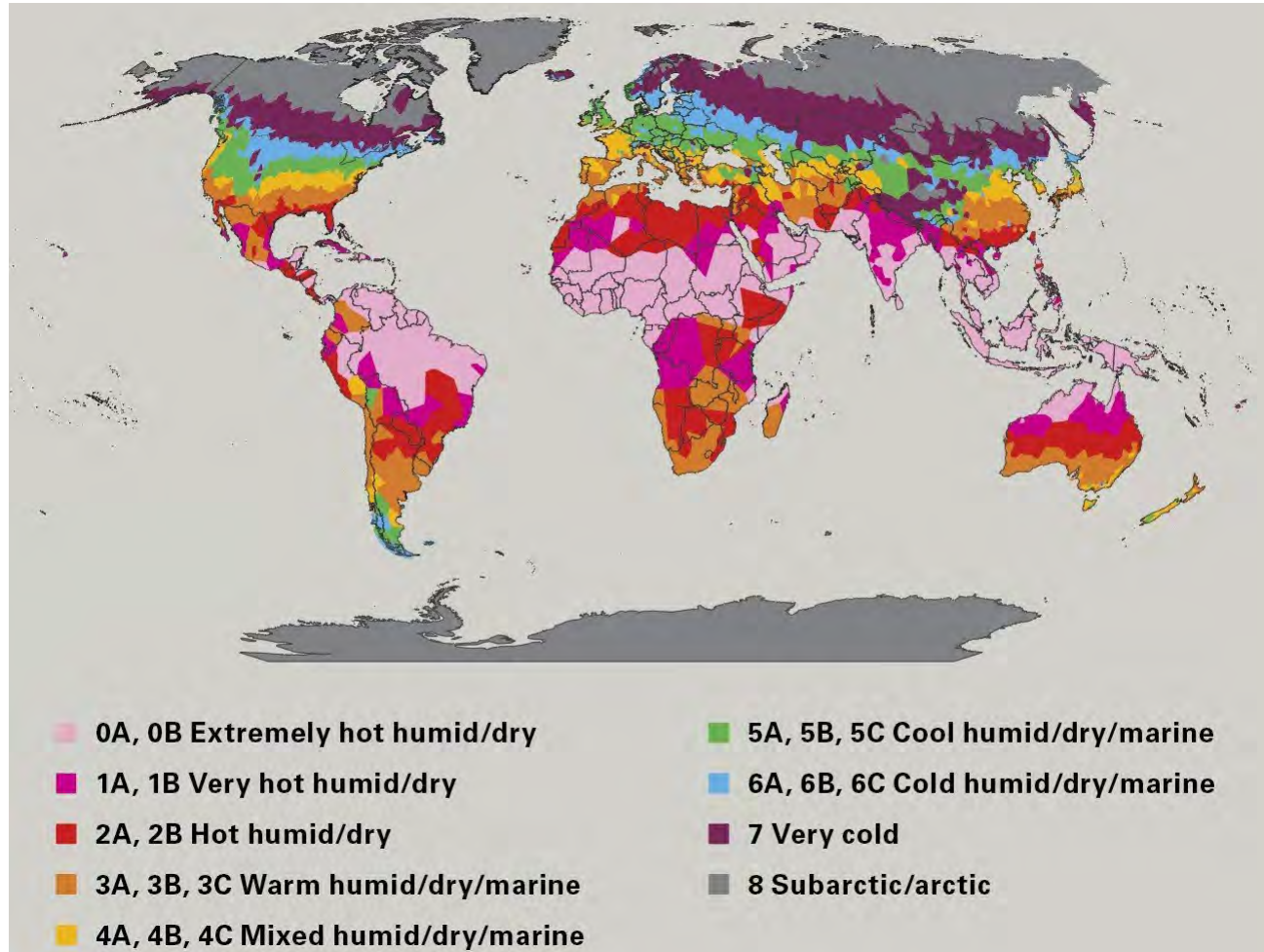
End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

CPlane x 605.40842 y -30.13813 z 0.00000 Meters windows Grid Snap Ortho Planar **Osnap SmartTrack Gumball** Record History Filter Available physical memory: 7682 MB

