Mechanical Dynamo Smorgasbord: Preliminary Equipment Sizing with Dynamo in Revit

Nat MacDonald, PE

Senior Mechanical Engineer, BuroHappold

@NatGMac

AUTODESK. UNIVERSITY

Smorgasbord: A little of a lot

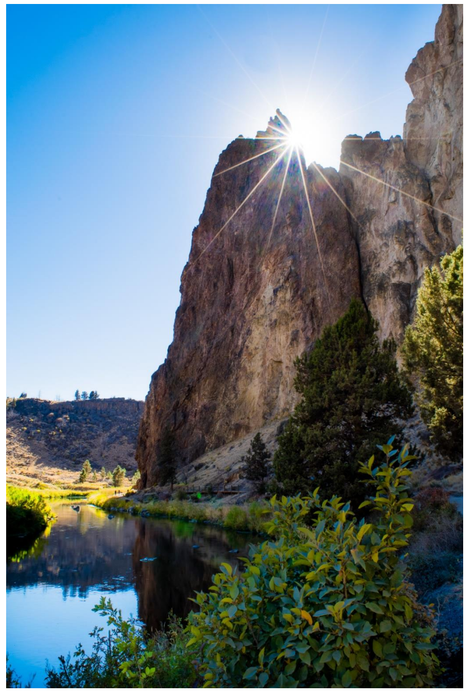
Image caption goes here

Learning Objectives

Learn how to import Excel data into 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



Nat MacDonald

Mechanical Engineer, PE

BuroHappold Engineering (NYC)

Co-Founder – ENCODE Boston

Former Co-Chair Dynamo-litia Boston

Enjoy photography, mountain biking, hiking

BUROHAPPOLD
ENGINEERING

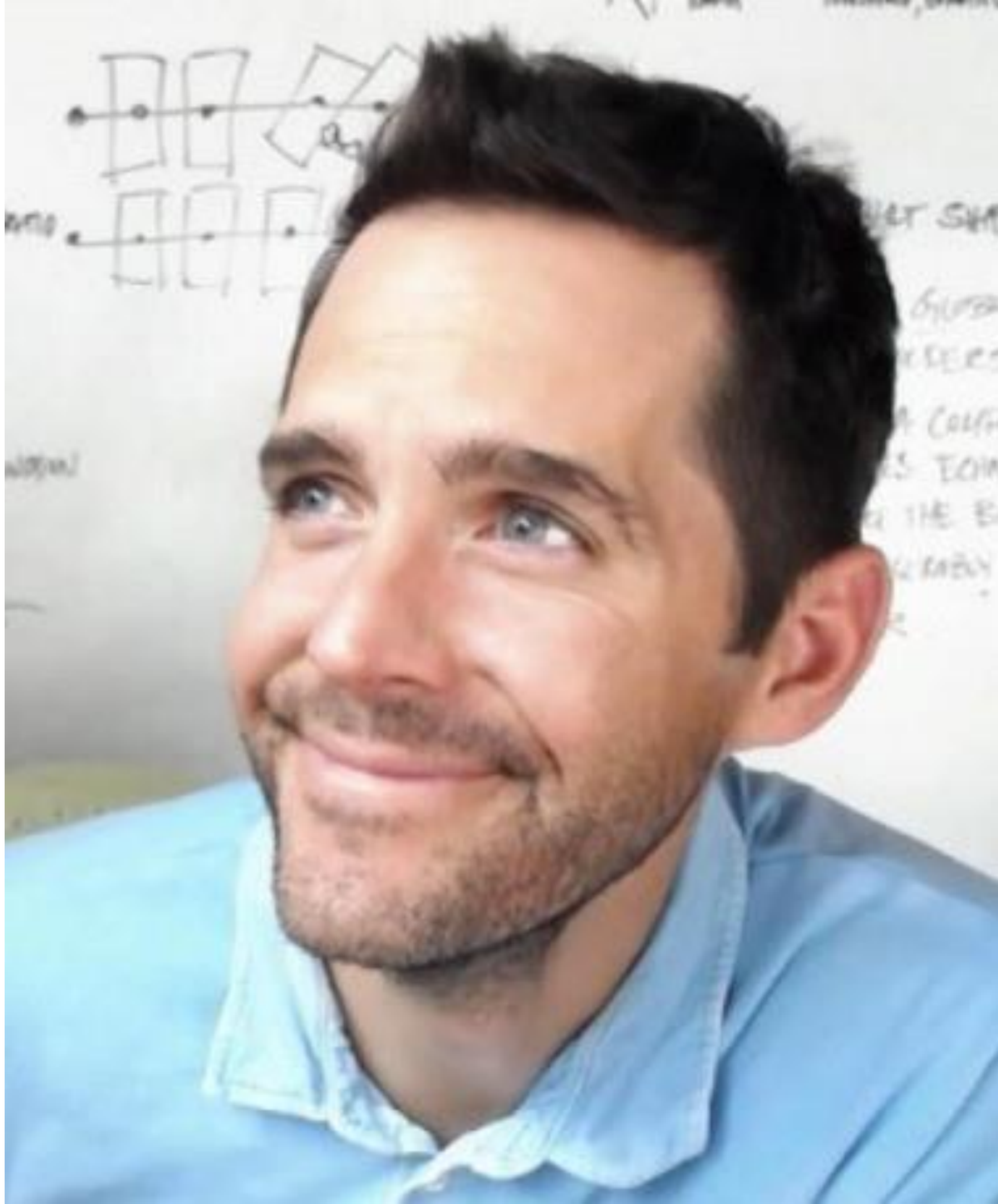
Who Are You?

Image caption goes here

60 Second Dynamo

Father of Dynamo

- Ian Keough
- Working on it in 2009
- Taught at AU 2011
- Open sourced 2011
- Autodesk joins the fun shortly thereafter
- Ian (& Anthony Hauck) now run Hypar

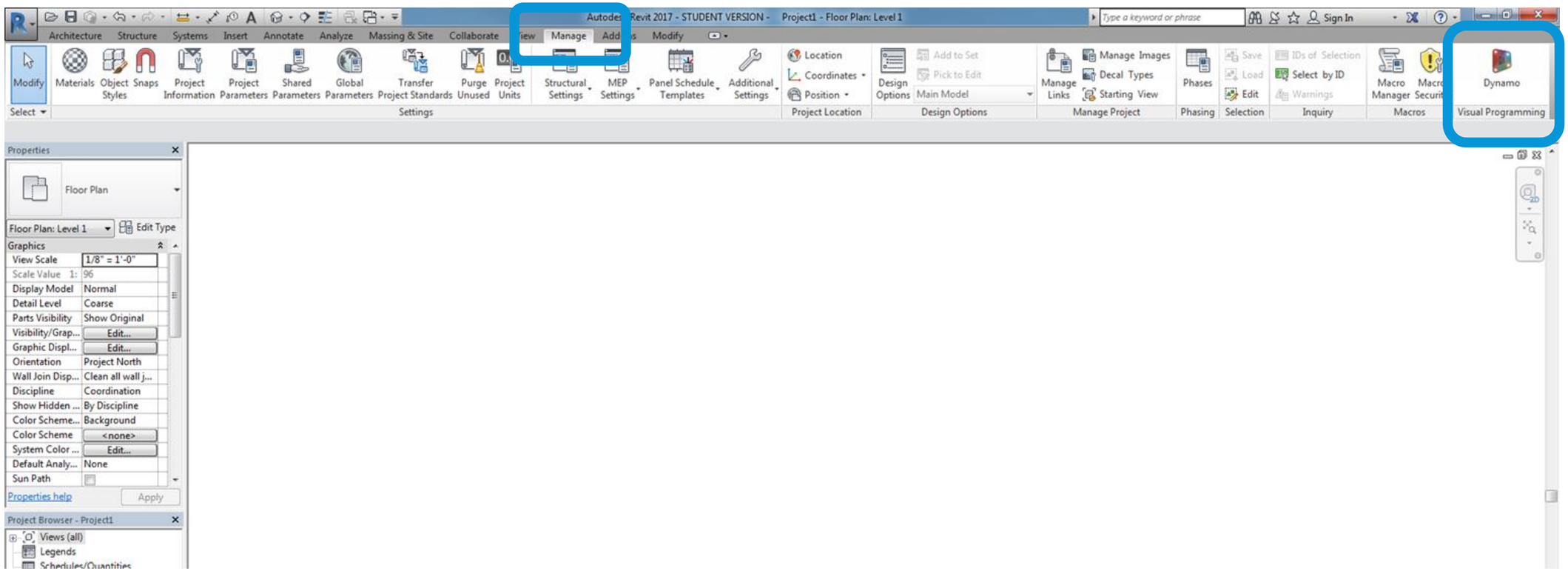


What is It?

> A visual programming tool that aims to be accessible to both non-programmers and programmers alike. It gives users the ability to visually script behavior, define custom pieces of logic, and script using various textual programming languages.

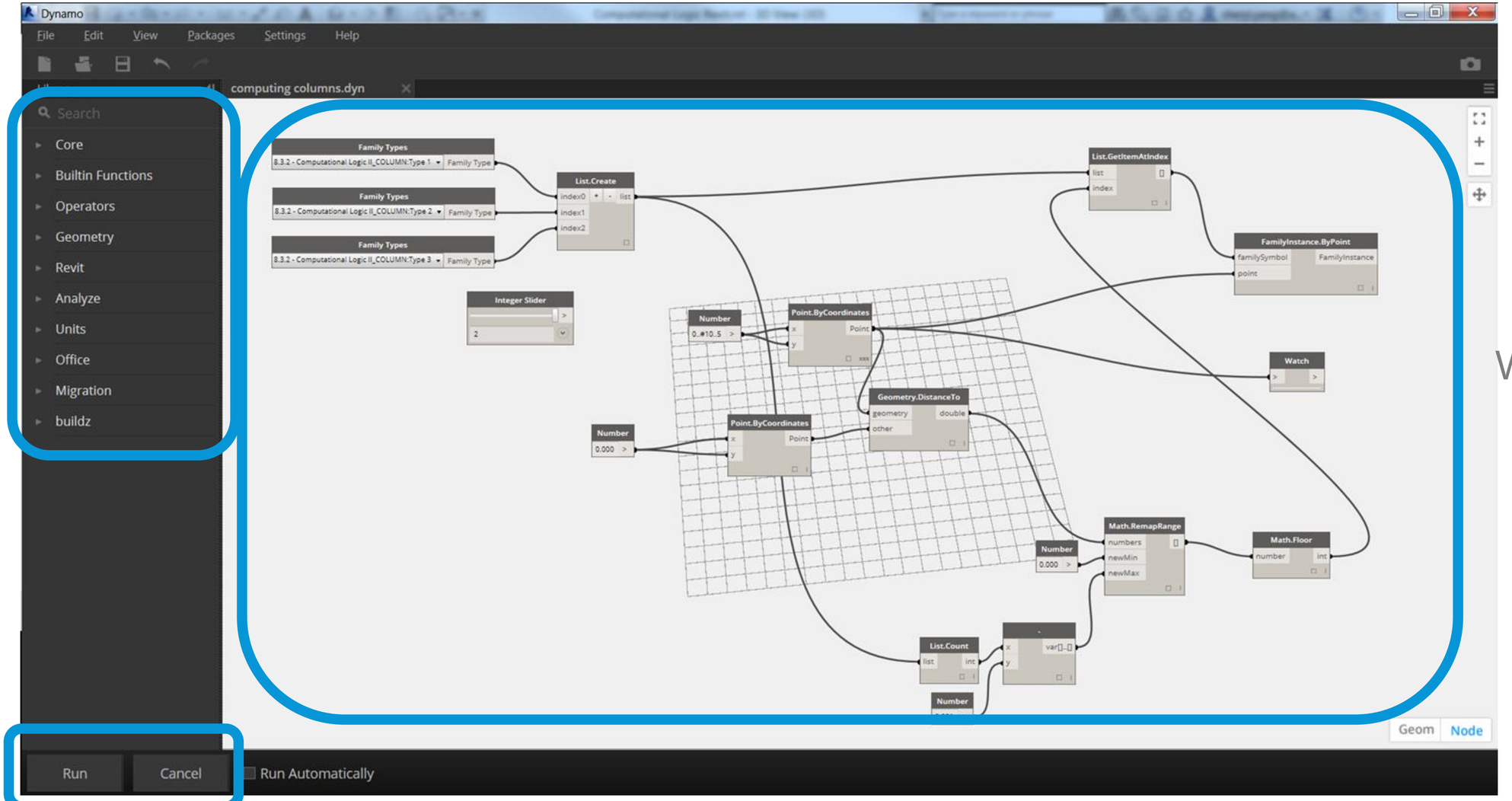
http://primer.dynamobim.org/en/01_Introduction/1-2_what_is_dynamo.html

Where is It?


Autodesk Revit 2017 - STUDENT VERSION - Project1 - Floor Plan: Level 1
Architecture
Structure
Systems
Insert
Annotate
Analyze
Massing & Site
Collaborate
Manage
Modify
Modify
Materials
Object Styles
Snaps
Project Information
Project Parameters
Shared Parameters
Global Parameters
Transfer Project Standards
Purge Unused
Project Units
Structural Settings
MEP Settings
Panel Schedule Templates
Additional Settings
Settings
Location
Coordinates
Position
Project Location
Design Options
Main Model
Manage Links
Manage Images
Decal Types
Starting View
Manage Project
Phases
Phasing
Save
Load
Edit
Selection
IDs of Selection
Select by ID
Warnings
Inquiry
Macro Manager
Macro Security
Macros
Dynamo
Visual Programming
Properties
Floor Plan
Floor Plan: Level 1
Edit Type
Graphics
View Scale 1/8" = 1'-0"
Scale Value 1: 96
Display Model Normal
Detail Level Coarse
Parts Visibility Show Original
Visibility/Grap... Edit...
Graphic Displ... Edit...
Orientation Project North
Wall Join Disp... Clean all wall j...
Discipline Coordination
Show Hidden ... By Discipline
Color Scheme... Background
Color Scheme <none>
System Color ... Edit...
Default Analy... None
Sun Path
Properties help
Apply
Project Browser - Project1
Views (all)
Legends
Schedules/Quantities

