BES225908

Mechanical Dynamo Smorgasbord: Preliminary Equipment Sizing with Dynamo in Revit

Nat MacDonald
CRB

Learning Objectives

- Learn how to import Excel data in Dynamo
- Learn how to calculate equipment sizes (RHCs, VAVs, diffusers/returns, AHUs, water side components) in Dynamo
- Learn how to place family instances in Revit using Dynamo

Description

From air handlers to air diffusers, mechanical engineers make a lot of calculations regarding equipment when designing a building. This class is designed to help you reduce the amount of time and effort it takes to complete them, while improving consistency. We'll dive into each calculation for a variety of air-side and water-side equipment, and we'll look at how to complete hundreds of them in a few minutes using Dynamo, and then transfer that data to Revit software. We'll also look at placement in the model and automatic scheduling in Revit.

Speaker(s)

Nathaniel MacDonald is a PE licensed Mechanical Engineer at CRB, a company that focuses on building and designing Biotech and Pharmaceutical manufacturing facilities as well as science and technology (S&T) laboratories. He graduated from Rensselaer Polytecnic Institute (RPI) with a degree in Mechanical Engineering after which he entered the HVAC design field gaining a broad knowledge of hospital, correctional, dormitory, and mission critical design. In his current position, Nathaniel harnesses Revit and Dynamo to progress and optimize company standard workflows. Additionally, he leverages Computational Fluid Dynamics (CFD), through the use of Autodesk CFD and OpenFOAM, to enhance clean room design for his clients. Along with leading the Programming Group at CRB he is a co-chair of the local Boston Dynamo User Group, Dynamo-litia.

Script Theory

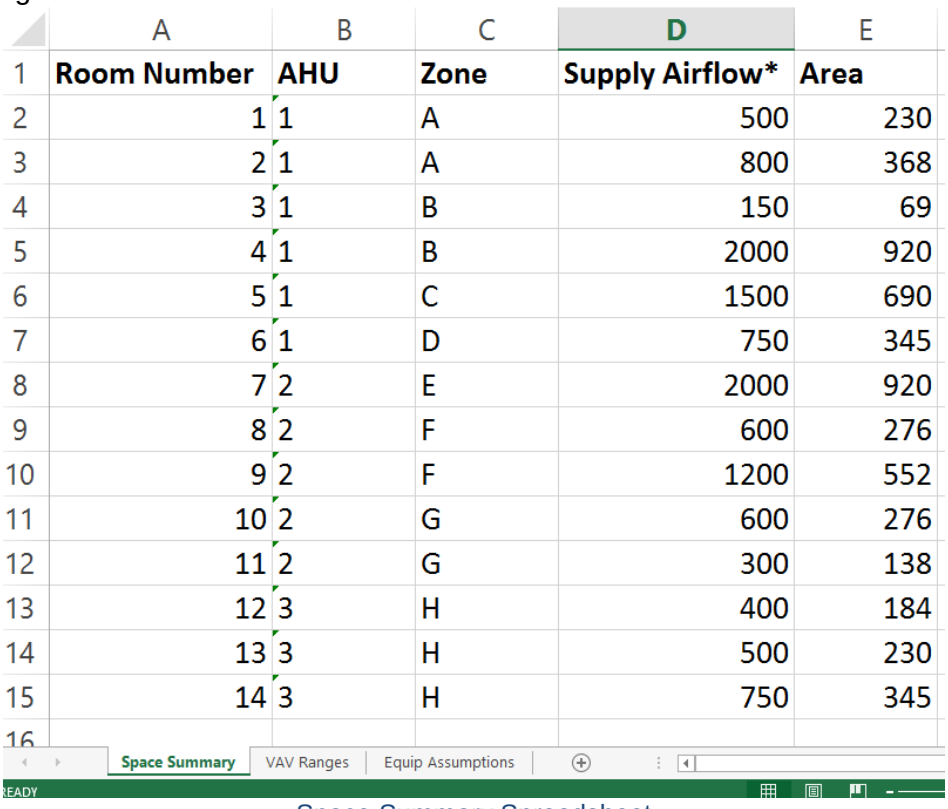
The idea behind the scripts of this course is to give you the basic building blocks of a robust Dynamo script. We want to give you a user interface that is accessible to many skill levels and Excel importing that allows non-Dynamo users to participate in the script usage.

