

Example

-High Performance Building Design-
PV Potential and Indoor Daylight Analysis

Goals

What are we solving for?

Use site context and a zoning boundary created in Revit to create a generative building form with maximum indoor daylight and PV potential analysis as the key focus.

Static Inputs and Variable Inputs:

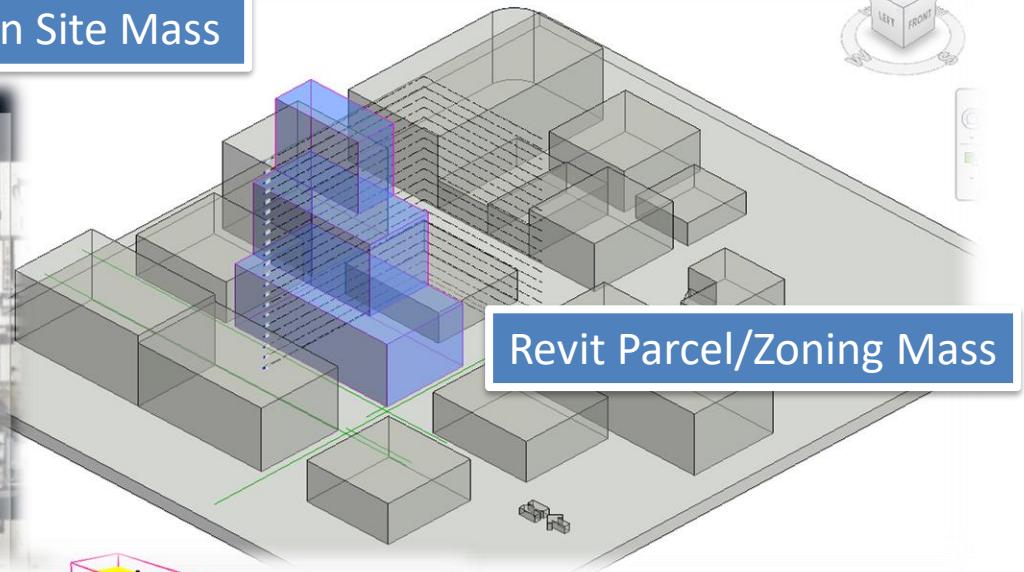
1. Parcel and Zoning Restrictions
2. Floor to Floor Height
3. Window to Wall Ratio per N,S,W,E Facade
4. Urban Site Context
5. Building Corner Distance Inputs
6. Date and Time

Goals:

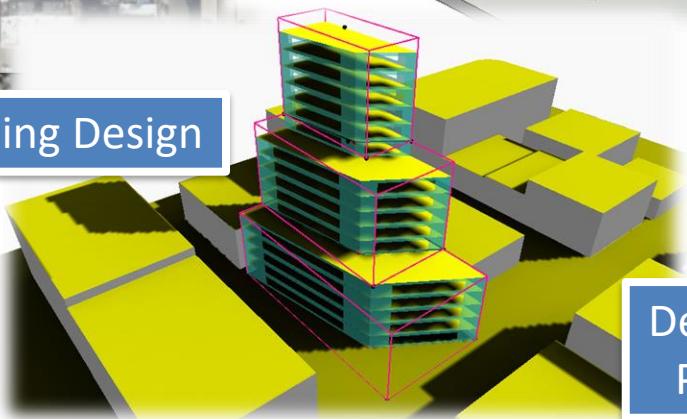
1. Solar Radiation Summary for Building+Site
2. Maximize Solar Exposure on Floors
3. Maximize Solar Exposure on Roofs
4. Minimize Window to Wall Ratio (WWR) per N,S,W,E Facade
5. Maximize Floor Area Ratio (FAR)
6. Calculate Floor Space Index (FSI)