This is It

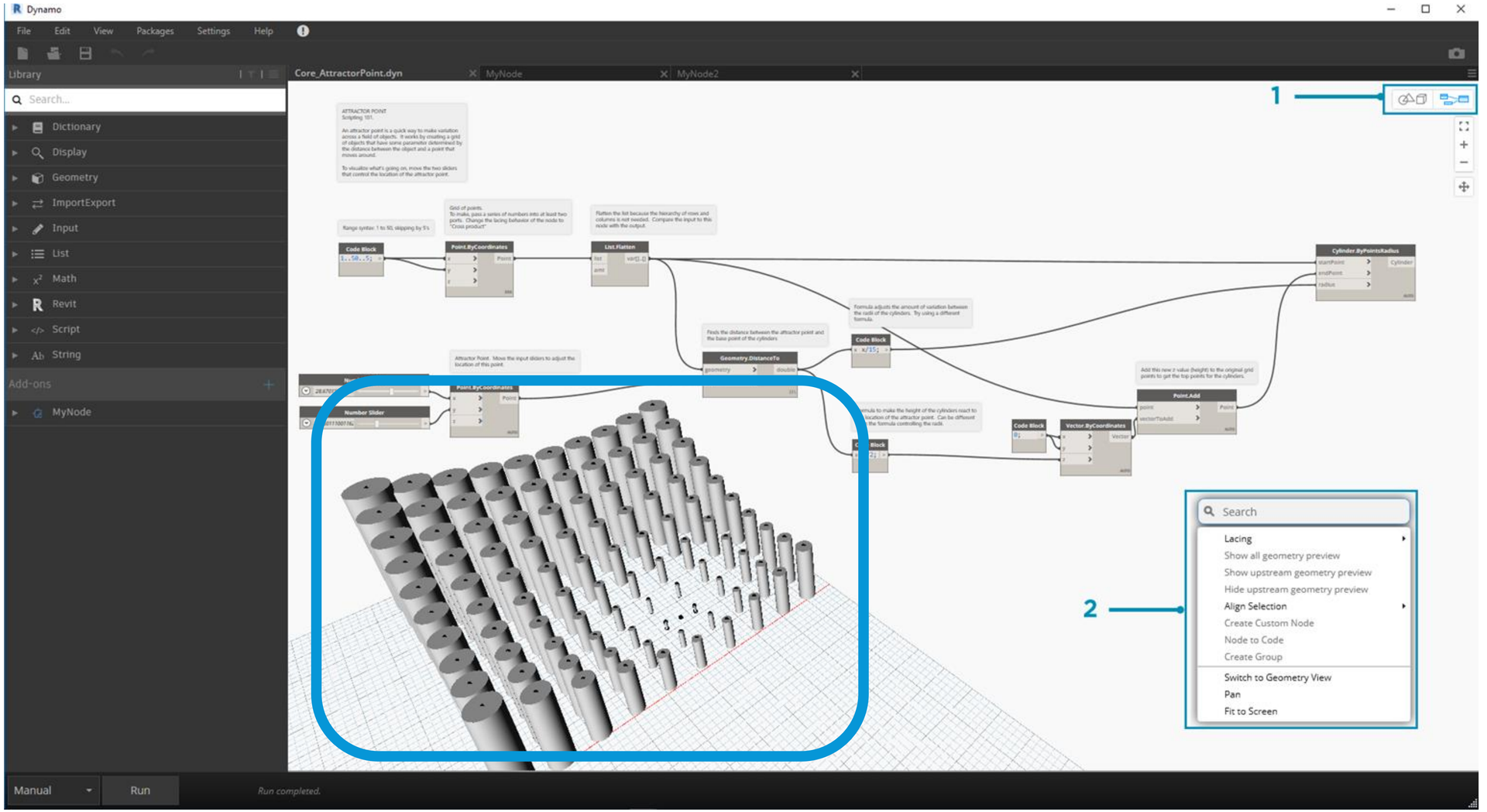
Packages



Workspace

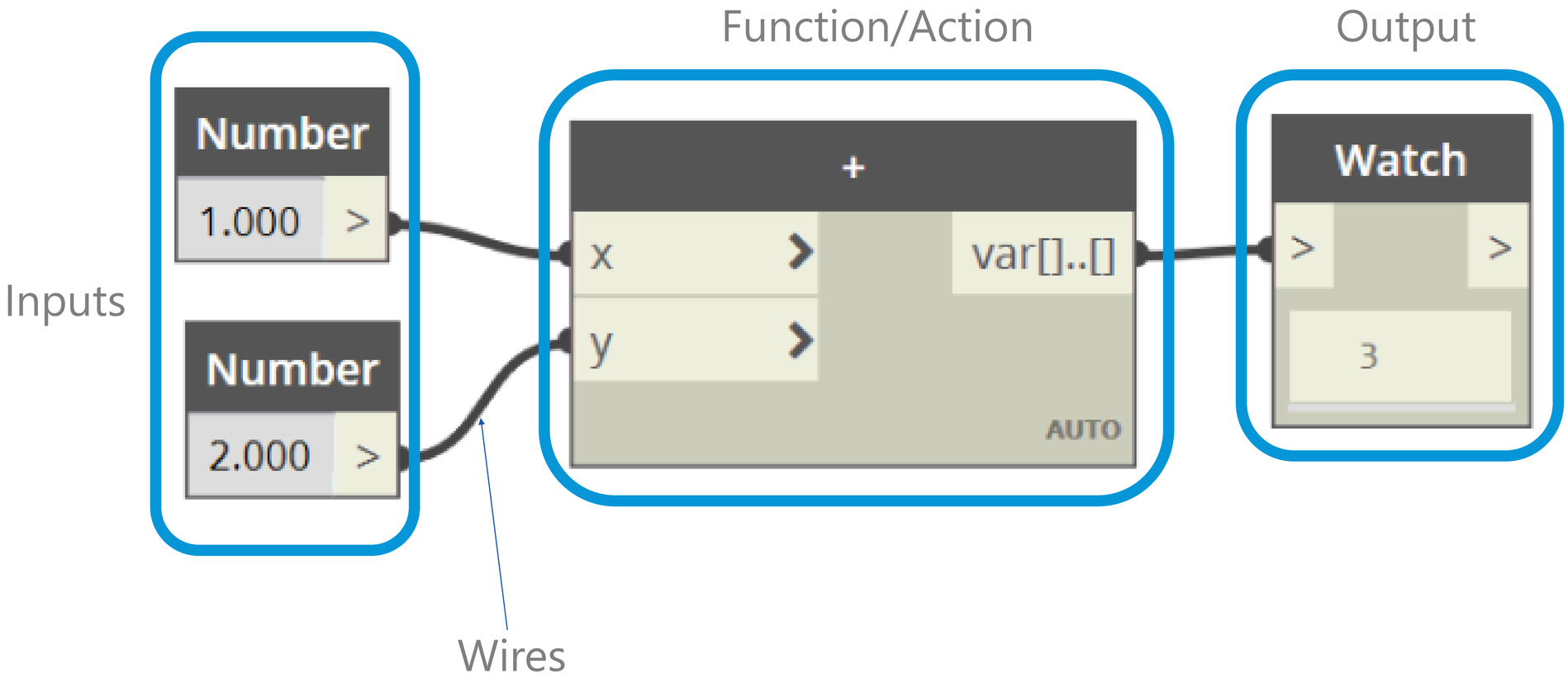
Run Modes

Workspace

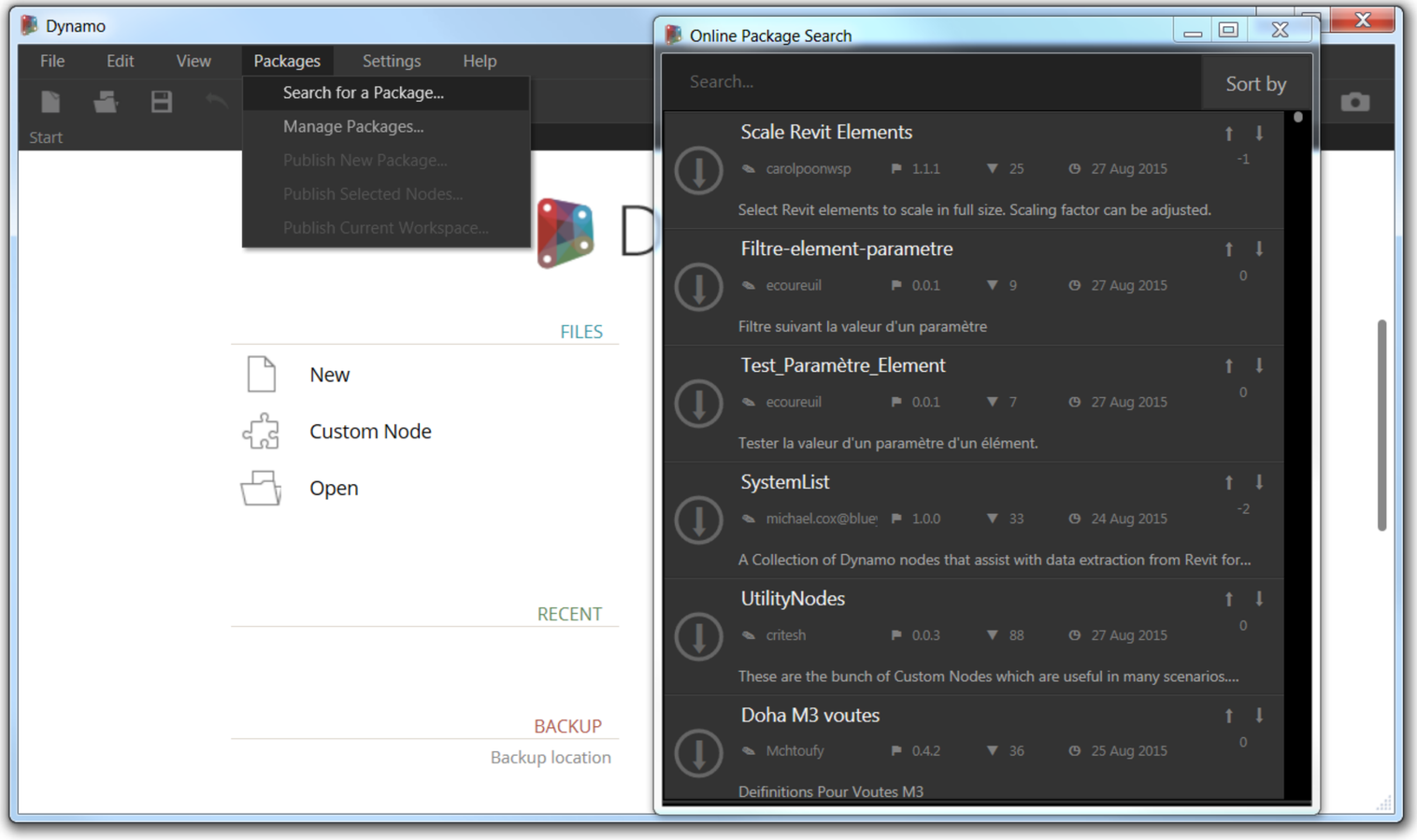


Within Dynamo

Basic Script



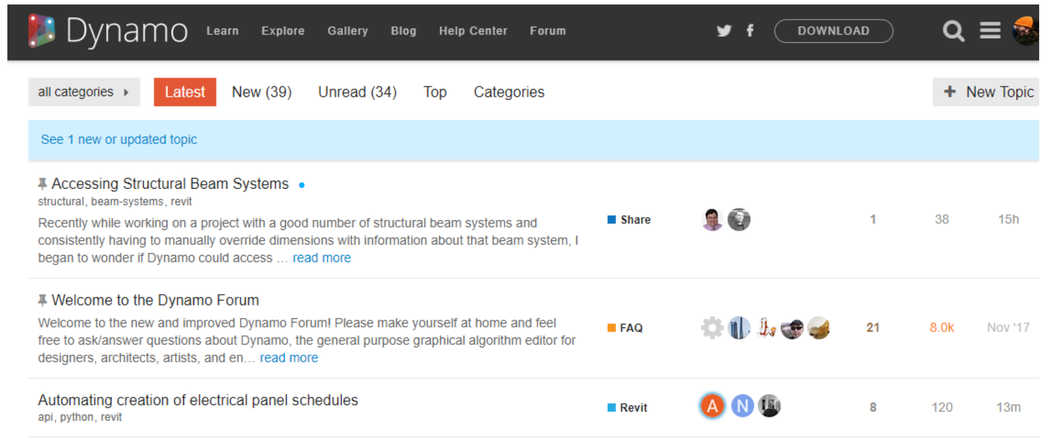
Packages


Dynamo
File
Edit
View
Packages
Settings
Help
Search for a Package...
Manage Packages...
Publish New Package...
Publish Selected Nodes...
Publish Current Workspace...
Start
FILES
New
Custom Node
Open
RECENT
BACKUP
Backup location
Online Package Search
Search...
Sort by
Scale Revit Elements
carolpoonwsp
1.1.1
25
27 Aug 2015
Select Revit elements to scale in full size. Scaling factor can be adjusted.
Filtre-element-parametre
ecoureuil
0.0.1
9
27 Aug 2015
Filtre suivant la valeur d'un paramètre
Test_Paramètre_Element
ecoureuil
0.0.1
7
27 Aug 2015
Tester la valeur d'un paramètre d'un élément.
SystemList
michael.cox@blue
1.0.0
33
24 Aug 2015
A Collection of Dynamo nodes that assist with data extraction from Revit for...
UtilityNodes
critesh
0.0.3
88
27 Aug 2015
These are the bunch of Custom Nodes which are useful in many scenarios....
Doha M3 voutes
Mchtoufy
0.4.2
36
25 Aug 2015
Deifinitions Pour Voutes M3

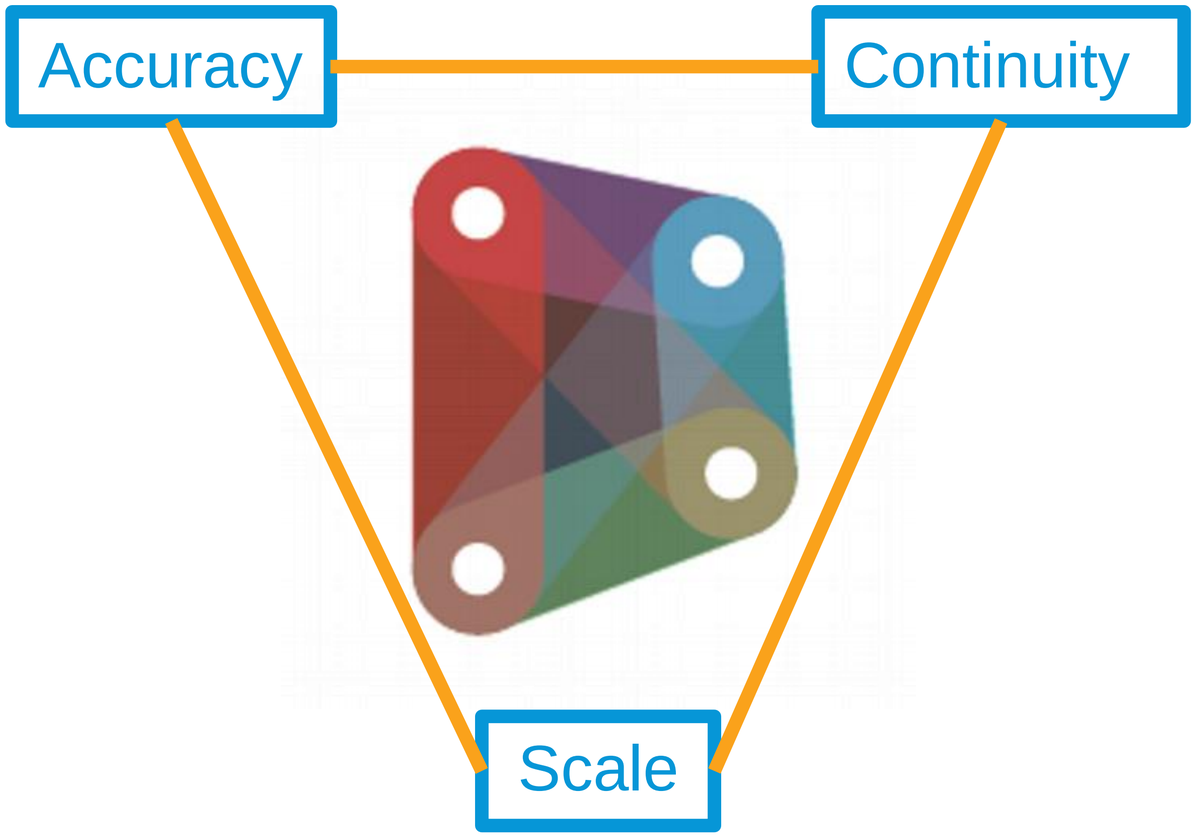
Resources

- Primer
- Dynamo Forum
- Twitter

The Dynamo Primer

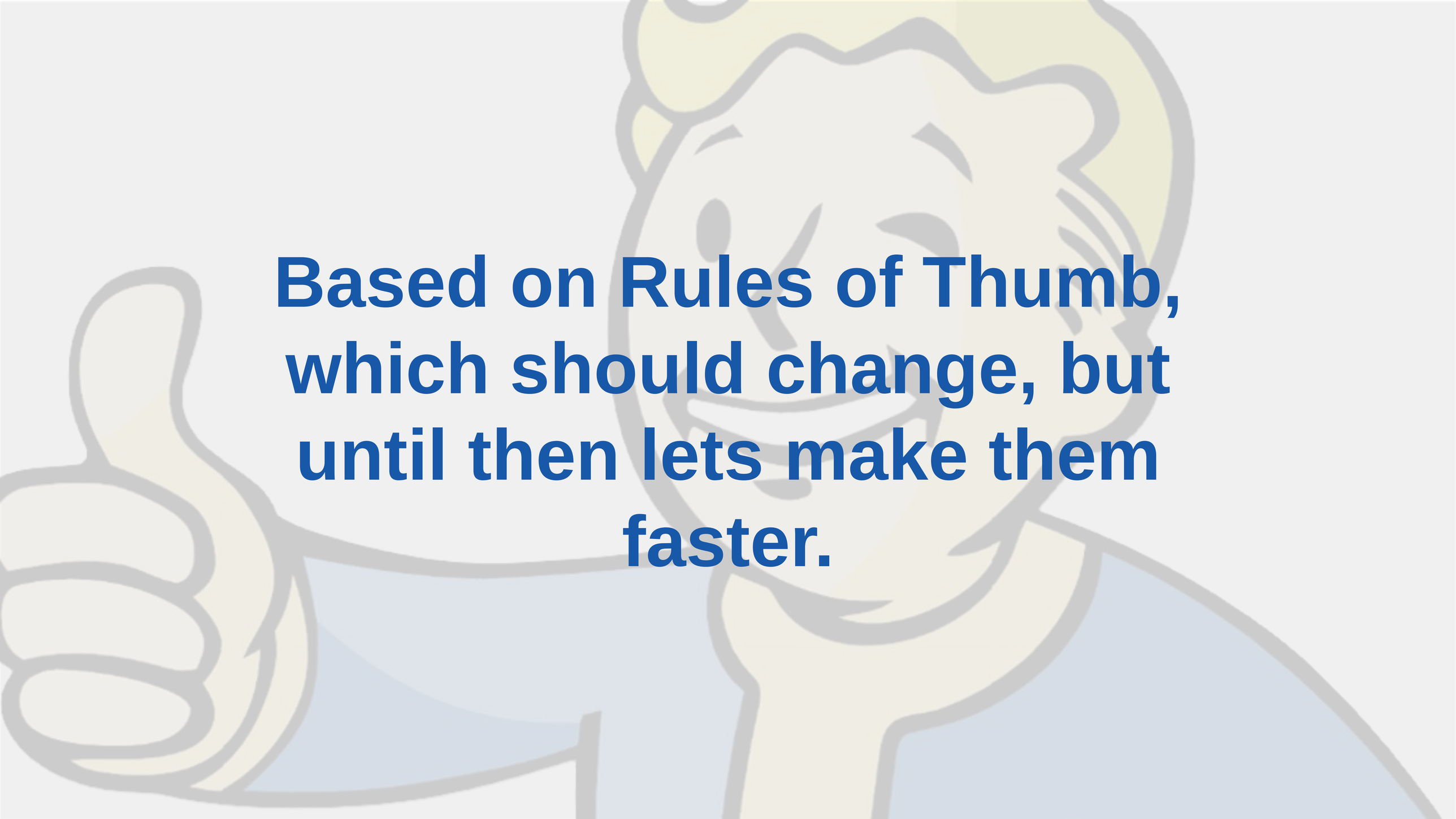


Why is Dynamo Important in Engineering?