Importing Excel Data into Dynamo

Excel is a useful tool in the engineering industry because nearly everyone understands it. Although many senior engineers and project managers are not using Revit, and especially not Dynamo, Excel is a great tool to allow data transfer between a non-Revit user and Dynamo.

In the case of the four scripts we are going to talk about in this handout, all of them reference an Excel document in some way. The Excel document holds conceptual room data (room number, area, AHU served, zone, and supply airflow) as well as equipment assumptions or ranges (VAV minimum and maximum airflow rates, Boiler HP per sq. ft.)

Below is an example of an Excel spreadsheet that can be used with the scripts in this handout. The idea with these scripts is that it can easily be adapted to any Excel spreadsheet you use for concept design.



	A	B	C	D	E
1	Room Number	AHU	Zone	Supply Airflow*	Area
2	1	1	A	500	230
3	2	1	A	800	368
4	3	1	B	150	69
5	4	1	B	2000	920
6	5	1	C	1500	690
7	6	1	D	750	345
8	7	2	E	2000	920
9	8	2	F	600	276
10	9	2	F	1200	552
11	10	2	G	600	276
12	11	2	G	300	138
13	12	3	H	400	184
14	13	3	H	500	230
15	14	3	H	750	345
16					

Space Summary Spreadsheet

Two of the equipment assumptions we are using are shown in the spreadsheet below.

	A	B	C	D
1	**Size**	**Minimum**	**Maximum**	
2	4	50	100	
3	5	100	150	
4	6	143	250	
5	7	250	300	
6	8	300	500	
7	9	500	625	
8	10	626	900	
9	12	901	1461	
0	14	1461	2100	
1	16	2102	3237	
2				
3				