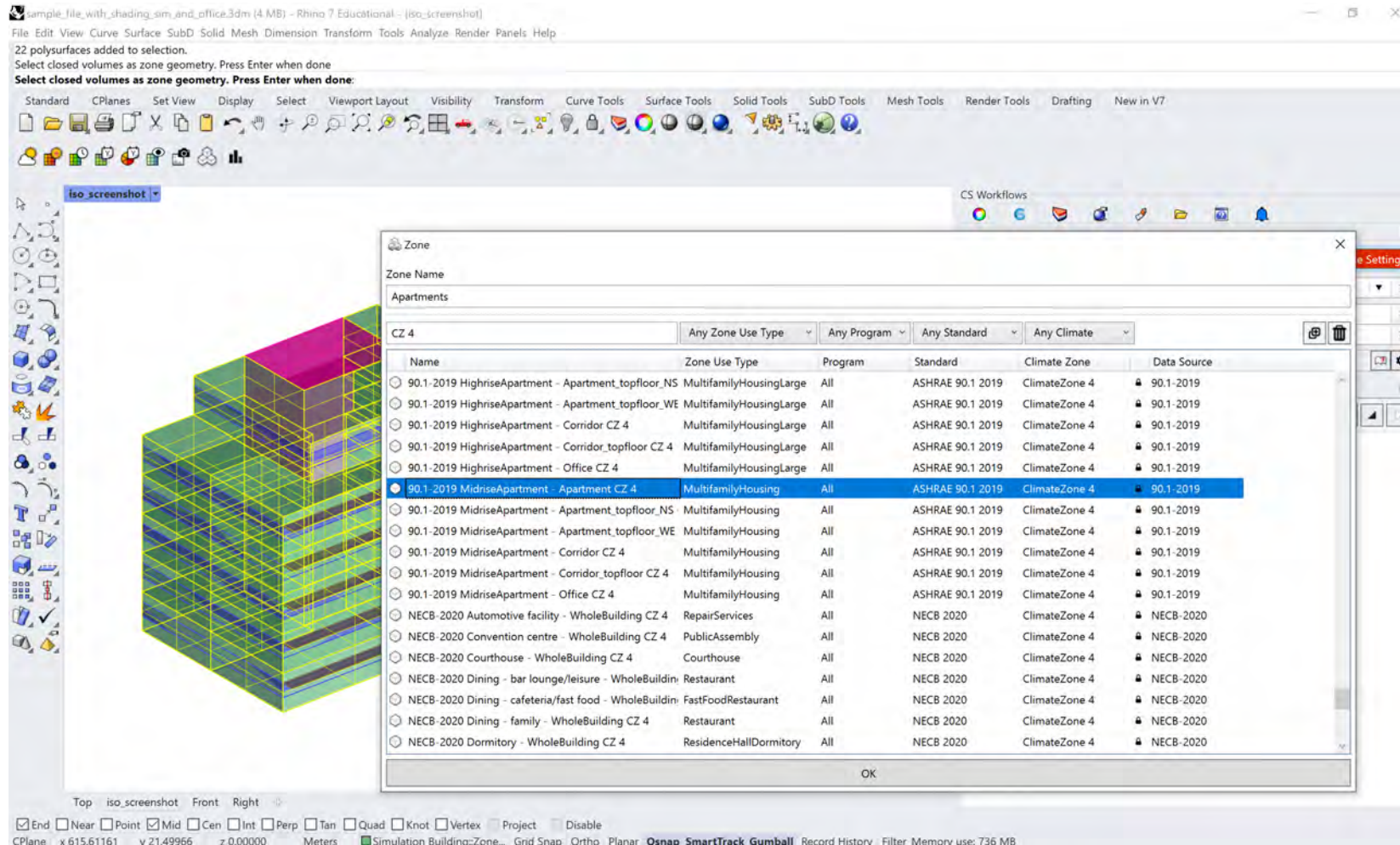
TASK B

Assign zone settings

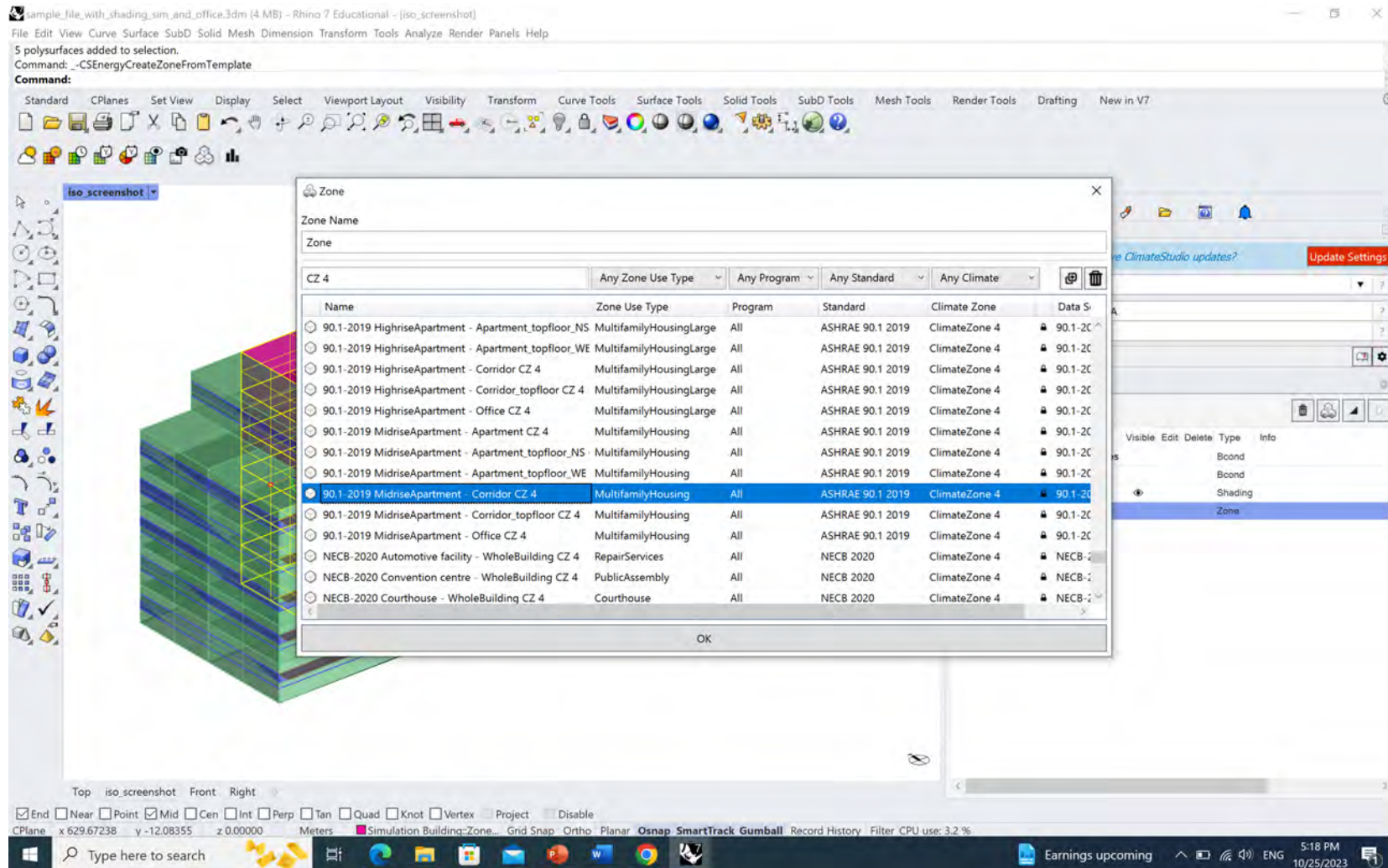
Select Climate Zone: Example CZ 4 -> Zone Ashrae 4



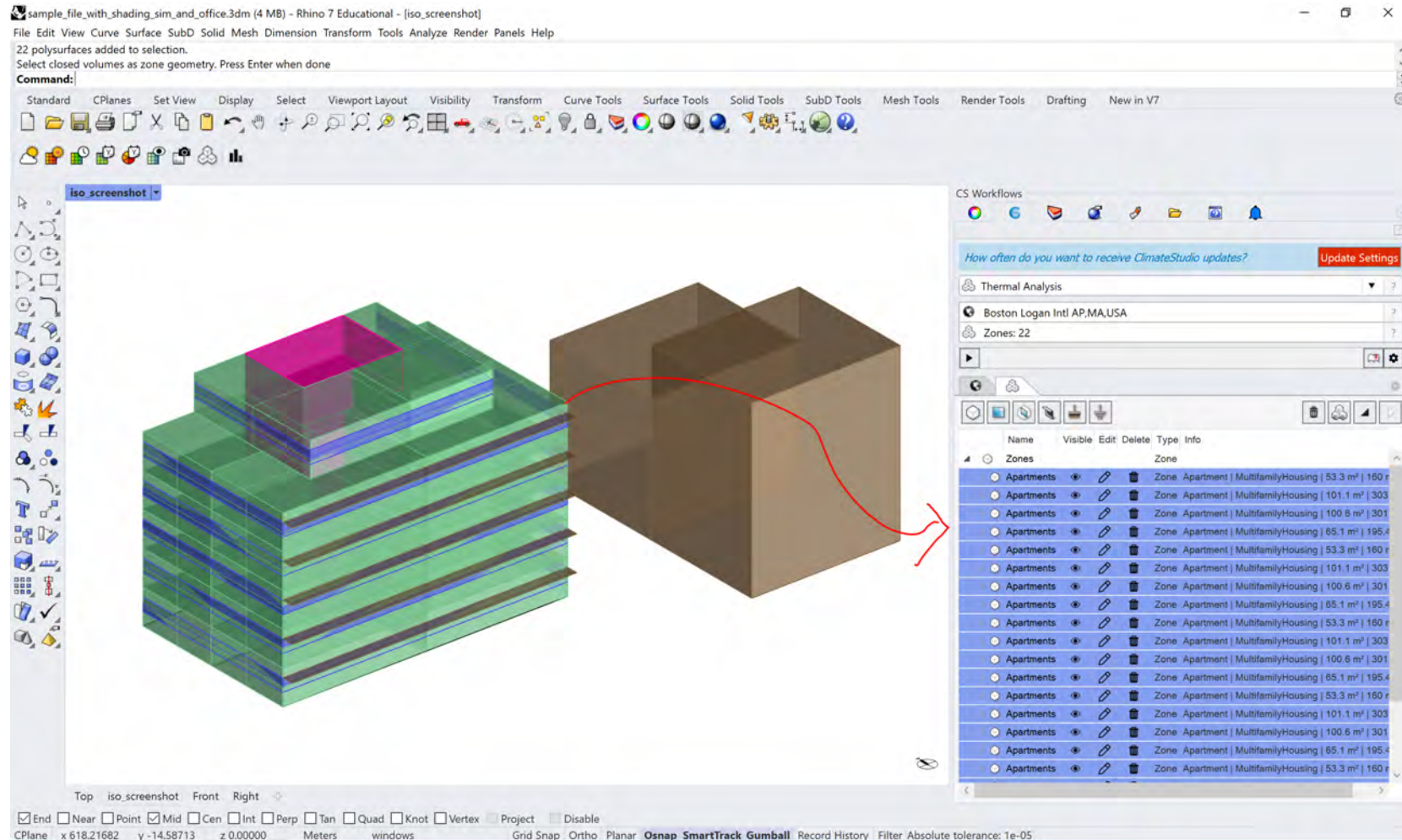
Select Climate Zone: Example CZ 4 -> Zone Ashrae 4



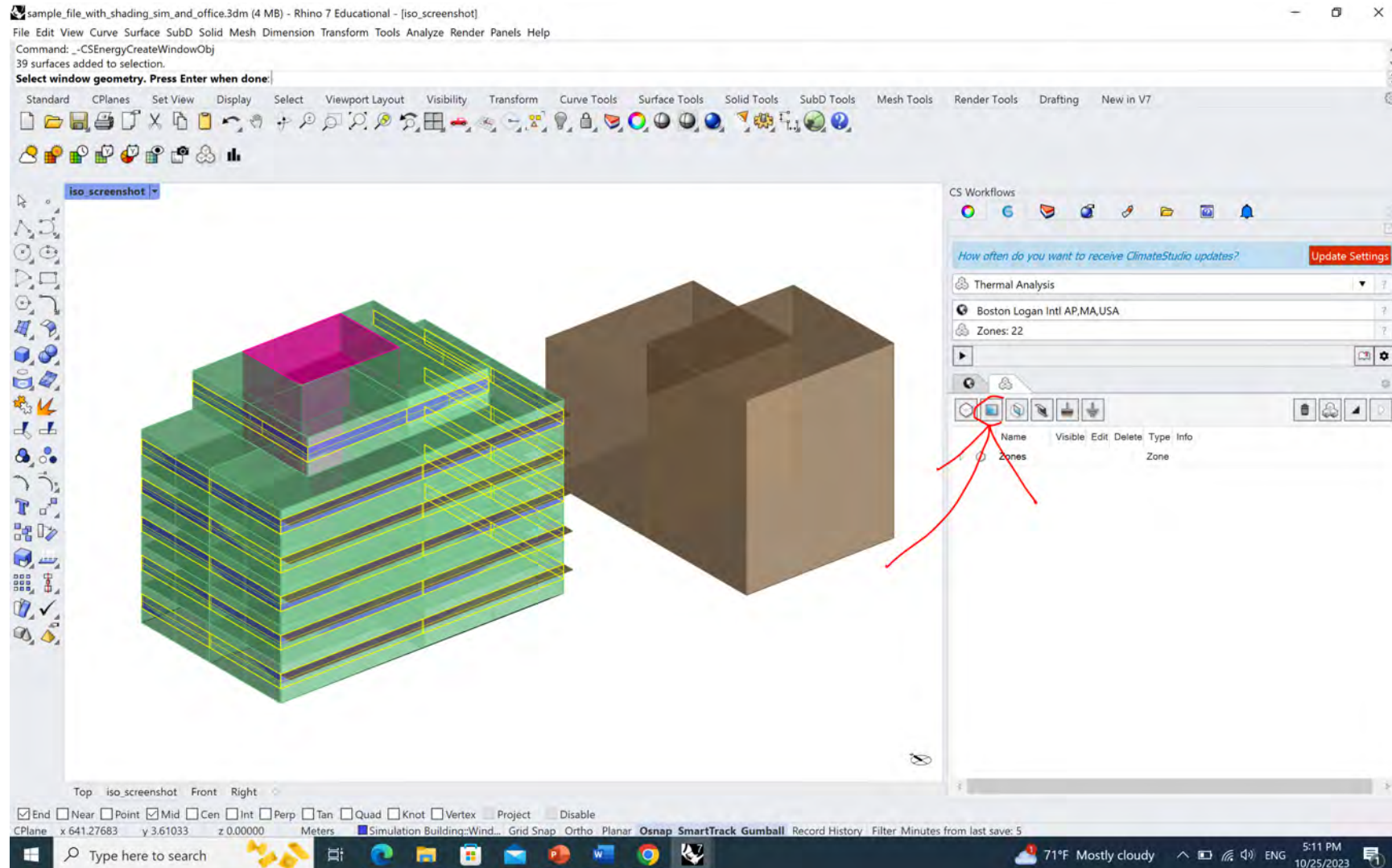
Different "Corridor" zone for circulation areas



