

Dynamo + Revit Systems Analysis True BIM for HVAC

Sean Fruin

Director of Design Technology – Sigma AEC Solutions | @SeanFruin

Majd Makhoul

Founder Manager – Building Information Researchers and Developers OÜ | @bird_tools

About the speakers

Sean Fruin



Sean Fruin is a Mechanical Engineer (EIT), design technologist, and innovator who has an ardent fascination with automation and the exploration of computational design solutions for the AEC industry. He has had the opportunity to learn many aspects of the design industry, having worked in manufacturing, MEP designing, and General Contracting. Sean started Sigma AEC Solutions to live his dream, having the opportunity to explore and implement the latest technologies to improve efficiency and increase quality in the AEC industry.

About the speakers

Majd Makhloof



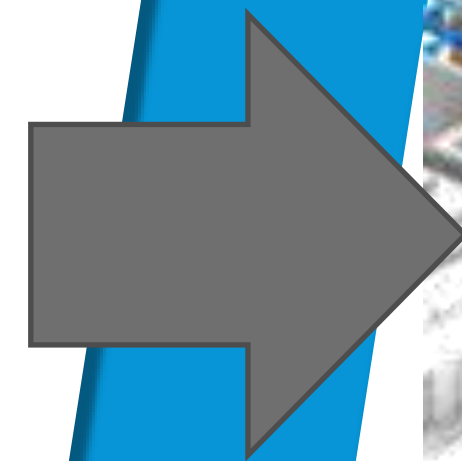
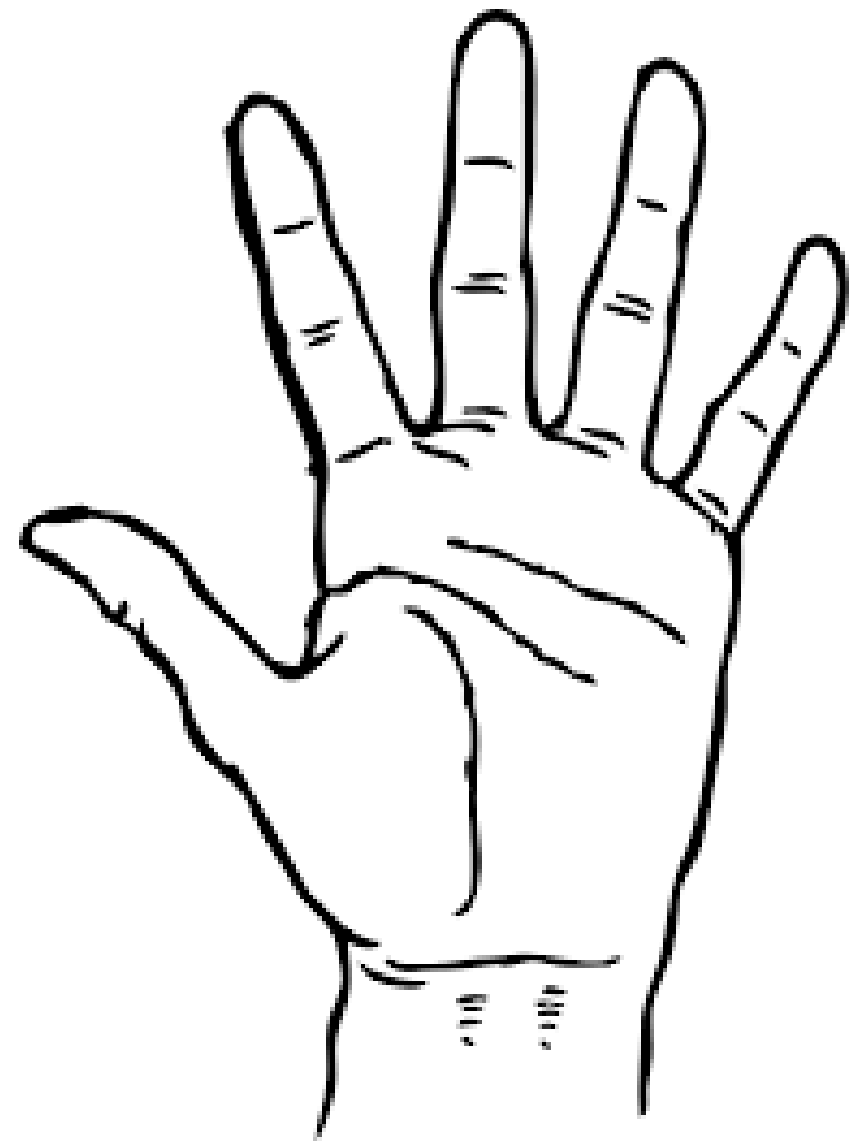
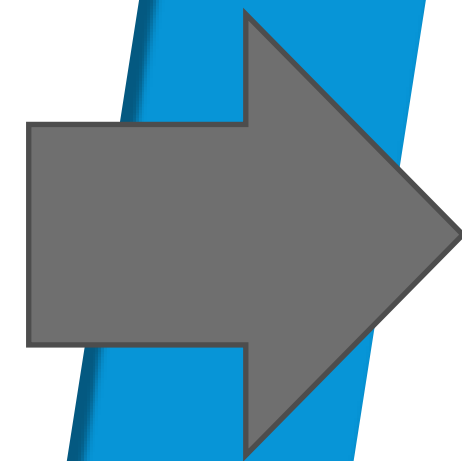
Majd Makhloof
[@bird_tools](#)

Majd is a Mechanical Engineer and Design Technologist, with a Master of Science in Mechanical Engineering. He's an Autodesk Revit Certified Professional and a member of the Autodesk Developer Network. In January 2020, he founded Building Information Researchers and Developers OÜ, a software development company based in Estonia and providing services for the AEC sector worldwide. He specializes in BIM Management, Autodesk Revit and AutoCAD Add-in development, both public and custom developed, Forge web and cloud-based apps, Dynamo Zero Touch Node Packs, and mobile VR/AR applications.



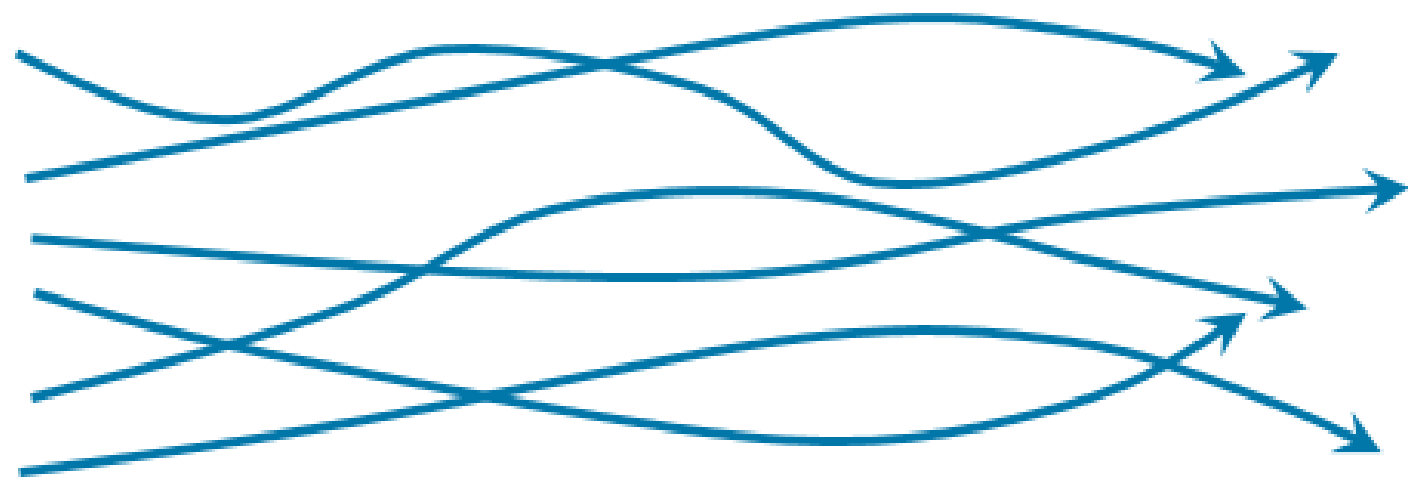
“Because the quality of our tools has finally caught up to the scope of their vision – small groups of dedicated DIY innovators can now tackle problems that were once solely the purview of big governments and large corporations.”

Problem?



True BIM

R



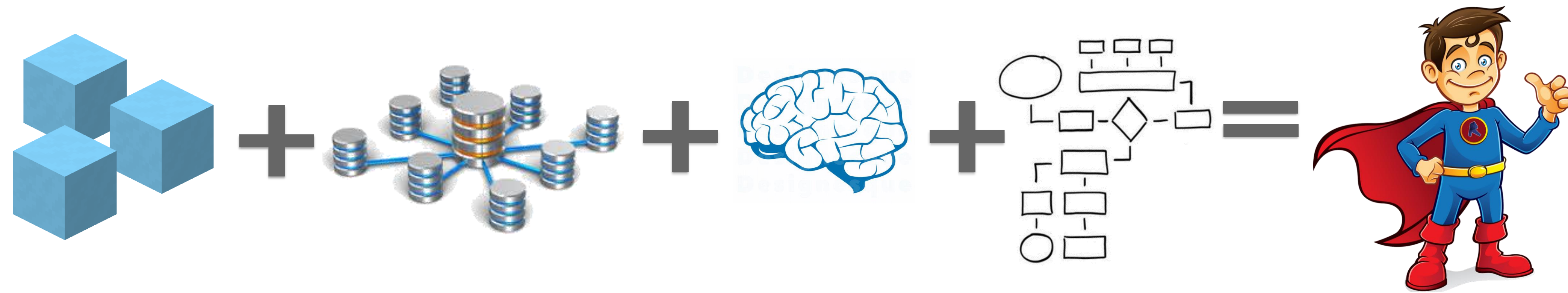
VS.

R

+

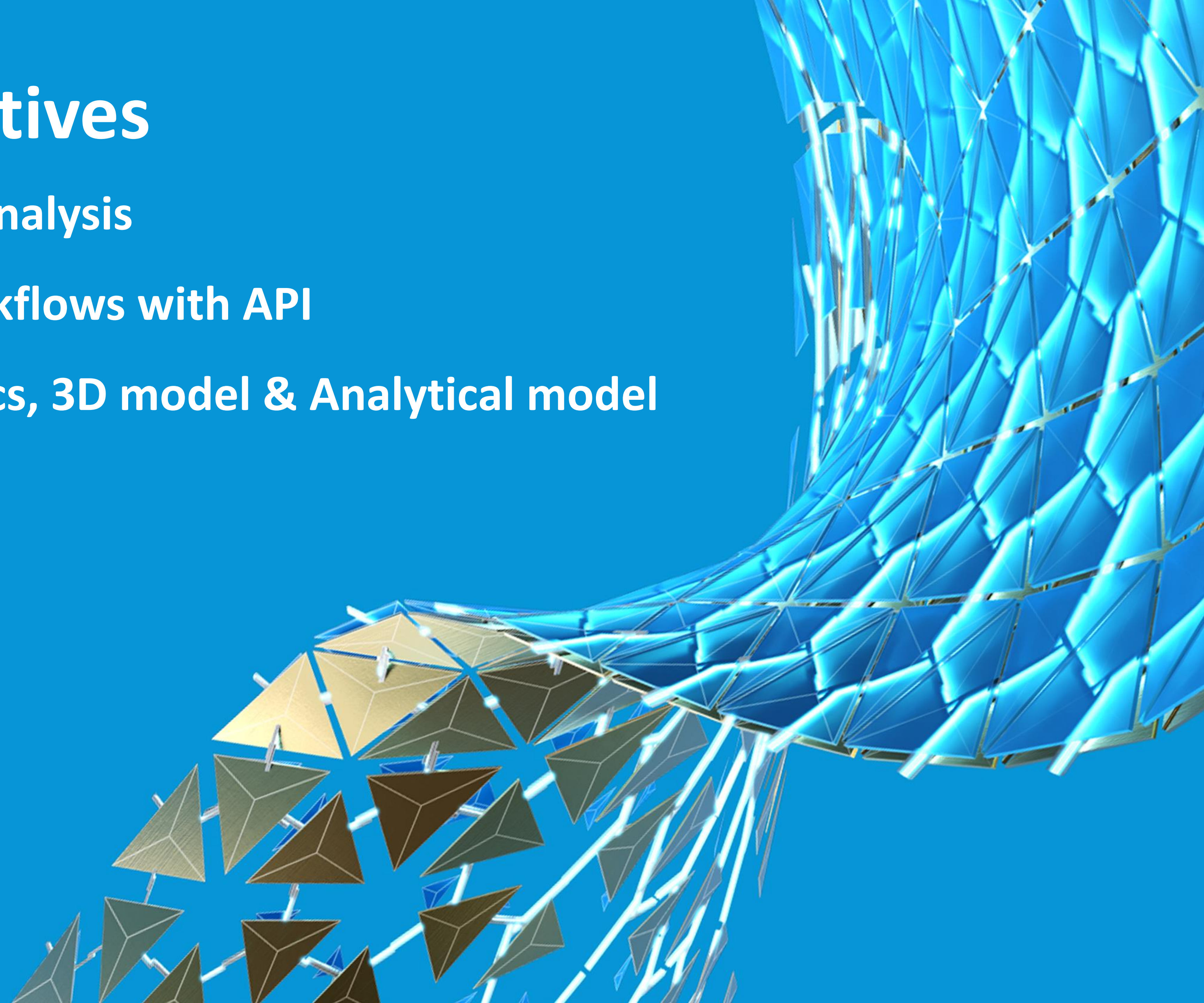


True BIM



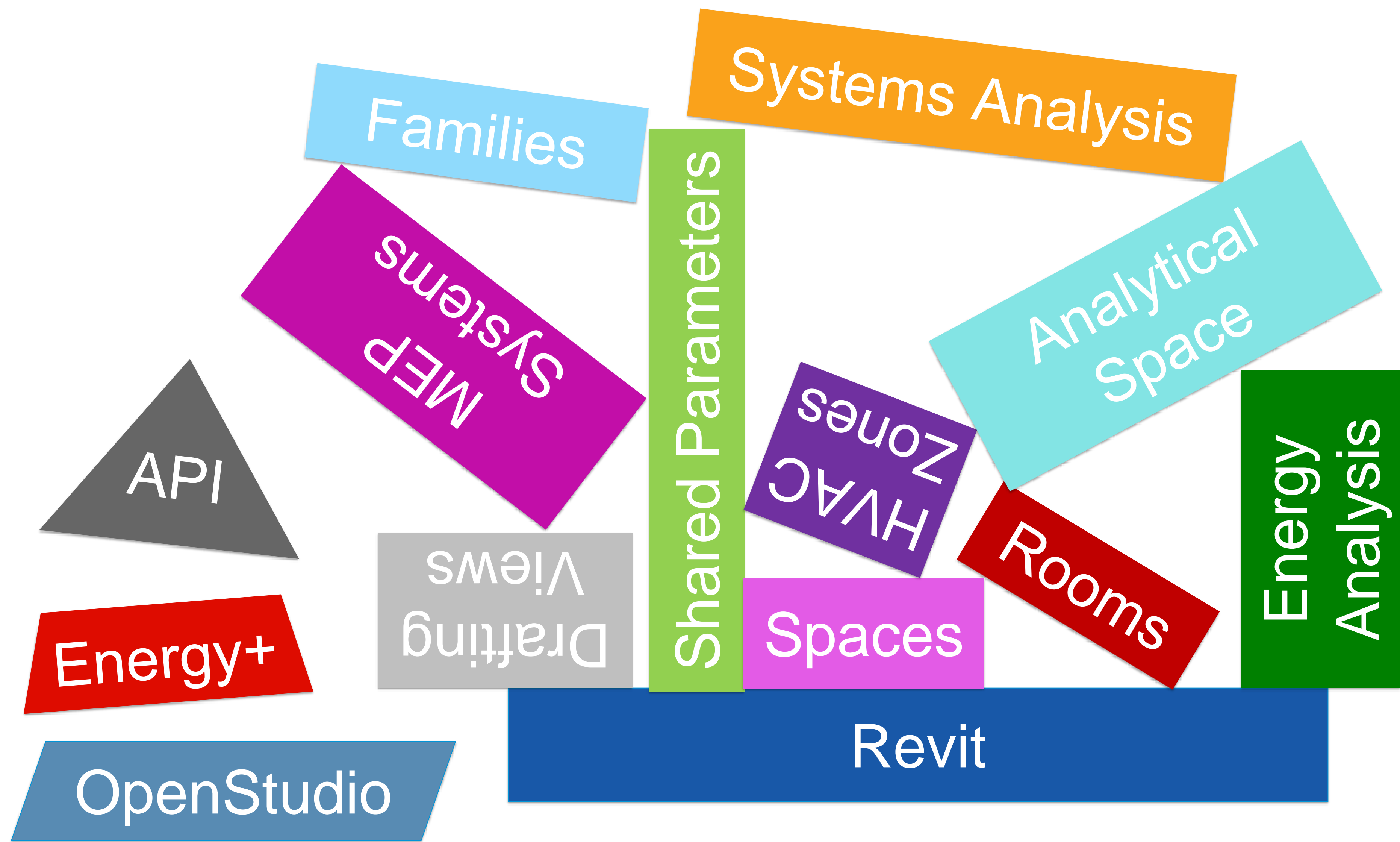
Learning Objectives

- ☐ 101 Revit's Systems Analysis
- ☐ Streamline Revit Workflows with API
- ☐ Connect 2D schematics, 3D model & Analytical model

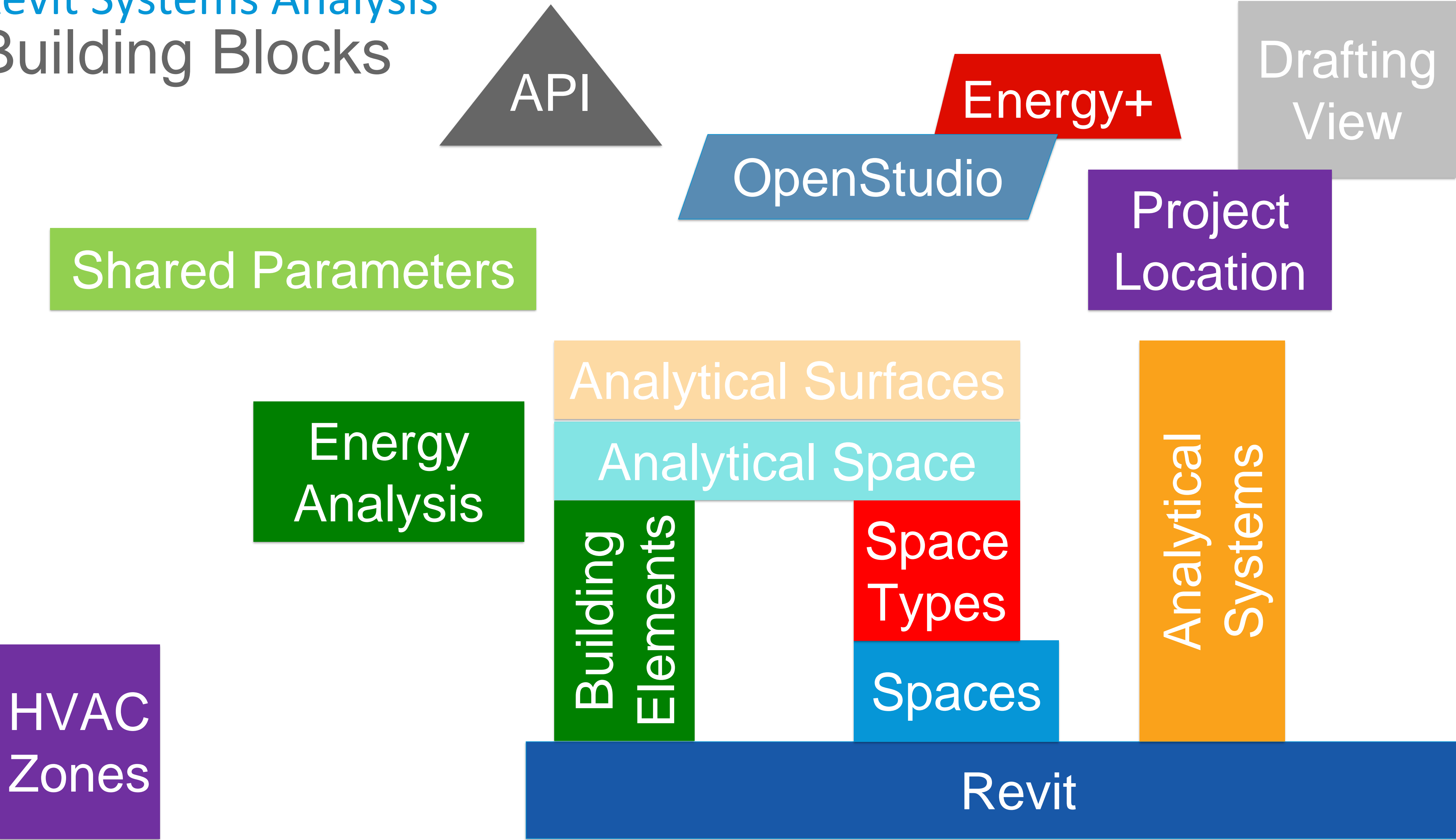


Revit Systems Analysis

Building Blocks ?