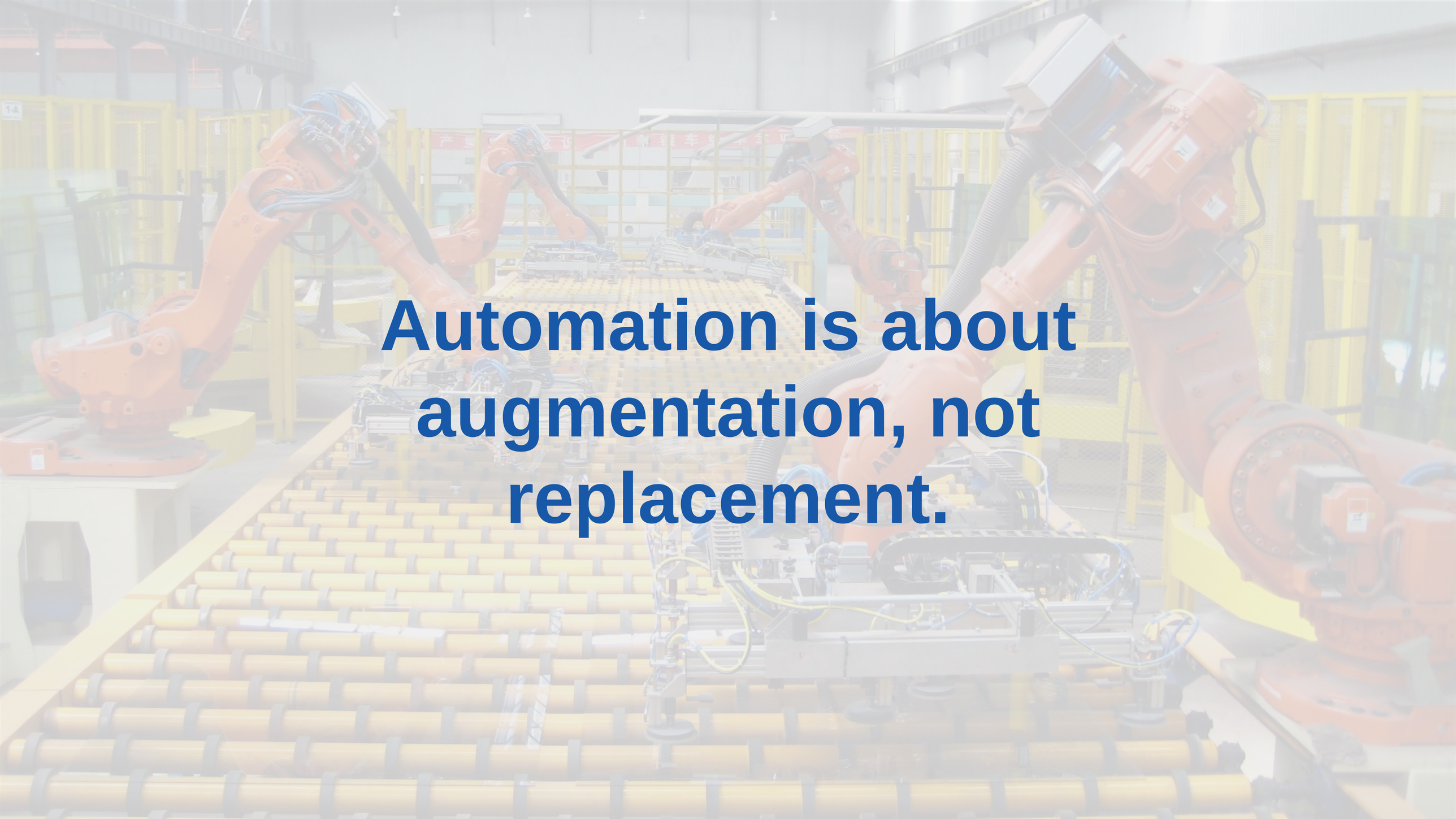


Theory Behind my Scripts

Ingredients for Future Scripts



Based on Rules of Thumb, which should change, but until then lets make them faster.


Automation is about
augmentation, not
replacement.

Script Overview

REHEAT COIL

User interface, place new families

VAV

Import from Excel, modify existing VAVs

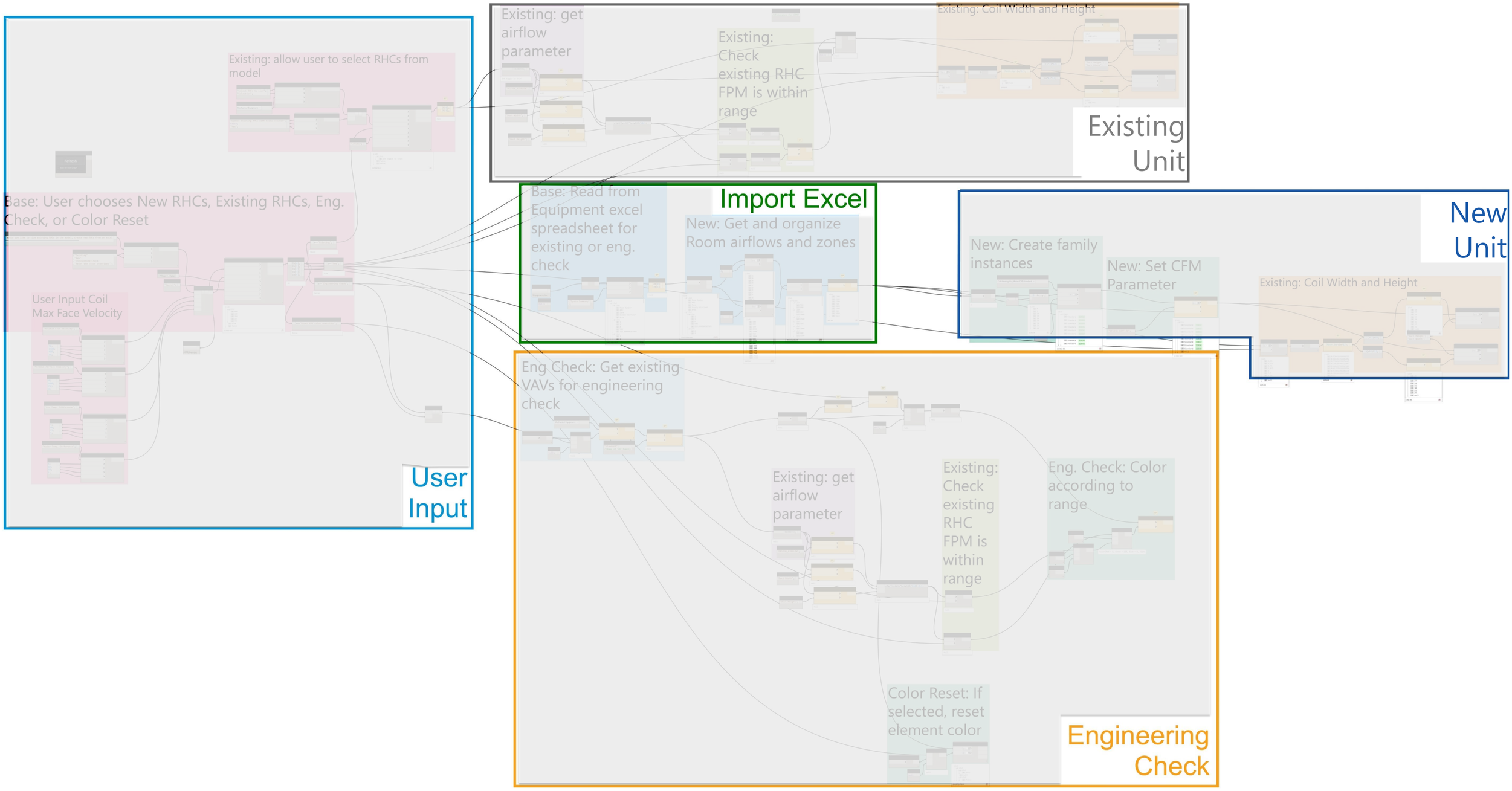
AHU

Engineering Check

BOILER

Regression Sizing

Script Building Blocks



Rules of Thumb

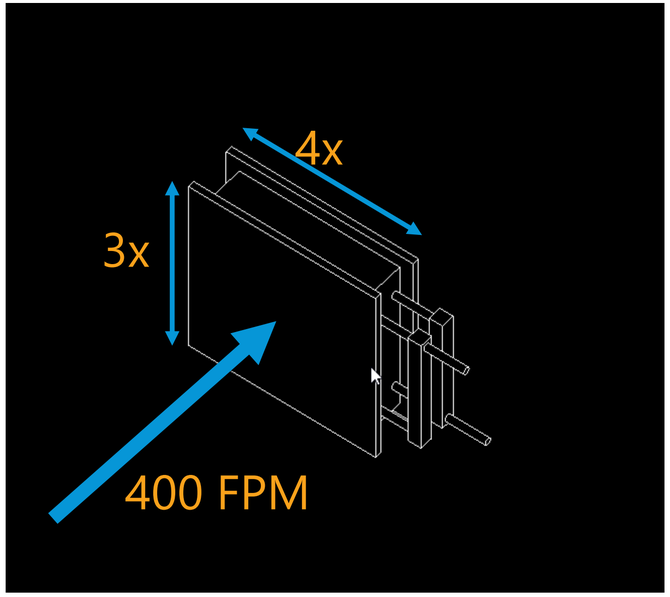
REHEAT COIL

Max Face Velocity less than 400 FPM

4/3 Width/Height Ratio

Btu/hr = 1.08*CFM*AirTempDiff

GPM = 500xWaterTempDiff.



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

Rules of Thumb

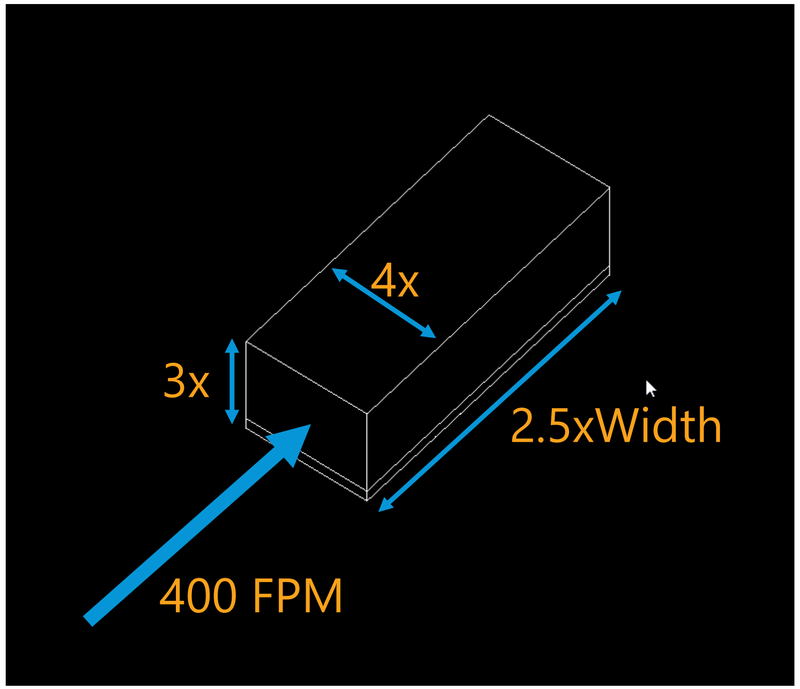
AIR HANDLING UNIT

Max Face Velocity less than 400 FPM, 4/3

Width/Height Ratio, Length is 2.5 times width

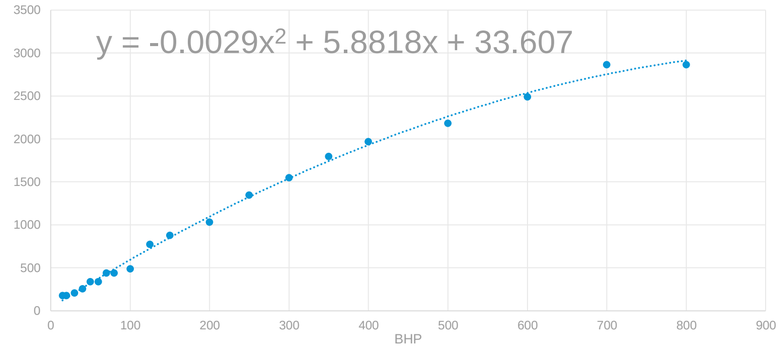
Btu/hr = 1.08*CFM*AirTempDiff

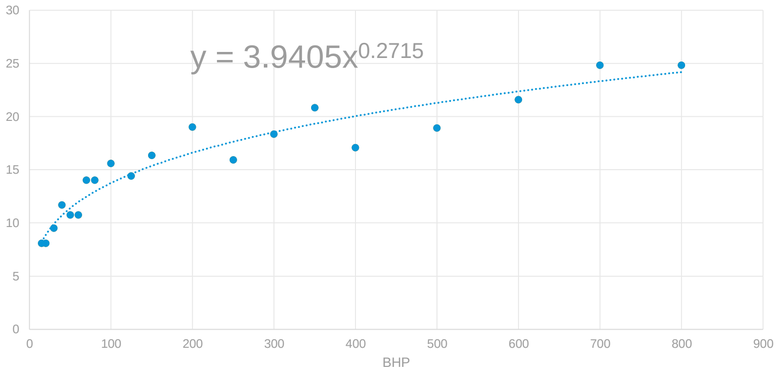
GPM = 500xWaterTempDiff.



BOILER

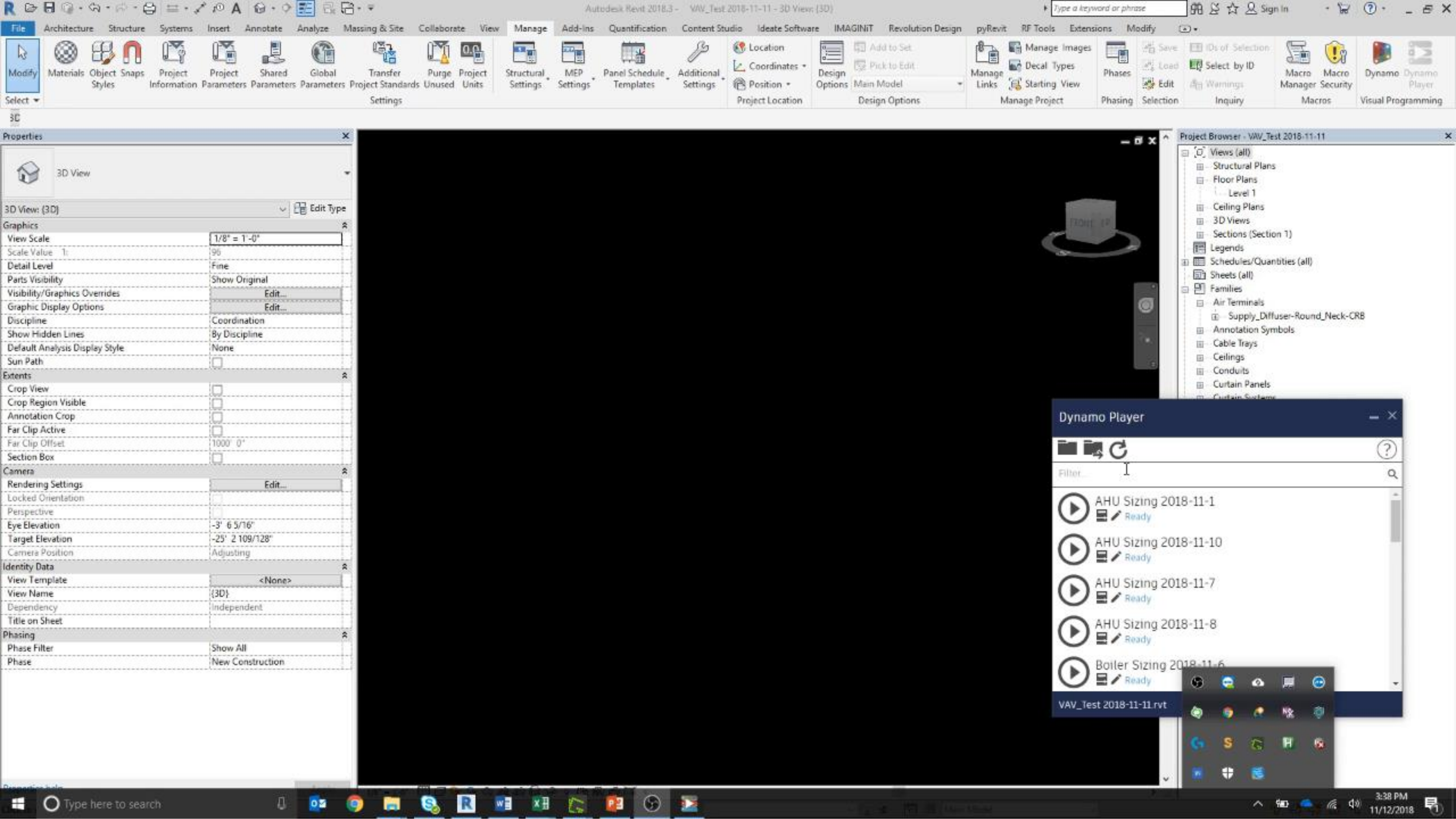
Regression Model, 1 BHP per 1000 sq. ft.