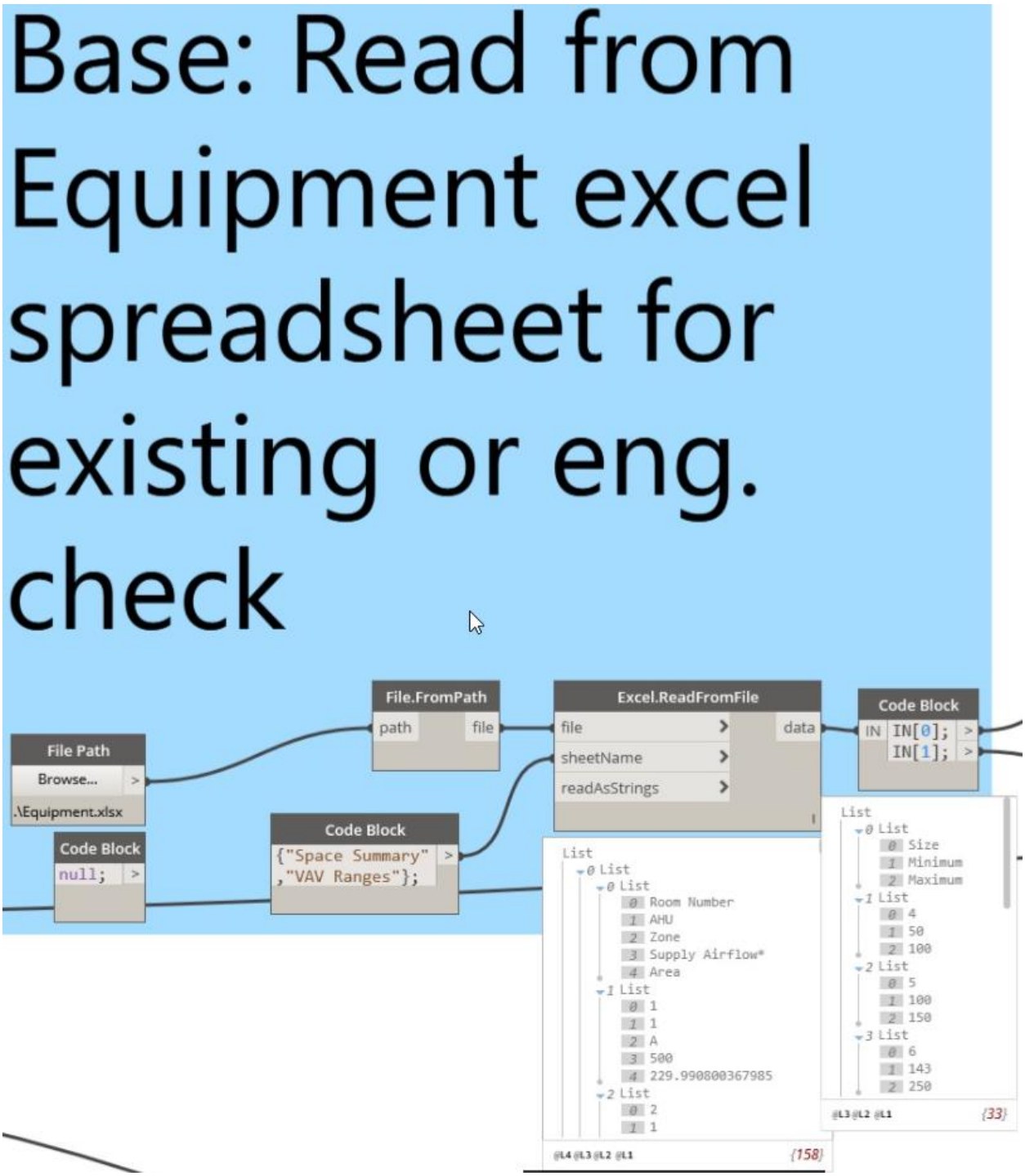
Space Summary | VAV Ranges

	A	B	C	D	E
1	**Boiler**	4	BHP per	1000	sq. ft.
2	**Chiller**	1	ton per	400	sq. ft.
3					
4					
5					
6					

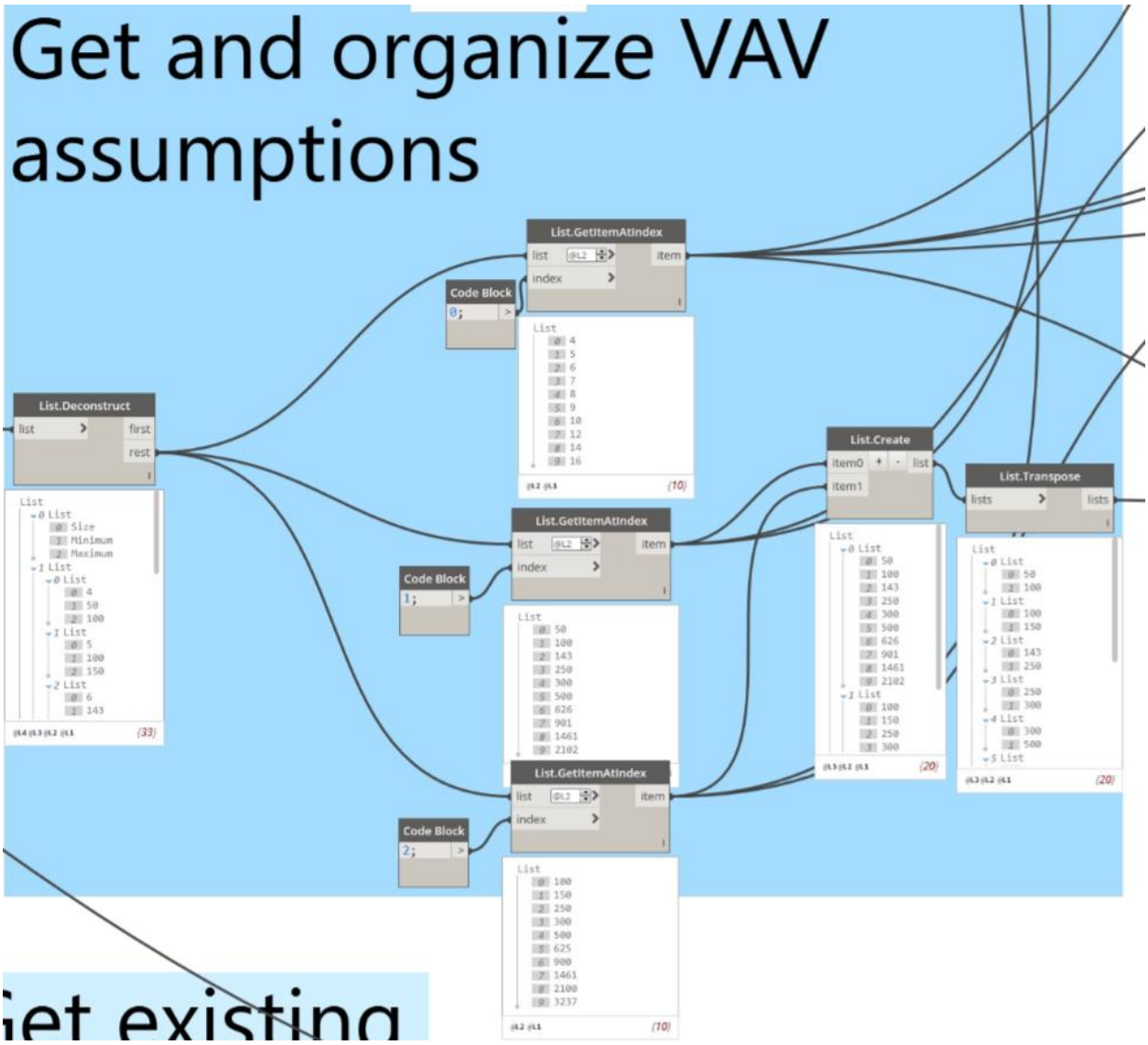
Space Summary | VAV Ranges | Equip Assumptions