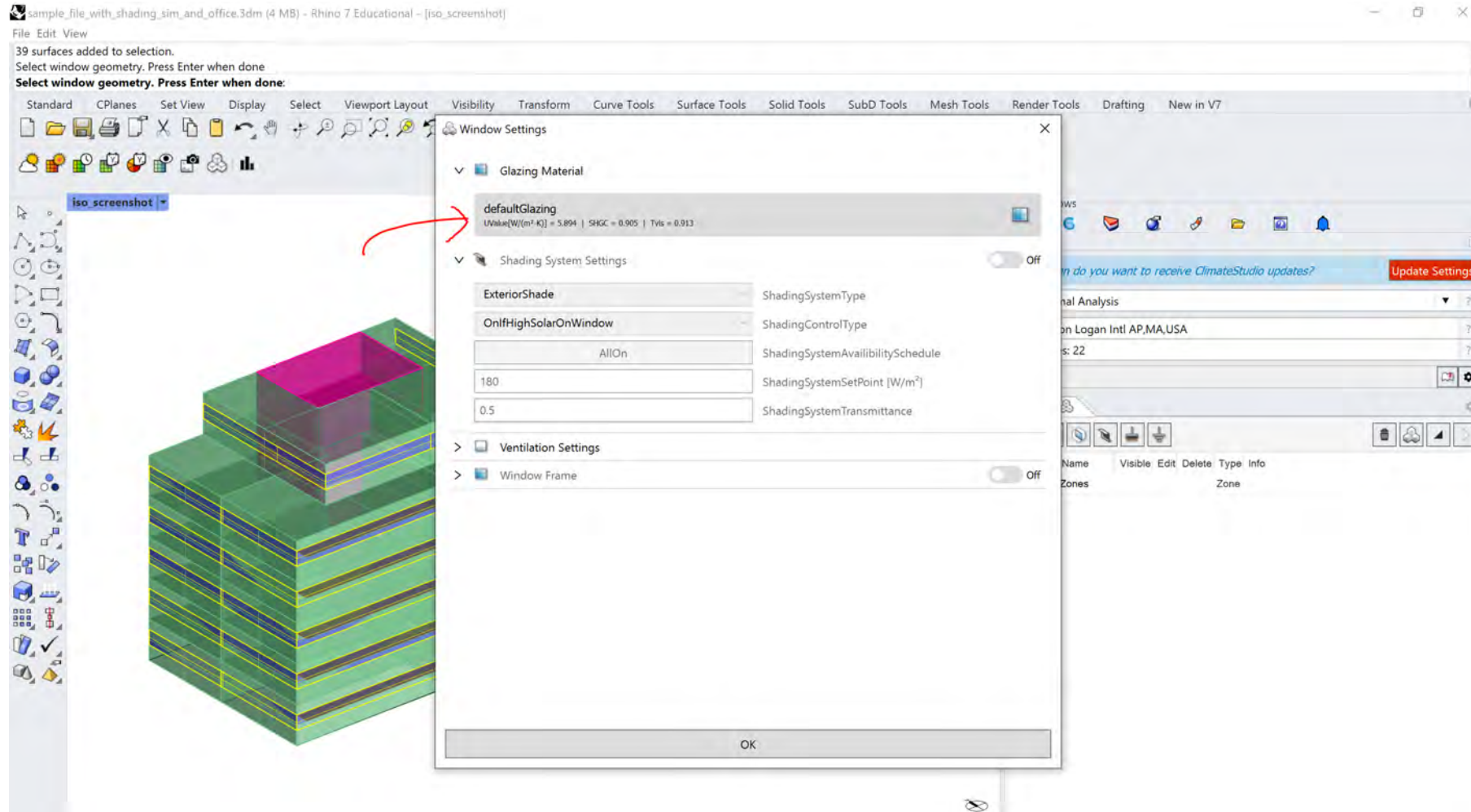
Select Climate Zone: CZ 4 -> Zone Ashrae 4



Add Windows



Change Glazing



Change Glazing

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help

39 surfaces added to selection.
Select window geometry. Press Enter when done.
Select window geometry. Press Enter when done.

Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools Solid Tools SubD Tools Mesh Tools Render Tools Drafting New in V7

Constructions

Outside

DoublePaneClr

U-Value[W/(m²·K)] = 2.72
SHGC = 0.764
TVIS = 0.812
Embodied Energy[MJ/m²] = 20
Embodied Carbon[kgCO₂/m²] = 2

Layers: (Outside - Inside)

Simple Glazing Model

Filter Constructions

Name: double

Type:

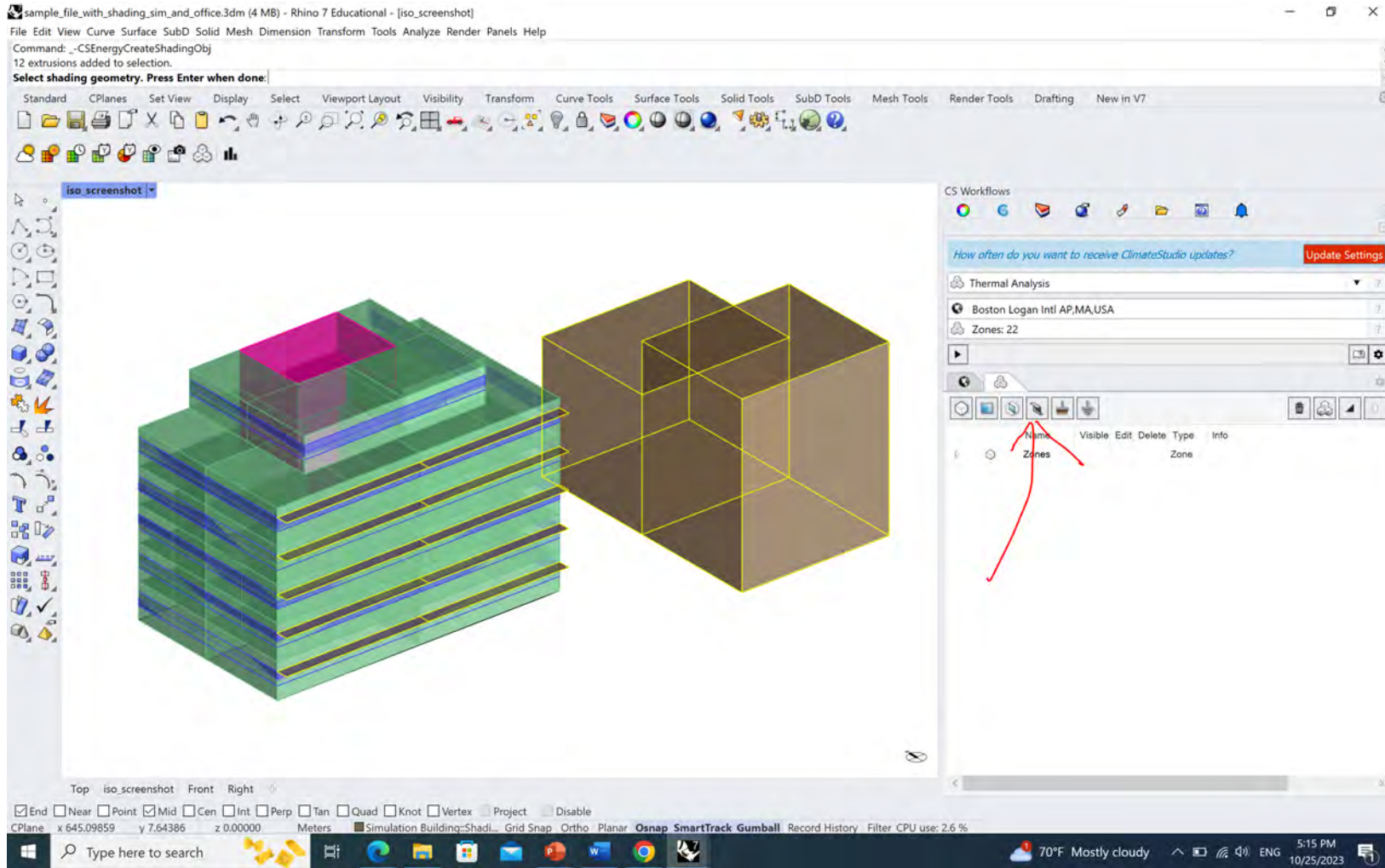
Name	Type	TVIS	UVal [W/(m ² ·K)]	SHGC	EE [MJ/m ²]	EC [kgCO ₂ /m ²]
DoublePaneLoEe2	Double	0.444	1.493	0.373	20	2
DoublePaneLoEe3	Double	0.769	1.507	0.649	20	2
DoublePaneClr	Double	0.812	2.72	0.764	20	2
DoublePaneLoEe2	Double	0.444	1.493	0.373	20	2
DoublePaneLoEe3	Double	0.769	1.507	0.649	20	2
DoublePaneClr	Double	0.812	2.72	0.764	20	2
DoublePaneLoEe2	Double	0.444	1.493	0.373	20	2
DoublePaneLoEe3	Double	0.769	1.507	0.649	20	2