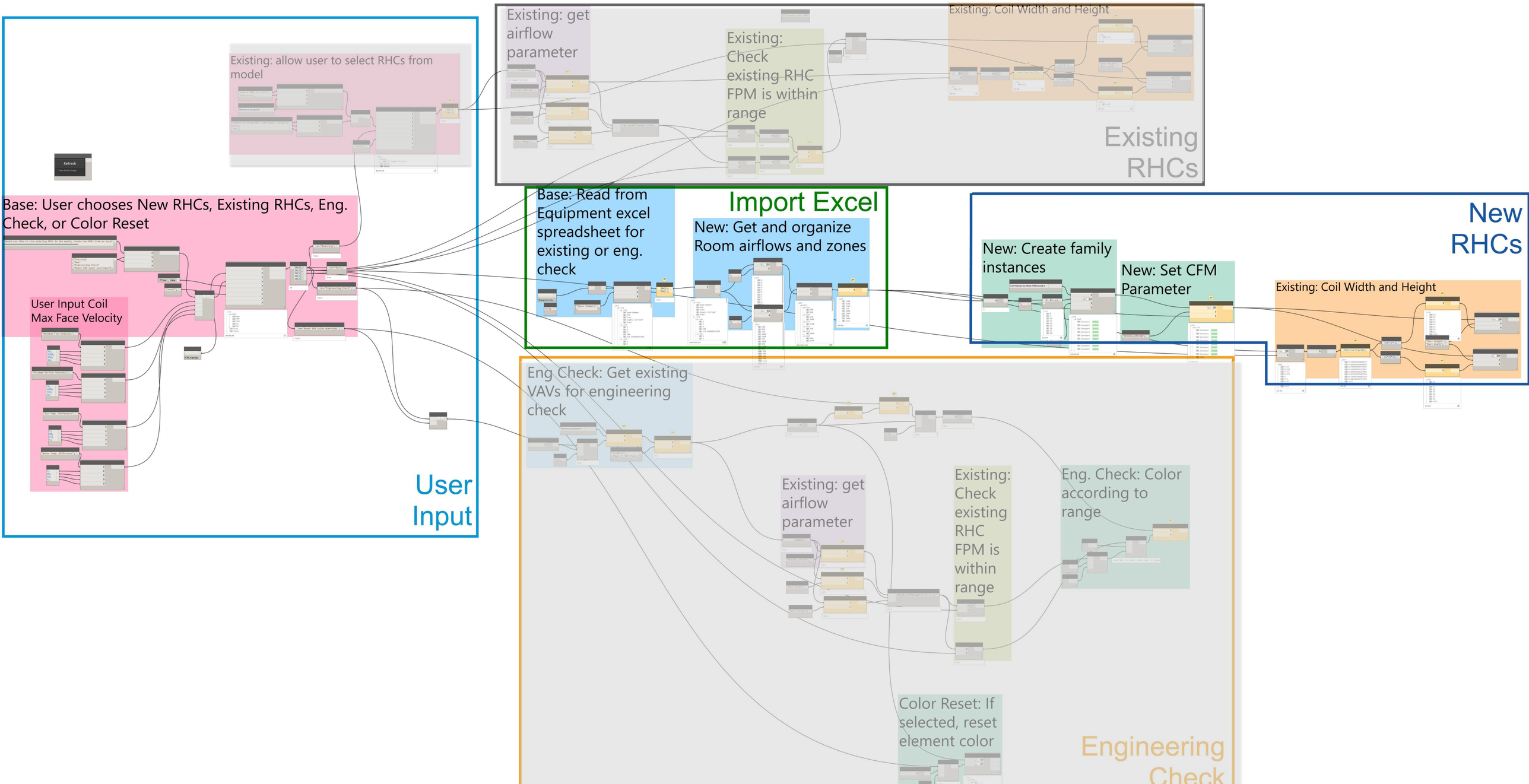


Reheat Coil Sizing

User interface, place new families


Autodesk Revit 2018.3 - VAV_Test 2018-11-11 - 3D View: {3D}
Type a keyword or phrase
Sign In
File
Architecture
Structure
Systems
Insert
Annotate
Analyze
Massing & Site
Collaborate
View
Manage
Add-Ins
Quantification
Content Studio
Ideate Software
IMAGINiT
Revolution Design
pyRevit
RF Tools
Extensions
Modify
Modify
Select
Materials
Object Styles
Snaps
Project Information
Project Parameters
Shared Parameters
Global Parameters
Transfer Project Standards
Purge Unused
Project Units
Settings
Structural Settings
MEP Settings
Panel Schedule Templates
Additional Settings
Location
Coordinates
Position
Project Location
Design Options
Main Model
Design Options
Manage Links
Manage Images
Decal Types
Starting View
Manage Project
Phases
Phasing
Edit
Selection
Select by ID
Inquiry
Macro Manager
Macro Security
Macros
Dynamo
Dynamo Player
Visual Programming
3D
Properties
3D View
3D View: {3D}
Edit Type
Graphics
View Scale 1/8" = 1'-0"
Scale Value 1: 96
Detail Level Fine
Parts Visibility Show Original
Visibility/Graphics Overrides Edit...
Graphic Display Options Edit...
Discipline Coordination
Show Hidden Lines By Discipline
Default Analysis Display Style None
Sun Path
Extents
Crop View
Crop Region Visible
Annotation Crop
Far Clip Active
Far Clip Offset 1000' 0"
Section Box
Camera
Rendering Settings Edit...
Locked Orientation
Perspective
Eye Elevation -3' 6 5/16"
Target Elevation -25' 2 109/128"
Camera Position Adjusting
Identity Data
View Template <None>
View Name {3D}
Dependency Independent
Title on Sheet
Phasing
Phase Filter Show All
Phase New Construction
Project Browser - VAV_Test 2018-11-11
Views (all)
Structural Plans
Floor Plans
Level 1
Ceiling Plans
3D Views
Sections (Section 1)
Legends
Schedules/Quantities (all)
Sheets (all)
Families
Air Terminals
Supply_Diffuser-Round_Neck-CRB
Annotation Symbols
Cable Trays
Ceilings
Conduits
Curtain Panels
Dynamo Player
Filter
AHU Sizing 2018-11-1
Ready
AHU Sizing 2018-11-10
Ready
AHU Sizing 2018-11-7
Ready
AHU Sizing 2018-11-8
Ready
Boiler Sizing 2018-11-6
Ready
VAV_Test 2018-11-11.rvt
Type here to search
3:38 PM
11/12/2018

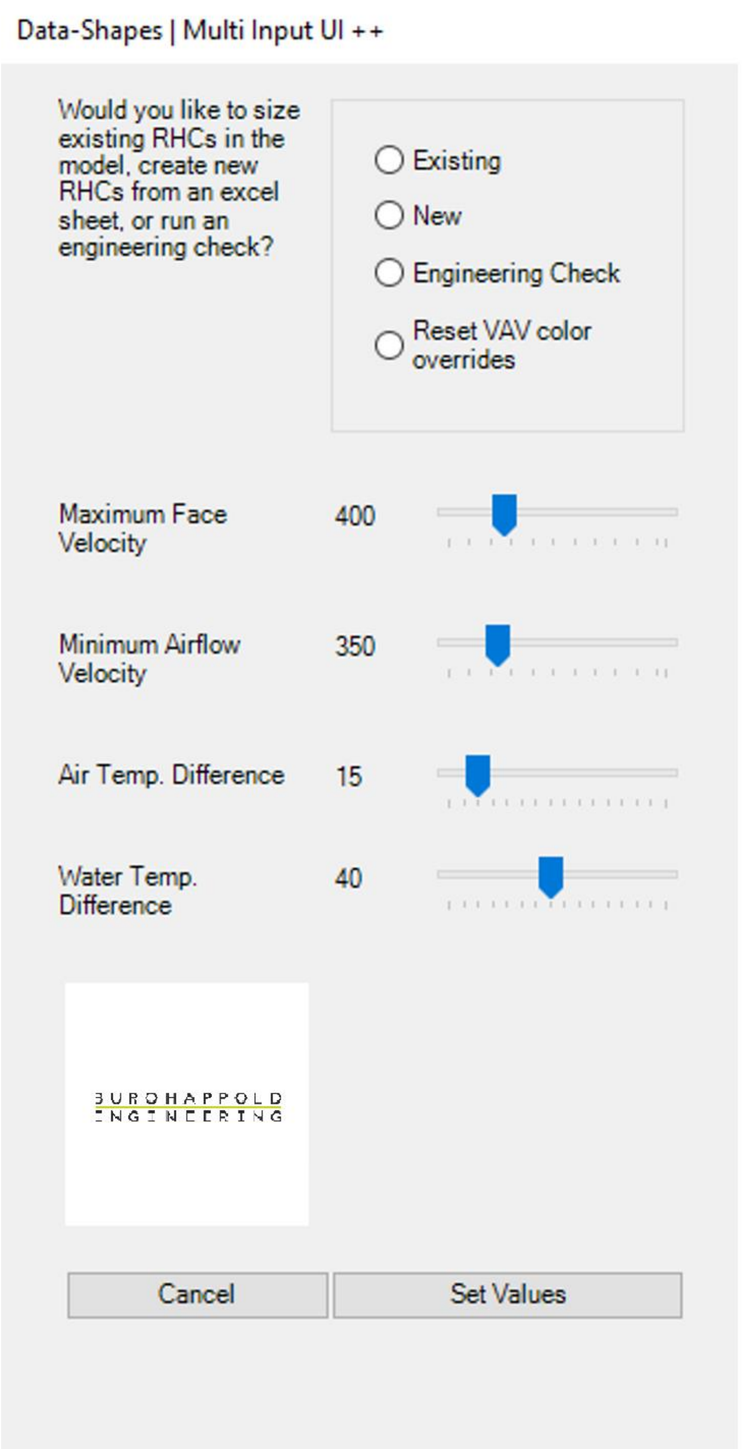
RHC Script


Existing: allow user to select RHCs from model
Refresh
Base: User chooses New RHCs, Existing RHCs, Eng. Check, or Color Reset
User Input Coil Max Face Velocity
User Input
Existing: get airflow parameter
Existing: Check existing RHC FPM is within range
Existing: Coil Width and Height
Existing RHCs
Base: Read from Equipment excel spreadsheet for existing or eng. check
Import Excel
New: Get and organize Room airflows and zones
New: Create family instances
New: Set CFM Parameter
Existing: Coil Width and Height
New RHCs
Eng Check: Get existing VAVs for engineering check
Existing: get airflow parameter
Existing: Check existing RHC FPM is within range
Eng. Check: Color according to range
Color Reset: If selected, reset element color
Engineering Check

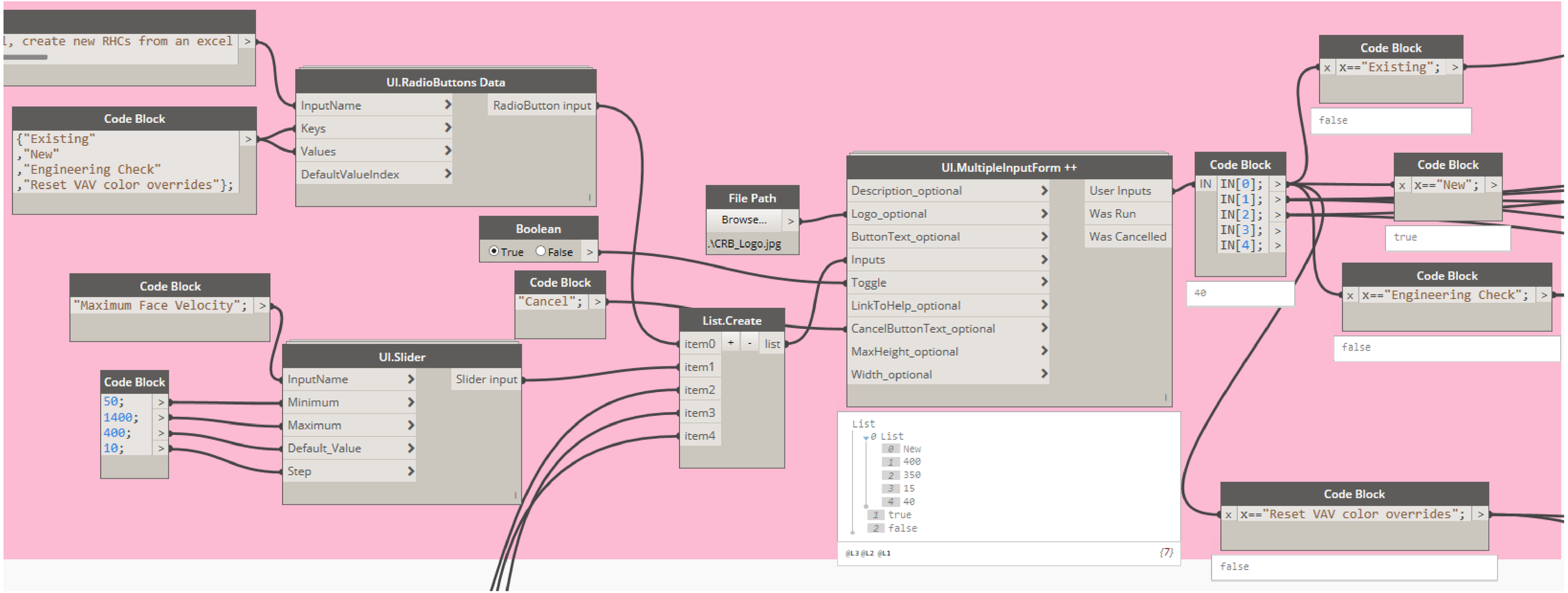
User Interface

Data-Shapes Package

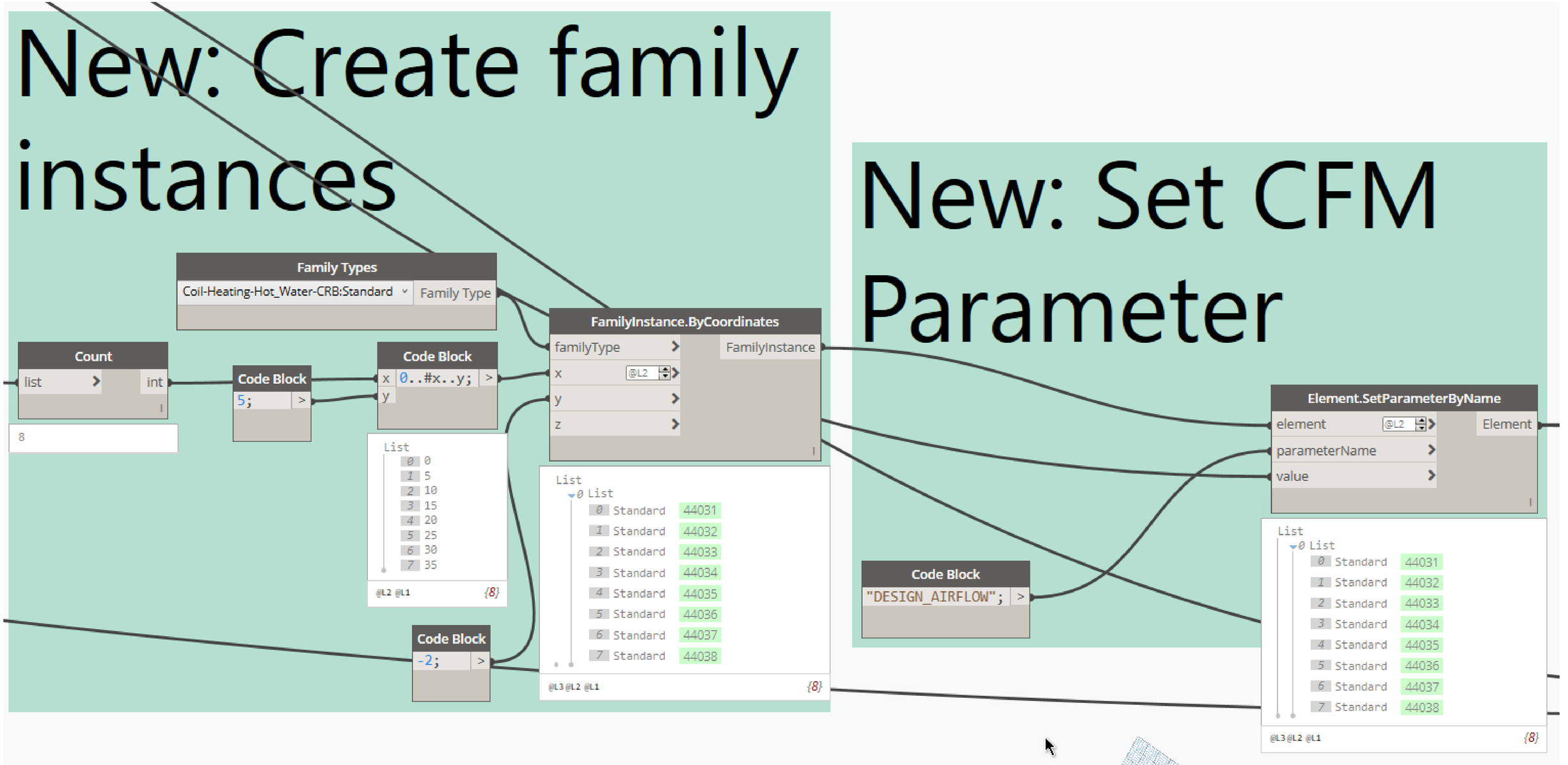
- Strengthens Dynamo Player
- Allow for a variety of kinds of inputs
  - Radio Buttons
  - Sliders
  - List Input
  - Text Input
  - Element Selection
- Allows users to never open Dynamo but modifiy inputs