Equipment Assumptions Tab

In order to extract this data from Excel, we use Dynamo's Excel.ReadFromFile node. By inputting the File.fromPath node and the sheet names as a list of strings{"Space Summary", "VAV Ranges"} we can get the output of the Excel file with columns as lists.



Using this output we can manipulate the list structure into a form that we want to use in the rest of the script.

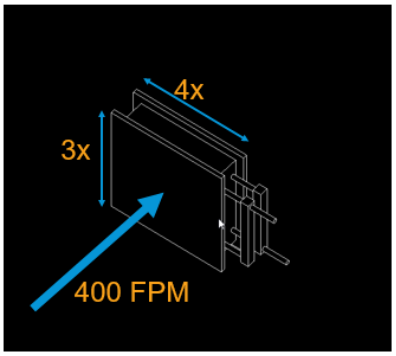

Get and organize VAV assumptions
List.GetItemAtIndex
list
index
item
Code Block
0;
List.Deconstruct
list
first
rest
List.Create
item0
item1
list
List.Transpose
lists
Code Block
1;
Code Block
2;
Get existing

Calculate Equipment Sizes in Dynamo

We use a variety of rules of thumb in the engineering industry. Although thorough calculations should be used, we will use Dynamo to speed up and make the current rules of thumb more accurate.