Goals

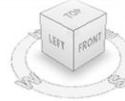
Revit Urban Site Mass



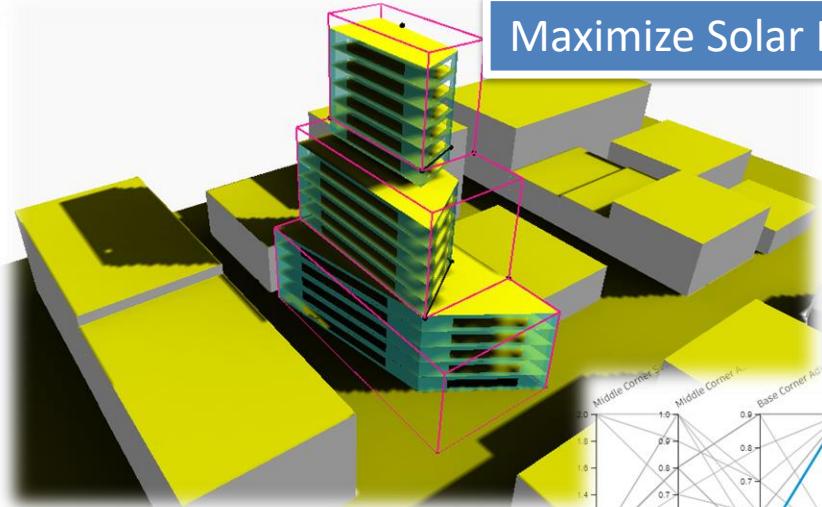
Generative Building Design



Design Constrained by
Parcel/Zoning Mass



Goals

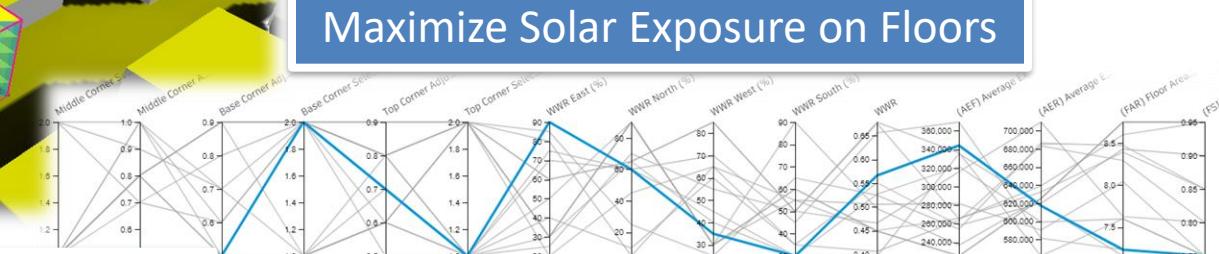


Maximize Solar Exposure on Roofs

Maximize Solar Exposure on Floors

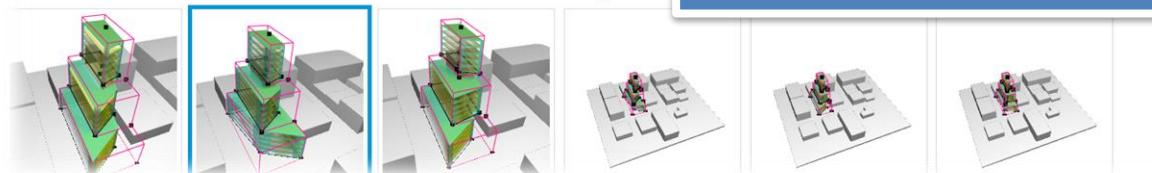
Minimize Window to Wall Ratio

Maximize Floor Area Ratio

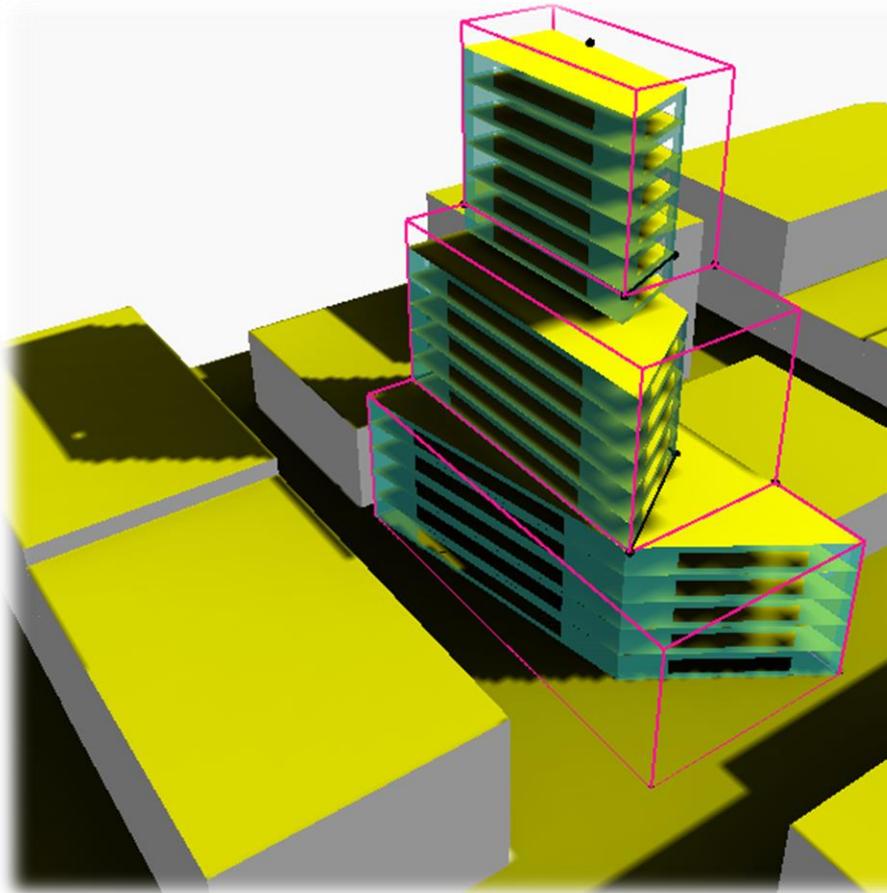


Sort by (AEF) Average Exposure ↑

1 | 2



Dynamo Graph Notes



ThreeSolidTower-04 Solar Analysis

DYNAMO PROJECT

ThreeSolidTower_SolarAnalysis_Final_2PT.dyn
ThreeSolidTower_SolarAnalysis_Final_4PT.dyn

ASSOCIATED FILE(S)

UrbanContextWithPark_2020_Final_1

AUTHOR(S) / CREATION DATE

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November 2019

DESCRIPTION

This example uses site context and a zoning boundary created in Revit to create a generative building form with solar radiation as the key focus. With the building form you can vary different options; parcel and zoning restrictions, floor to floor height, window to wall ratio (WWR), corner distance inputs (building shape), date/time, and more. Outputs include; solar exposure on roof/floors, floor area ratio (FAR), floor space index (FSI), and WWR.