Revit Systems Analysis
Building Blocks



Revit Systems Analysis

101



Revit Systems Analysis

Energy Model – GBXML

- Location / Weather Data
- Building Geometry
- Thermal Properties
- HVAC Systems



Revit Frameworks

Energy Model – Weather Data

Location Weather and Site

Location Weather Site

Define Location by:

Internet Mapping Service

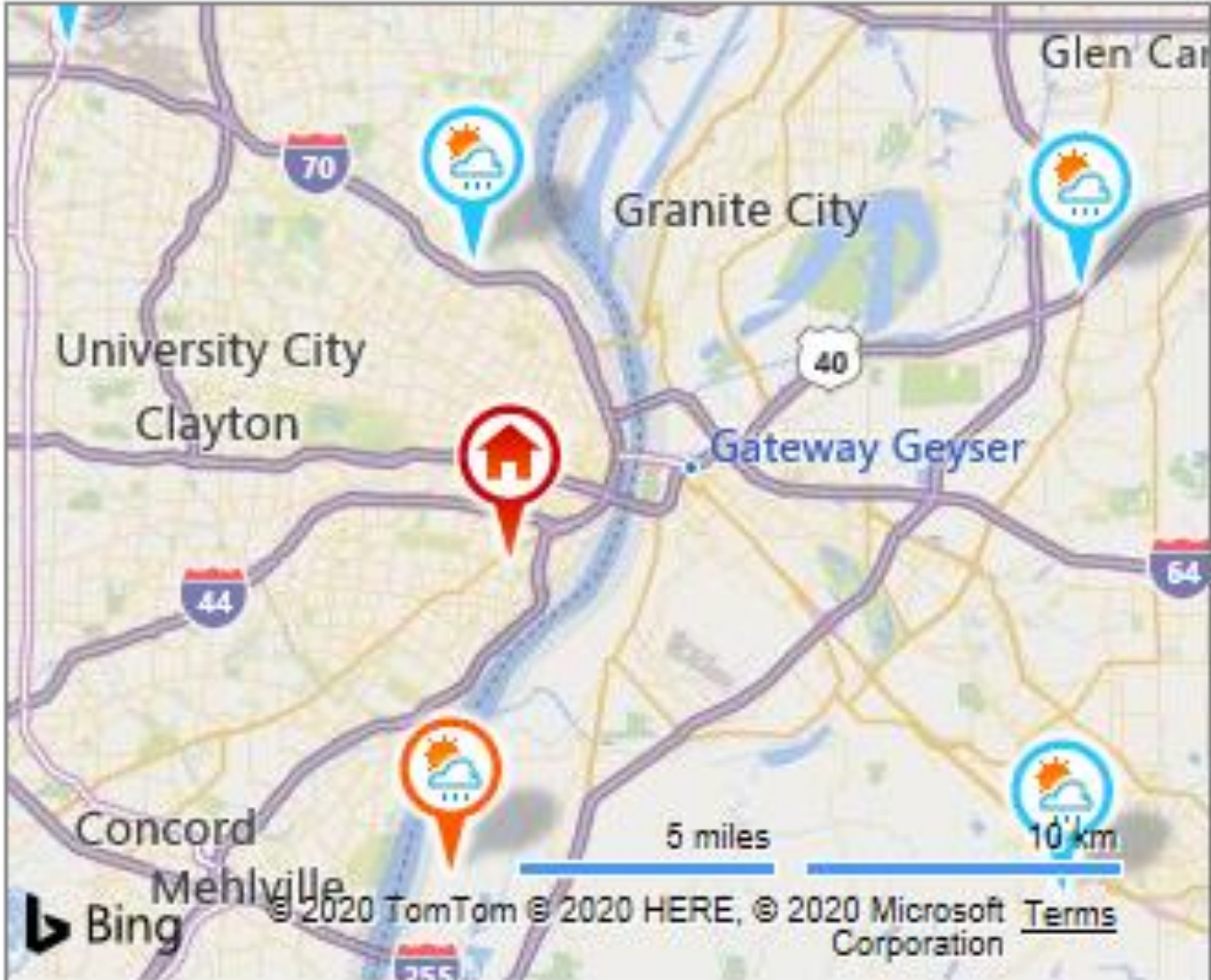
Project Address:

1200 Lynch St, St Louis, MO 63118

Search

Weather Stations:

- 35608 (5.60 miles away)
- 35609 (5.60 miles away)
- 35827 (12.50 miles away)
- 35828 (12.50 miles away)
- 59307 (13.70 miles away)
- 35389 (14.80 miles away)
- 35390 (14.80 miles away)
- 35607 (18.60 miles away)



Map showing the project location (red house icon) and several weather stations (blue and orange icons) in the St. Louis area. The map includes labels for University City, Clayton, Granite City, Gateway Geyser, Concord, and Mehlville. A scale bar indicates 5 miles and 10 km.

☐ Use Daylight Savings time

OK Cancel Help

Revit Frameworks

Energy Model - Settings

Energy Settings

Parameter	Value
Energy Analytical Model	
Mode	Use Conceptual Masses and Building Elements
Ground Plane	Level 1
Project Phase	New Construction
Analytical Space Resolution	0' 6"
Analytical Surface Resolution	0' 4"
Perimeter Zone Depth	0' 0"
Perimeter Zone Division	<input type="checkbox"/>
Average Vertical Void Height Threshold	6' 0"
Horizontal Void/Chase Area Threshold	1.00 SF
Advanced	
Other Options	Edit...

[How do these settings affect energy analysis?](#)

OK

Cancel

Advanced Energy Settings

Parameter	Value
Detailed Model	
Target Percentage Glazing	0%
Target Sill Height	2' 6"
Glazing is Shaded	<input type="checkbox"/>
Shade Depth	1' 6"
Target Percentage Skylights	0%
Skylight Width & Depth	3' 0"
Building Data	
Building Type	Office
Building Operating Schedule	Default
HVAC System	Central VAV, HW Heat, Chiller 5.96 COP, Boilers 84.5 eff
Outdoor Air Information	Edit...
Room/Space Data	
Export Category	Spaces
Material Thermal Properties	
Conceptual Types	Edit...
Schematic Types	<Building>
Detailed Elements	<input type="checkbox"/>

[How do these settings affect energy analysis?](#)

OK

Cancel

Revit Frameworks

Energy Model – Material U value

Schematic Types

Construction Types

<Building>

Analysis Properties

By default, analysis properties are generated from information in Conceptual Types.
Properties of Schematic Types are used when override is selected.

Category	Override	Analytic Construction
Roofs	<input type="checkbox"/>	4 in lightweight concrete (U=0.2245 BTU/(h·ft²·°F))
Exterior Walls	<input type="checkbox"/>	8 in lightweight concrete block (U=0.1428 BTU/(h·ft²·°F))
Interior Walls	<input type="checkbox"/>	Frame partition with 3/4 in gypsum board (U=0.2595 BTU/(h·ft²·°F))
Ceilings	<input type="checkbox"/>	8 in lightweight concrete ceiling (U=0.2397 BTU/(h·ft²·°F))
Floors	<input type="checkbox"/>	Passive floor, no insulation, tile or vinyl (U=0.5210 BTU/(h·ft²·°F))
Slabs	<input type="checkbox"/>	Un-insulated solid (U=0.1243 BTU/(h·ft²·°F))
Doors	<input type="checkbox"/>	Metal (U=0.6520 BTU/(h·ft²·°F))
Exterior Windows	<input type="checkbox"/>	Large double-glazed windows (reflective coating) - industry (U
Interior Windows	<input type="checkbox"/>	Large single-glazed windows (U=0.6498 BTU/(h·ft²·°F), SHGC=0.
Skylights	<input type="checkbox"/>	Large double-glazed windows (reflective coating) - industry (U

All

None

Shading factor for exterior windows: 0

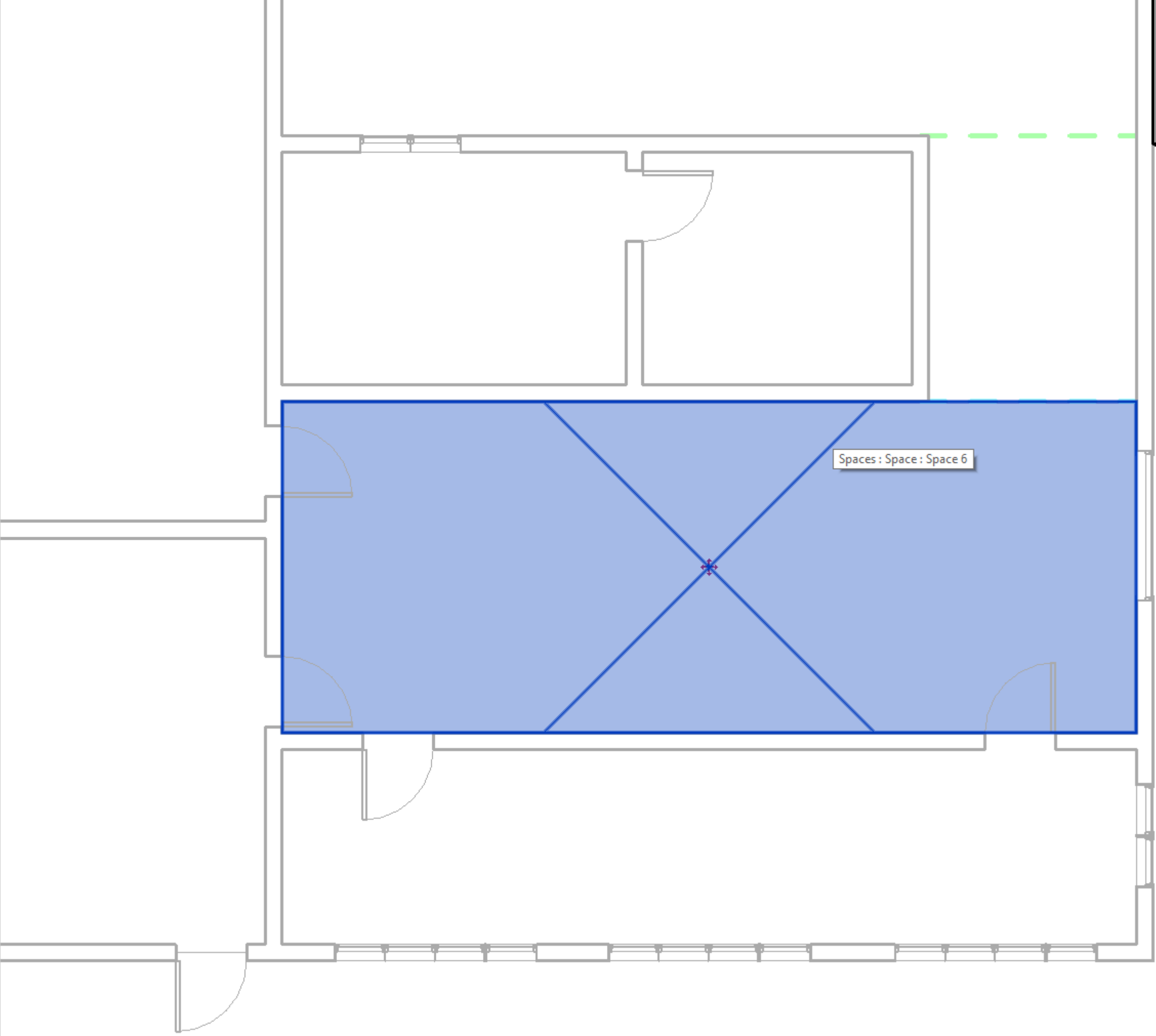
OK

Cancel

Revit Frameworks

Spaces

Mini - Floor Plan: Level 1



1/8" = 1'-0"

Properties

Spaces (1)

Edit Type

Constraints

Level: Level 1

Upper Limit: Level 1

Limit Offset: 8' 0"

Base Offset: 0' 0"

Electrical - Lighting

Average Estimated Illumi...: 0.00 fc

Room Cavity Ratio: 0.000000

Lighting Calculation Wor...: 2' 6"

Lighting Calculation Lu...: Not Computed

Ceiling Reflectance: 75.0000%

Wall Reflectance: 50.0000%

Floor Reflectance: 20.0000%

Electrical - Loads

Design HVAC Load per ar...: 0.00 W/ft²

Design Other Load per area: 0.00 W/ft²

Dimensions

Area: 457.78 SF

Perimeter: 95' 4"

Unbounded Height: 8' 0"

Volume: 3662.22 CF

Computation Height: 0' 0"

Mechanical - Flow

Specified Supply Airflow: 0.00 CFM

Calculated Supply Airflow: Not Computed

Actual Supply Airflow: 0.00 CFM

Return Airflow: Specified

Specified Return Airflow: 0.00 CFM

Actual Return Airflow: 0.00 CFM

Specified Exhaust Airflow: 0.00 CFM

Actual Exhaust Airflow: 0.00 CFM

Outdoor Airflow: 27.47 CFM

Identity Data

Number: 6

Name: Space

Room Number: 1

Room Name: Room

Image:

Comments:

Phasing

Phase: New Construction

Energy Analysis

Zone: Default

Plenum: ☐

Occupiable: ☒

Condition Type: Heated and cooled

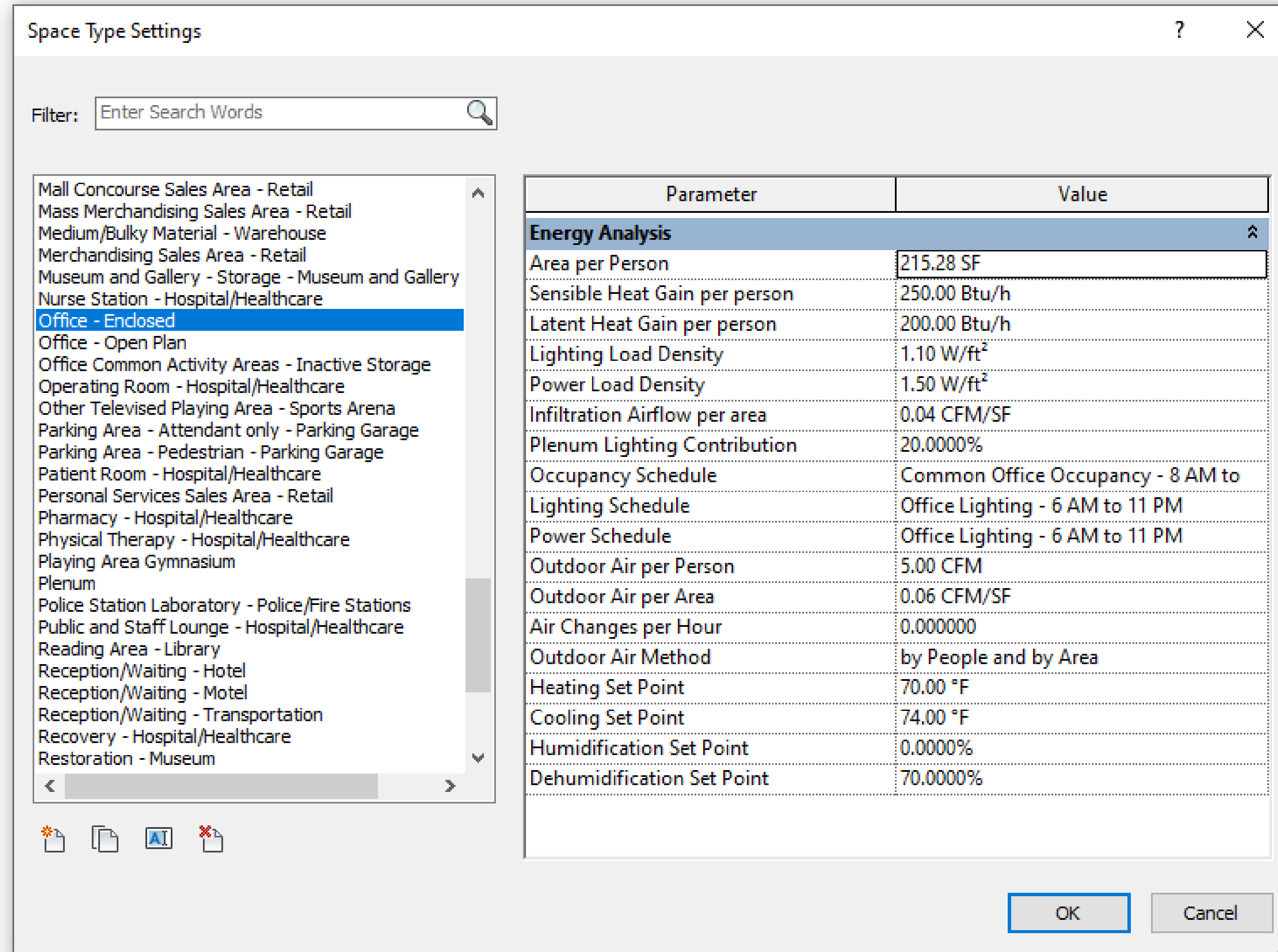
Space Type: <Building>

Properties help

Apply

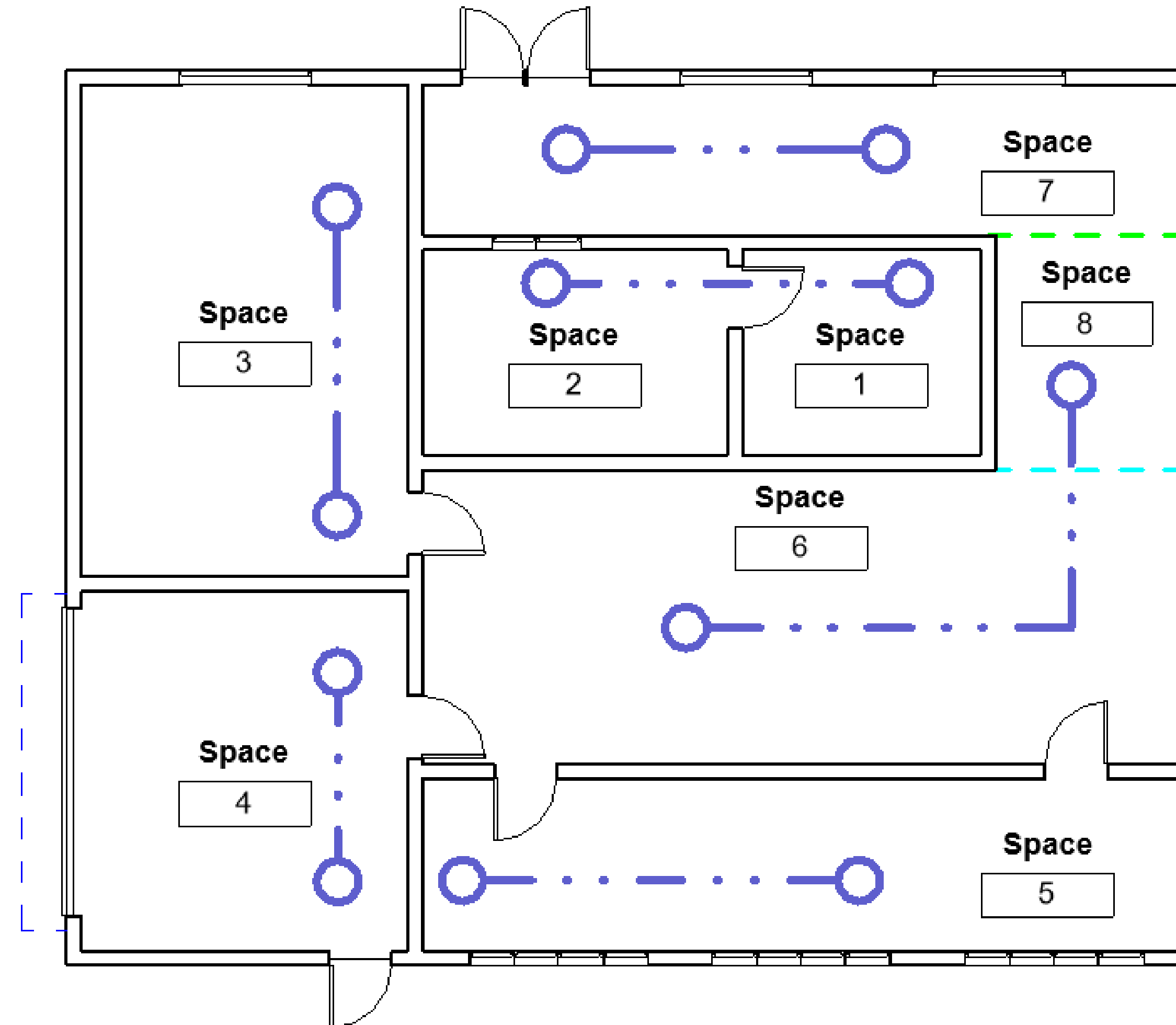
Revit Frameworks

Spaces – Building/Space Type



Revit Frameworks

System Zones



Revit Frameworks

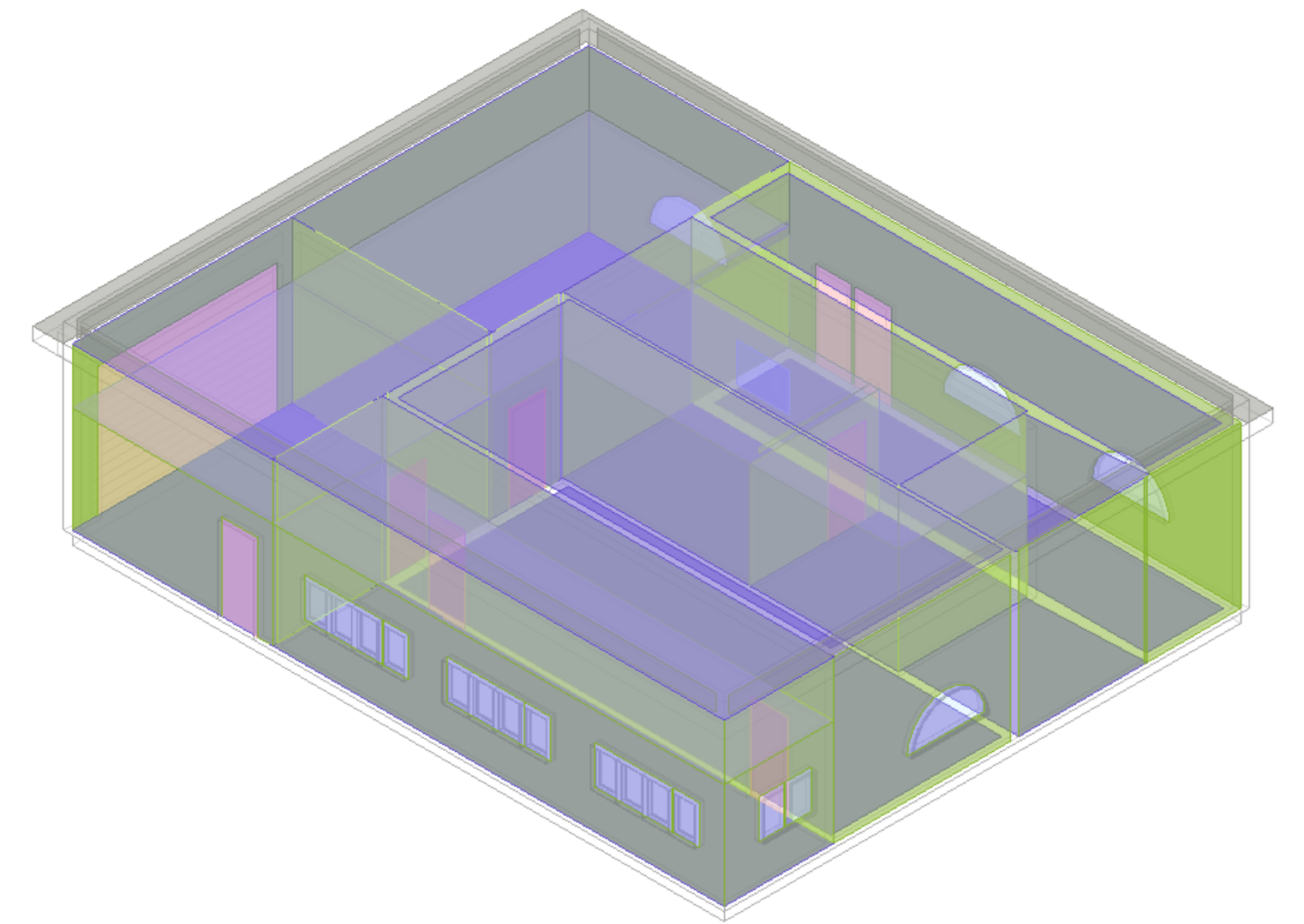
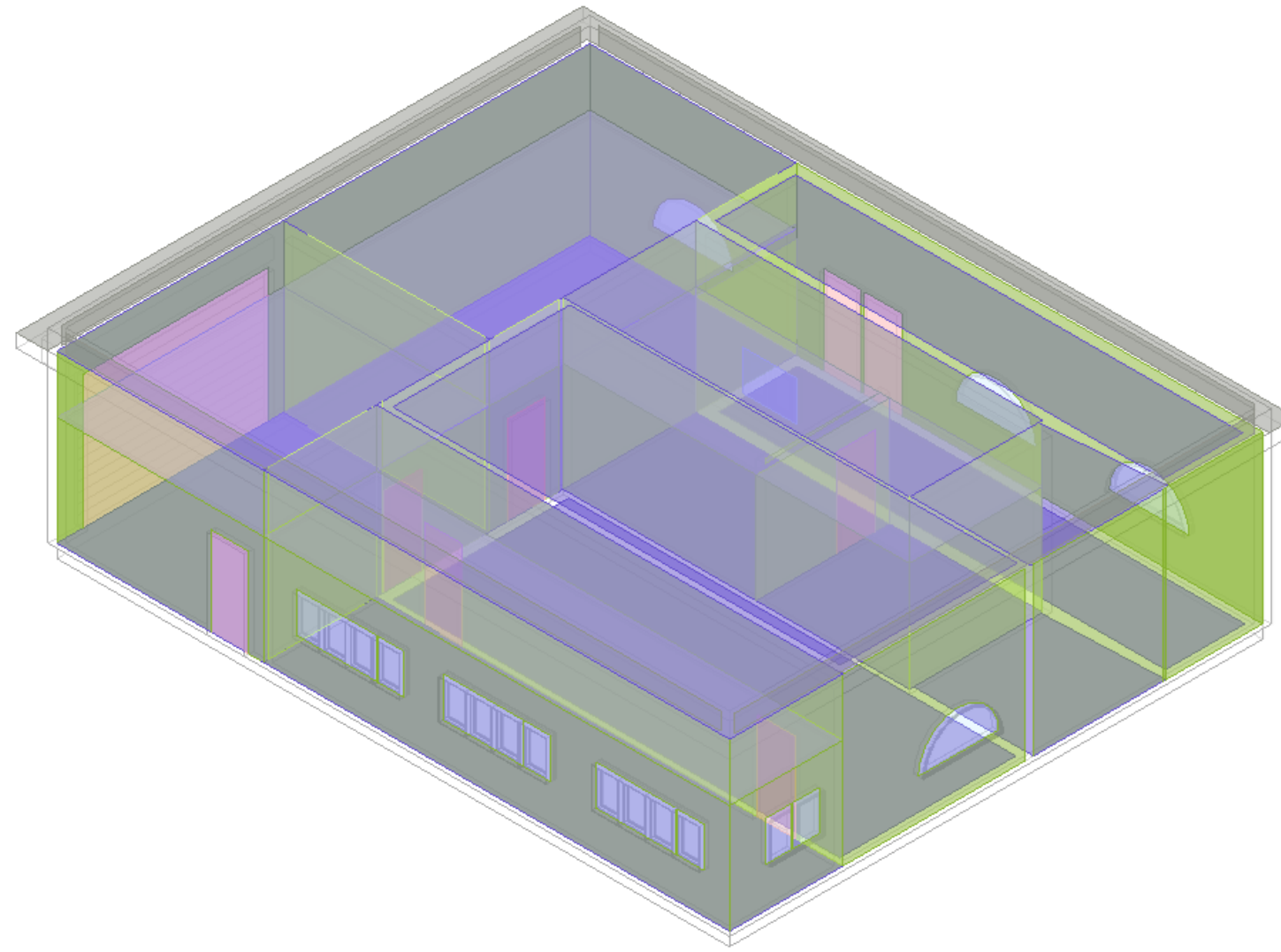
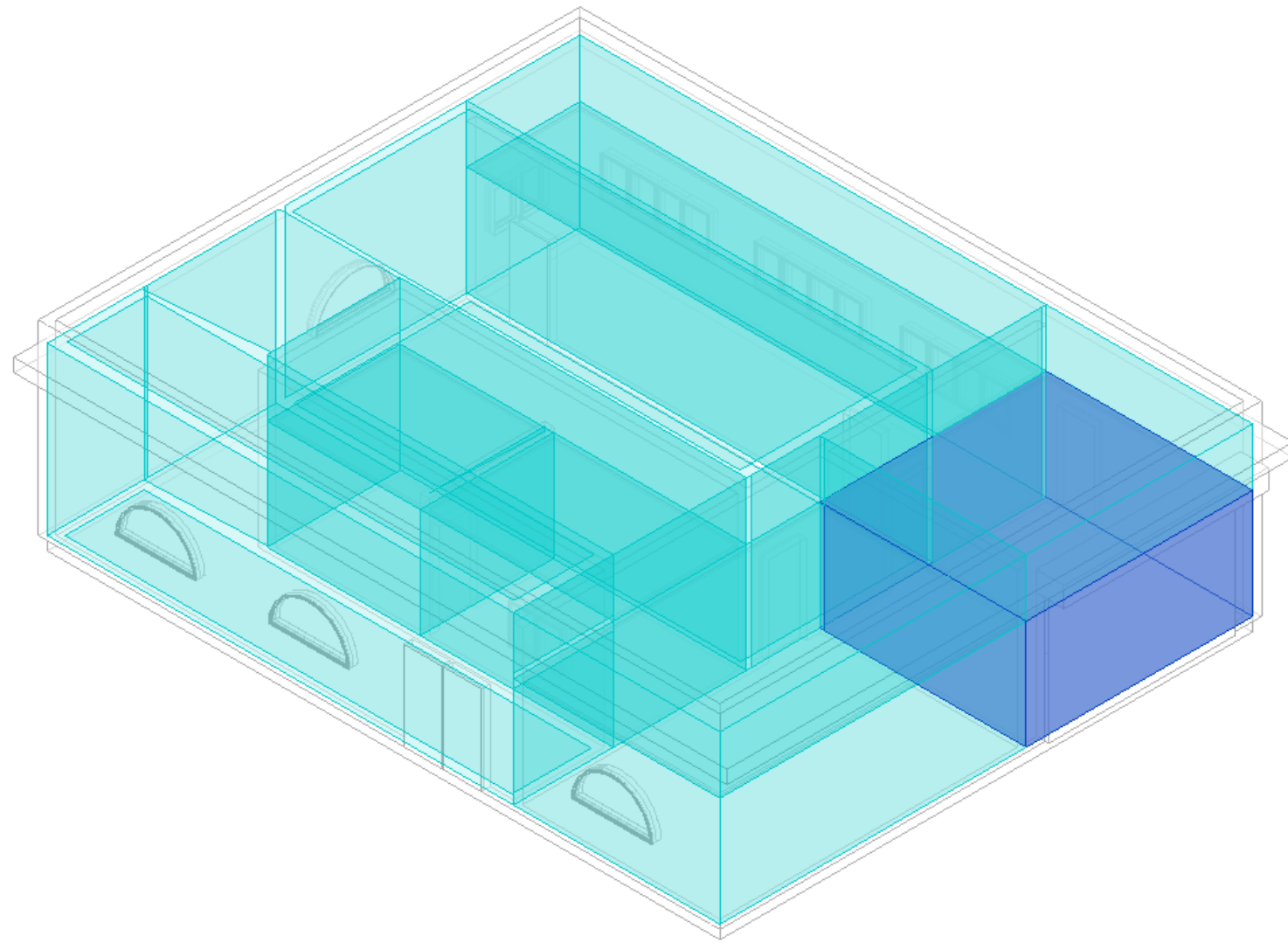
Energy Model – Analytical Systems

Energy Model – Create Energy Model

- Analyze tab ➤ Energy Optimization panel ➤ 

Revit Frameworks

Energy Model – Analytical Geometry



Revit Frameworks

Energy Model – Analytical Geometry Data

<Analytical Spaces Schedule>										
A	B	C	D	E	F	G	H	I	J	K
Room Name		Heating Set Point	Area	Volume	Air Changes per Hour	Latent Heat Gain per person	Outdoor Airflow	Peak Latent Cooling Load	Peak Cooling Load	Peak Heating Load
Space 5	<Building>	70 °F	298 SF	2180.7	0	200	21	Not Computed	Not Computed	Not Computed
Space 6	<Building>	70 °F	444 SF	5267.2	0	200	35	Not Computed	Not Computed	Not Computed
Space 8	<Building>	70 °F	88 SF	906.7	0	200	7	Not Computed	Not Computed	Not Computed