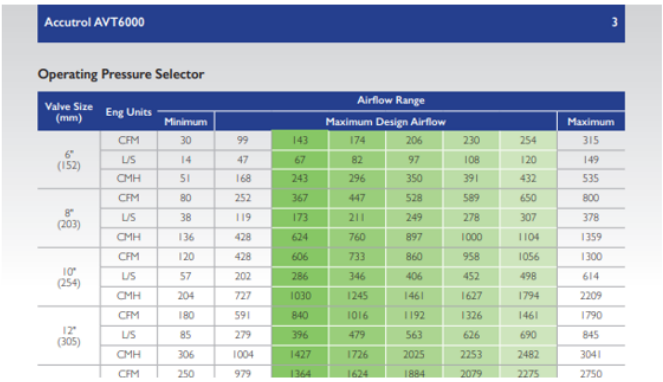
REHEAT COIL

Max Face Velocity less than 400 FPM, 4/3 Width/Height Ratio



VAV

Manufacturer Library



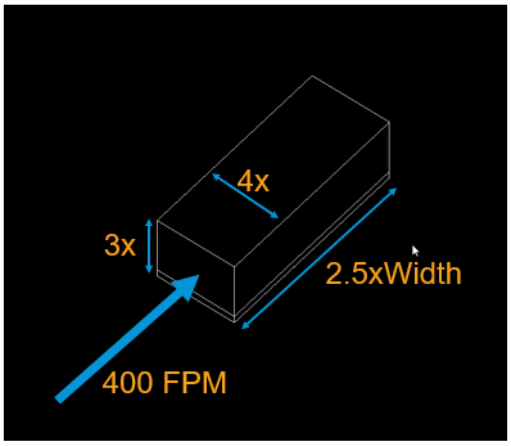
Accutrol AVT6000 3

Operating Pressure Selector

Valve Size (mm)	Eng Units	Airflow Range							
		Minimum	Maximum Design Airflow						Maximum
6" (152)	CFM	30	99	143	174	206	230	254	315
	L/S	14	47	67	82	97	108	120	149
	CMH	51	168	243	296	350	391	432	535
8" (203)	CFM	80	252	367	447	528	589	650	800
	L/S	38	119	173	211	249	278	307	378
	CMH	136	428	624	760	897	1000	1104	1359
10" (254)	CFM	120	428	606	733	860	958	1056	1300
	L/S	57	202	286	346	406	452	498	614
	CMH	204	727	1030	1245	1461	1627	1794	2209
12" (305)	CFM	180	591	840	1016	1192	1326	1461	1790
	L/S	85	279	396	479	563	626	690	845
	CMH	306	1004	1427	1726	2025	2253	2482	3041
	CFM	250	979	1364	1624	1884	2079	2275	2750

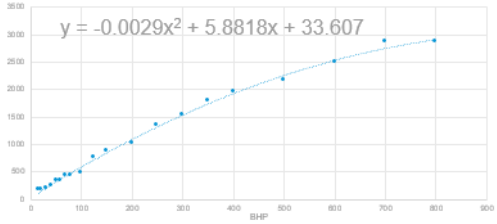
AIR HANDLING UNIT

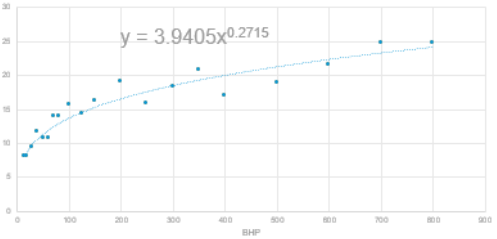
Max Face Velocity less than 400 FPM, 4/3 Width/Height Ratio, Length is 2.5 times width