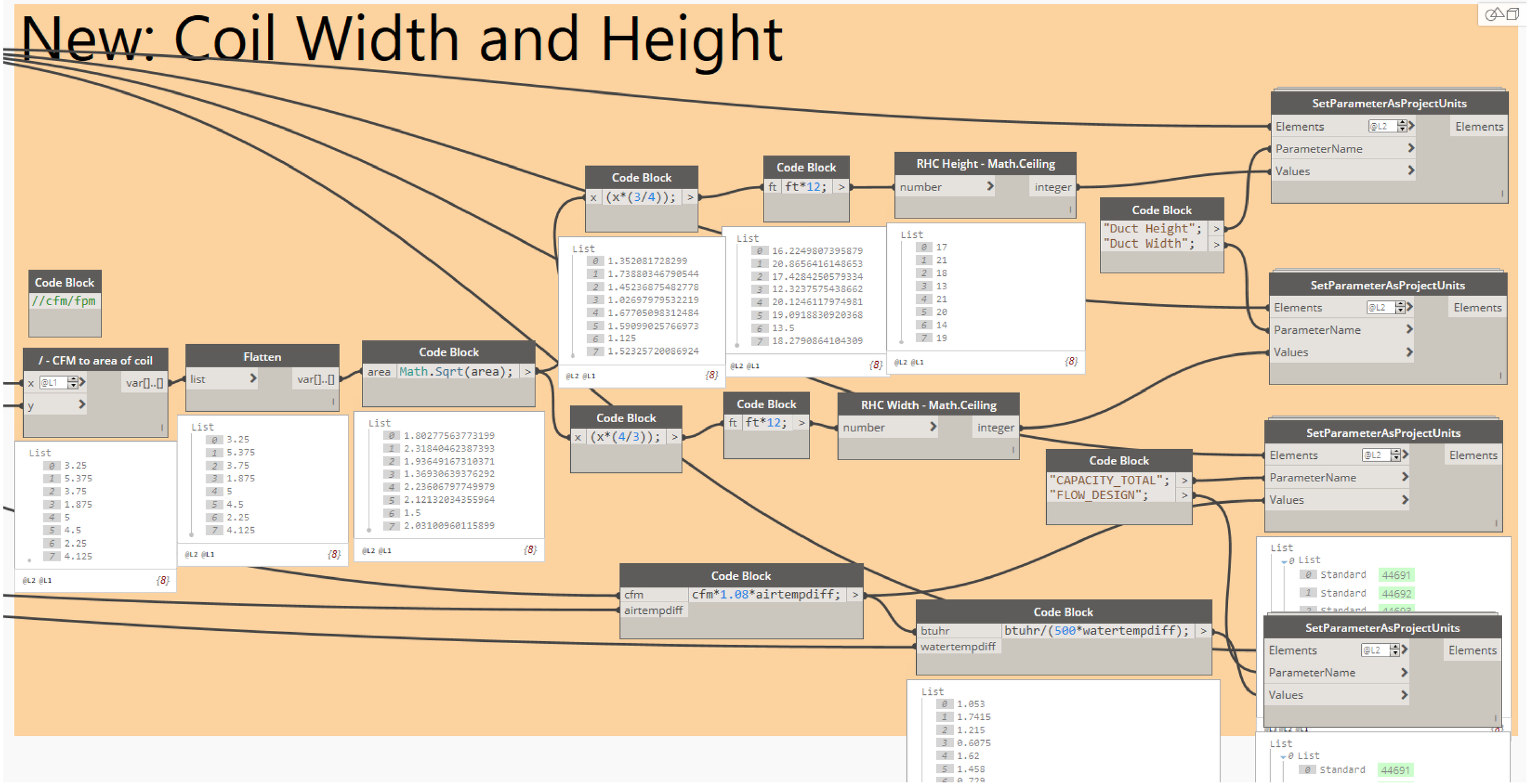
User Interface



Placing Families

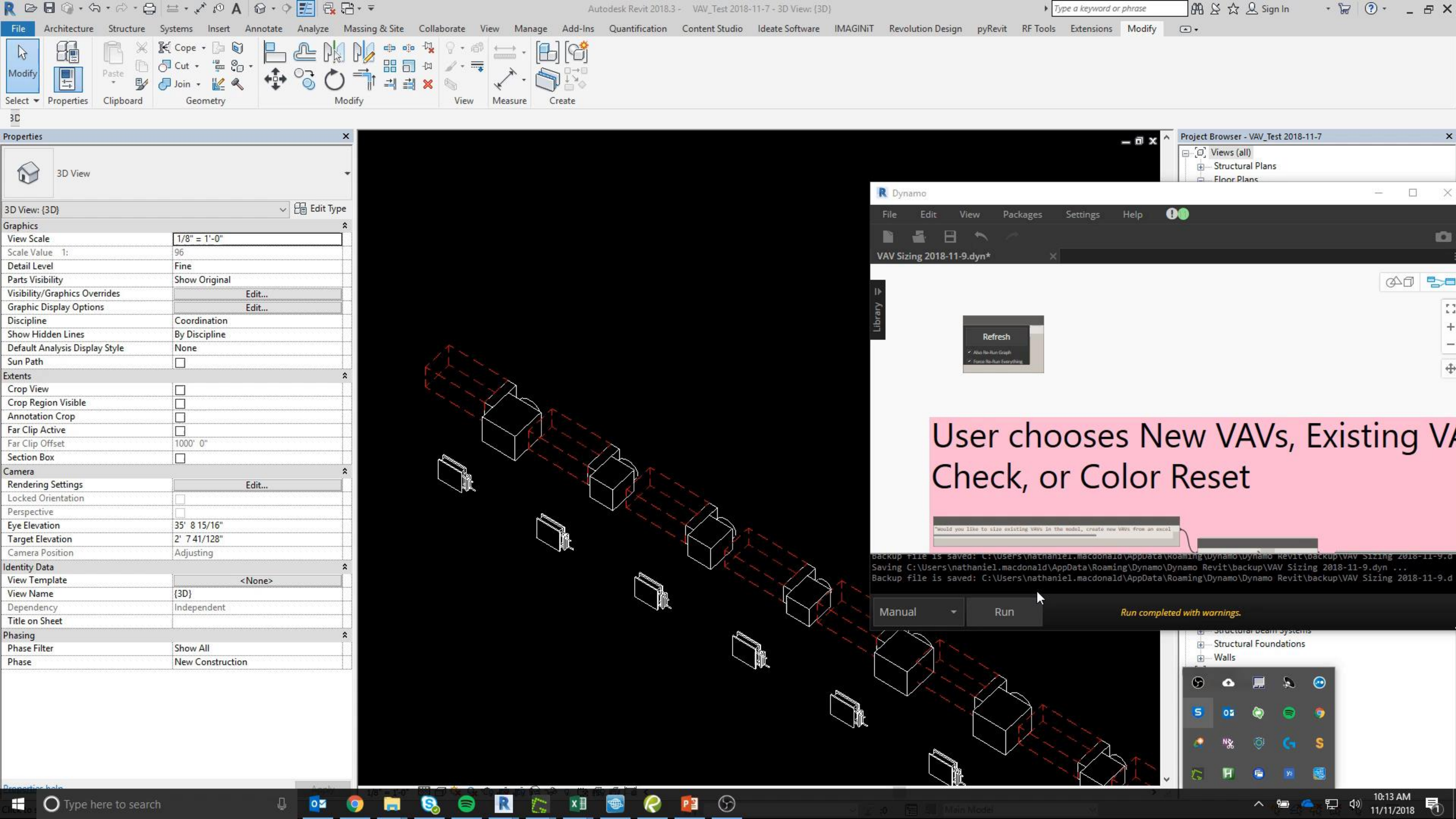


Engine of Script

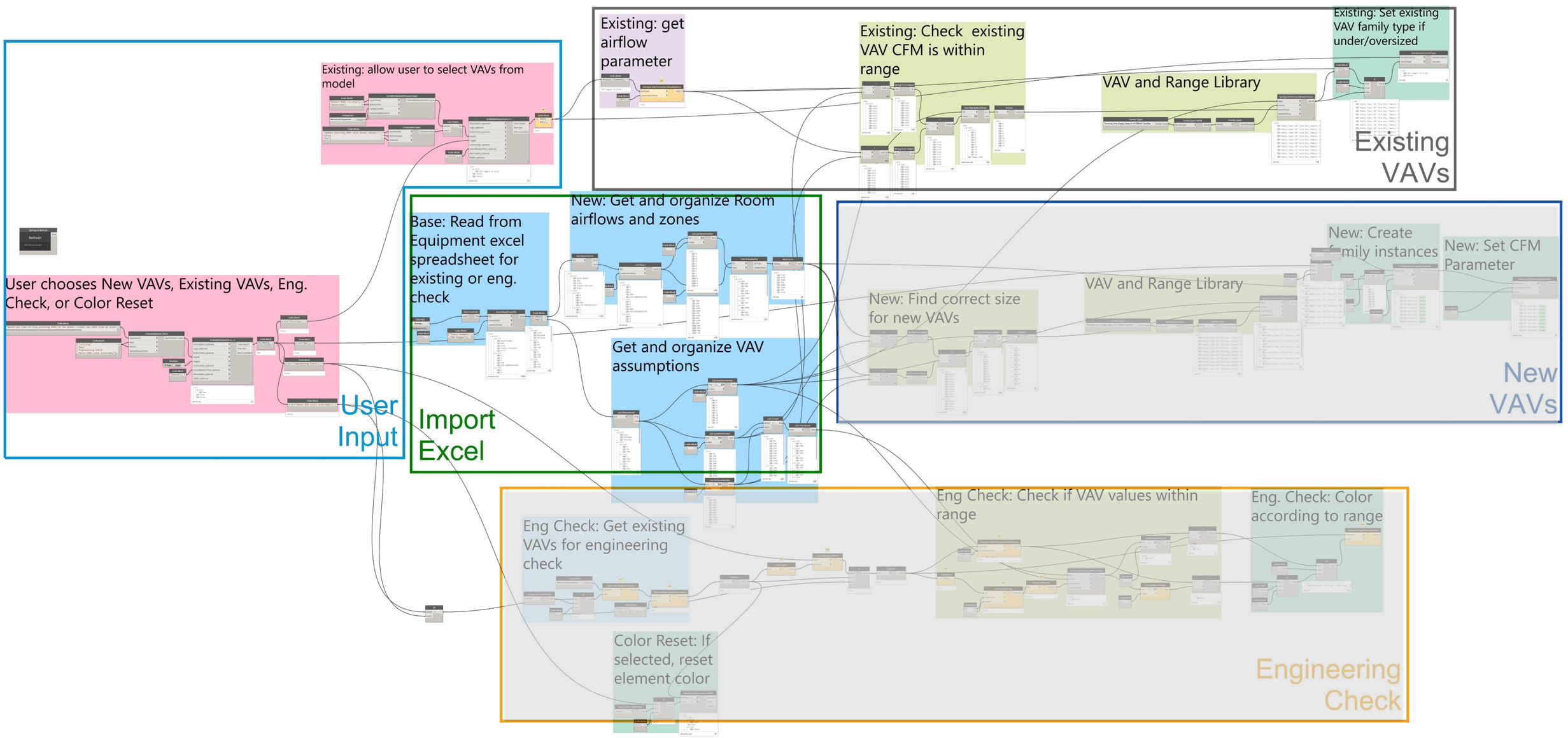


VAV Sizing

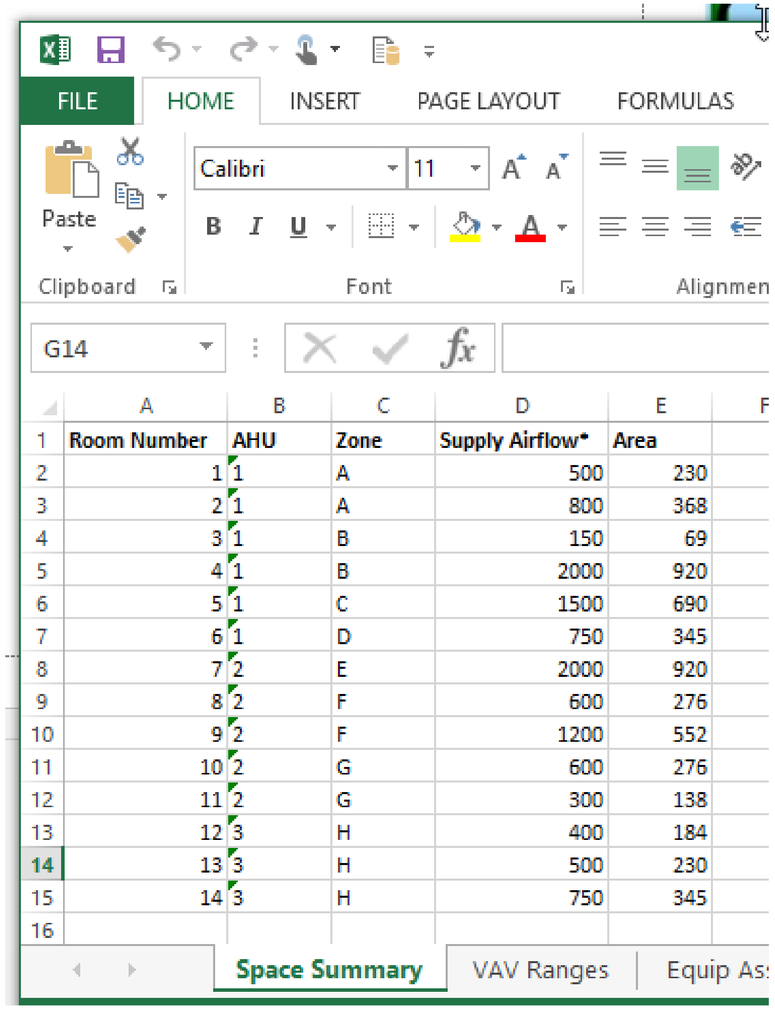
Import from Excel, modify existing VAVs


Autodesk Revit 2018.3 - VAV_Test 2018-11-7 - 3D View: {3D}
File Architecture Structure Systems Insert Annotate Analyze Massing & Site Collaborate View Manage Add-Ins Quantification Content Studio Ideate Software IMAGINiT Revolution Design pyRevit RF Tools Extensions Modify
Modify Select Properties Clipboard Cope Cut Join Geometry Modify View Measure Create
3D
Properties
3D View
3D View: {3D}
Edit Type
Graphics
View Scale 1/8" = 1'-0"
Scale Value 1: 96
Detail Level Fine
Parts Visibility Show Original
Visibility/Graphics Overrides Edit...
Graphic Display Options Edit...
Discipline Coordination
Show Hidden Lines By Discipline
Default Analysis Display Style None
Sun Path
Extents
Crop View
Crop Region Visible
Annotation Crop
Far Clip Active
Far Clip Offset 1000' 0"
Section Box
Camera
Rendering Settings Edit...
Locked Orientation
Perspective
Eye Elevation 35' 8 15/16"
Target Elevation 2' 7 41/128"
Camera Position Adjusting
Identity Data
View Template <None>
View Name {3D}
Dependency Independent
Title on Sheet
Phasing
Phase Filter Show All
Phase New Construction
Project Browser - VAV_Test 2018-11-7
Views (all)
Structural Plans
Floor Plans
Dynamo
File Edit View Packages Settings Help
VAV Sizing 2018-11-9.dyn*
Library
Refresh
Also Re-Run Graph
Force Re-Run Everything
User chooses New VAVs, Existing VA
Check, or Color Reset
"Would you like to size existing VAVs in the model, create new VAVs from an excel
Backup file is saved: C:\Users\nathaniel.macdonald\AppData\Roaming\Dynamo\Dynamo Revit\backup\VAV Sizing 2018-11-9.d
Saving C:\Users\nathaniel.macdonald\AppData\Roaming\Dynamo\Dynamo Revit\backup\VAV Sizing 2018-11-9.dyn ...
Backup file is saved: C:\Users\nathaniel.macdonald\AppData\Roaming\Dynamo\Dynamo Revit\backup\VAV Sizing 2018-11-9.d
Manual
Run
Run completed with warnings.
Structural Foundations
Walls
Type here to search
10:13 AM
11/11/2018

VAV

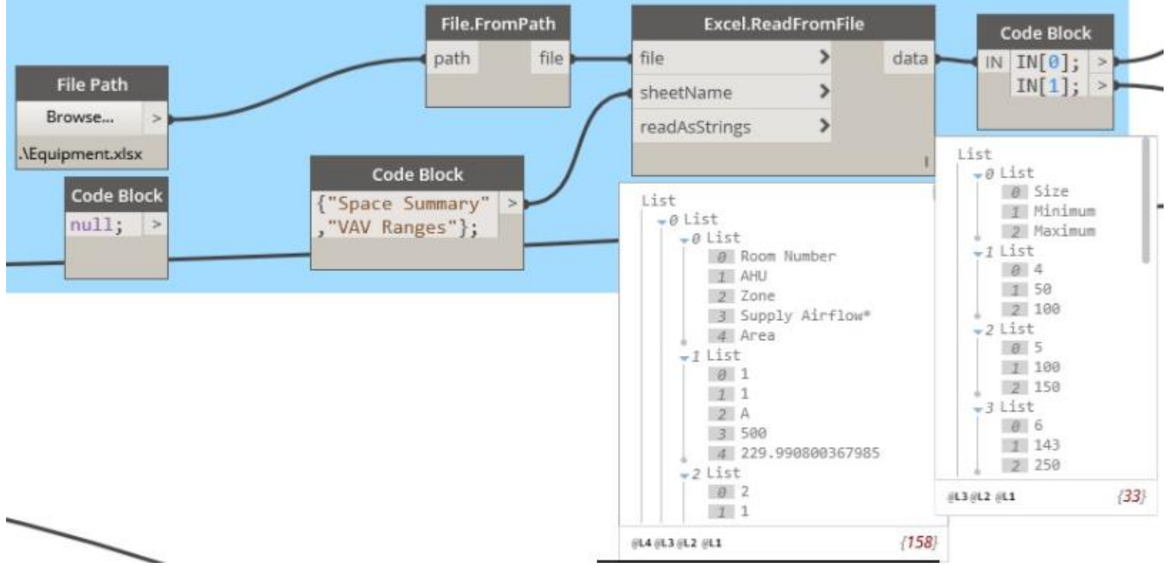

Existing: allow user to select VAVs from model
Existing: get airflow parameter
Existing: Check existing VAV CFM is within range
VAV and Range Library
Existing: Set existing VAV family type if under/oversized
Existing VAVs
User chooses New VAVs, Existing VAVs, Eng. Check, or Color Reset
User Input
Base: Read from Equipment excel spreadsheet for existing or eng. check
New: Get and organize Room airflows and zones
Get and organize VAV assumptions
Import Excel
New: Find correct size for new VAVs
VAV and Range Library
New: Create mily instances
New: Set CFM Parameter
New VAVs
Eng Check: Get existing VAVs for engineering check
Eng Check: Check if VAV values within range
Eng. Check: Color according to range
Color Reset: If selected, reset element color
Engineering Check