With these metrics established it will help inform us of our goals for minimizing WWR, maximize exposure on floors and roofs, and computing the FAR.

DYNAMO VERSION

2.0.2+

REQUIRED DYNAMO PACKAGES

-Package Manager
Ampersand
Solar Analysis for Dynamo
-Manual Install
Refinery Toolkit for Massing
Refinery Toolkit for Space Planning
<https://github.com/DynamoDS/RefineryToolkits>

ADDITIONAL COMMENTS

N/A

Dynamo Graph Color Key

PINK = INPUTS

INPUT:

Select urban context
from Revit



GRAY = INTERGRATE

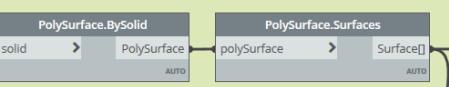
INTEGRATE:

Convert to Dynamo objects



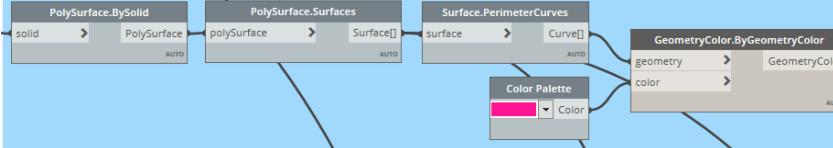
GREEN = EXTRACT

EXTRACT: Site outline



BLUE = DISPLAY

DISPLAY: Color zoning boundary



TEAL = ANALYZE

ANALYZE: Direction of surrounding roofs

This step is an important one in running solar analysis. If the z parameter of surface normals are -1 (meaning they're facing down) the analysis values will be all the same (blank). This if condition evaluates the direction of the surfaces and mirrors them if they're facing downwards.