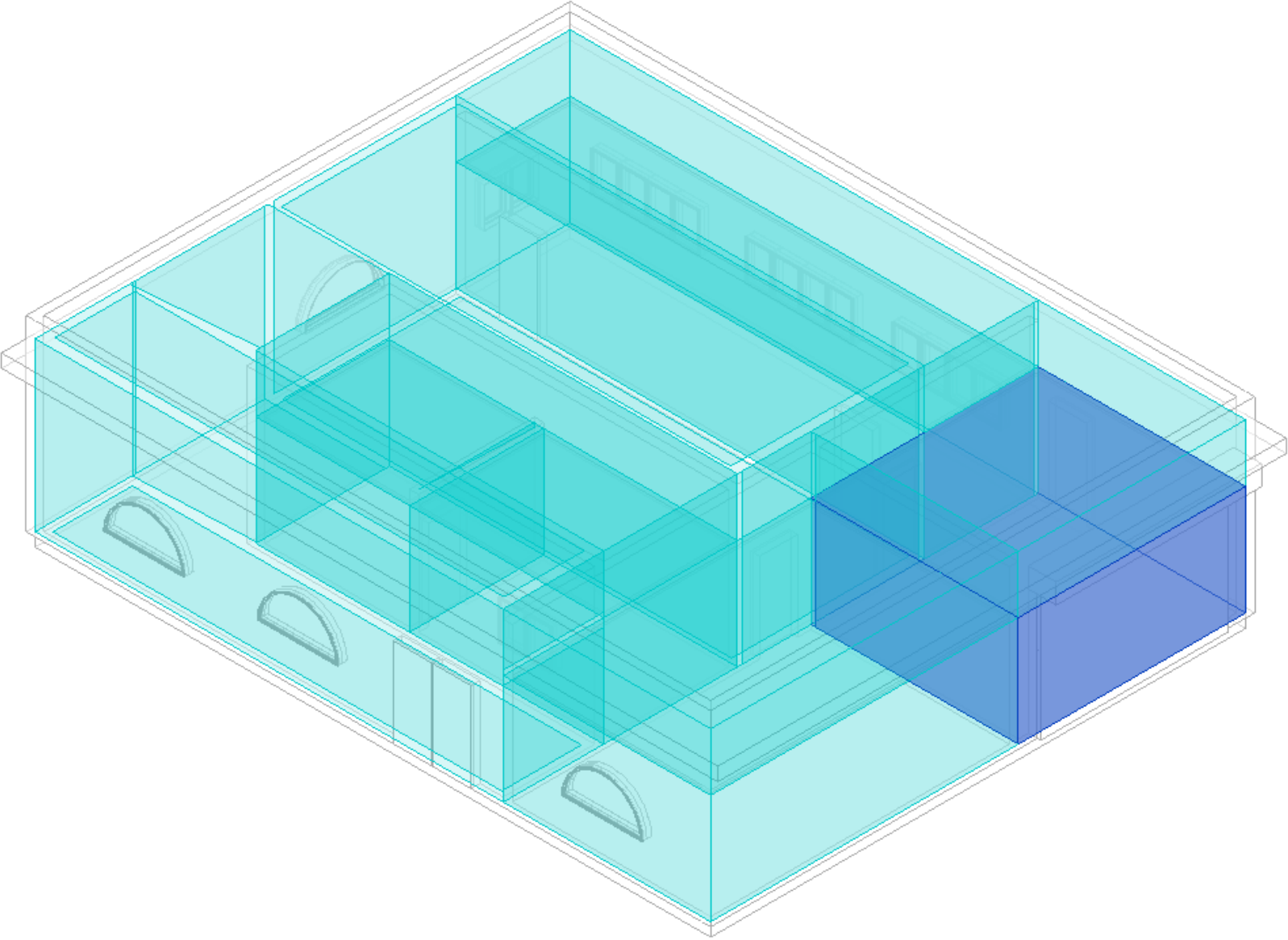
<Analytical Glass>				
A	B	C	D	E
Opening Type		Solar Heat Gain Coefficient	Visual Light Transmittance	Heat Transfer Coefficient (U)
Operable Window	6	0.76	0.81	0.503
Operable Window	6	0.76	0.81	0.503
Operable Window	18	0.76	0.81	0.503
Operable Window	18	0.76	0.81	0.503
Operable Window	6	0.76	0.81	0.503
Operable Window	18	0.76	0.81	0.503
Operable Window	14	0.76	0.81	0.503

<Analytical Surfaces>					
A	B	C	D	E	F
Surface Type	Area	Thermal Resistance (R)	Thermal Mass	Heat Transfer Coefficient (U)	#
		2.59	1.82	0.39	10
Ceiling		1.54	9.45	0.65	5
Exterior Wall		11.66	1.74	0.09	16
Interior Wall		1.75	1.04	0.57	24
Raised Floor		22.16	2.70	0.05	7
Slab on Grade		21.03	34.08	0.05	8

Revit Frameworks

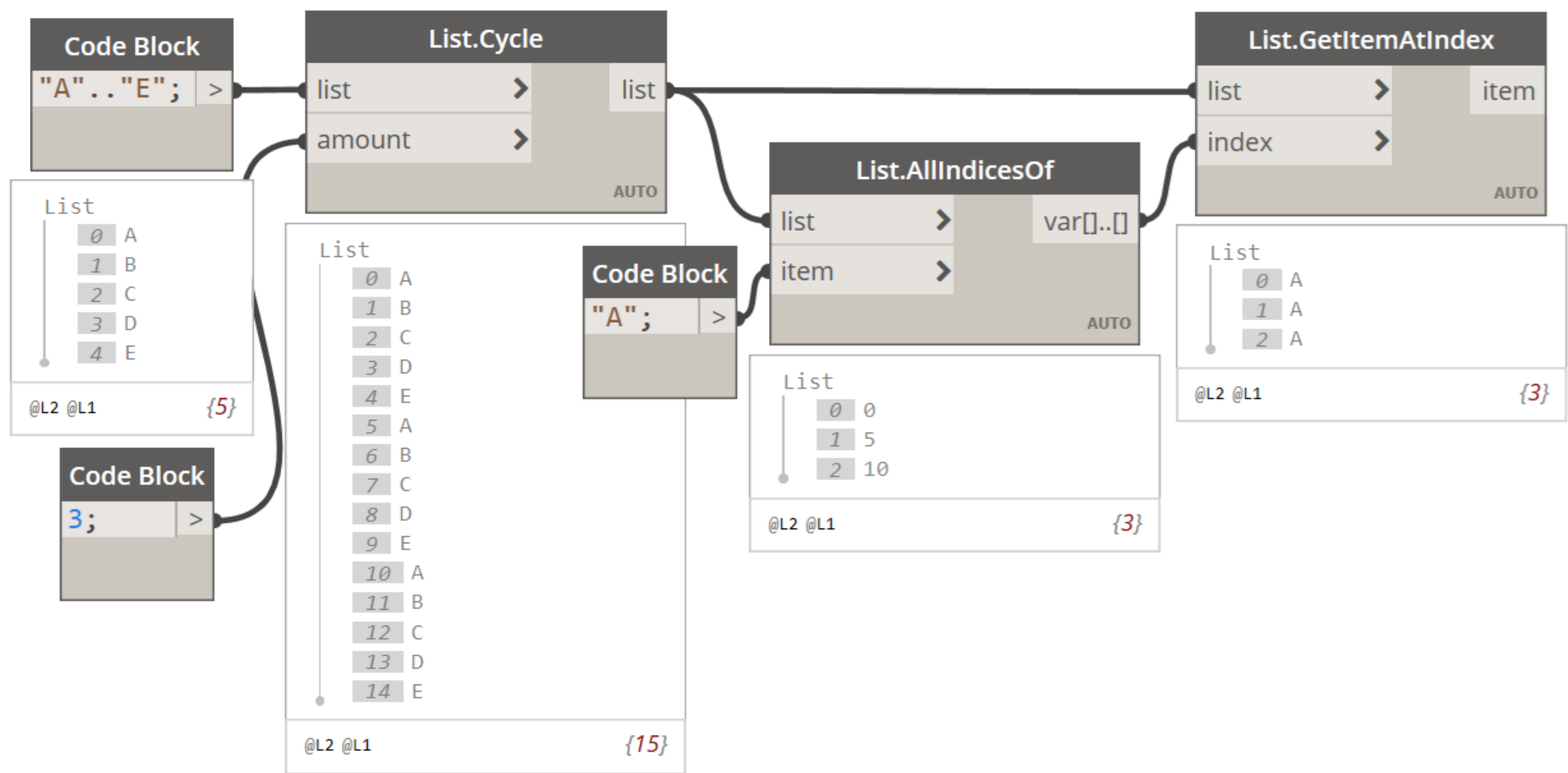
Analytical Spaces

<Analytical Spaces Schedule>										
A	B	C	D	E	F	G	H	I	J	K
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Space 8	<Building>	70 °F	88 SF	906.7	0	200	7	Not Computed	Not Computed	Not Computed
Space 7	<Building>	70 °F	200 SF	2556.9	0	200	18	Not Computed	Not Computed	Not Computed
Space 1	<Building>	70 °F	115 SF	799.2	0	200	8	Not Computed	Not Computed	Not Computed
Space 2	<Building>	70 °F	145 SF	1020.5	0	200	10	Not Computed	Not Computed	Not Computed
Space 4	<Building>	70 °F	264 SF	1963.2	0	200	18	Not Computed	Not Computed	Not Computed
Space 3	<Building>	70 °F	357 SF	2648.9	0	200	25	Not Computed	Not Computed	Not Computed
Analytical Space 1	<Building>	70 °F	264 SF	856.5	0	0	0	Not Computed	Not Computed	Not Computed
Analytical Space 3	<Building>	70 °F	357 SF	1156.6	0	0	0	Not Computed	Not Computed	Not Computed
Analytical Space 2	<Building>	70 °F	298 SF	960.9	0	0	0	Not Computed	Not Computed	Not Computed
Analytical Space 4	<Building>	70 °F	260 SF	825.5	0	0	0	Not Computed	Not Computed	Not Computed