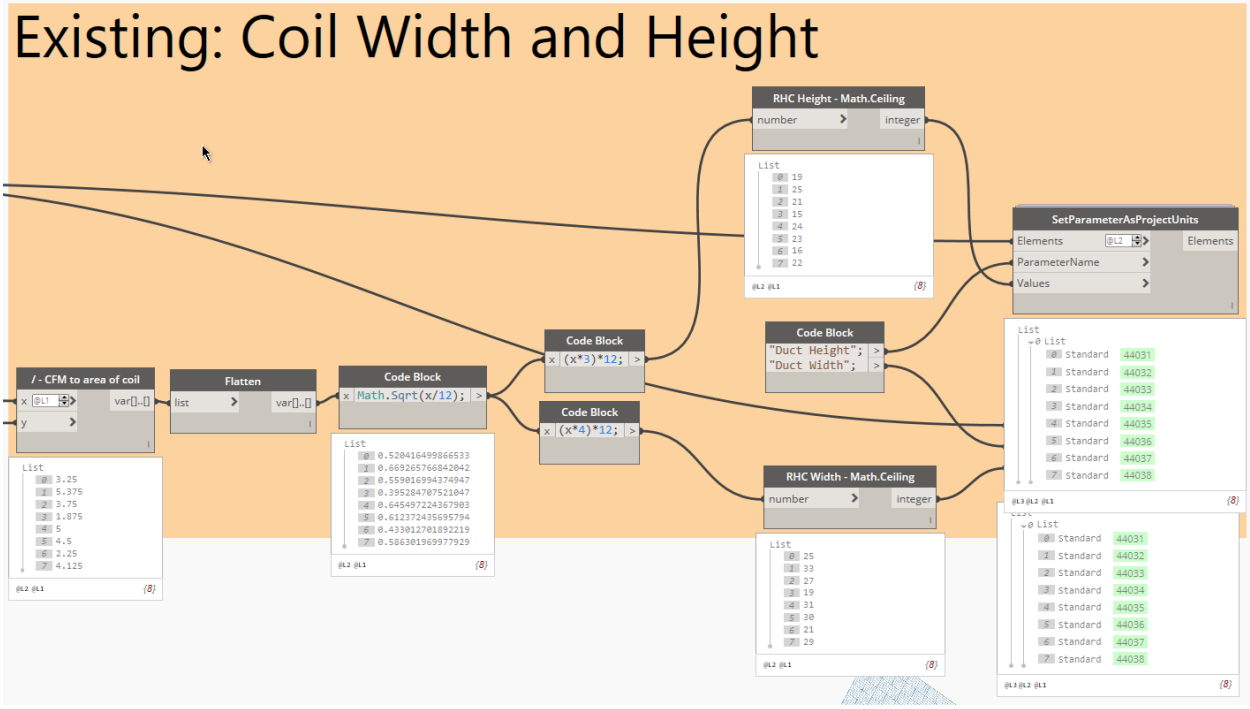
BOILER

Regression Model, 1 BHP per 1000 sq. ft.





For reheat coils we use a maximum value of 400 FPM face velocity across the coil. Although a standard square coil could be assumed, we use a 4/3 width to height ratio. The engine that replicates this in the script is shown below.



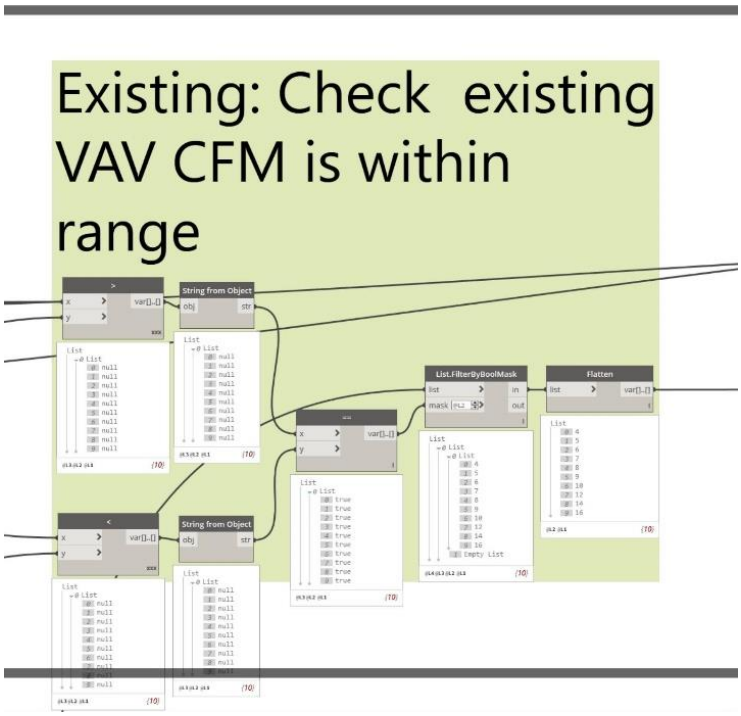
As you can see, the input is the CFM divided by the face velocity of the (FPM) of the coil to get the face area of the coil. By taking the square root and the multiplying by the ratio, we get the correct width and height of the coil.

VAV boxes are sized using a standard manufacturer performance data sheet. By defining minimum and maximum airflow ranges to the VAV sizes we can accurately determine the proper size. Excel data is imported to define these ranges.

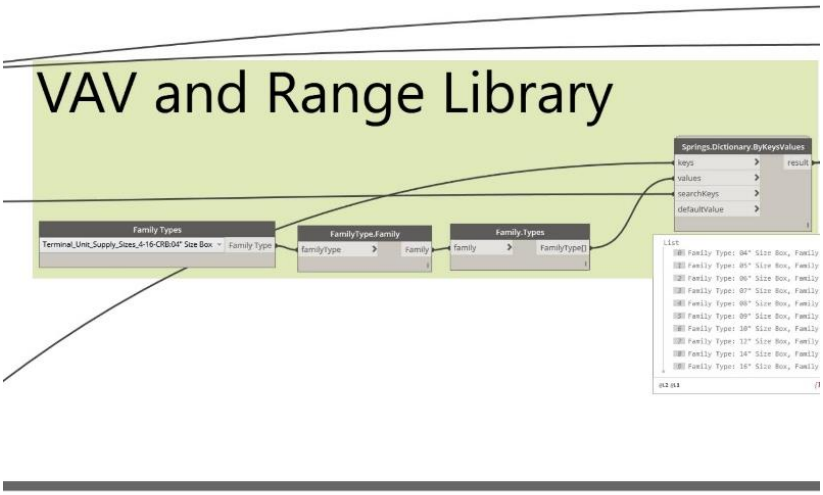
	A	B	C	D
1	**Size**	**Minimum**	**Maximum**	
2	4	50	100	
3	5	100	150	
4	6	143	250	
5	7	250	300	
6	8	300	500	
7	9	500	625	
8	10	626	900	
9	12	901	1461	
0	14	1461	2100	
1	16	2102	3237	
2				
3				