PURPLE = CREATE

CREATE: Top Tower

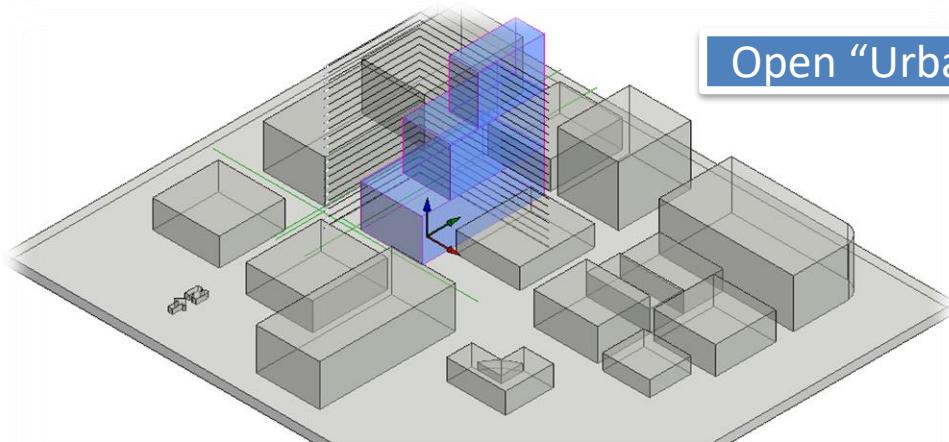


BROWN = OUTPUT

OUTPUT - Floor Area Ratio (FAR)

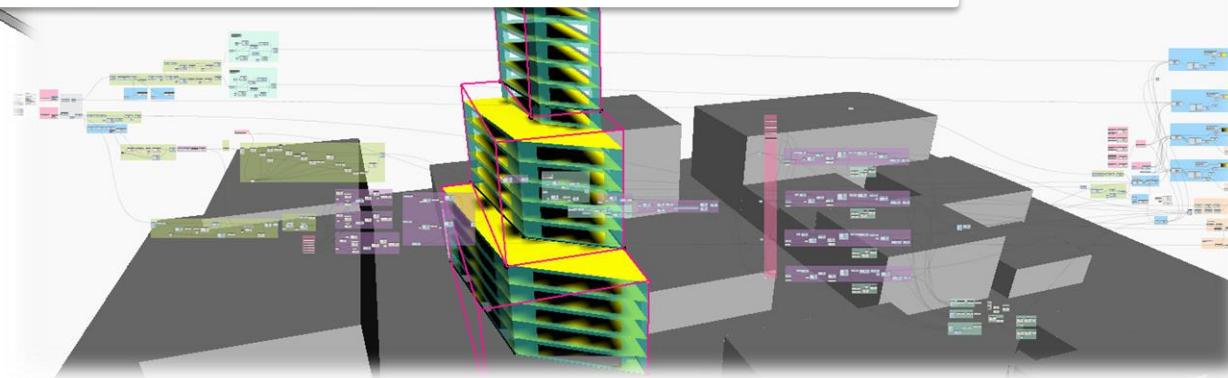


Getting Started



Open “UrbanContextWithPark_2020_Final_I.rvt”

Open “ThreeSolidTower_SolarAnalysis_Final_4PT.dyn” and pick Run

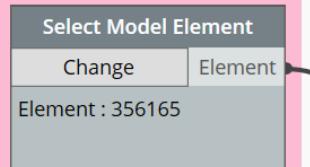


Static Input Options

Use the “Change” buttons to select the appropriate masses

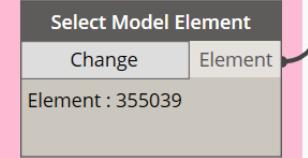
INPUT:
Select urban context
from Revit

Select a Revit mass representing the urban context.



INPUT:
Select site volume from
Revit

Select a Revit mass representing the volumetric
constraints of a site (heights, setbacks, etc)



Static Input Options

Use the “Slider Bar” to select the appropriate height

INPUT: Floor heights

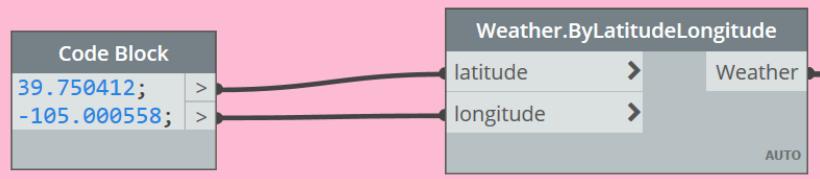


Currently the minimum is set to 10, maximum is set to 16, and is stepping by 1

Static Input Options

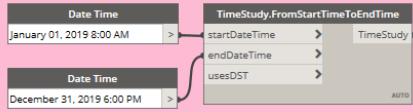
Use the “Code Block” to enter the latitude and longitude of the building location.