Importing from Excel

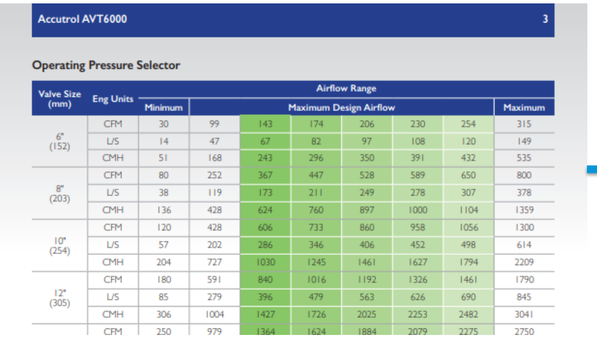


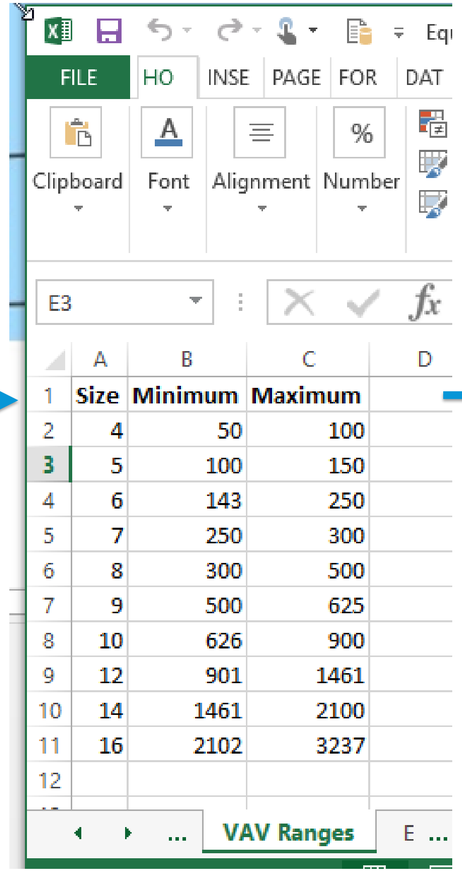
	A	B	C	D	E
1	Room Number	AHU	Zone	Supply Airflow*	Area
2	1	1	A	500	230
3	2	1	A	800	368
4	3	1	B	150	69
5	4	1	B	2000	920
6	5	1	C	1500	690
7	6	1	D	750	345
8	7	2	E	2000	920
9	8	2	F	600	276
10	9	2	F	1200	552
11	10	2	G	600	276
12	11	2	G	300	138
13	12	3	H	400	184
14	13	3	H	500	230
15	14	3	H	750	345
16					

Base: Read from Equipment excel spreadsheet for existing or eng. check

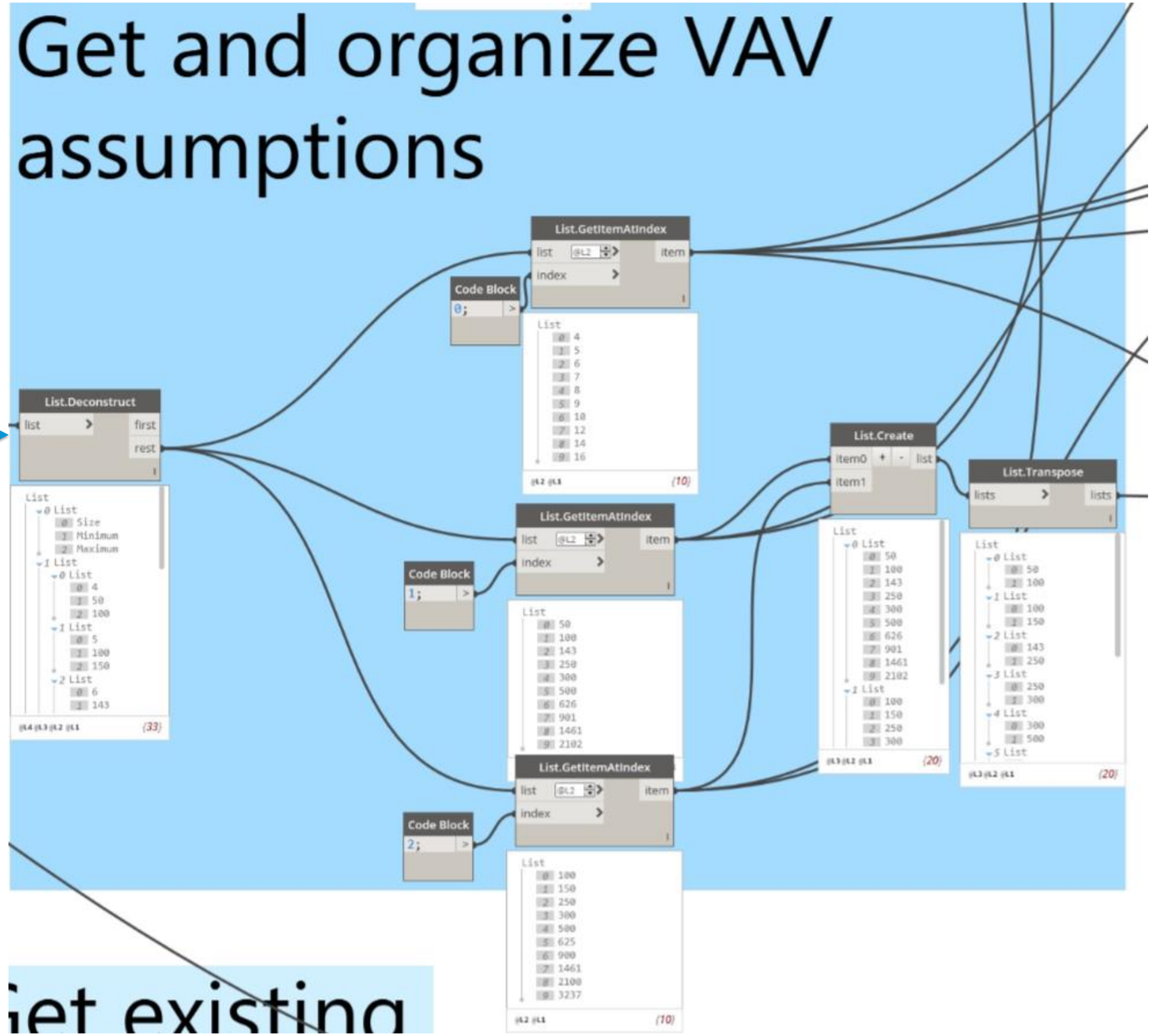


Importing from Excel

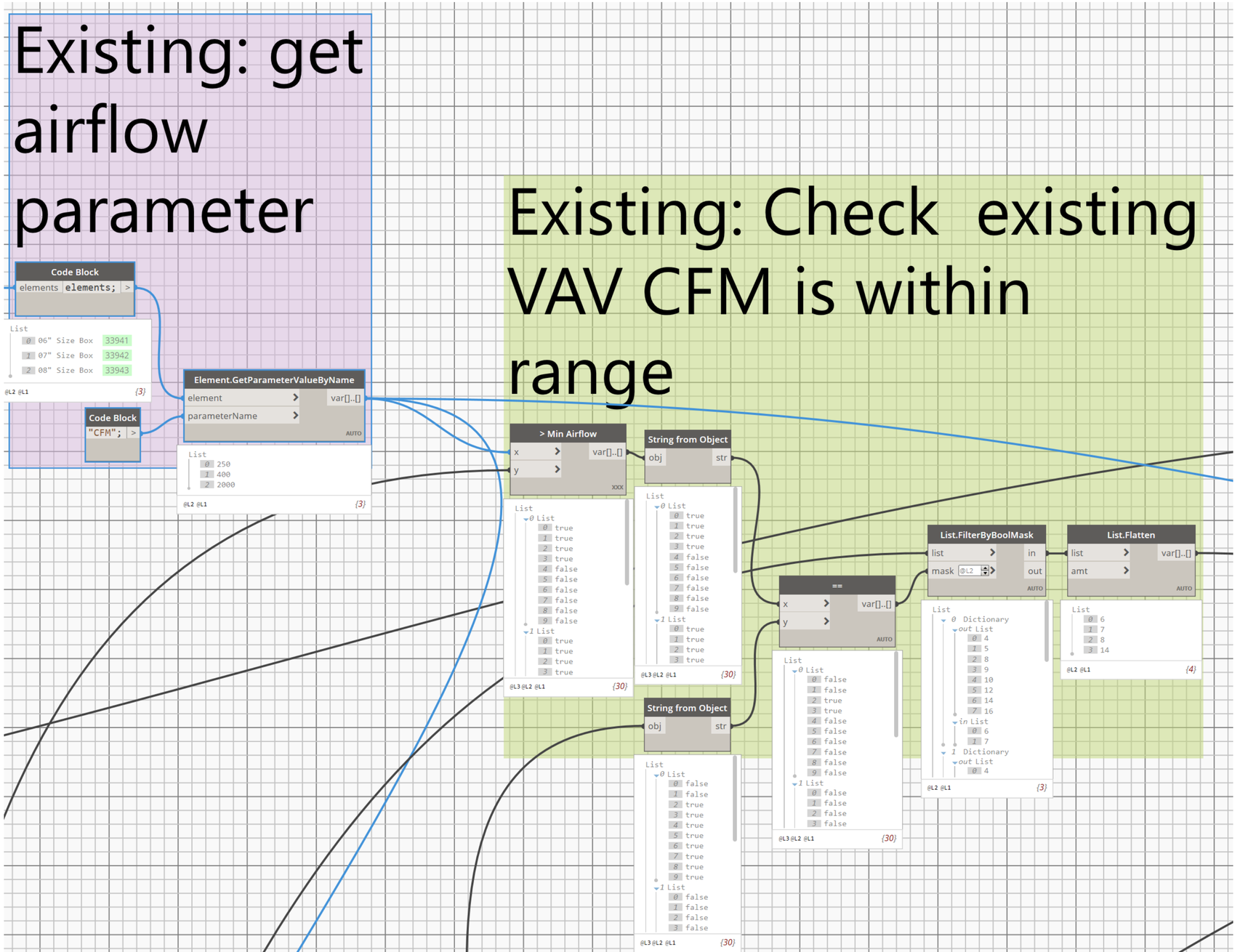




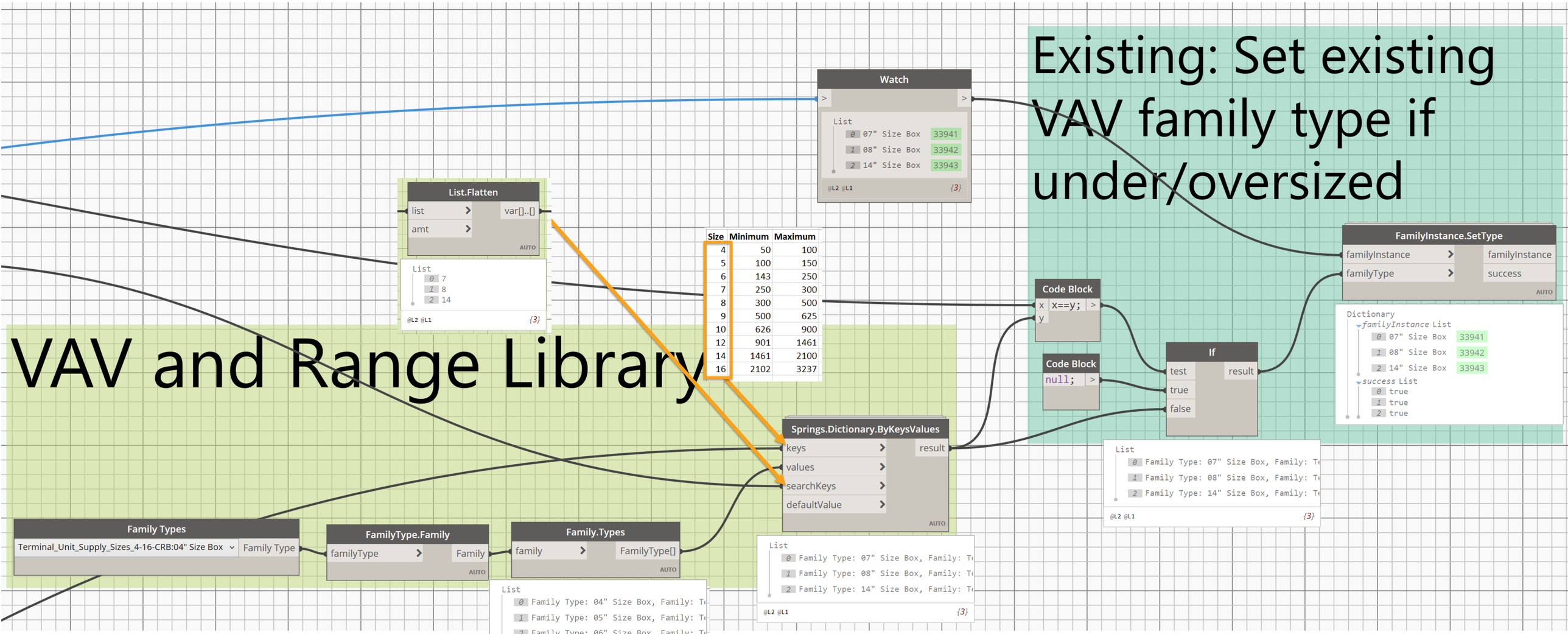
	A	B	C	D
1	Size	Minimum	Maximum	
2	4	50	100	
3	5	100	150	
4	6	143	250	
5	7	250	300	
6	8	300	500	
7	9	500	625	
8	10	626	900	
9	12	901	1461	
10	14	1461	2100	
11	16	2102	3237	
12				