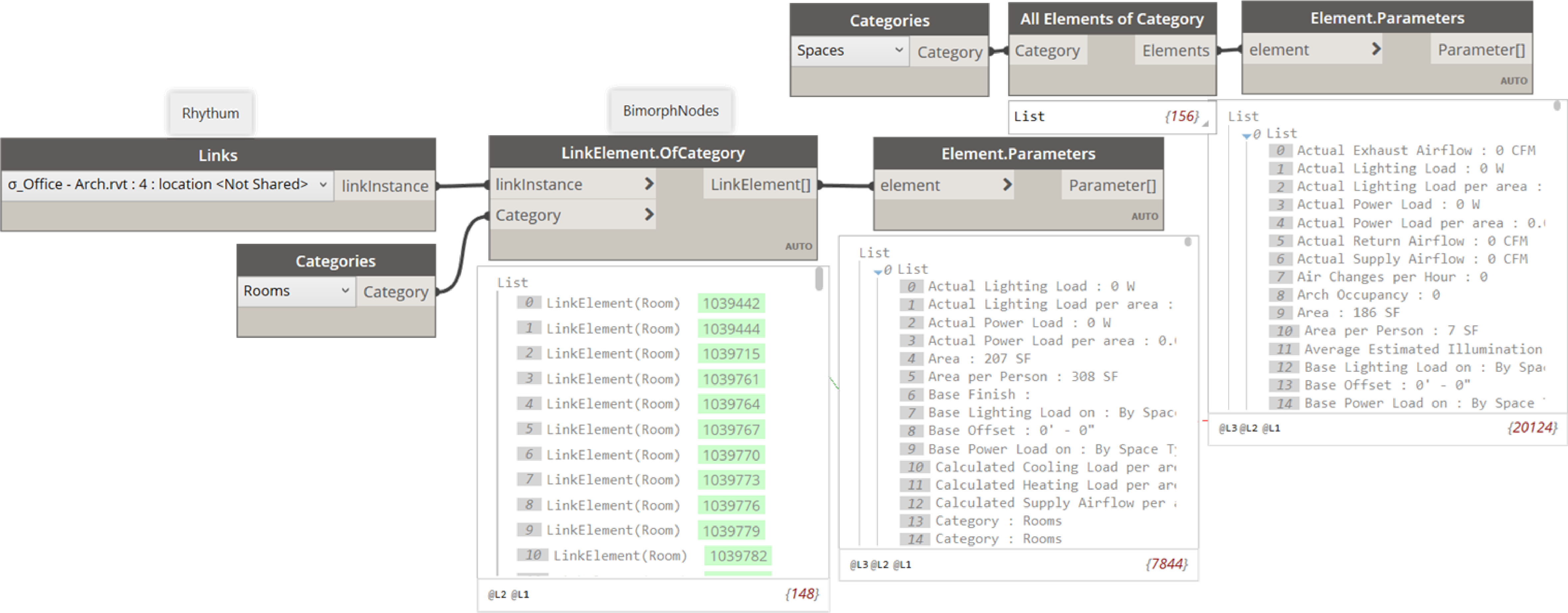
Revit Frameworks

Dynamo – 101



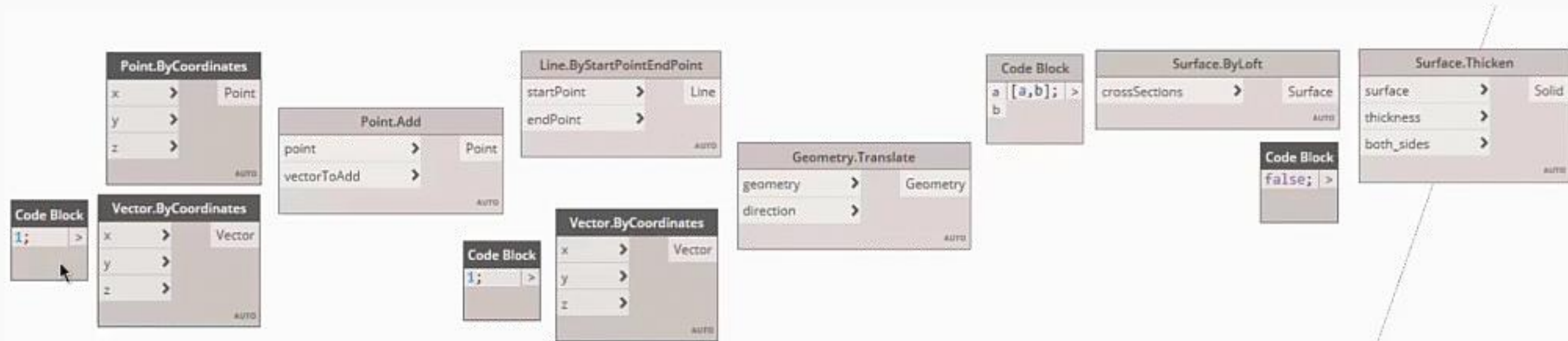
Revit Frameworks

Dynamo – Data Mining



Revit Frameworks

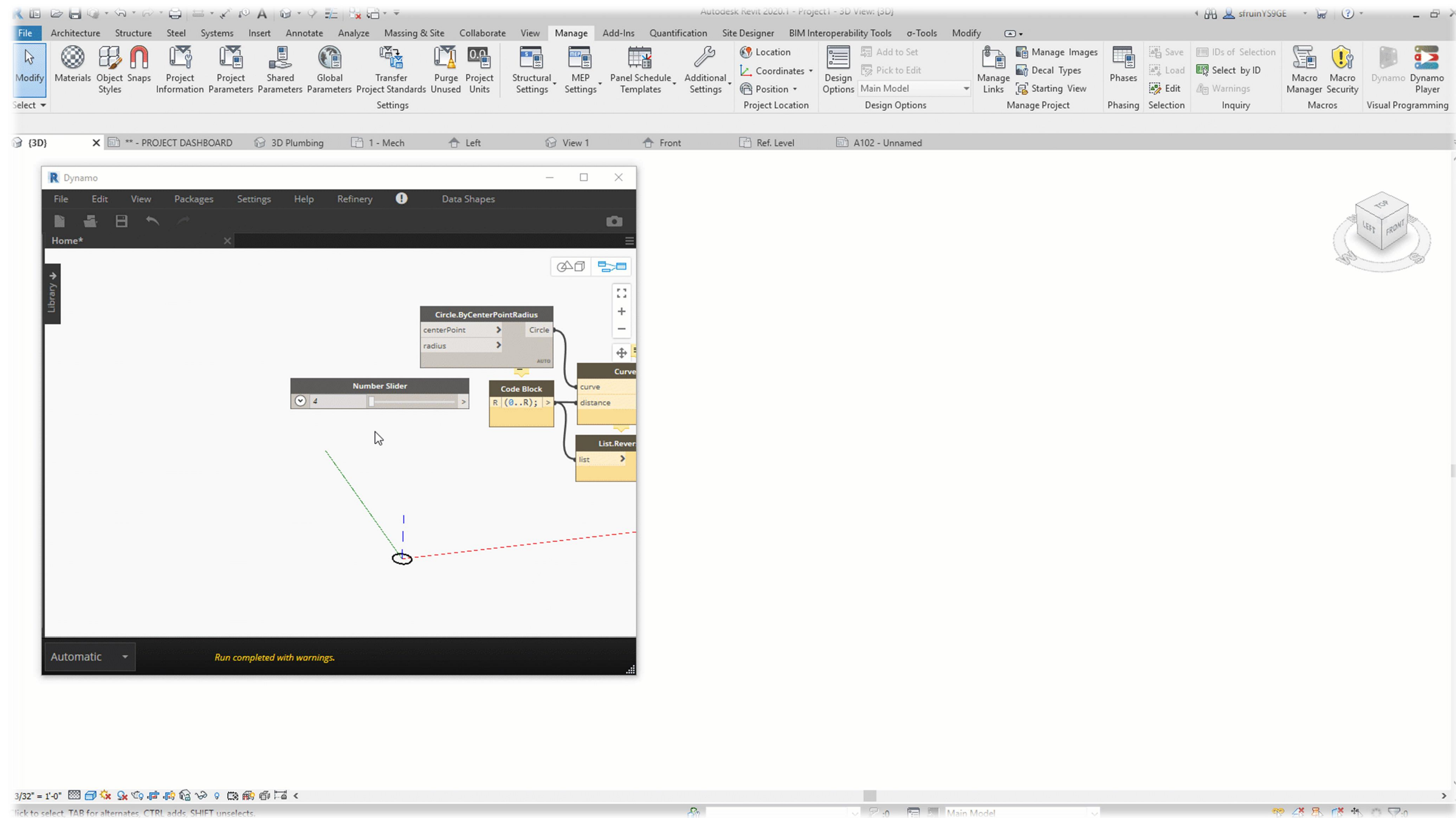
Dynamo – Geometry



Points → Lines → Surfaces → Solids

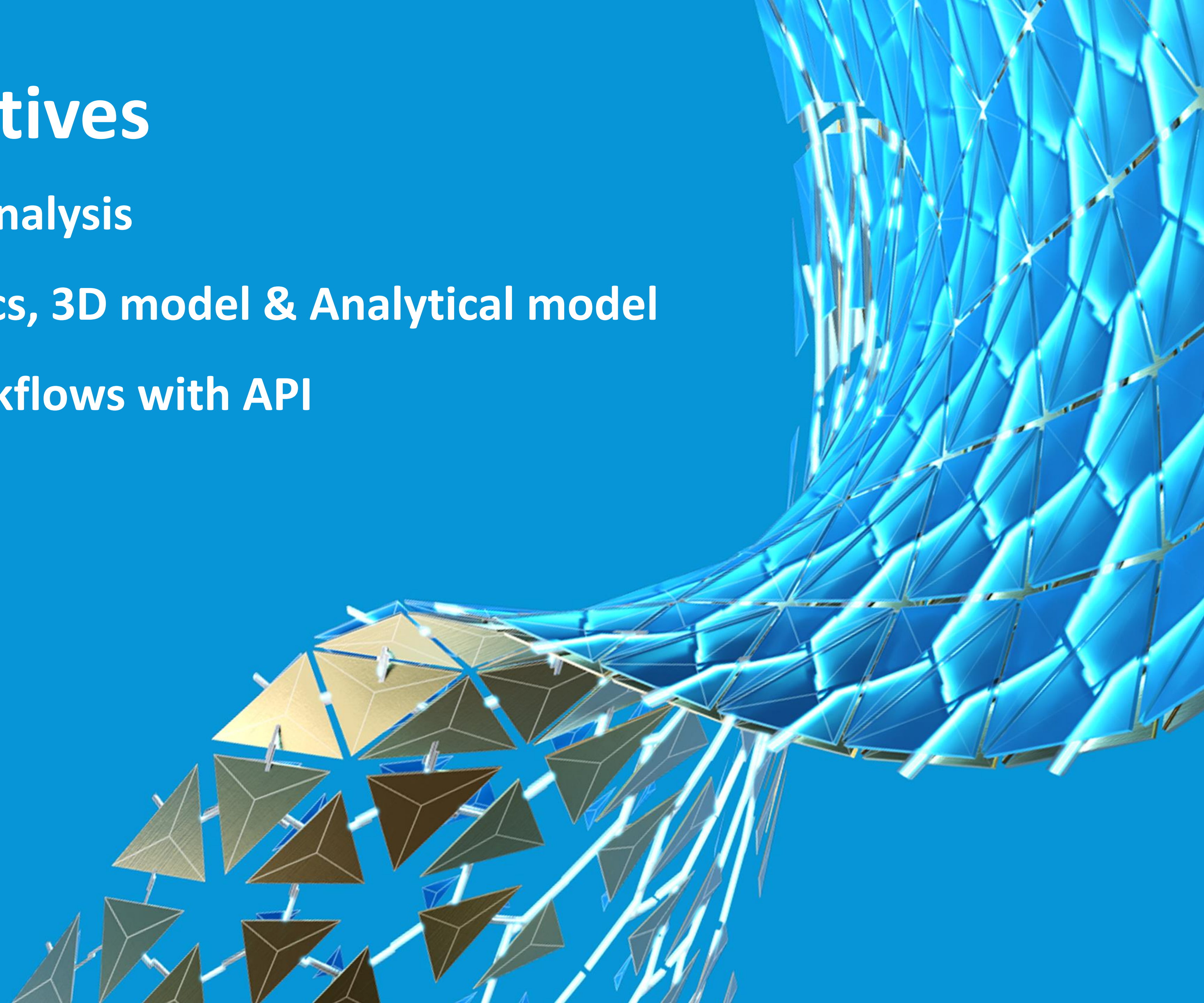
Revit Frameworks

Dynamo – Place Objects In Revit



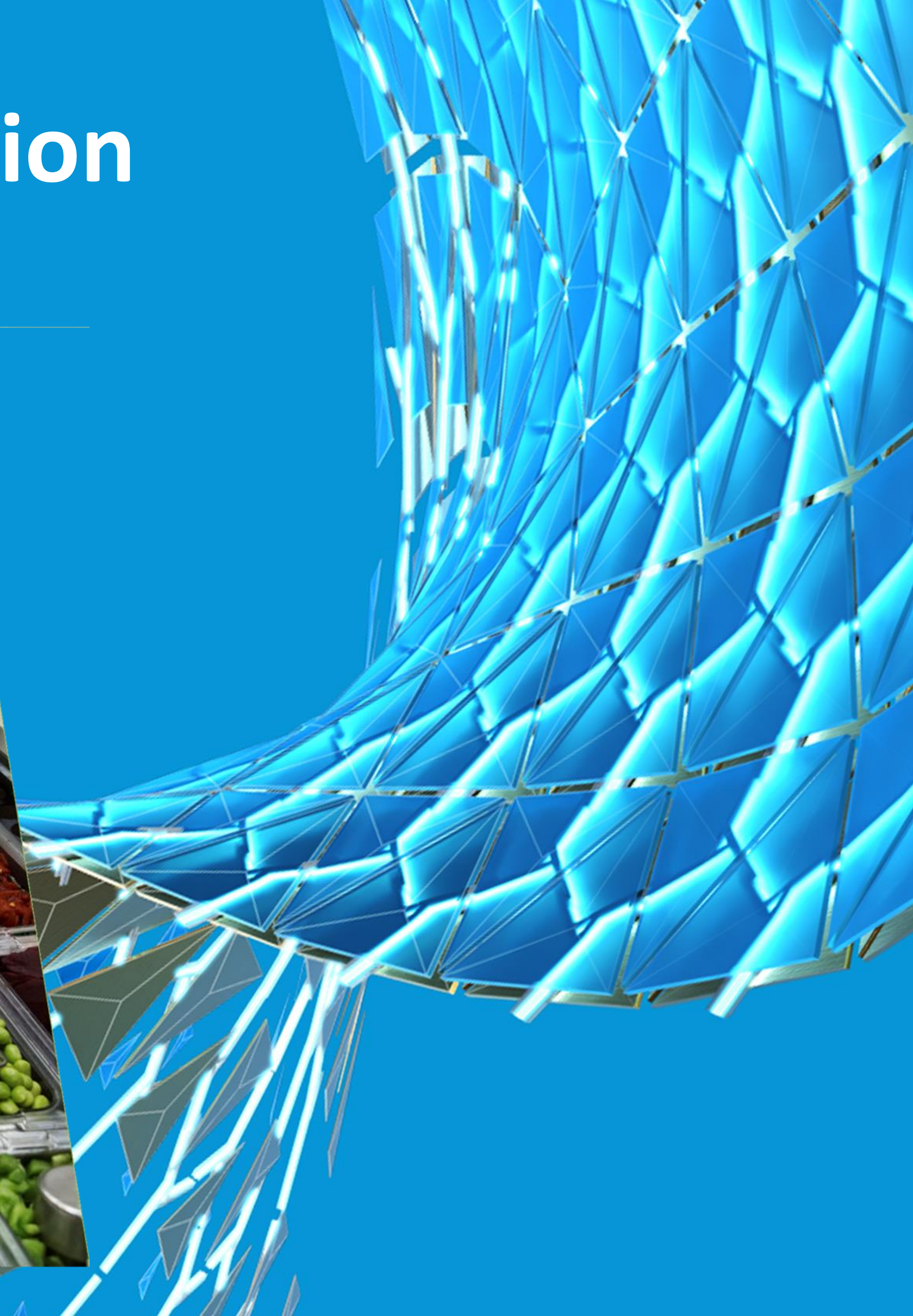
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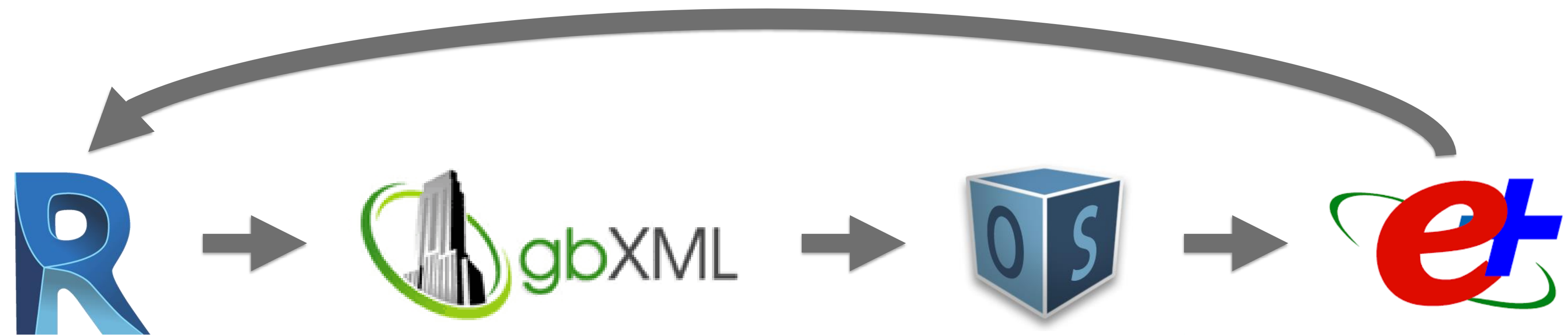
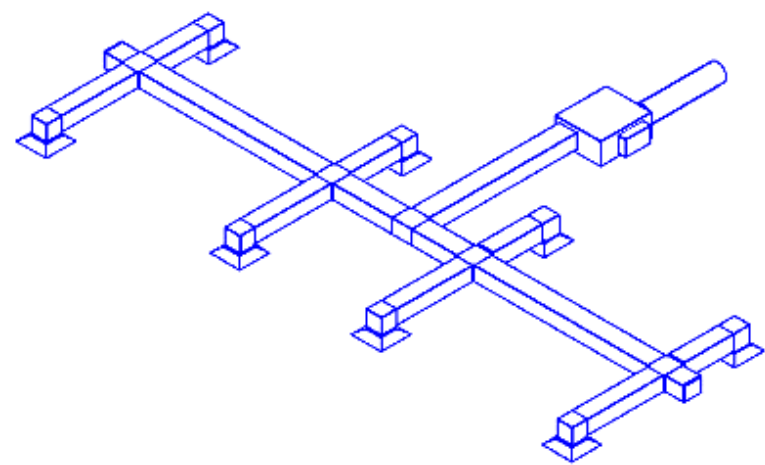
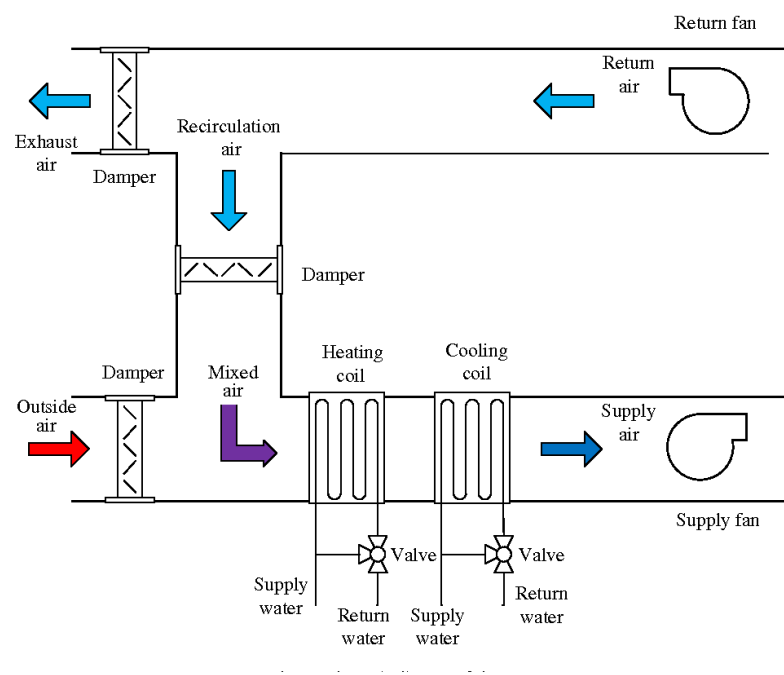


Customization & Data Connection

Mise en place (Everything In Its Place)