Space Summary | VAV Ranges

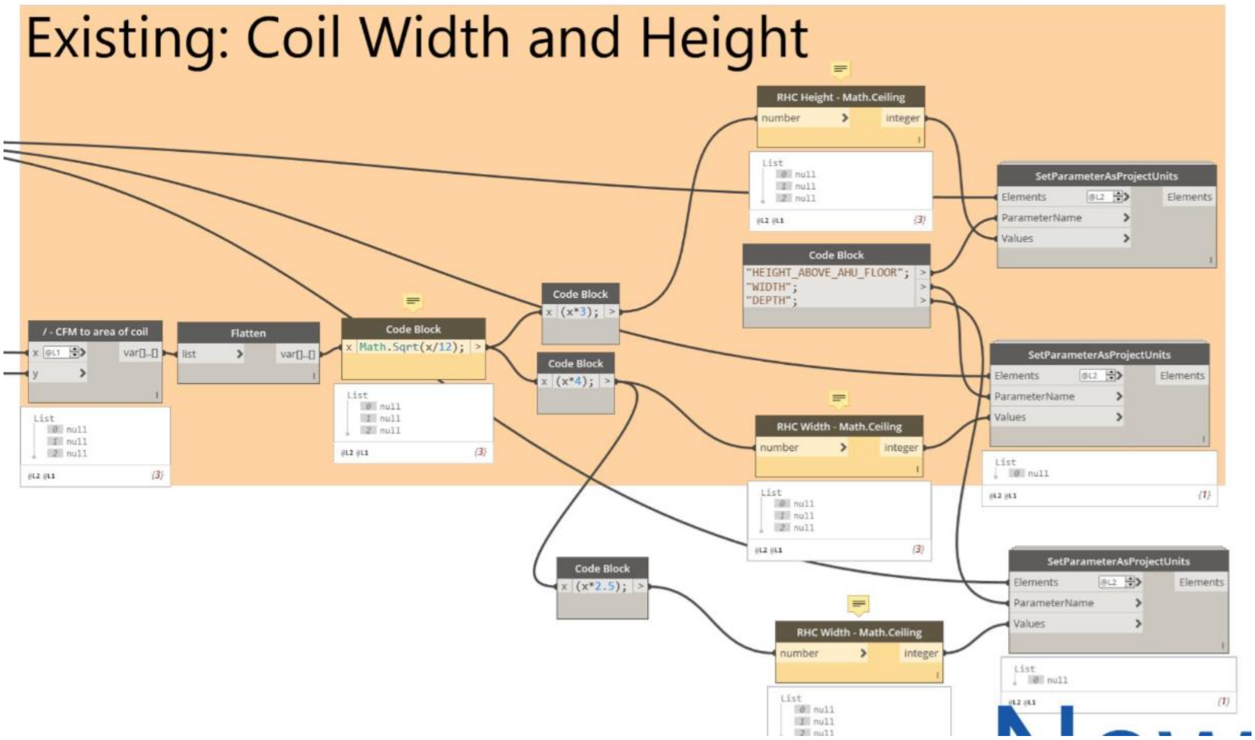
Below we compare the necessary VAV airflow to the VAV ranges. It is determined what size box falls within the range.



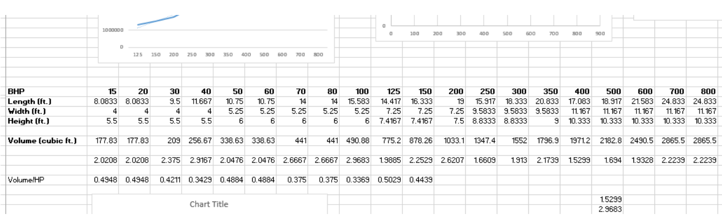
We use Springs.DictionaryByKeysValues node to create a dictionary of the VAV sizes (keys), VAV family types (values), and the actual VAV sizes (searchKeys).