Engine of Script

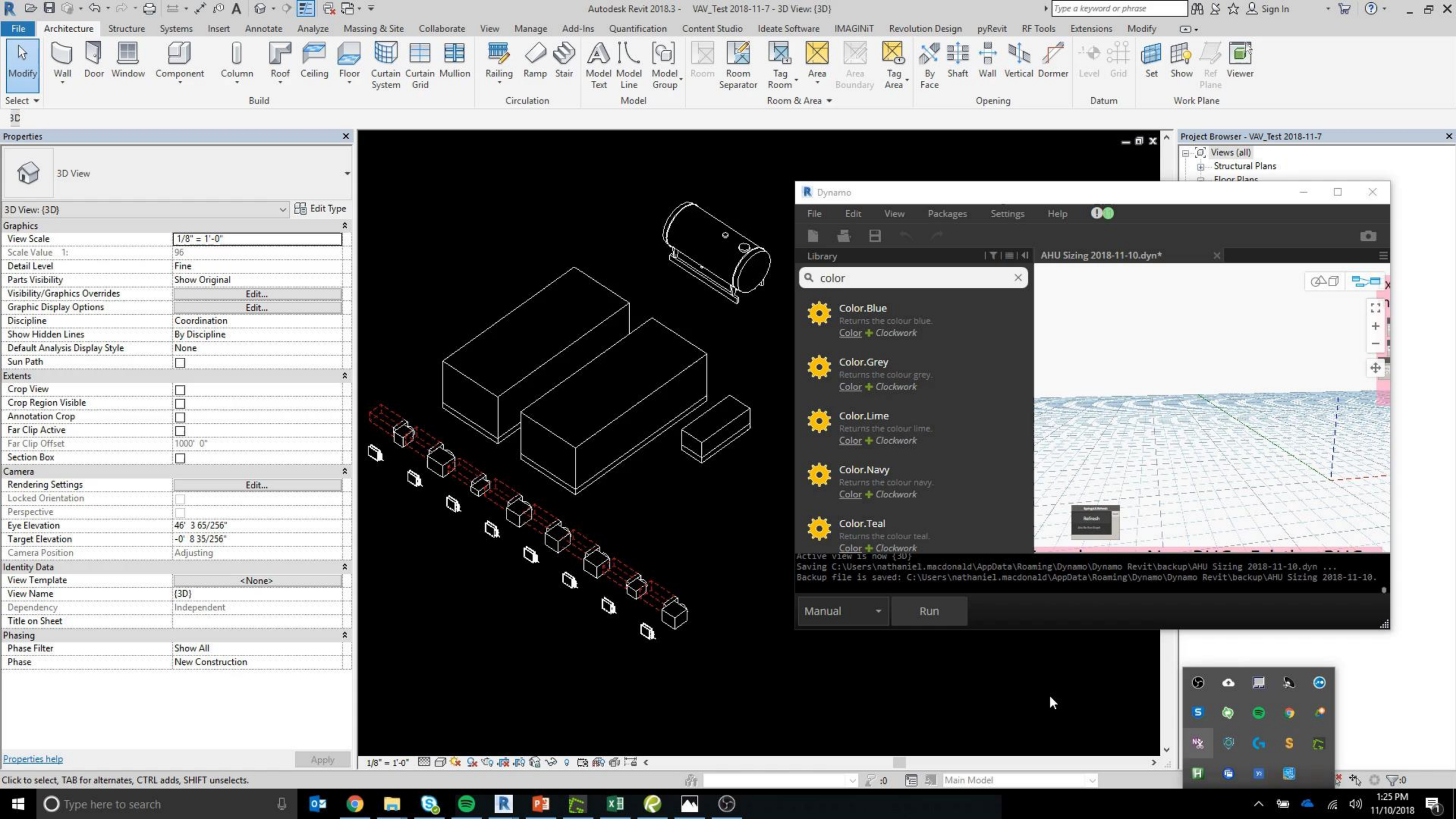


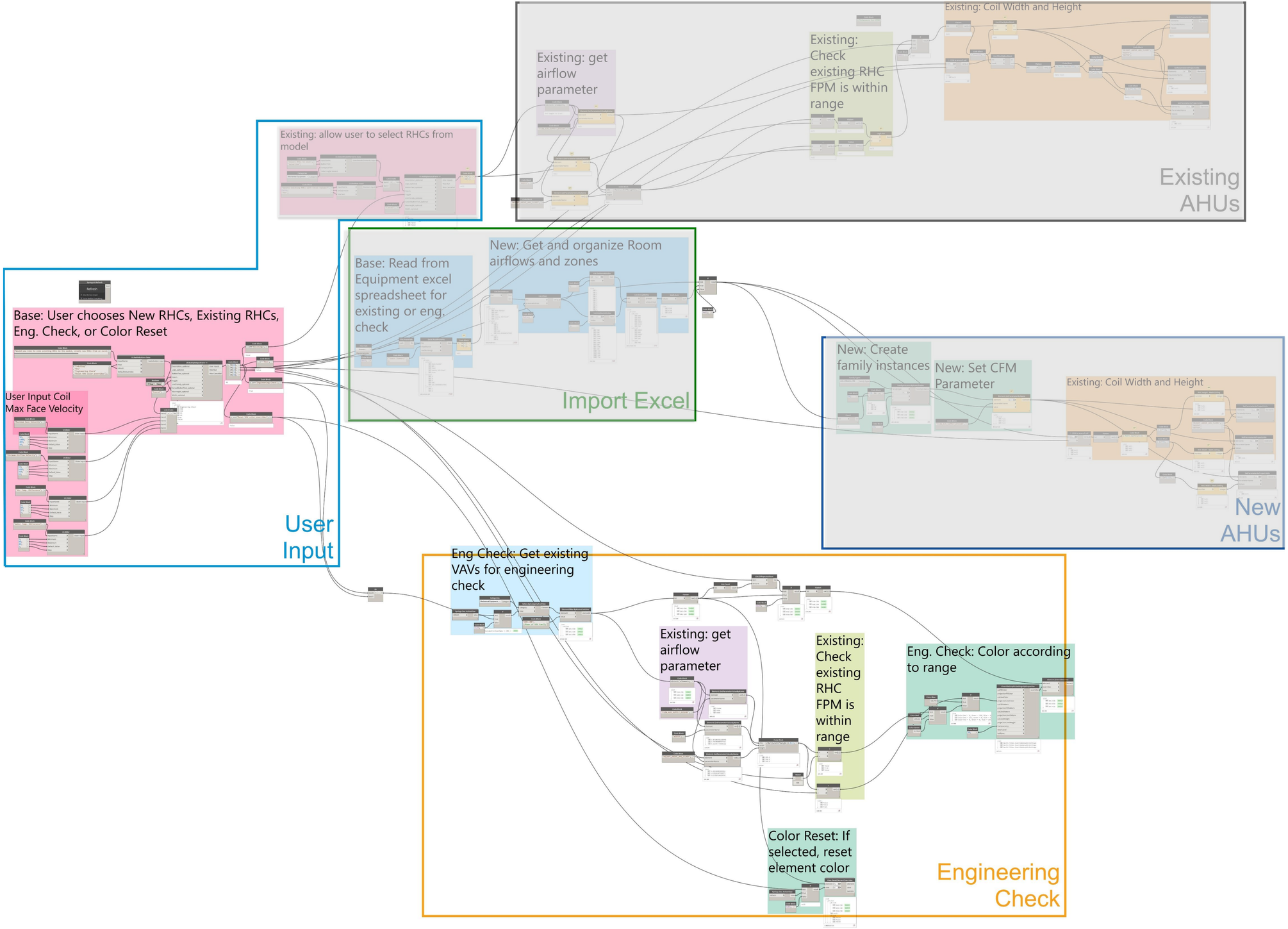
Engine of Script

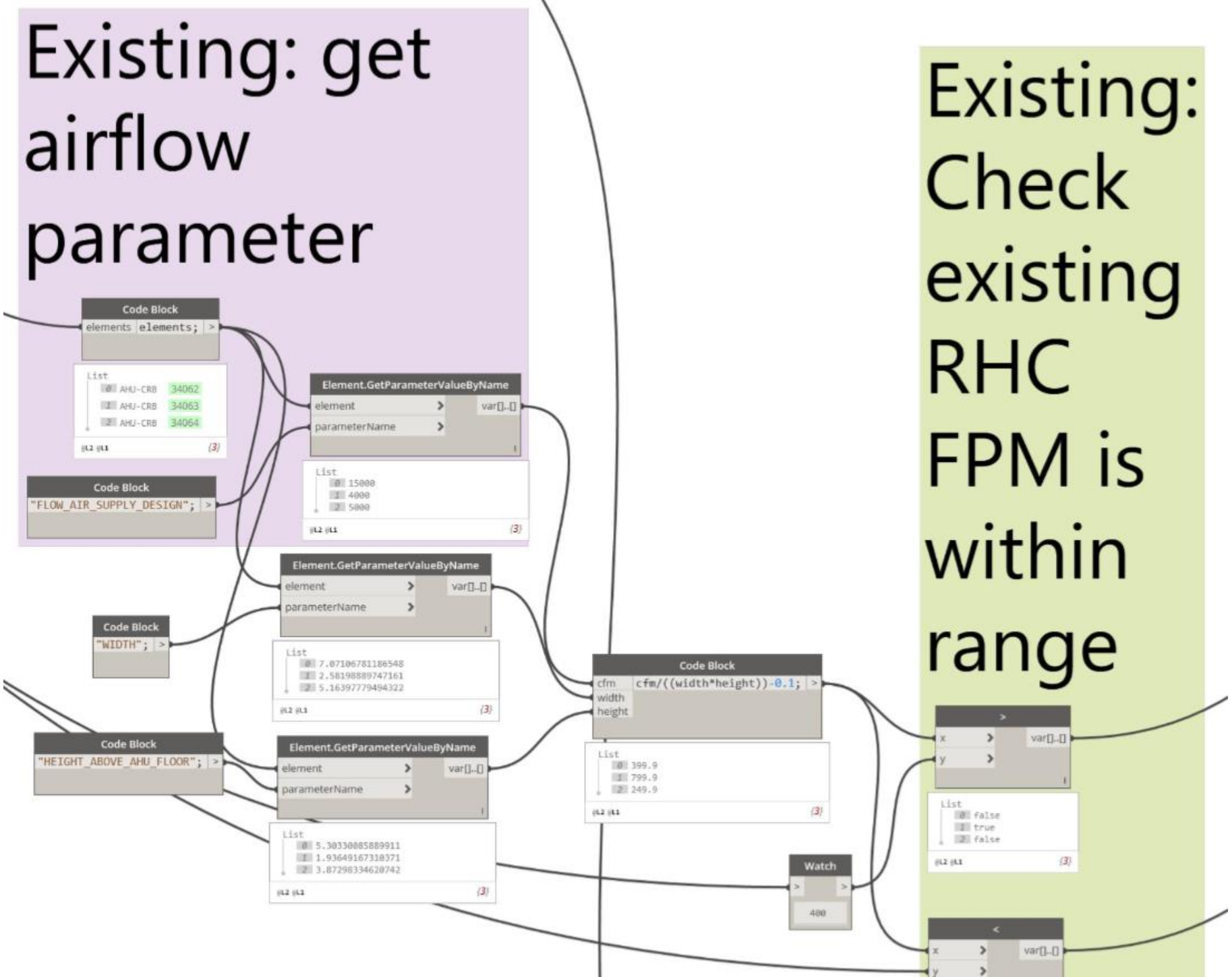


AHU Sizing

Engineering Check


Autodesk Revit 2018.3 - VAV_Test 2018-11-7 - 3D View: {3D}
Properties
3D View
Graphics
Extents
Camera
Identity Data
Phasing
Project Browser - VAV_Test 2018-11-7
Views (all)
Structural Plans
Dynamo
Library
color
Color.Blue
Color.Grey
Color.Lime
Color.Navy
Color.Teal
AHU Sizing 2018-11-10.dyn*
Manual
Run


Existing: get airflow parameter
Existing: Check existing RHC FPM is within range
Existing: Coil Width and Height
Existing AHUs
Existing: allow user to select RHCs from model
Base: User chooses New RHCs, Existing RHCs, Eng. Check, or Color Reset
User Input Coil Max Face Velocity
User Input
Base: Read from Equipment excel spreadsheet for existing or eng. check
New: Get and organize Room airflows and zones
Import Excel
New: Create family instances
New: Set CFM Parameter
Existing: Coil Width and Height
New AHUs
Eng Check: Get existing VAVs for engineering check
Existing: get airflow parameter
Existing: Check existing RHC FPM is within range
Eng. Check: Color according to range
Color Reset: If selected, reset element color
Engineering Check


Existing: get airflow parameter
Code Block
elements elements;
List
0 AHU-CR8 34062
1 AHU-CR8 34063
2 AHU-CR8 34064
{3}
Element.GetParameterValueByName
element
parameterName
var[]..[]
List
0 15000
1 4000
2 5000
{3}
Code Block
"FLOW_AIR_SUPPLY_DESIGN";
Element.GetParameterValueByName
element
parameterName
var[]..[]
List
0 7.07106781186548
1 2.58198889747161
2 5.16397779494322
{3}
Code Block
"WIDTH";
Code Block
"HEIGHT_ABOVE_AHU_FLOOR";
Element.GetParameterValueByName
element
parameterName
var[]..[]
List
0 5.30330085889911
1 1.93649167310371
2 3.87298334620742
{3}
Code Block
cfm
width
height
cfm/((width*height))-0.1;
List
0 399.9
1 799.9
2 249.9
{3}
Watch
400
Existing: Check existing RHC FPM is within range
>
x
y
var[]..[]
List
0 false
1 true
2 false
{3}
<
x
y
var[]..[]

xisting:
heck
xisting
HC
PM is
ithin
ange

Eng. Check: Color according to range

Boiler Sizing

Regression Sizing

Autodesk Revit 2018.3 - VAV_Test 2018-11-7 - 3D View: {3D}

File | Architecture | Structure | Systems | Insert | Annotate | Analyze | Massing & Site | Collaborate | View | Manage | Add-Ins | Quantification | Content Studio | Ideate Software | IMAGINiT | Revolution Design | pyRevit | RF Tools | Extensions | Modify

Modify | Wall | Door | Window | Component | Column | Roof | Ceiling | Floor | Curtain System | Curtain Grid | Mullion | Railing | Ramp | Stair | Model Text | Model Line | Model Group | Room | Room Separator | Tag Room | Area | Area Boundary | Tag Area | By Face | Shaft | Wall | Vertical | Dormer | Level | Grid | Set | Show | Ref Plane | Viewer

Select | Build | Circulation | Model | Room & Area | Opening | Datum | Work Plane

3D

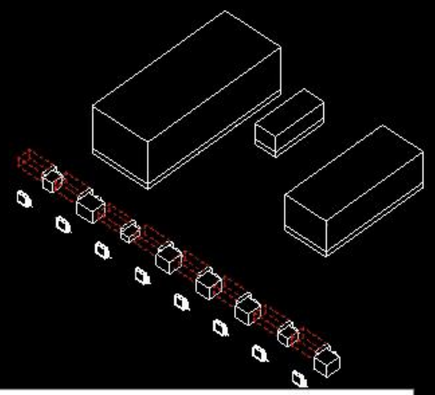
Properties

3D View

3D View: {3D} | Edit Type

Graphics	
View Scale	1/8" = 1'-0"
Scale Value 1:	96
Detail Level	Fine
Parts Visibility	Show Original
Visibility/Graphics Overrides	Edit...
Graphic Display Options	Edit...
Discipline	Coordination
Show Hidden Lines	By Discipline
Default Analysis Display Style	None
Sun Path	
Extents	
Crop View	
Crop Region Visible	
Annotation Crop	
Far Clip Active	
Far Clip Offset	1000' 0"
Section Box	
Camera	
Rendering Settings	
Locked Orientation	
Perspective	
Eye Elevation	46' 3 65/256"
Target Elevation	-0' 8 35/256"
Camera Position	Adjusting
Identity Data	
View Template	
View Name	{3D}
Dependency	Independent
Title on Sheet	
Phasing	
Phase Filter	Show All
Phase	New Construction

Properties help | Apply



Project Browser - VAV_Test 2018-11-7

- Views (all)
  - Structural Plans
  - Floor Plans
    - Level 1
  - Ceiling Plans

Equipment - Excel

FILE | HO | INSE | PAGE | FOR | DAT | REVI | VIEW | ADD | Nathaniel...

Clipboard | Font | Alignment | Number | Conditional Formatting | Format as Table | Cell Styles | Styles | Cells

G14

	A	B	C	D	E	F	G
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 ... | READY | 85%

Dynamo

File | Edit | View | Packages | Settings | Help

Library | Boiler Sizing 2018-11-8.dyn*

color

- **Color.Blue** — Returns the colour blue. Color + Clockwork
- **Color.Grey** — Returns the colour grey. Color + Clockwork
- **Color.Lime** — Returns the colour lime. Color + Clockwork
- **Color.Navy** — Returns the colour navy. Color + Clockwork
- **Color.Teal** — Returns the colour teal. Color + Clockwork

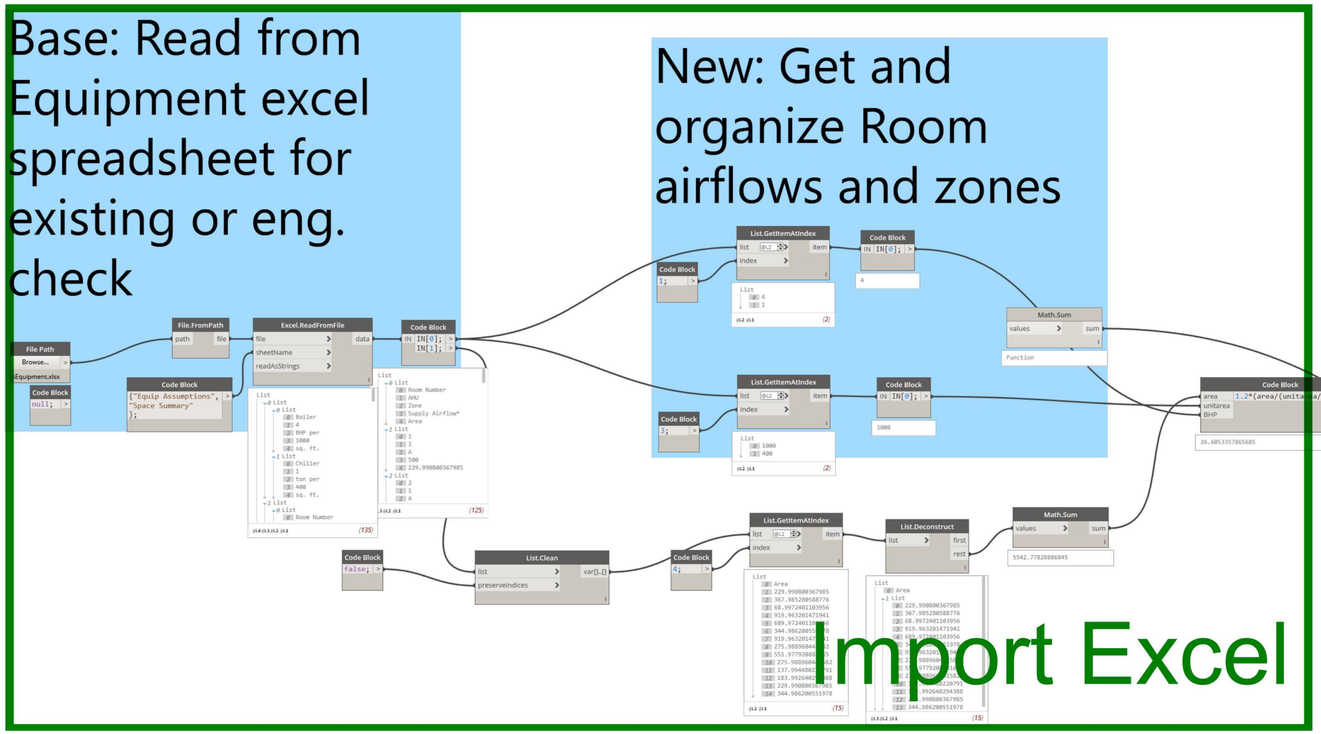

```
Active view is now {3D}
Saving C:\Users\nathaniel.macdonald\AppData\Roaming\Dynamo\Dynamo Revit\backup\Boiler Sizing 2018-11-8.dyn ...
Backup file is saved: C:\Users\nathaniel.macdonald\AppData\Roaming\Dynamo\Dynamo Revit\backup\Boiler Sizing 2018-11-
```