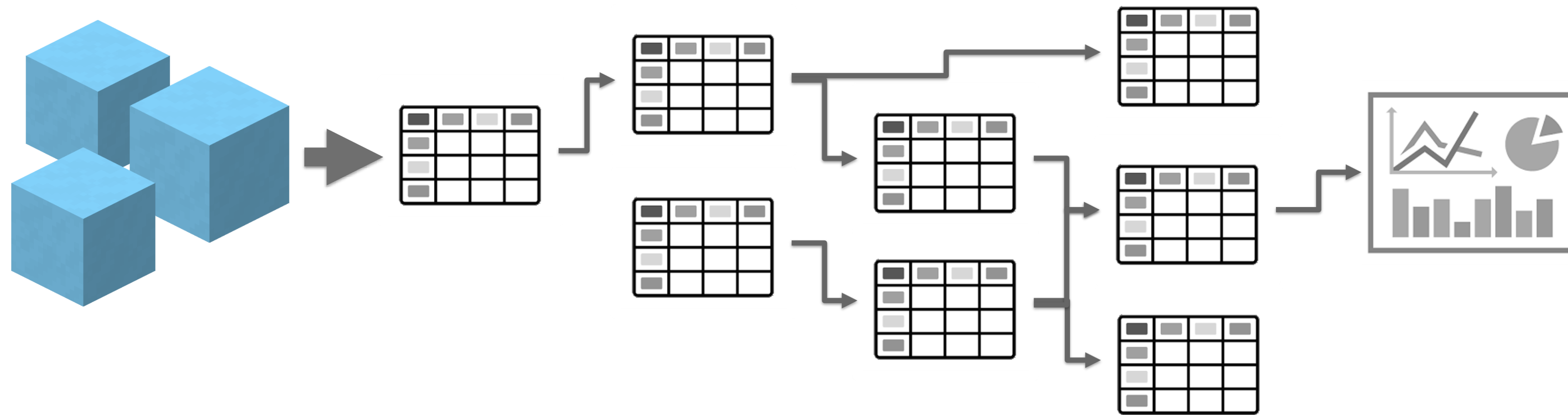


Revit Systems Analysis 101



Revit Frameworks

Revit



Revit Frameworks

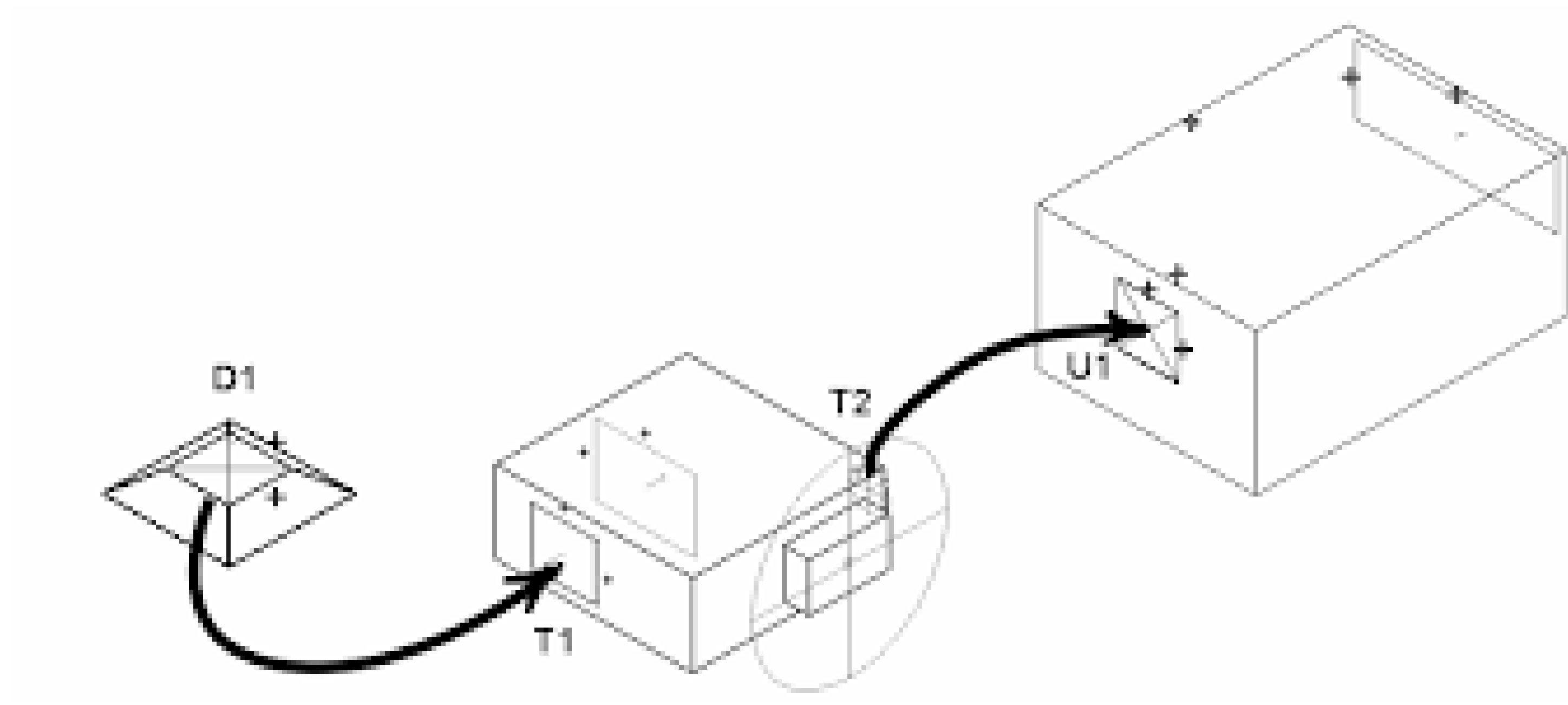
Shared Parameters

Revit Frameworks

Families

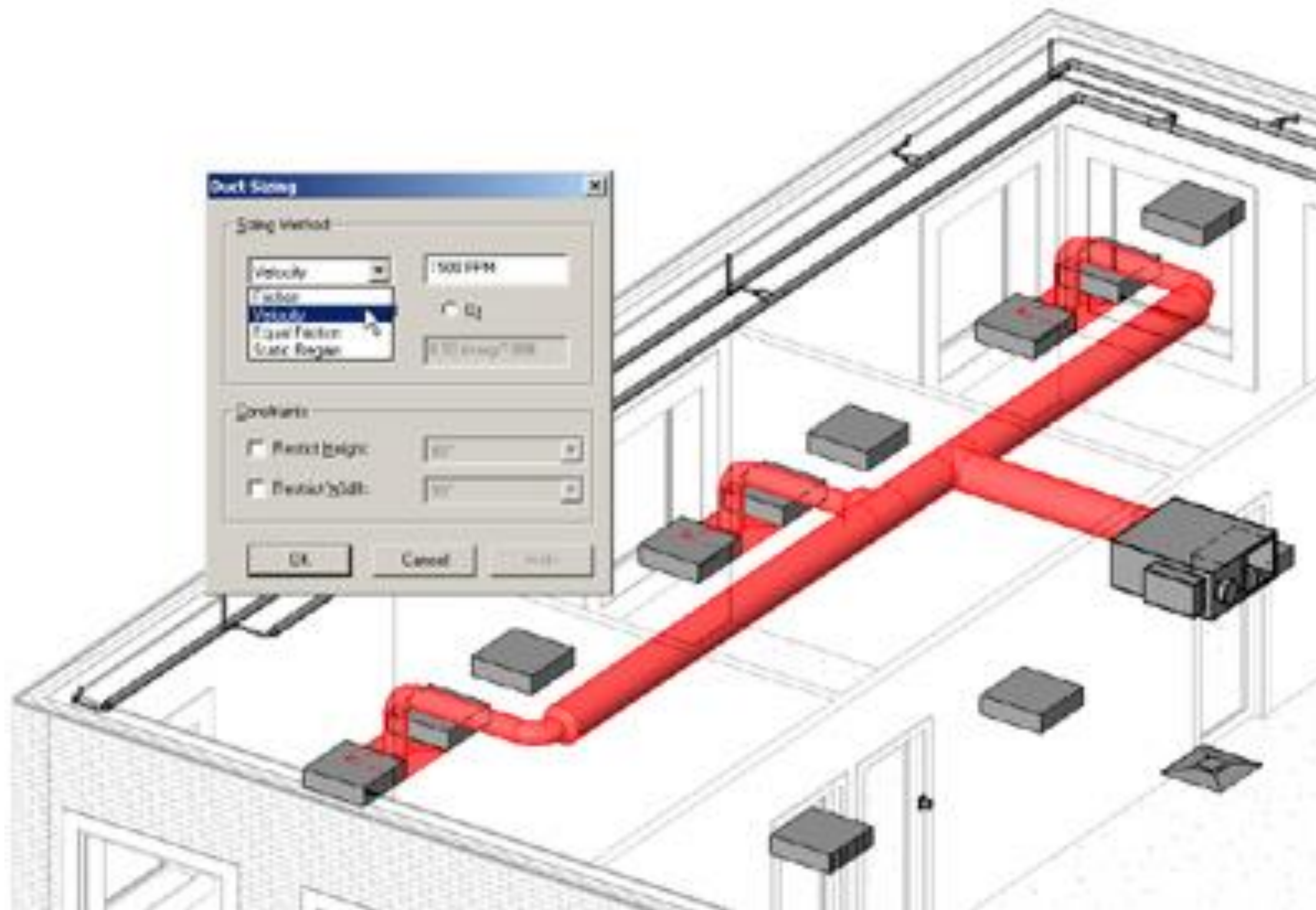
Revit Frameworks

MEP Families



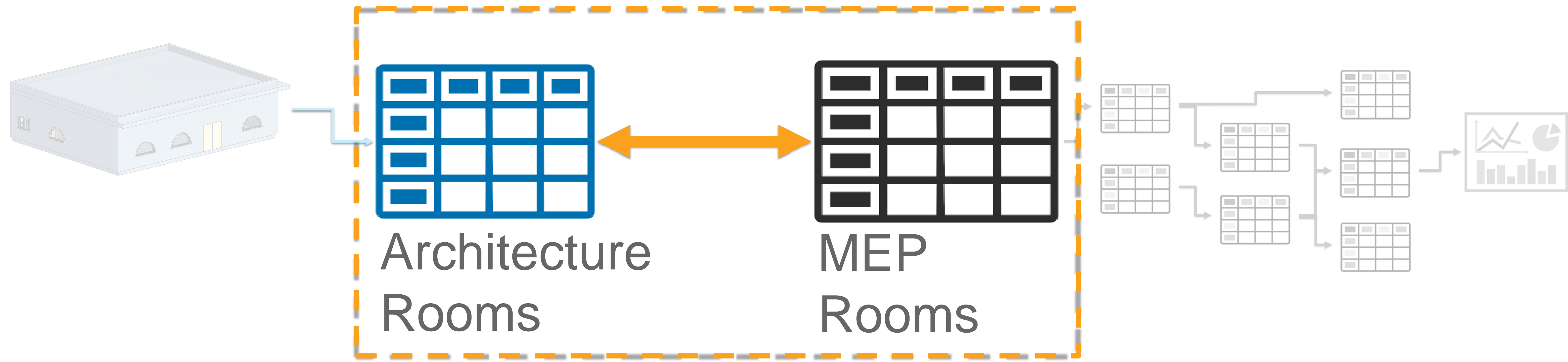
Revit Frameworks

MEP Systems



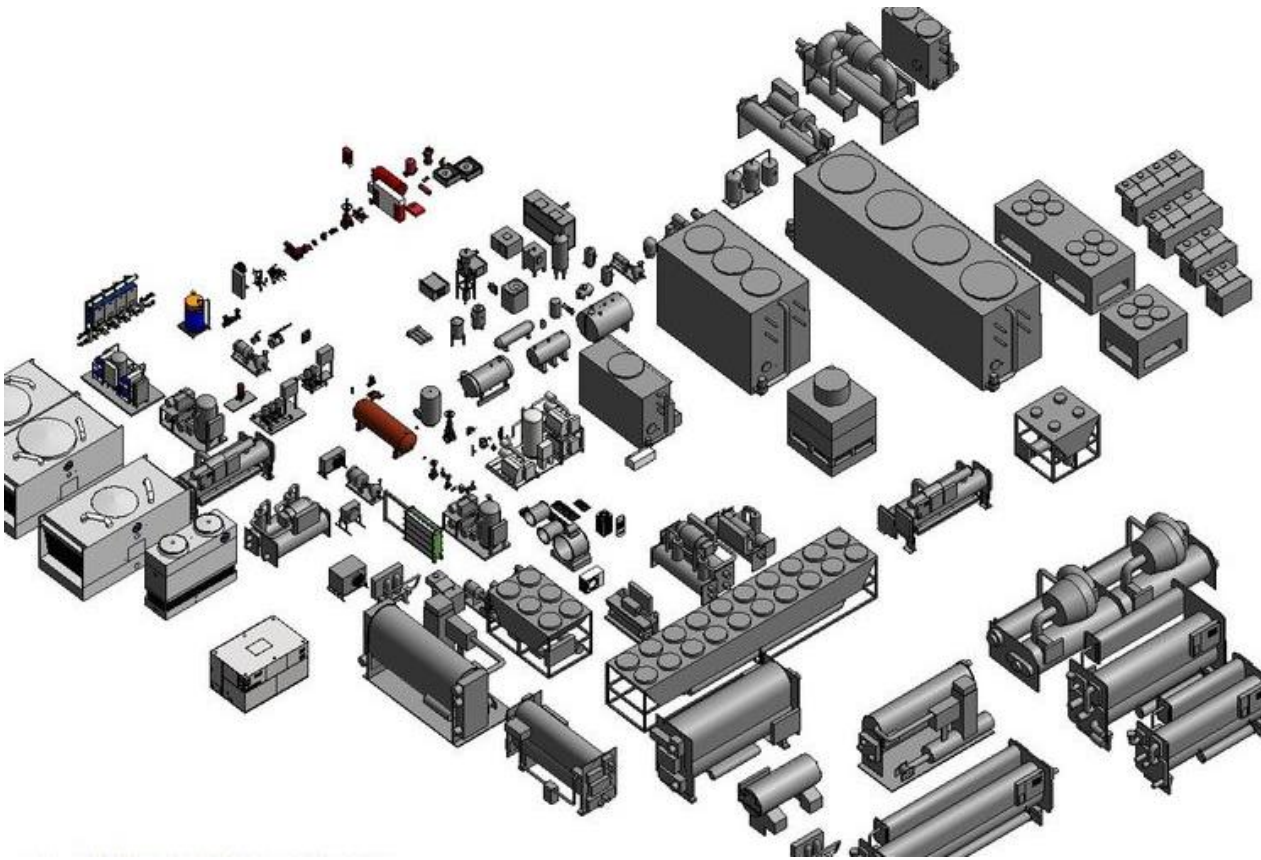
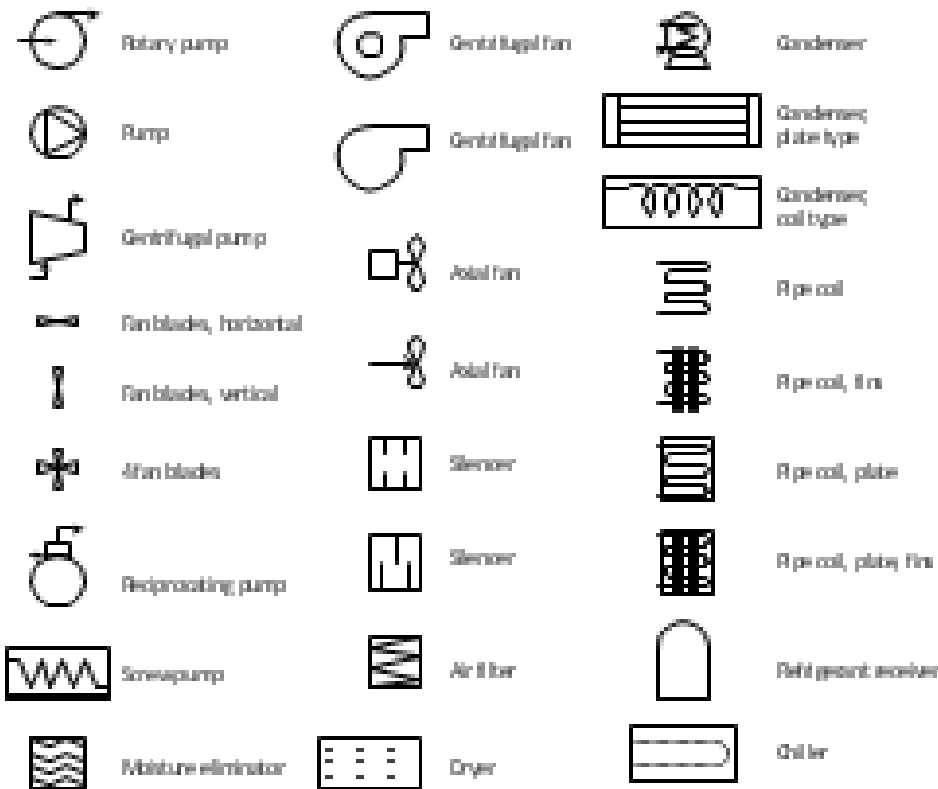
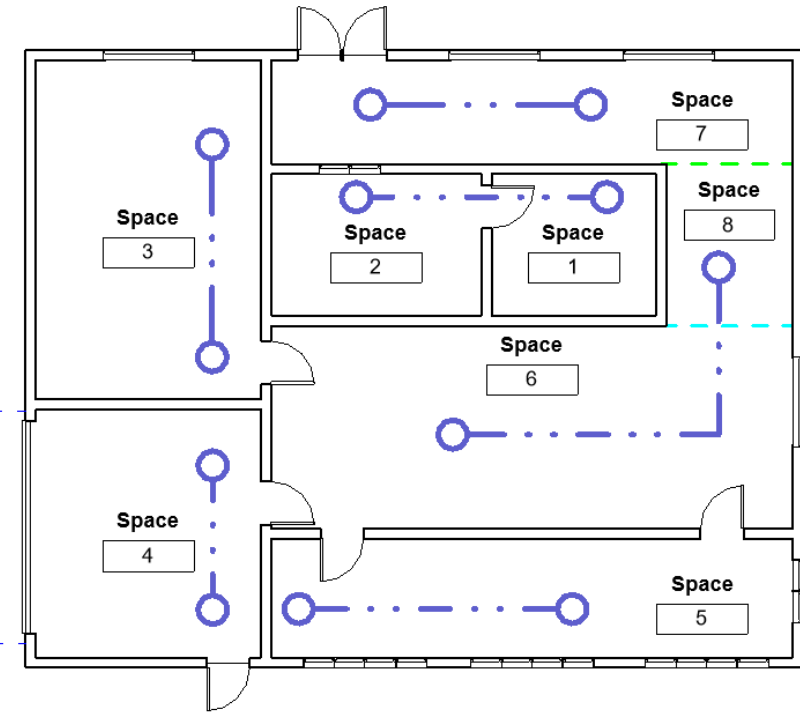
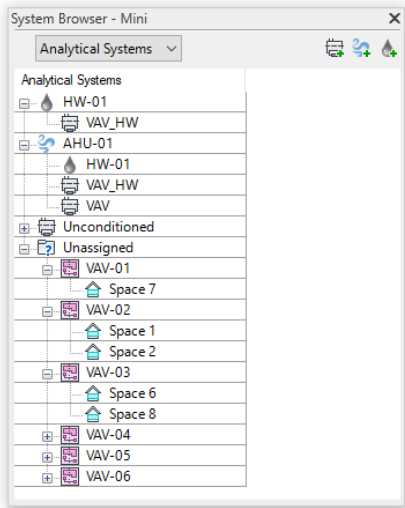
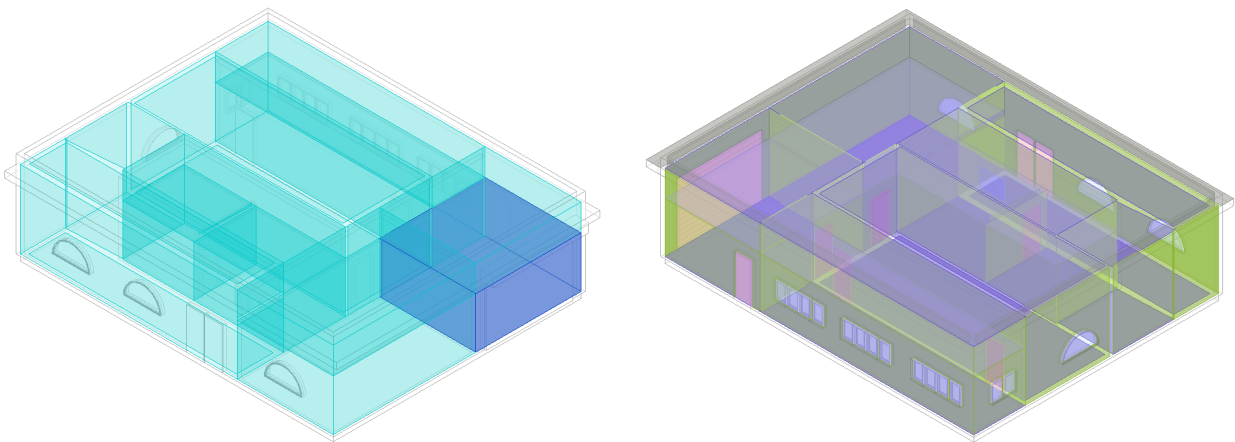
Revit Frameworks

Rooms



Integrated Workflow

Project Template



<Analytical Spaces Schedule>										
A	B	C	D	E	F	G	H	I	J	K
Room Name	Space Type	Heating Set Point	Area	Volume	Air Changes per Hour	Latent Heat Gain per person	Outdoor Airflow	Peak Latent Cooling Load	Peak Cooling Load	Peak Heating Load
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Space 8	<Building>	70 °F	88 SF	1056.7	0	200	7	Not Computed	Not Computed	Not Computed
Space 7	<Building>	70 °F								
Space 1	<Building>	70 °F								
Space 2	<Building>	70 °F								
Space 4	<Building>	70 °F								
Space 3	<Building>	70 °F								
Analytical Space 1	<Building>	70 °F								
Analytical Space 3	<Building>	70 °F								
Analytical Space 2	<Building>	70 °F								
Analytical Space 4	<Building>	70 °F								

<Analytical Surfaces>					
A	B	C	D	E	F
Surface Type	Area	Thermal Resistance (R)	Thermal Mass	Heat Transfer Coefficient (U)	#

		2.59	1.82	0.39	10
Ceiling		1.54			
Exterior Wall		11.66			
Interior Wall		1.75			
Raised Floor		22.16			
Slab on Grade		21.03			

<Analytical Glass>				
A	B	C	D	E
Opening Type	Area	Solar Heat Gain Coefficient	Visual Light Transmittance	Heat Transfer Coefficient (U)
Operable Window	6	0.76	0.81	0.503
Operable Window	6	0.76	0.81	0.503
Operable Window	18	0.76	0.81	0.503
Operable Window	18	0.76	0.81	0.503
Operable Window	6	0.76	0.81	0.503
Operable Window	18	0.76	0.81	0.503
Operable Window	14	0.76	0.81	0.503
Operable Window	6	0.76	0.81	0.503
Operable Window	6	0.76	0.81	0.503
Operable Window	14	0.76	0.81	0.503
Operable Window	14	0.76	0.81	0.503
Operable Window	14	0.76	0.81	0.503
Operable Window	12	0.76	0.81	0.503

Integrated Workflow

Project Setup

- 1) Import Link Model
- 2) Set Room Bounding
- 3) Aline Model
- 4) Set Survey Point
- 5) Set Origin Point
- 6) Set Project Base Point
- 7) Pin Link Model
- 8) Phase
- 9) Scope Boxes
- 10) Copy Levels
- 11) Copy Grids
- 12) Copy Match Line
- 13) Enter Project Info
- 14) Make Ceiling Plans
- 15) Name Ceiling Plans
- 16) Make Floor Plans Views
- 17) Name Floor Plans
- 18) Assign View Templates
- 19) Make Keynote Schedules
- 20) Name Keynote Schedules
- 21) Set Keynote Filter
- 22) Make Sheets
- 23) Name Sheets
- 24) Set Sheet Number
- 25) Set Sheet Id
- 26) Place Floor Plan Views
- 27) Place Sheet Legends
- 28) Place Keynote Schedules
- 29) Aline View on Sheet
- 30) Create Worksets

Autodesk Revit 2019 - Project1 - Sheet: α - PROJECT DASHBOARD

File Architecture Structure Steel Systems Insert Annotate Analyze Massing & Site Collaborate View Manage Add-Ins Site Designer DEWALT Modify Precast

Object Styles Project Parameters Transfer Project Standards Materials Snaps Shared Parameters Purge Unused Project Information Global Parameters Project Units Additional Settings Project Location Design Options Main Model Manage Project Phasing Selection Inquiry Macros Visual Programming

Project Browser - Project1

Views (α) Legend Schedule Sheets Family Groups Revisions

Dynamo Player

Filter...

00_HVAC Project Set Up - Add Shard Parameters Ready

00_HVAC Project Set Up - Add Shard Parameters Ready

01_HVAC Project Set Up - Import Link Model Ready

02_HVAC Project Set Up - Link Model Copy Ready

03_HVAC Project Set Up - Views Ready

04_HVAC Project Set Up - Sheets Ready

05_HVAC Project Set Up - Worksets Ready

Unsaved document

PROJECT DASHBOARD

SIGMA AEC SOLUTIONS

Project Number
Project Name

Client
Client Name

PROJECT ADDRESS
Project Address

PROJECT STATUS
Project Status

IN EFFORTS

VIEW

THE SIGMA HVAC CONTENT

CURRENT VIEW ONLY IN THEIR RESPECTIVE

LAST SYNC

REFERENCE PLANES WILL BE DELETED.