OK

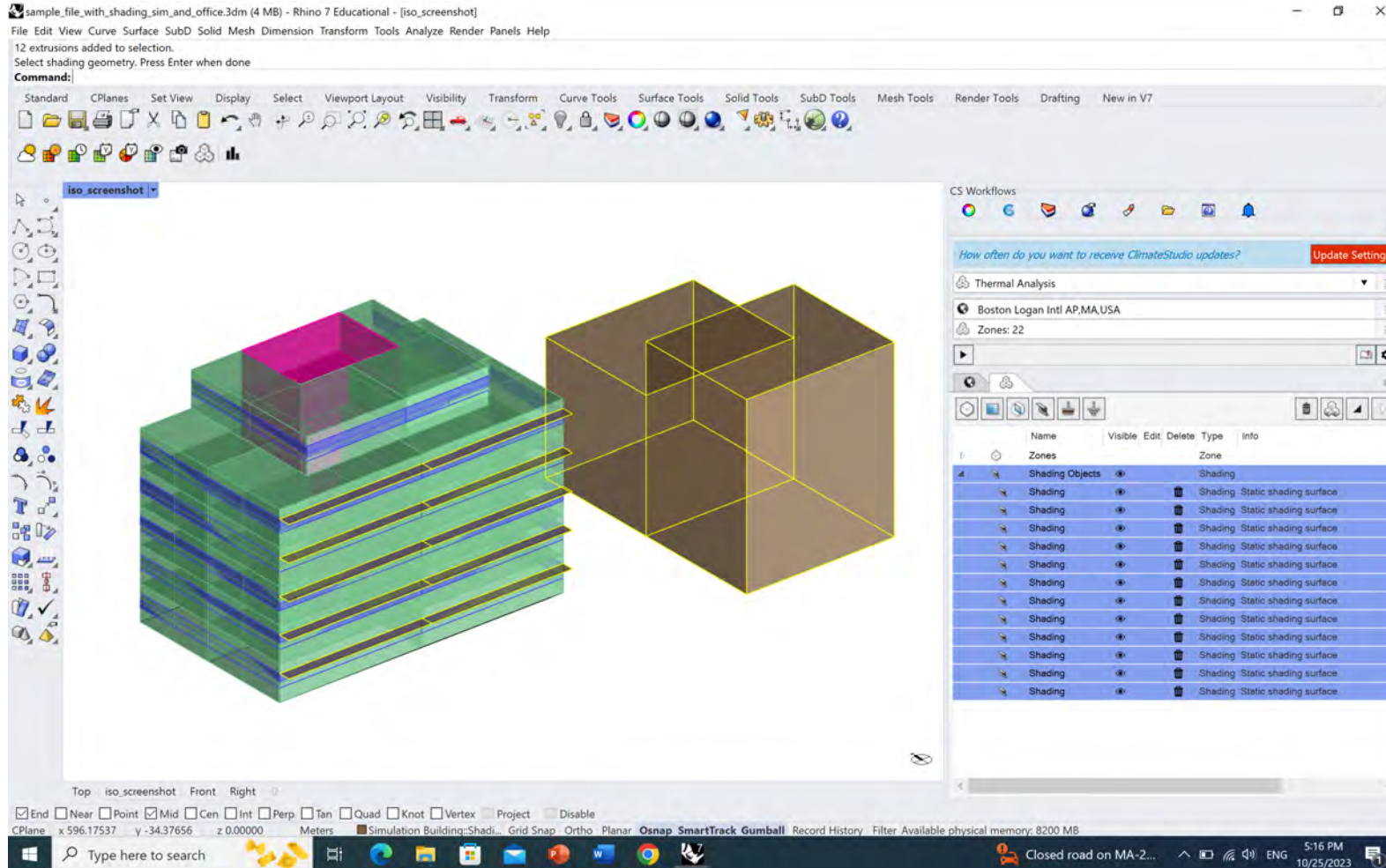
Top iso_screenshot Front Right

End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

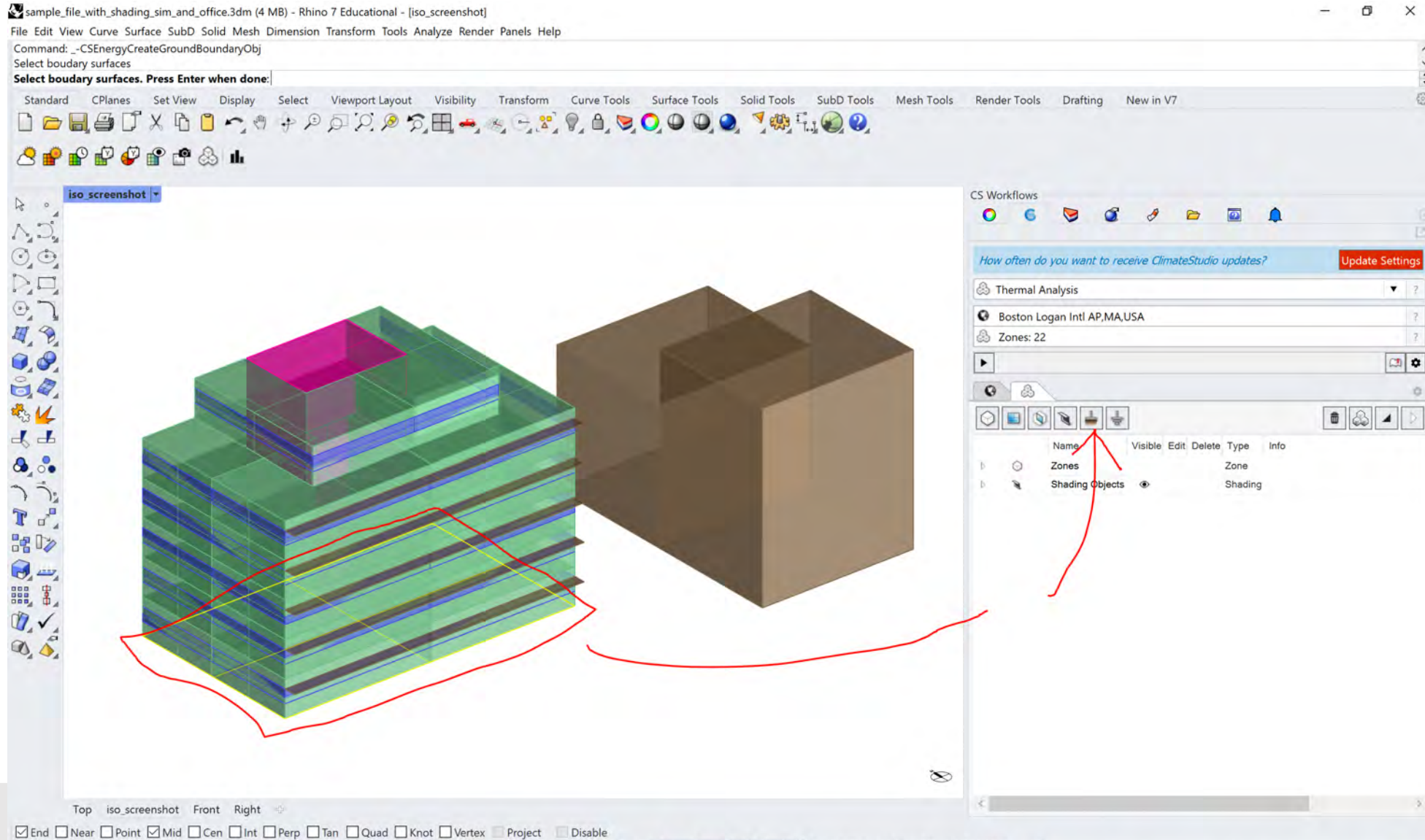
Add Shading (Shade + Context Building)



Add Shading (Shade + Context Building)



Add Ground



First energy model!!!