INPUT: Set the location -
Denver, CO

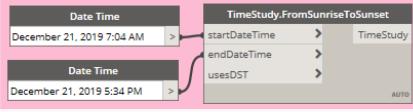


Static Input Options

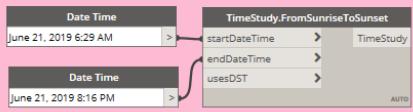
INPUT: Entire Year



INPUT: Winter Solstice



INPUT: Summer Solstice



INPUT: Still: Solstices

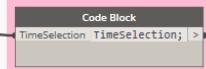


INPUT: Choose Date Time



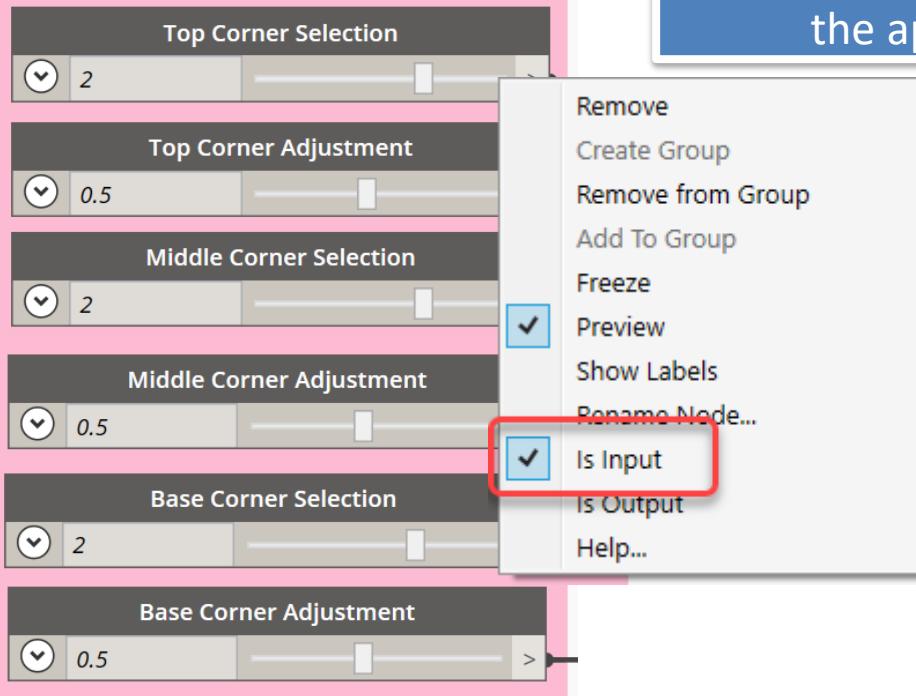
Use the different date/time options when needed. For Generative Design choose the “INPUT: Entire Year”

INPUT: Feed
Date Time Here



Variable Input: “Is Input”

INPUT: Tower corner locations



Note that on the “Variable Inputs” the “Is Input” has been check marked. This is how we tell Generative Design to look at and modify the values. Right-click on the appropriate node to see this option.

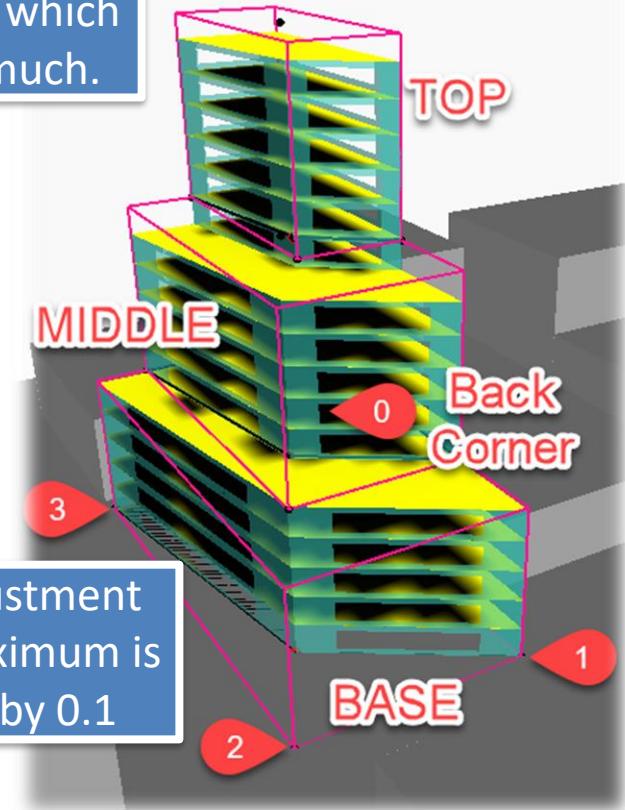
This is the difference between “Static Inputs” and “Variable Inputs.”