PROJECT NOTES

Project Tasks

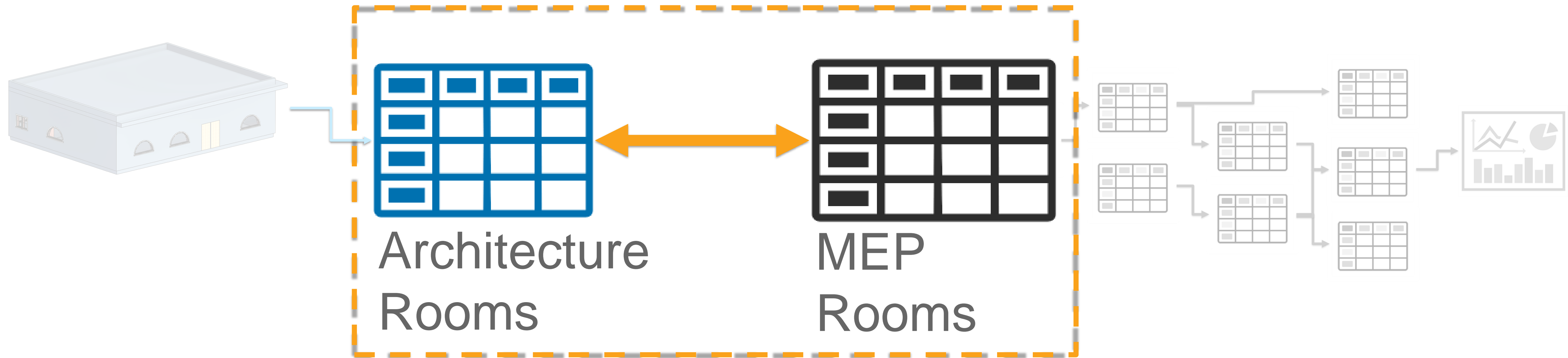
Number	Description	Status	Completed	Approved	Comments
1.0	PROJECT SET UP	0%	No	No	
2.0	HVAC LOADS	0%	No	No	
3.0	SPACE CALCS	0%	No	No	
4.0	SYSTEM SELECTIONS	0%	No	No	
5.0	BUILDING AIR BALANCE	0%	No	No	
6.0	SYSTEM ZONING	0%	No	No	
7.0	EQUIPMENT PLACEMENT	0%	No	No	
8.0	SYSTEM ROUTING	0%	No	No	
9.0	SYSTEM CALCULATION	0%	No	No	
10.0	DOCUMENTATION	0%	No	No	

Schedule Graphics: Schedule Graphics: Project Tasks

Main Model

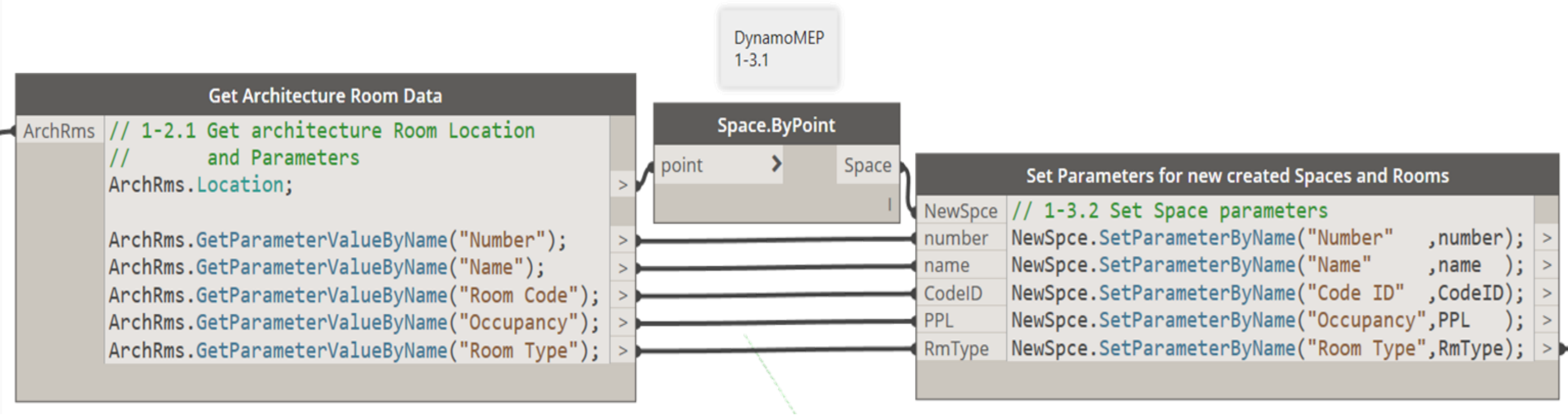
Integrated Workflow

Copy Linked Rooms



Integrated Workflow

Create Space At Room Location



Integrated Workflow

Add Spaces To Remaining Openings

Integrated Workflow

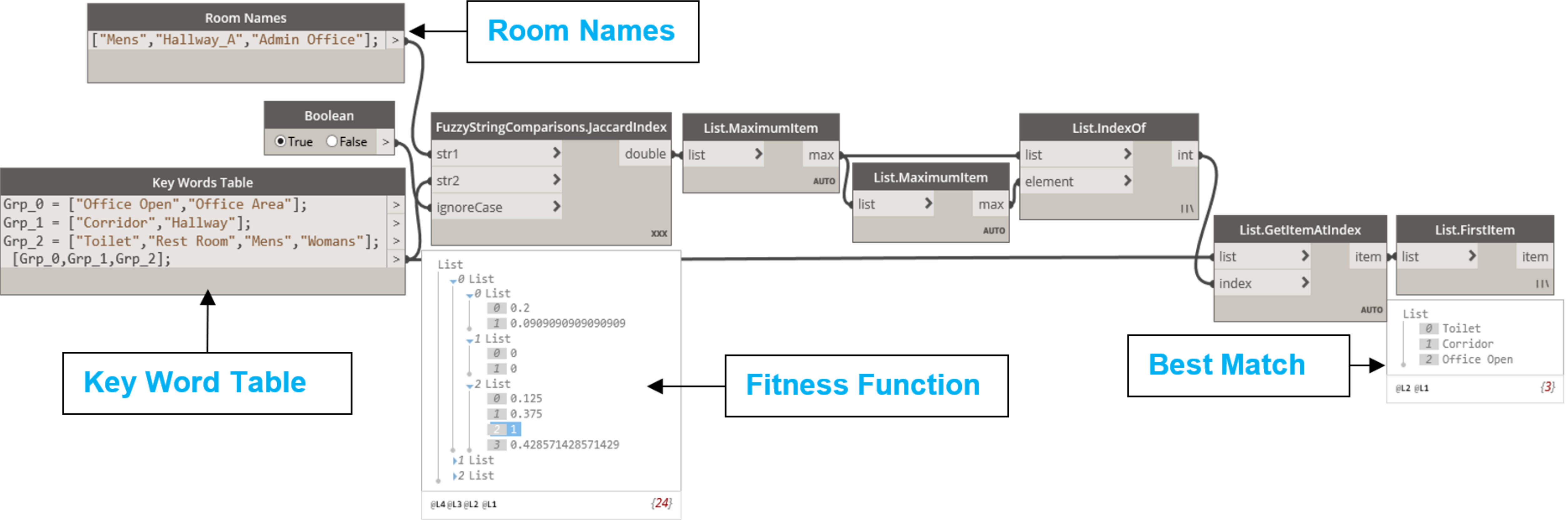
Subdivide Large Rooms

Integrated Workflow

Add Space Type

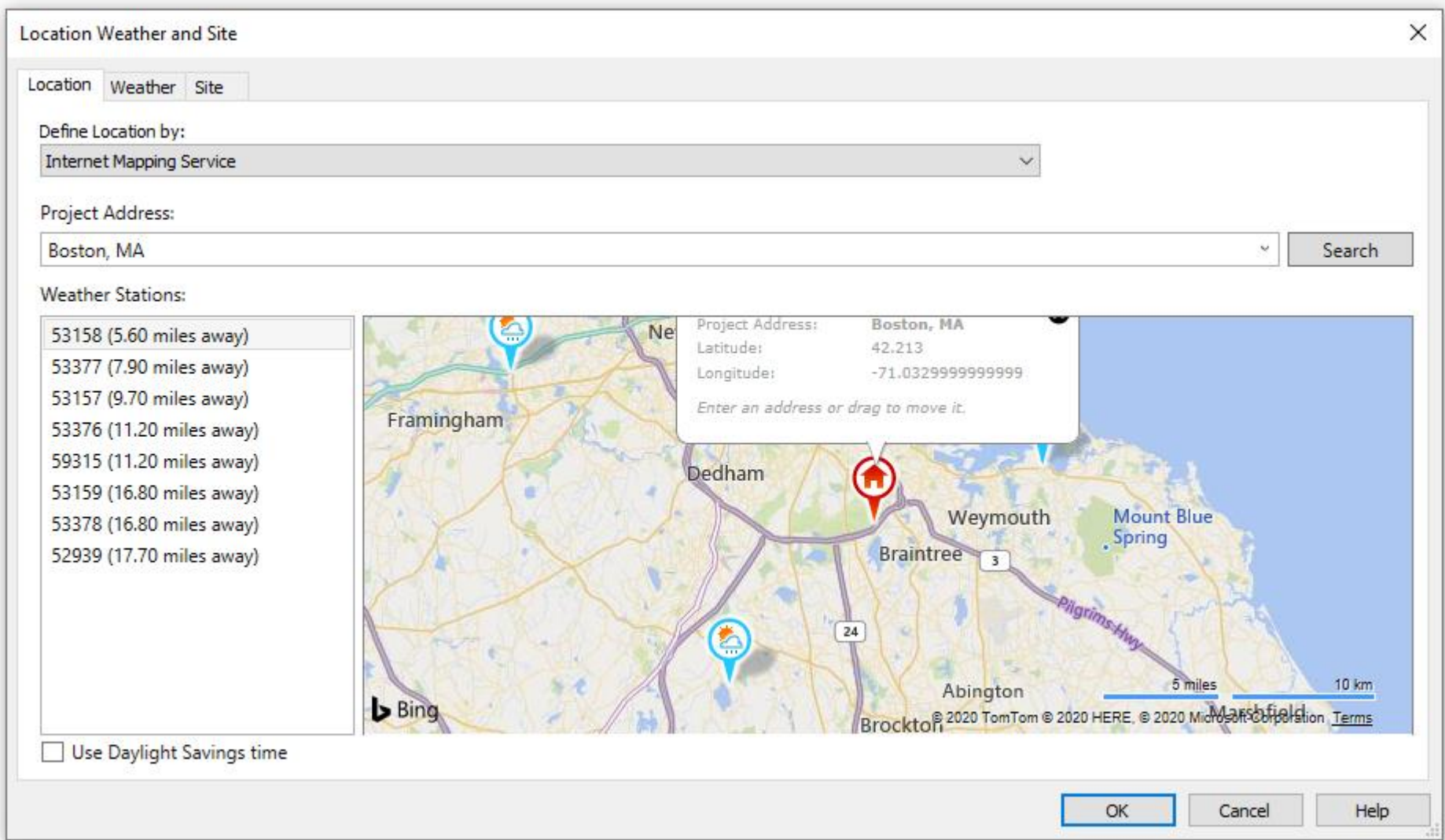
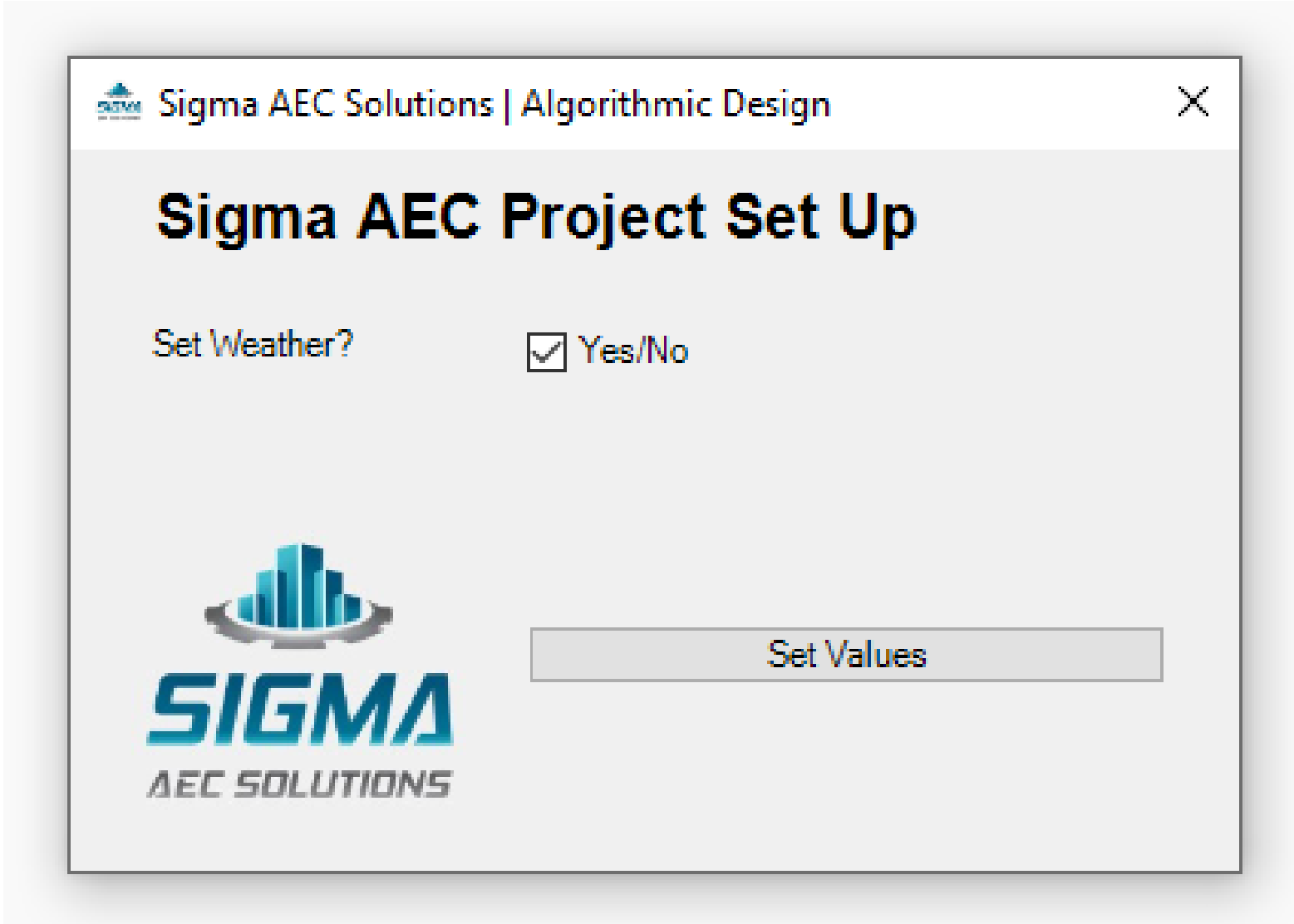
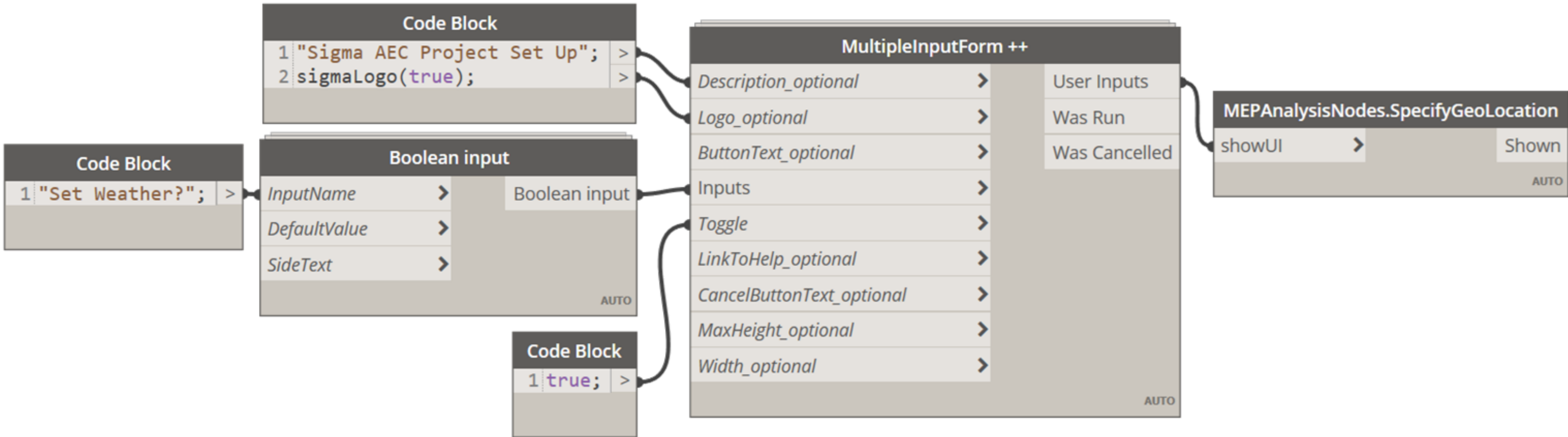
Integrated Workflow