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help

Command: _CSResultsPanel

Command:

Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools Solid Tools SubD Tools Mesh Tools Render Tools Drafting New in V7

iso_screenshot

CS Results

Result Files

Name	Tags	Date	Path
Energy 1		10/25/2023 17:22:51	C:\Users\reweber\Desktop\class\sample_file

Energy 1

111	42	8	29%	156
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m ²	kgCO ₂ /m ²	\$/m ²	Vs-Baseline	kWh/m ²

Building

Energy Use Intensity

Month	Energy Use Intensity (kWh/m ²)
Jan	18.5
Feb	16.5
Mar	14.5
Apr	7.5
May	4.5
Jun	5.5
Jul	6.5
Aug	5.5
Sep	4.5
Oct	4.5
Nov	8.5
Dec	14.5

Top iso_screenshot Front Right

End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

CPlane x 622.65124 y 4.27922 z 0.00000 Meters Simulation Building:Zone... Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter Memory use: 1057 MB

Sunset 5:23 PM 10/25/2023

TASK C

Adjust internal gains
and schedules

TASK C

1. Occupancy

Put in your apartment sizes to get occupancy loads

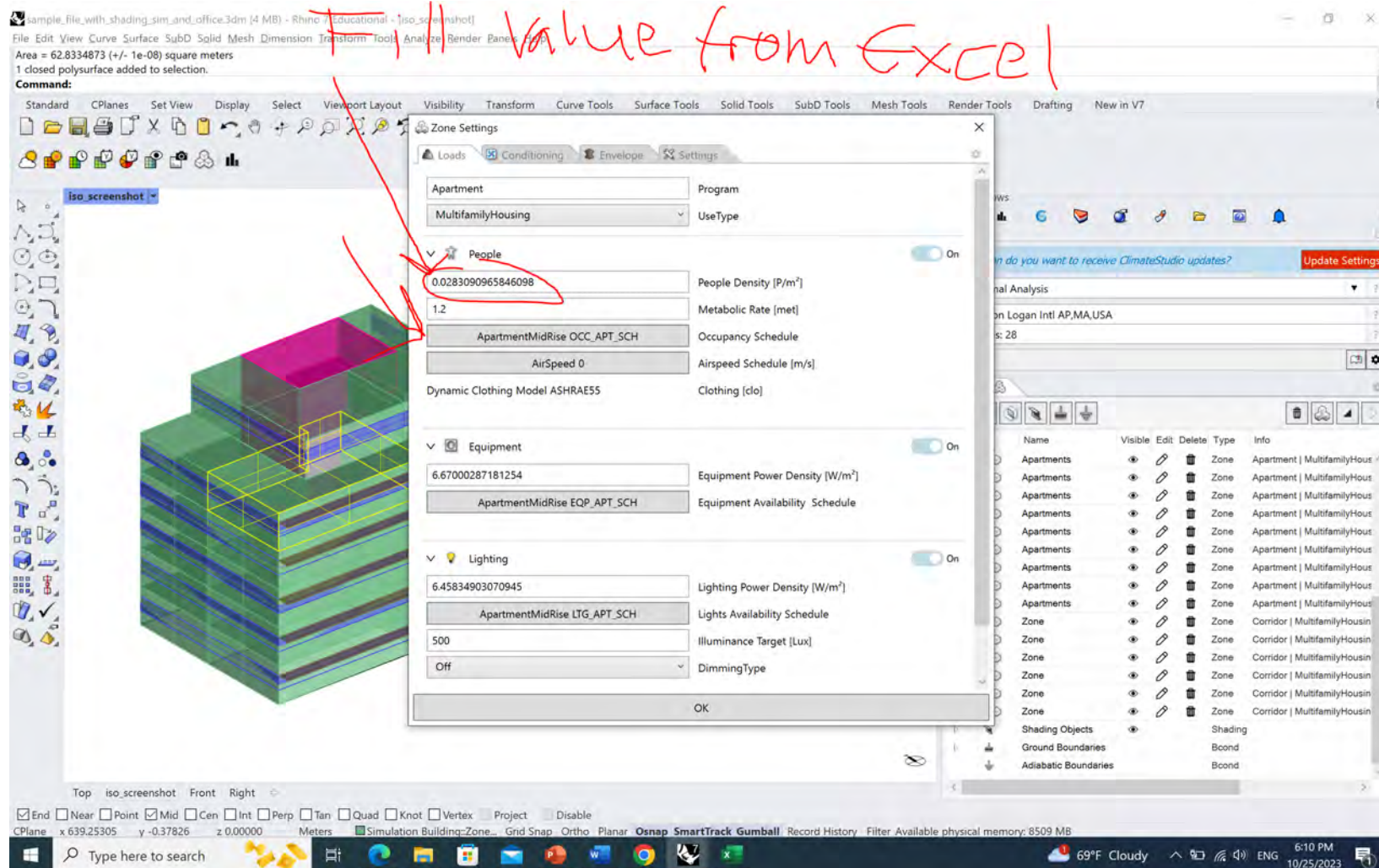
Apartment Type	Min Size	Max Size	Number of Rooms	Room Size in m2	Number of Occupants	People Density
Studio	35	45	2	65	2	0.030769231
1 Bedroom	45	65	2	100	4	0.04
2 Bedroom	65	90	3	101	4	0.03960396
3 Bedroom	90	120	4	53	2	0.037735849
4 Bedroom	120	500	5			

FILL IN THIS ROW

Plug this number into your zone settings



Put in your apartment sizes to get occupancy loads



Change schedules

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Bender Panels Help

Area = 62.8334873 (+/- 1e-08) square meters
1 closed polysurface added to selection.

Command:

Standard CPlanes Set View Display Select View

iso_screenshot

Schedules

Jan 1

Schedule Value

Time of Day

Day of Year

Name	Category	Standard	Program	Type	Hours	Da
ApartmentMidRise All Off	Unknown	ClimateStudio	All	Fraction	0	Frc
ApartmentMidRise BLDG_ELEVATORS	Elevator	ClimateStudio	All	Fraction	2154	Frc
ApartmentHighRise EQP_OFF_SCH_2010_2013	Equipment	ClimateStudio	All	Fraction	3960	Frc
ApartmentHighRise LTG_OFF_SCH_2013	Unknown	ClimateStudio	All	Fraction	3210	Frc
ApartmentHighRise OCC_OFF_SCH	Occupancy	ClimateStudio	All	Fraction	2660	Frc
ApartmentMidRise APT_DHW_SCH	Unknown	ClimateStudio	All	Fraction	4592	Frc
ApartmentMidRise EQP_APT_SCH	Equipment	ClimateStudio	All	Fraction	5763	Frc
ApartmentMidRise INF_APT_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc
ApartmentMidRise LTG_APT_SCH	Unknown	ClimateStudio	All	Fraction	5270	Frc
ApartmentMidRise OCC_APT_SCH	Occupancy	ClimateStudio	All	Fraction	5993	Frc
ApartmentMidRise INF_COR_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc

OK

Top iso_screenshot Front Right

End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

CPlane x:639.25305 y:-0.37826 z:0.00000 Meters Simulation Building:Zone... Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter CPU use: 0.7%

TASK C

2. Lighting

Lighting Power Density from home office (electric lighting homework)

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help

Area = 62.8334873 (+/- 1e-08) square meters
1 closed polysurface added to selection.