Air handling units are similar to RHCs in that they rely on the 400 FPM and 4/3rds ratio, however the length of the unit needs to be taken into account. In the case of most air handlers the length is 2.5 times the width of the coil.

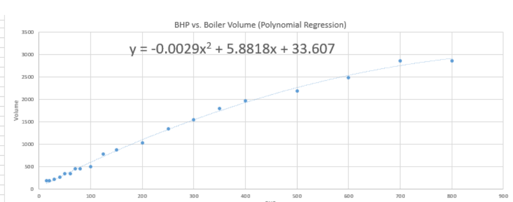


We could take a similar approach to boilers however a more interesting way to do it is to plot the unit volume vs. the boiler HP. Using a manufacturers dimensions we scatter plot the results. By doing this we can use Excel's regression function to find an accurate trend line to match its size.



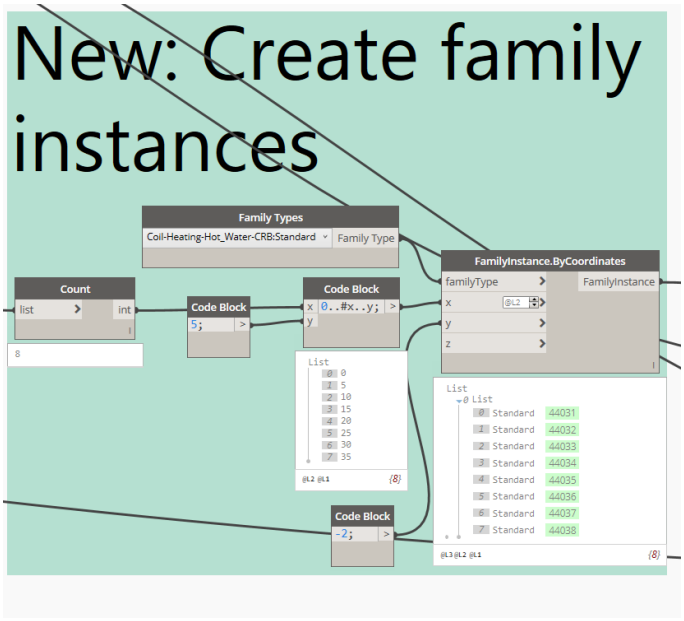
BHP	15	20	30	40	50	60	70	80	100	125	150
Length (ft.)	8.0833	8.0833	9.5	11.667	10.75	10.75	14	14	15.583	14.417	16.333
Width (ft.)	4	4	4	4	5.25	5.25	5.25	5.25	5.25	7.25	7.25
Height (ft.)	5.5	5.5	5.5	5.5	6	6	6	6	6	7.4167	7.4167
Volume (cubic ft.)	177.83	177.83	209	256.67	338.63	338.63	441	441	490.88	775.2	878.26
	2.0208	2.0208	2.375	2.9167	2.0476	2.0476	2.6667	2.6667	2.9683	1.9885	2.2529
Volume/HP	0.4948	0.4948	0.4211	0.3429	0.4884	0.4884	0.375	0.375	0.3369	0.5029	0.4439

BHP	200	250	300	350	400	500	600	700	800
Length (ft.)	19	15.917	18.333	20.833	17.083	18.917	21.583	24.833	24.833
Width (ft.)	7.25	9.5833	9.5833	9.5833	11.167	11.167	11.167	11.167	11.167
Height (ft.)	7.5	8.8333	8.8333	9	10.333	10.333	10.333	10.333	10.333
Volume (cubic ft.)	1033.1	1347.4	1552	1796.9	1971.2	2182.8	2490.5	2865.5	2865.5
	2.6207	1.6609	1.913	2.1739	1.5299	1.694	1.9328	2.2239	2.2239
Volume/HP									
						1.5299			
						2.9683			



Place family instances in Revit using Dynamo

To place family instances in Revit, we need to collect the family types and points for the FamilyInstance.ByCoordinates node.



By counting the number of family instances to be placed and inputting it into (0..#x..y;) we create a line of points in Revit where the families can be placed in the x direction. We place the families along -2 in the y-axis and given we don't care where they are in the z-direction, we let it default to zero.