Add Space Type



Integrated Workflow

Energy Model Setup - Weather



Integrated Workflow

Energy Model Setup – Thermal Properties

Integrated Workflow

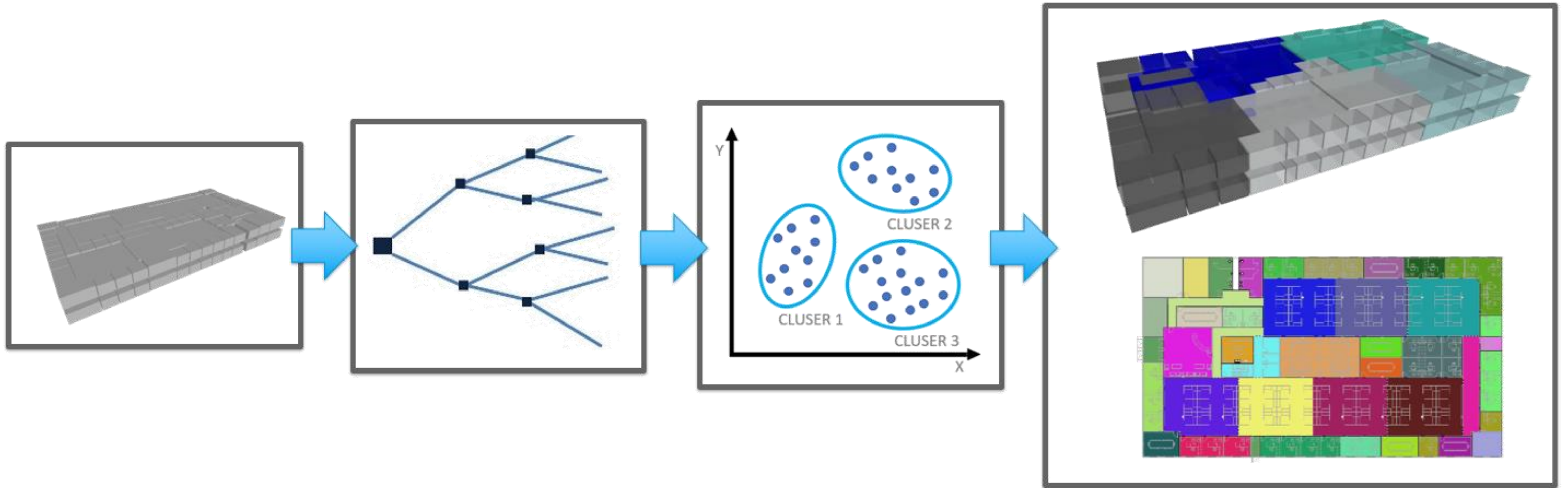
Energy Model Review – Dynamo

Integrated Workflow

Systems Analysis – Analytical Space Loads

Integrated Workflow Systems Configurator

Integrated Workflow Systems Configurator -



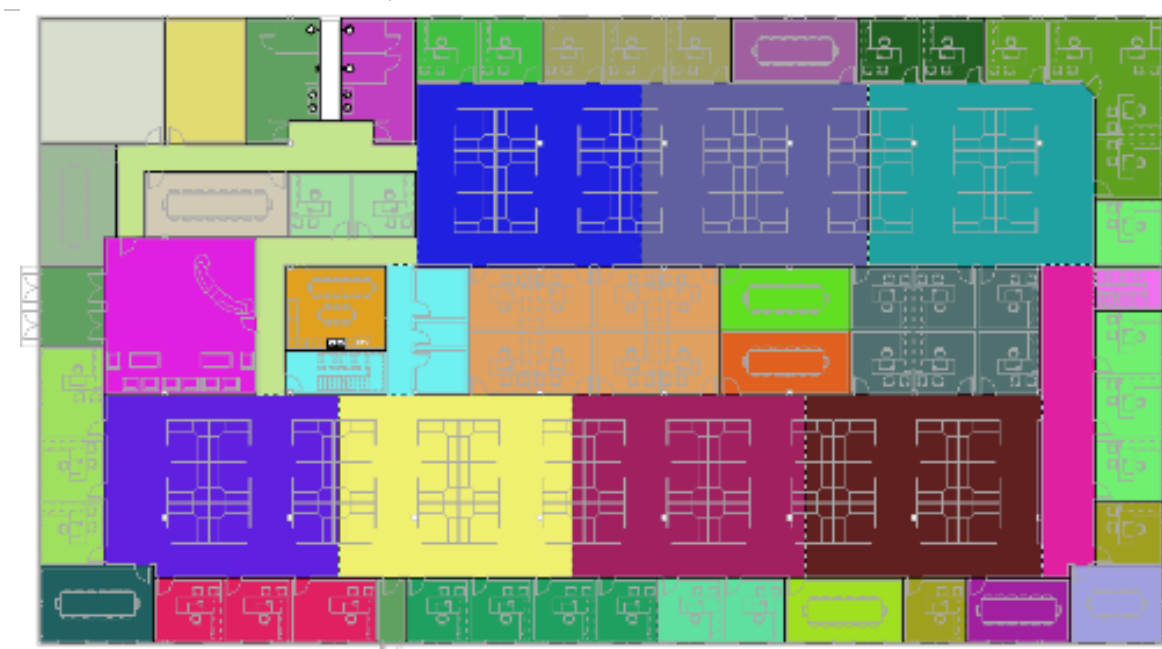
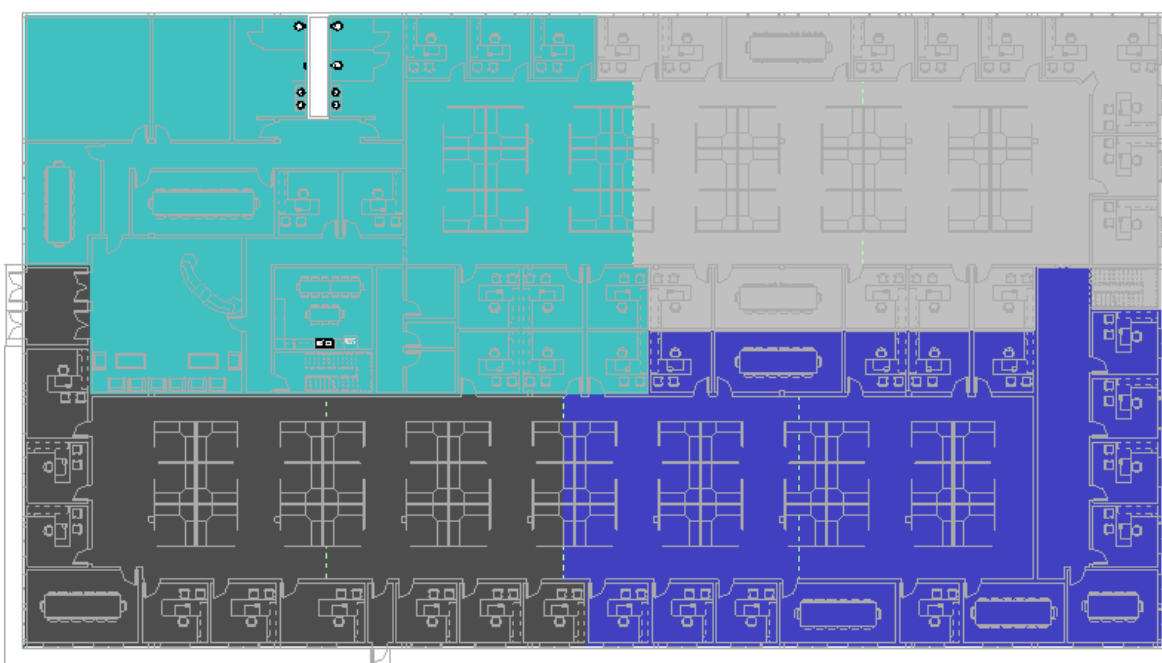
Integrated Workflow

Analytical System Set Up

MEPAnalysisNodes.SpacesToSystemZone	
Spaces	> System-Zone
Name	>
AUTO	

MEPAnalysisNodes.AirSystem	
Name	> Air System
AUTO	

MEPAnalysisNodes.WaterLoop	
Name	> Water Loop
AUTO	



Main Title – 1 column with bullets

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- **First-level bullet: closed circle. Text style: gray, 1.4 spaced, Arial 30pt font.**
 - Second-level bullet: open circle. Text style: gray, 1.4 spaced, Arial 30pt font.
 - Third-level bullet: closed square. Text style: gray, 1.4 spaced, Arial 30pt font.

Main Title – 2 column bullets

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1 column with image

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 - Third-level bullet: closed square. Text style: gray, 1.4 spaced

Title Goes Here

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Title 2

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Text with image background

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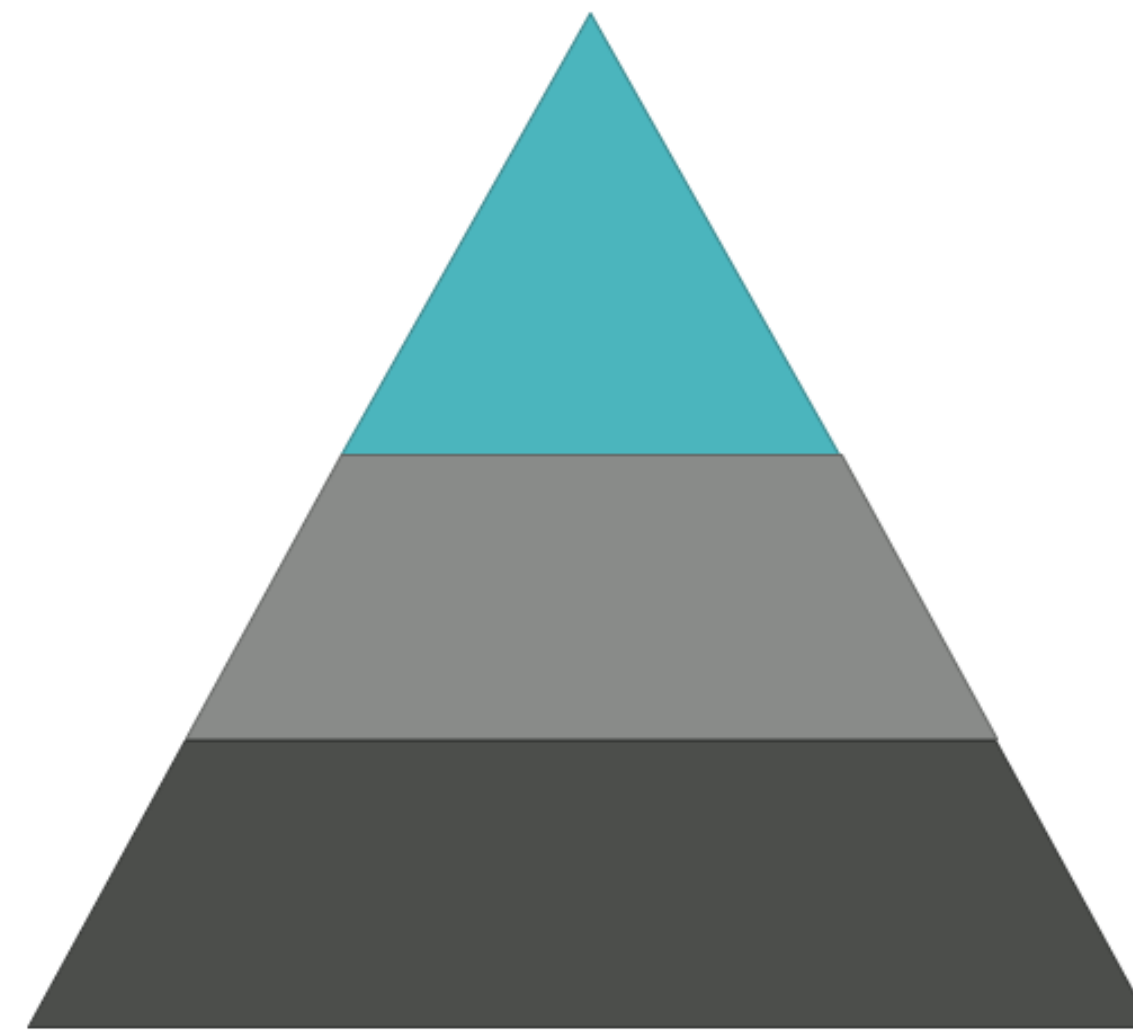
What is BIM?

Opportunities

“If it was easy it would just be the way!”



+



Cool Stuff

Standard Process

Revit Template



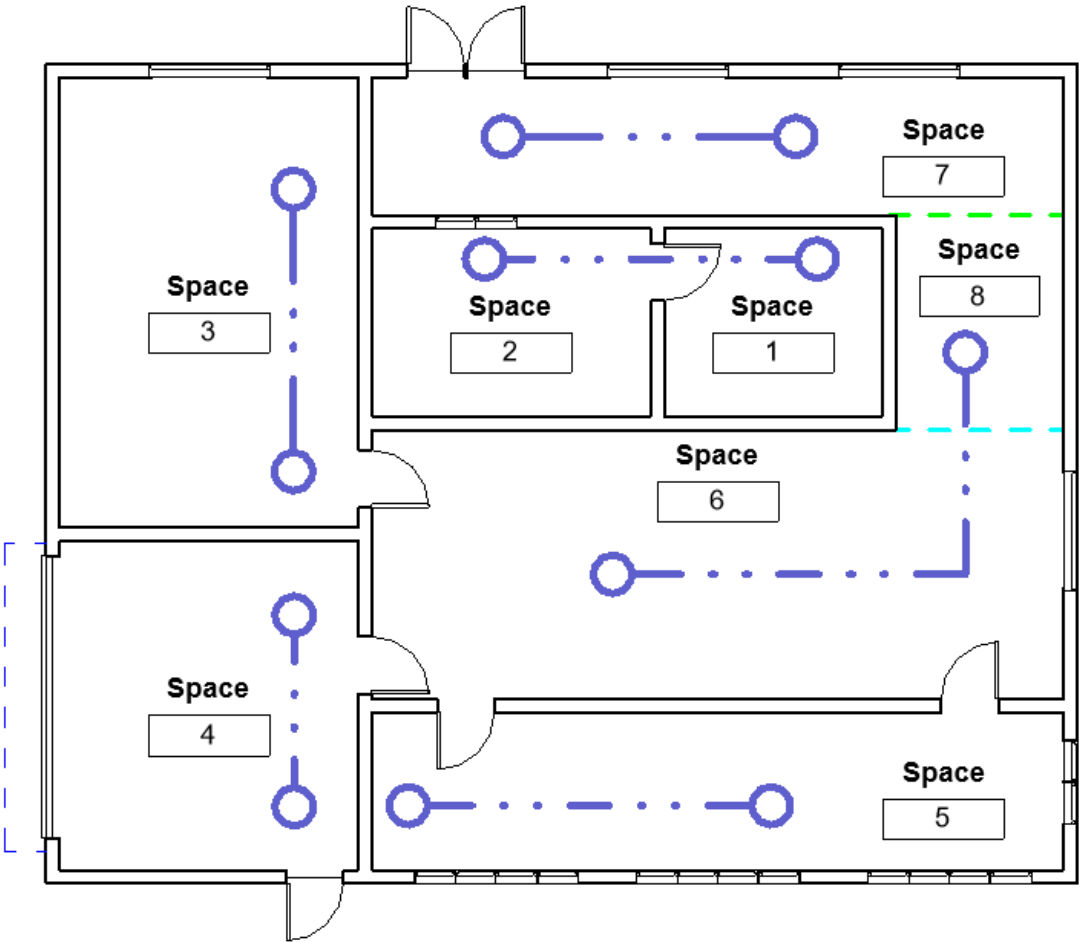
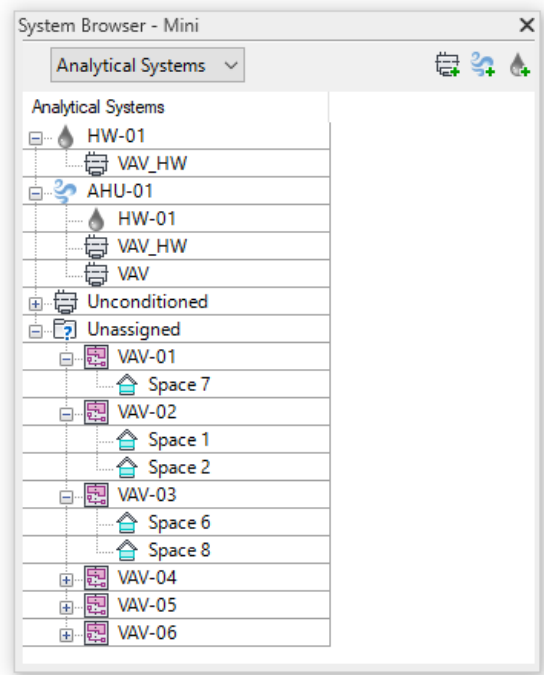
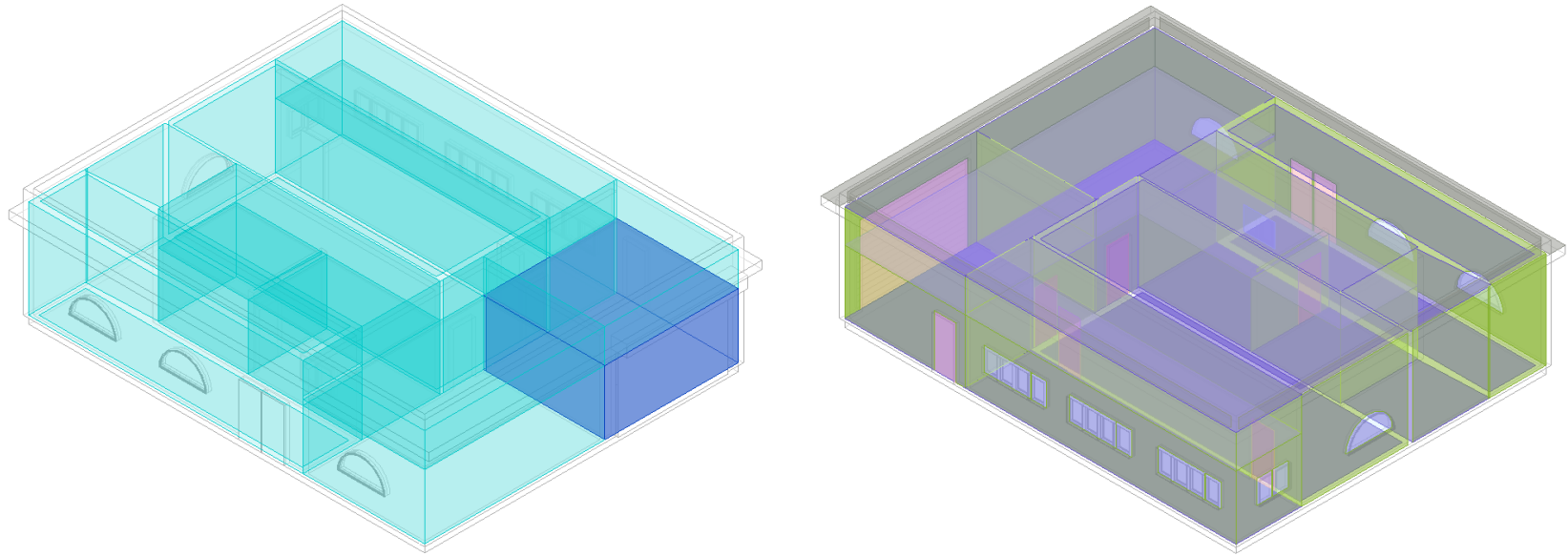
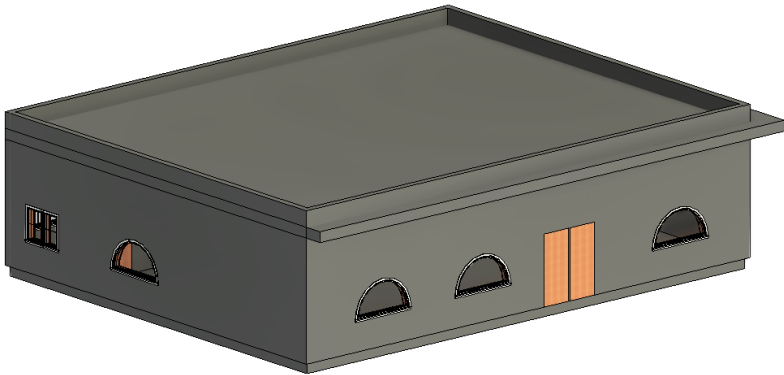
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Revit Systems Analysis

True BIM



ENVELOPE

Window-Wall Ratio

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [ft2]	2172.47	631.31	494.41	546.70	500.05
Above Ground Wall Area [ft2]	2172.47	631.31	494.41	546.70	500.05
Window Opening Area [ft2]	117.17	26.42	20.18	70.57	0.00
Gross Window-Wall Ratio [%]	5.39	4.18	4.08	12.91	0.00
Above Ground Window-Wall Ratio [%]	5.39	4.18	4.08	12.91	0.00

Conditioned Window-Wall Ratio

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [ft2]	1678.64	564.46	457.75	328.90	327.53
Above Ground Wall Area [ft2]	1678.64	564.46	457.75	328.90	327.53
Window Opening Area [ft2]	117.17	26.42	20.18	70.57	0.00
Gross Window-Wall Ratio [%]	6.98	4.68	4.41	21.46	0.00
Above Ground Window-Wall Ratio [%]	6.98	4.68	4.41	21.46	0.00