Command:

Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools Solid Tools SubD Tools Mesh Tools Render Tools Drafting New in V7

Zone Settings

Loads Conditioning Envelope Settings

Apartment Program
MultifamilyHousing UseType

People On

0.0283090965846098 People Density [P/m²]
1.2 Metabolic Rate [met]
ApartmentMidRise OCC_APT_SCH Occupancy Schedule
AirSpeed 0 Airspeed Schedule [m/s]
Dynamic Clothing Model ASHRAE55 Clothing [clo]

Equipment On

6.45834903070945 Equipment Power Density [W/m²]
ApartmentMidRise EQP_APT_SCH Equipment Availability Schedule

Lighting On

6.45834903070945 Lighting Power Density [W/m²]
ApartmentMidRise LTG_APT_SCH Lights Availability Schedule

Name	Visible	Edit	Delete	Type	Info
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Apartments	<input checked="" type="checkbox"/>			Zone	Apartment MultifamilyHous
Zone	<input checked="" type="checkbox"/>			Zone	Corridor MultifamilyHous

Change Schedule for lights

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help

Area = 62.8334873 (+/- 1e-08) square meters
1 closed polysurface added to selection.

Command:

Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface T

Zone Settings

Loads Conditioning Envelope

Apartment

MultifamilyHousing

People

0.0283090965846098

1.2

ApartmentMidRise OCC_APT_SCH

AirSpeed 0

Dynamic Clothing Model ASHRAE55

Equipment

6.67000287181254

ApartmentMidRise EQP_APT_SCH

Lighting

6.45834903070945

ApartmentMidRise LTG_APT_SCH

500

Off

Schedules

Jan 1

Schedule Value

Time of Day

Day of Year

Any Category Any Standard Any Program

Name	Category	Standard	Program	Type	Hours	De
ApartmentHighRise LTG_COR_SCH_2013	Unknown	ClimateStudio	All	Fraction	5053	Frc
ApartmentMidRise All Off	Unknown	ClimateStudio	All	Fraction	0	Frc
ApartmentMidRise BLDG_ELEVATORS	Elevator	ClimateStudio	All	Fraction	2154	Frc
ApartmentHighRise EQP_OFF_SCH_2010_2013	Equipment	ClimateStudio	All	Fraction	3960	Frc
ApartmentHighRise LTG_OFF_SCH_2013	Unknown	ClimateStudio	All	Fraction	3210	Frc
ApartmentHighRise OCC_OFF_SCH	Occupancy	ClimateStudio	All	Fraction	2660	Frc
ApartmentMidRise APT_DHW_SCH	Unknown	ClimateStudio	All	Fraction	4592	Frc
ApartmentMidRise EQP_APT_SCH	Equipment	ClimateStudio	All	Fraction	5763	Frc
ApartmentMidRise INF_APT_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc
ApartmentMidRise LTG_APT_SCH	Unknown	ClimateStudio	All	Fraction	527	Frc
ApartmentMidRise OCC_APT_SCH	Occupancy	ClimateStudio	All	Fraction	5003	Frc

OK

Top iso_screenshot Front Right

End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

CPlane x:639.25305 y:-0.37826 z:0.00000 Meters Simulation Building:Zone... Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter CPU use: 3.9 %

69°F Cloudy 6:15 PM 10/25/2023

Change Schedule for lights to OCC_APT_SCH

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help

Area = 62.8334873 (+/- 1e-08) square meters
1 closed polysurface added to selection.

Command:

Standard CPanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools

Zone Settings

Loads Conditioning Envelope

Apartment

MultifamilyHousing

People

0.0283090965846098

1.2

ApartmentMidRise OCC_APT_SCH

AirSpeed 0

Dynamic Clothing Model ASHRAE55

Equipment

6.67000287181254

ApartmentMidRise EQP_APT_SCH

Lighting

6.45834903070945

ApartmentMidRise LTG_APT_SCH

500

Off

Schedules

Time of Day

Day of Year

Name	Category	Standard	Program	Type	Hours	Da
ApartmentMidRise All Off	Unknown	ClimateStudio	All	Fraction	0	Frc
ApartmentMidRise BLDG_ELEVATORS	Elevator	ClimateStudio	All	Fraction	2154	Frc
ApartmentMidRise APT_DHW_SCH	Unknown	ClimateStudio	All	Fraction	4592	Frc
ApartmentMidRise EQP_APT_SCH	Equipment	ClimateStudio	All	Fraction	5763	Frc
ApartmentMidRise INF_APT_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc
ApartmentMidRise LTG_APT_SCH	Unknown	ClimateStudio	All	Fraction	527	Frc
ApartmentMidRise OCC_APT_SCH	Occupancy	ClimateStudio	All	Fraction	5993	Frc
ApartmentMidRise INF_COR_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc
ApartmentMidRise LTG_COR_SCH_2013	Unknown	ClimateStudio	All	Fraction	4655	Frc
ApartmentMidRise EQP_OFF_SCH_2010_2013	Equipment	ClimateStudio	All	Fraction	3960	Frc
ApartmentMidRise INF_OFF_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc

OK

Change Schedule for lights to OCC_APT_SCH

sample_file_with_shading_sim_and_office.3dm (4 MB) - Rhino 7 Educational - [iso_screenshot]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help

Area = 62.8334873 (+/- 1e-08) square meters
1 closed polysurface added to selection.

Command:

Standard CPanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools

Zone Settings

Loads Conditioning Envelope

Apartment

MultifamilyHousing

People

0.0283090965846098

1.2

ApartmentMidRise OCC_APT_SCH

AirSpeed 0

Dynamic Clothing Model ASHRAE55

Equipment

6.67000287181254

ApartmentMidRise EQP_APT_SCH

Lighting

6.45834903070945

ApartmentMidRise LTG_APT_SCH

500

Off

Schedules

Time of Day

Day of Year

Name	Category	Standard	Program	Type	Hours	Da
ApartmentMidRise All Off	Unknown	ClimateStudio	All	Fraction	0	Frc
ApartmentMidRise BLDG_ELEVATORS	Elevator	ClimateStudio	All	Fraction	2154	Frc
ApartmentMidRise APT_DHW_SCH	Unknown	ClimateStudio	All	Fraction	4592	Frc
ApartmentMidRise EQP_APT_SCH	Equipment	ClimateStudio	All	Fraction	5763	Frc
ApartmentMidRise INF_APT_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc
ApartmentMidRise LTG_APT_SCH	Unknown	ClimateStudio	All	Fraction	527	Frc
ApartmentMidRise OCC_APT_SCH	Occupancy	ClimateStudio	All	Fraction	5993	Frc
ApartmentMidRise INF_COR_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc
ApartmentMidRise LTG_COR_SCH_2013	Unknown	ClimateStudio	All	Fraction	4655	Frc
ApartmentMidRise EQP_OFF_SCH_2010_2013	Equipment	ClimateStudio	All	Fraction	3960	Frc
ApartmentMidRise INF_OFF_SCH	Unknown	ClimateStudio	All	Fraction	8760	Frc

OK

TASK C

3. Equipment

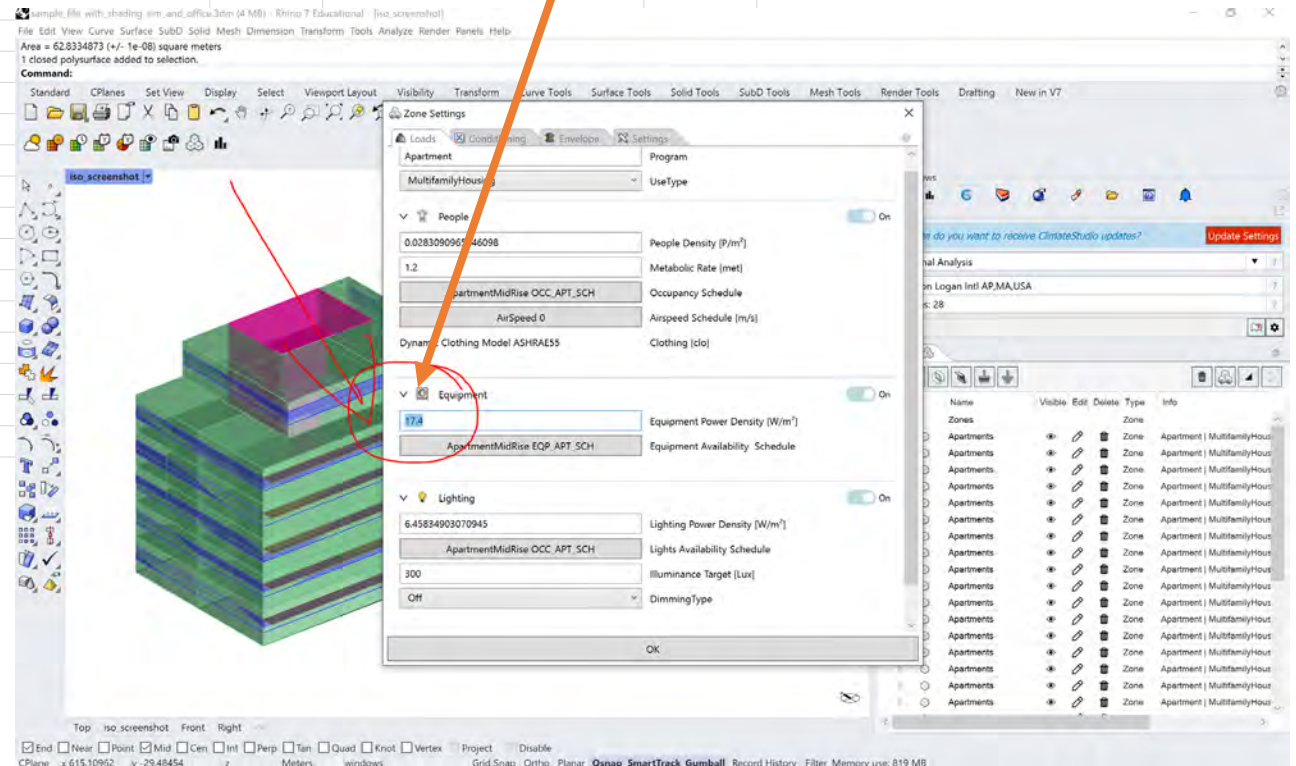
Task C: Equipment Loads

<https://sustainabilityworkshop.venturewell.org/buildings/equipment-and-lighting-loads.html>