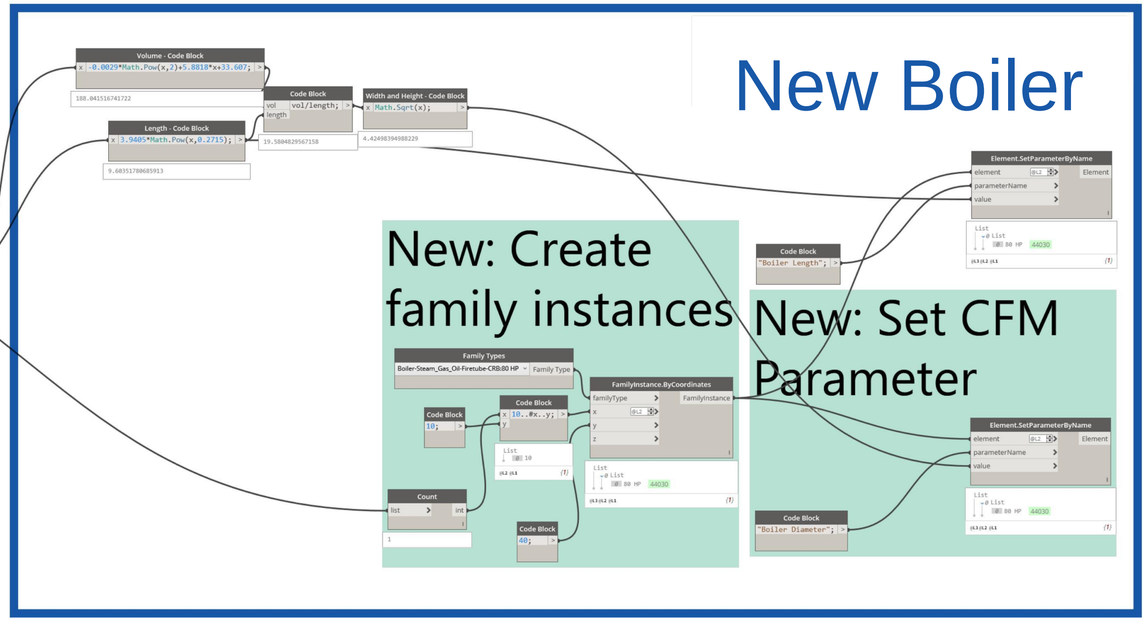
Manual | Run

Type here to search

2:30 PM
11/10/2018

Regression Sizing

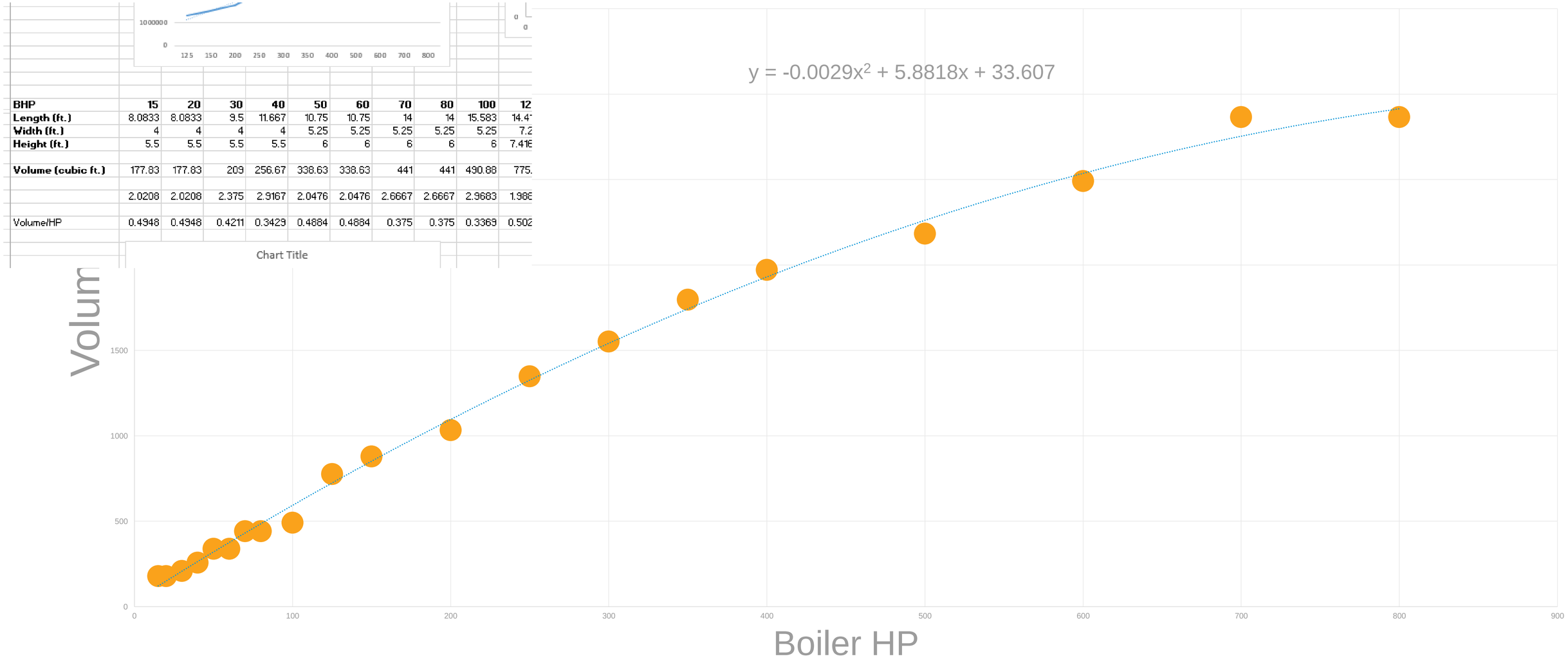




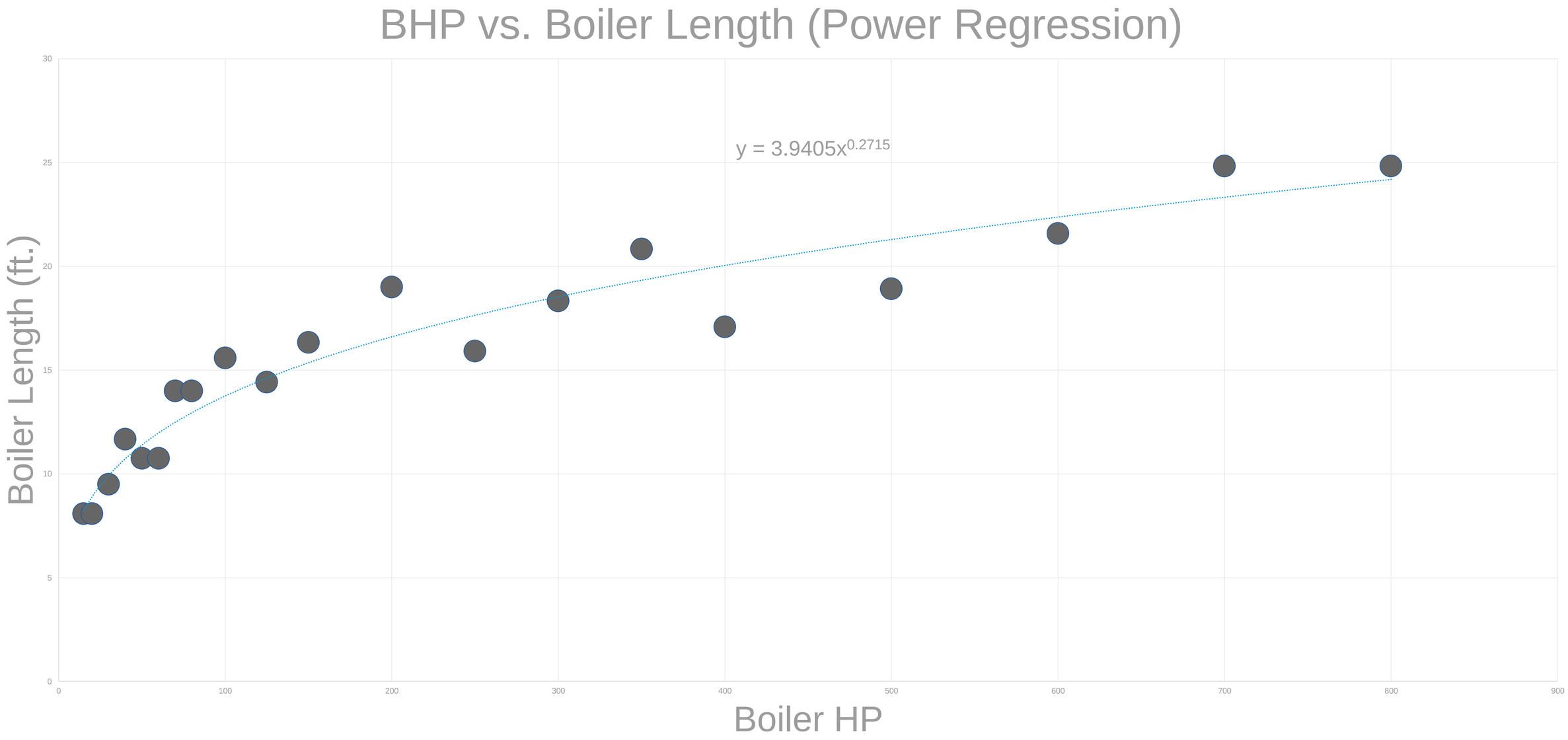
Regression Sizing

BHP vs. Boiler Volume (Polynomial Regression)

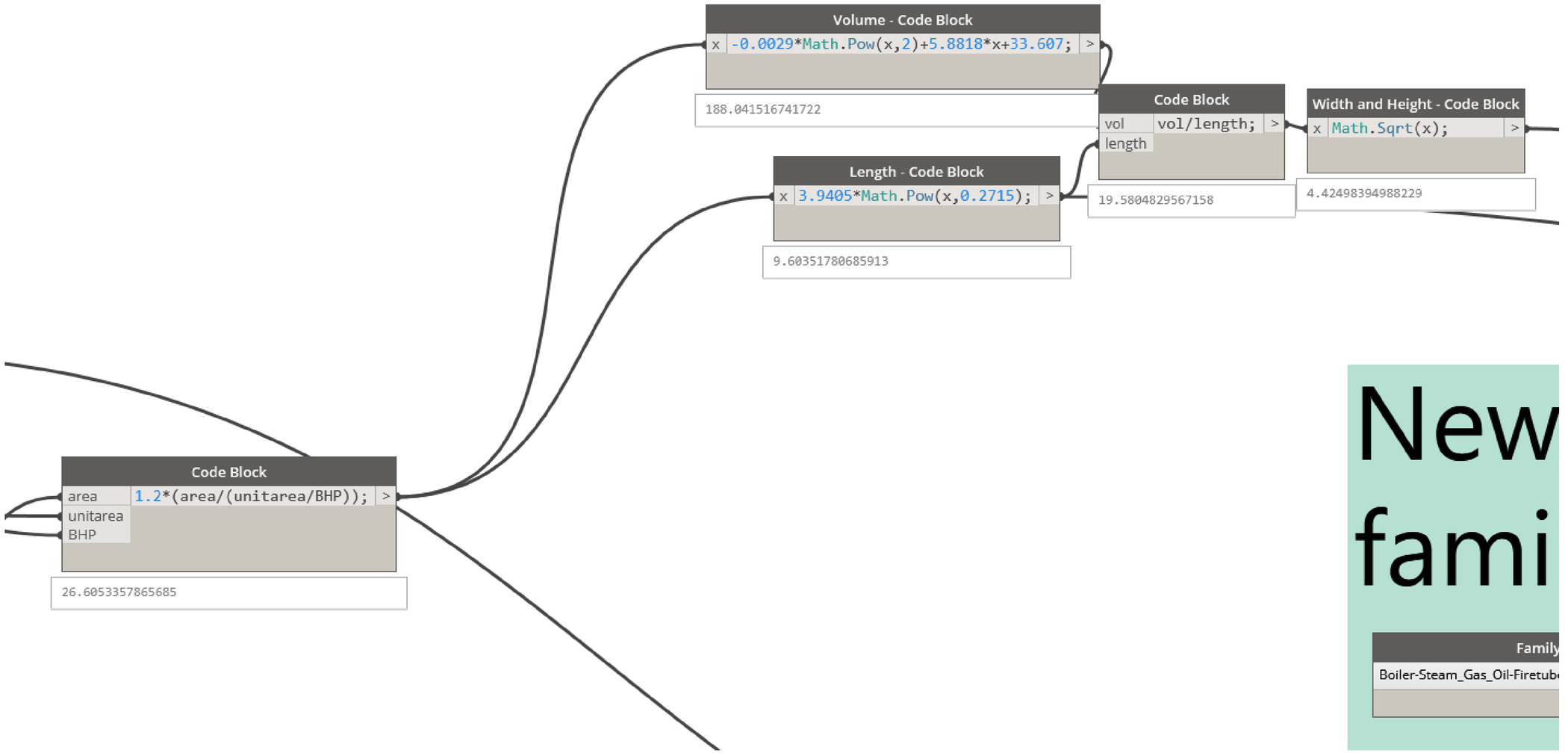
BHP	15	20	30	40	50	60	70	80	100	12
Length (ft.)	8.0833	8.0833	9.5	11.667	10.75	10.75	14	14	15.583	14.4
Width (ft.)	4	4	4	4	5.25	5.25	5.25	5.25	5.25	7.2
Height (ft.)	5.5	5.5	5.5	5.5	6	6	6	6	6	7.41
Volume (cubic ft.)	177.83	177.83	209	256.67	338.63	338.63	441	441	490.88	775.
	2.0208	2.0208	2.375	2.9167	2.0476	2.0476	2.6667	2.6667	2.9683	1.98
Volume/HP	0.4948	0.4948	0.4211	0.3429	0.4884	0.4884	0.375	0.375	0.3369	0.502

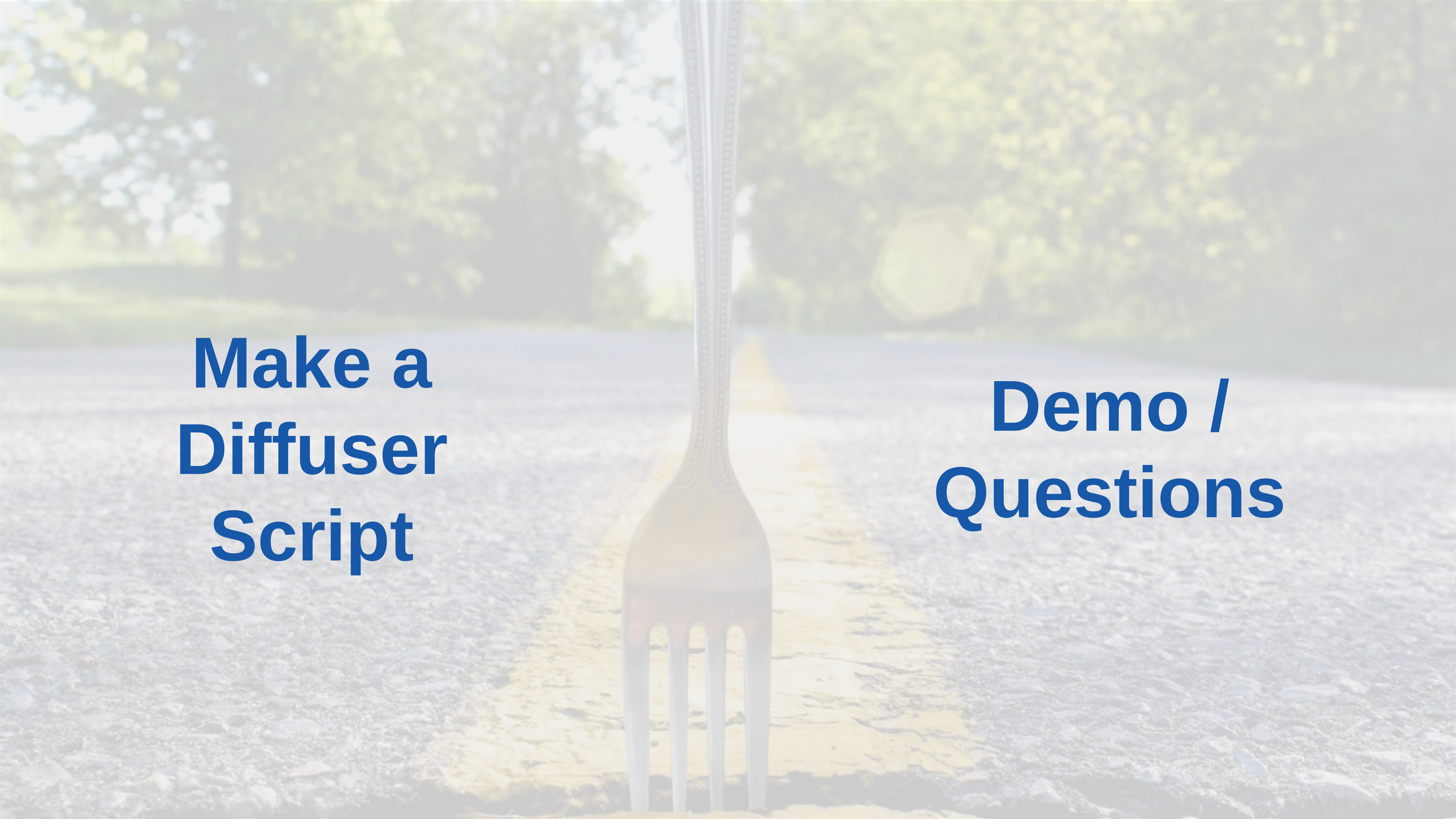


Regression Sizing



Regression Sizing





Make a Diffuser Script

Demo / Questions

Smorgasbord=Buffet

Thank you, Dynamo Community

Mechanical Dynamo Smorgasbord: Preliminary Equipment Sizing with Dynamo in Revit

Nat MacDonald, PE

Mechanical Engineer, BuroHappold

Nathaniel.MacDonald@BuroHappold.com

@NatGMac

Please submit feedback on the app!

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