Equipment Load Per Apartment

	Loads in watts	Apartment Size	Equipment Power Density
	120	50	17.4
Refridgerator	750		
..add more			

Total 870



Area = 62.8334873 (+/- 1e-08) square meters
1 closed polysurface added to selection.

Command:

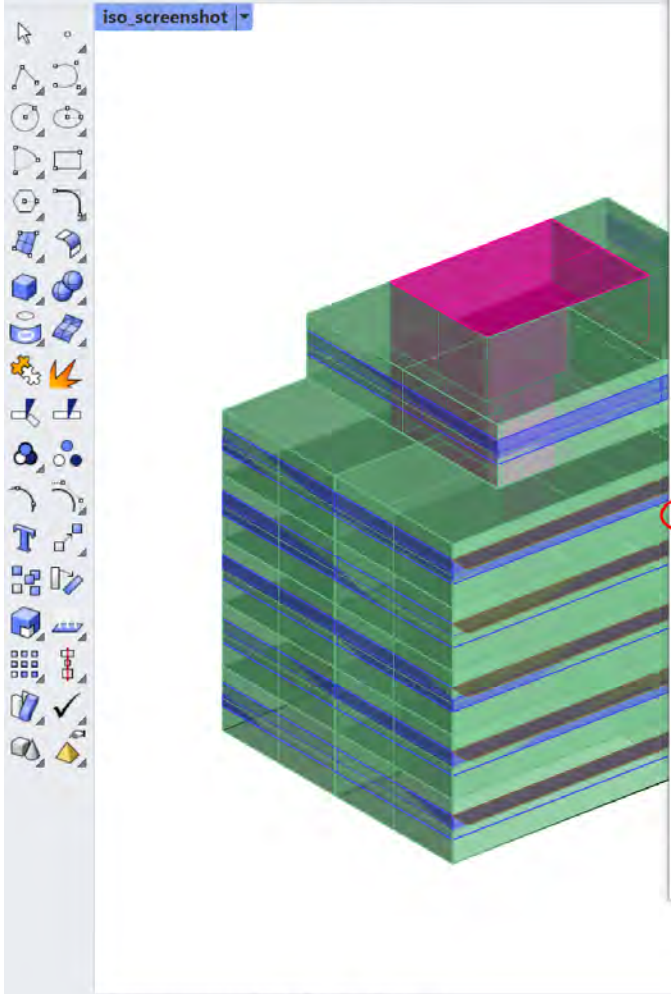
Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface

Zone Settings

Loads Conditioning Envelope

Apartment

MultifamilyHousing



People

0.0283090965846098

1.2

ApartmentMidRise OCC_APT_SCH

AirSpeed 0

Dynamic Clothing Model ASHRAE55

Equipment

17.4

ApartmentMidRise EQP_APT_SCH

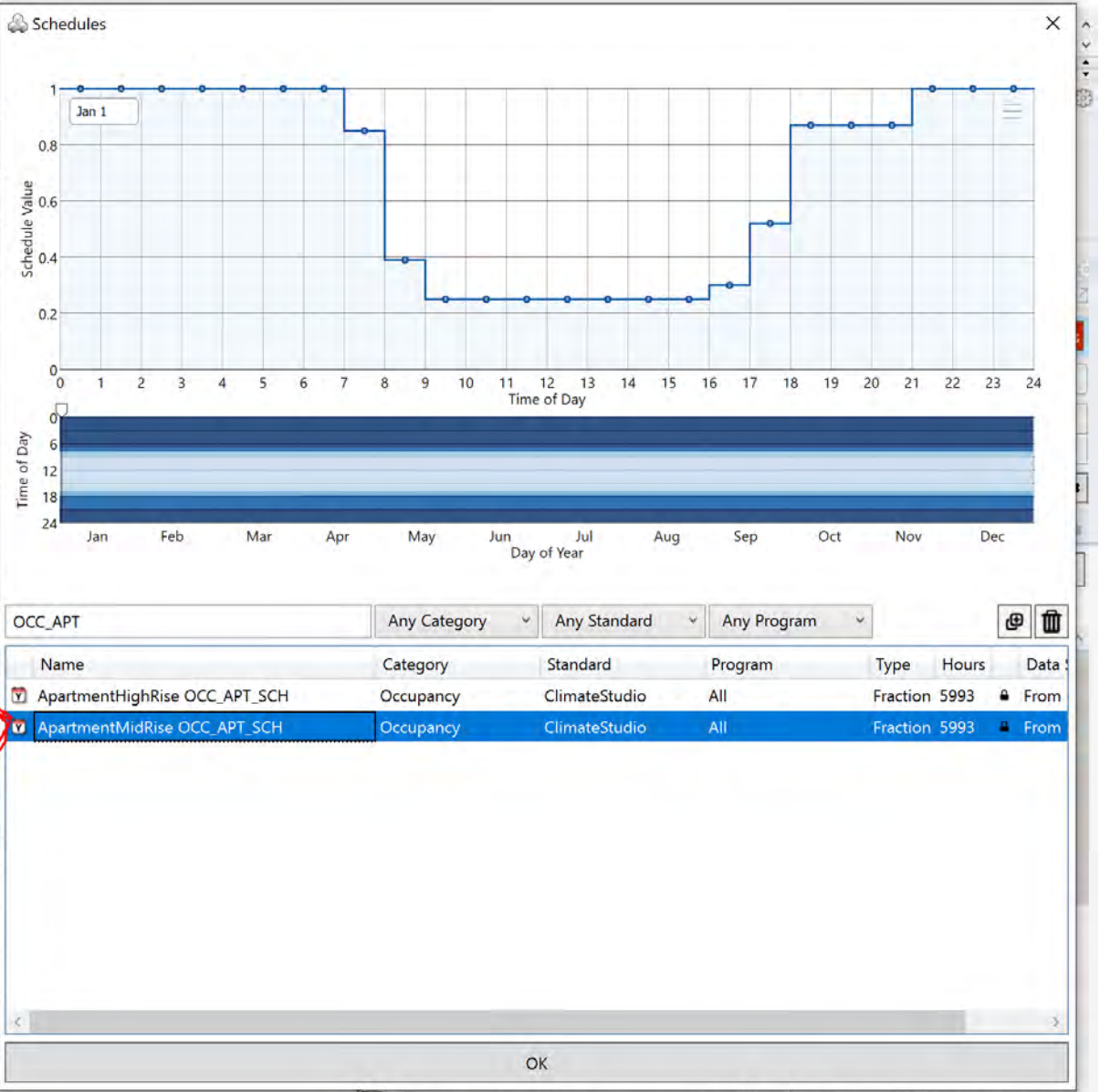
Lighting

6.45834903070945

ApartmentMidRise OCC_APT_SCH

300

Off



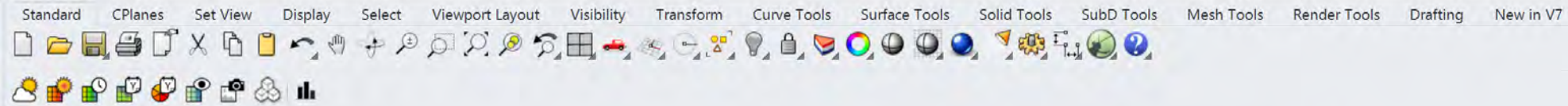
Top iso_screenshot Front Right

End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

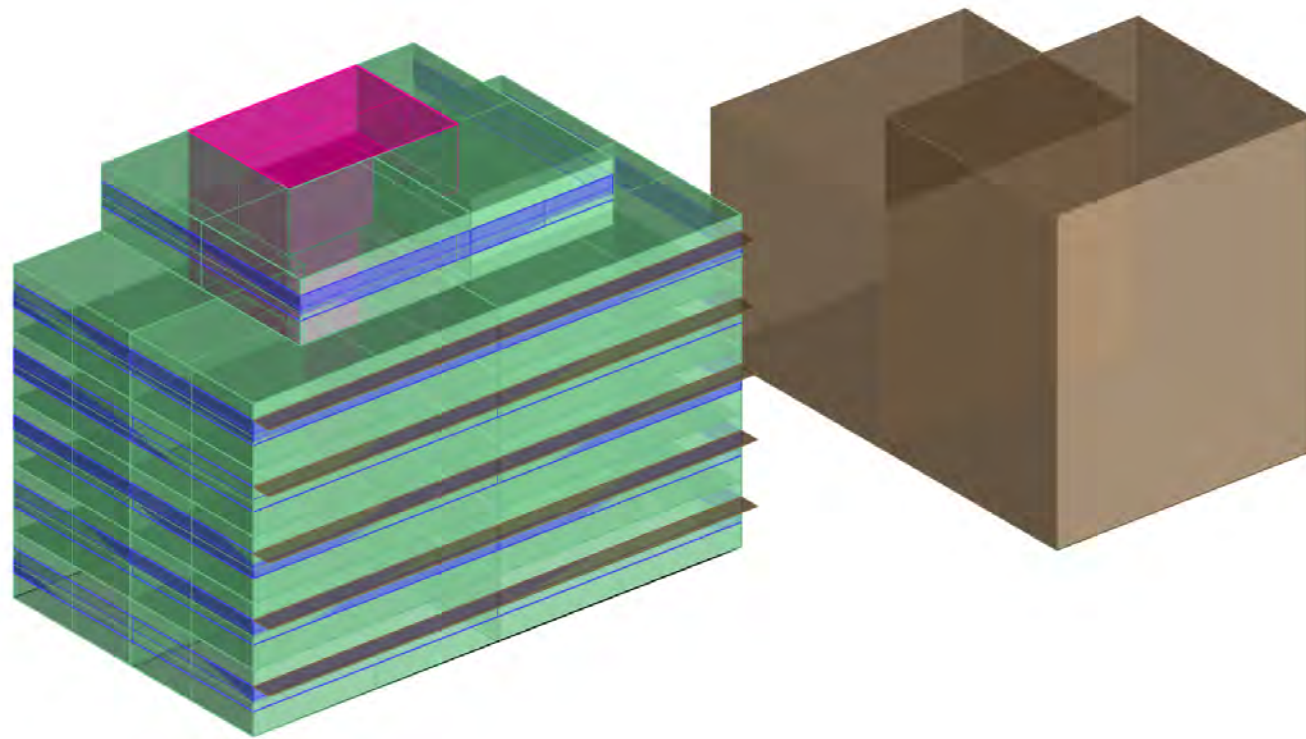
CPlane x 615.10962 y -29.48454 z Meters windows Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter Minutes from last save: 85

Command: _CSResultsPanel

Command:



iso_screenshot



CS Results

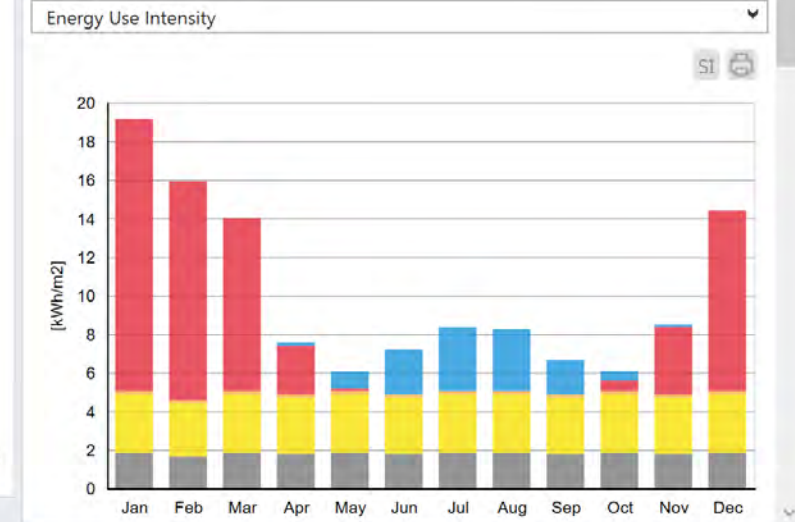
Result Files

Name	Tags	Date	Path
Energy 2		10/25/2023 18:33:47	C:\Users\reweber\Desktop\class\sample_fil

Energy 2

122	53	10	22%	156
Site EUI kWh/m ²	Op. Carbon kgCO ₂ /m ²	Energy Cost \$/m ²	Saved Vs. Baseline	Baseline EUI kWh/m ²

Building

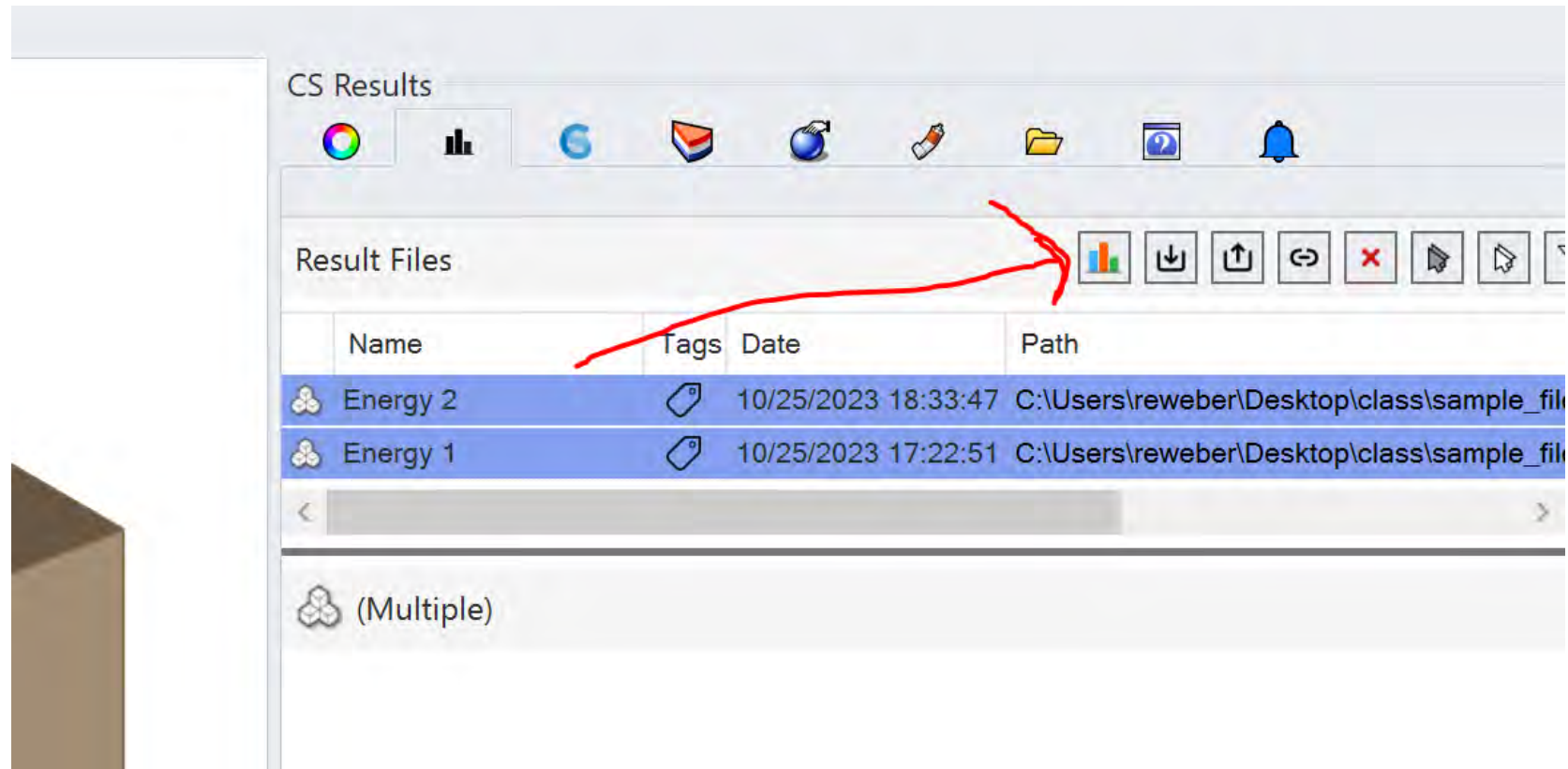


Top iso_screenshot Front Right

End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable

CPlane x 600.81401 y -20.39560 z Meters windows Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter Available physical memory: 6869 MB

Select both



TASK C
FINAL SIMULATION

Compare... Not Better, MORE ACCURATE!!