Variable Input Options

INPUT: Tower corner locations

Use the “Slider Bars” to select which corner to move and by how much.

Top Corner Selection	<input type="radio"/> 2	<input type="range"/>	>
Top Corner Adjustment	<input type="radio"/> 0.5	<input type="range"/>	>
Middle Corner Selection	<input type="radio"/> 2	<input type="range"/>	>
Middle Corner Adjustment	<input type="radio"/> 0.5	<input type="range"/>	>
Base Corner Selection	<input type="radio"/> 2	<input type="range"/>	>
Base Corner Adjustment	<input type="radio"/> 0.5	<input type="range"/>	>



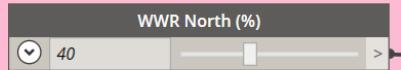
Currently the Corner Adjustment minimum is set to 0.1, maximum is set to 1, and is stepping by 0.1

Variable Input Options

INPUT:
WWR

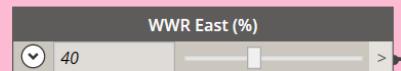
WWR North (%)

40



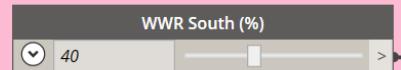
WWR East (%)

40



WWR South (%)

40



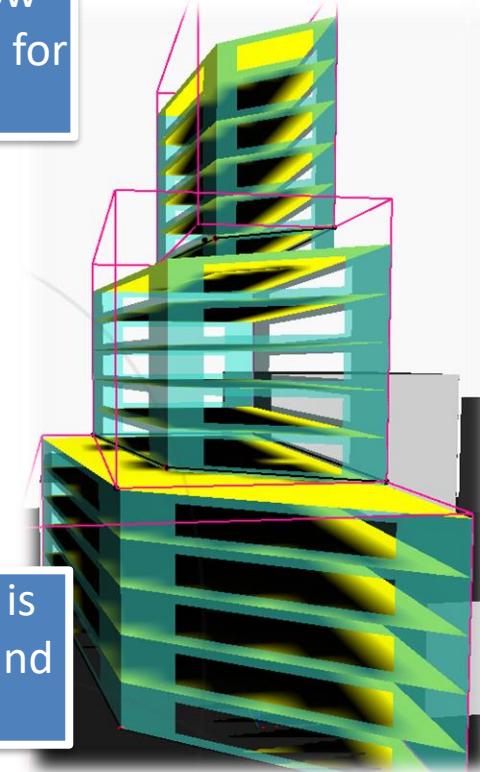
WWR West (%)

40



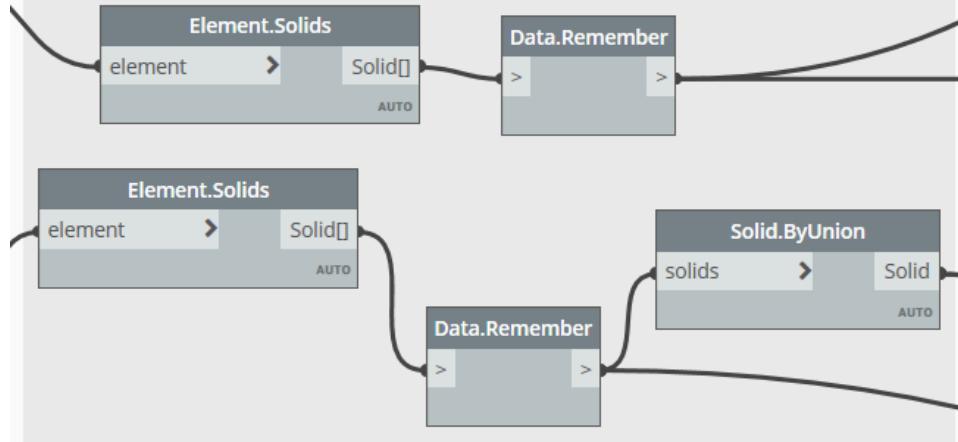
Use the “Slider Bars” to select how much window to wall ratio (WWR) for each side of the building.

Currently each WWR minimum is set to 5, maximum is set to 95, and is stepping by 5



Data.Remember Node

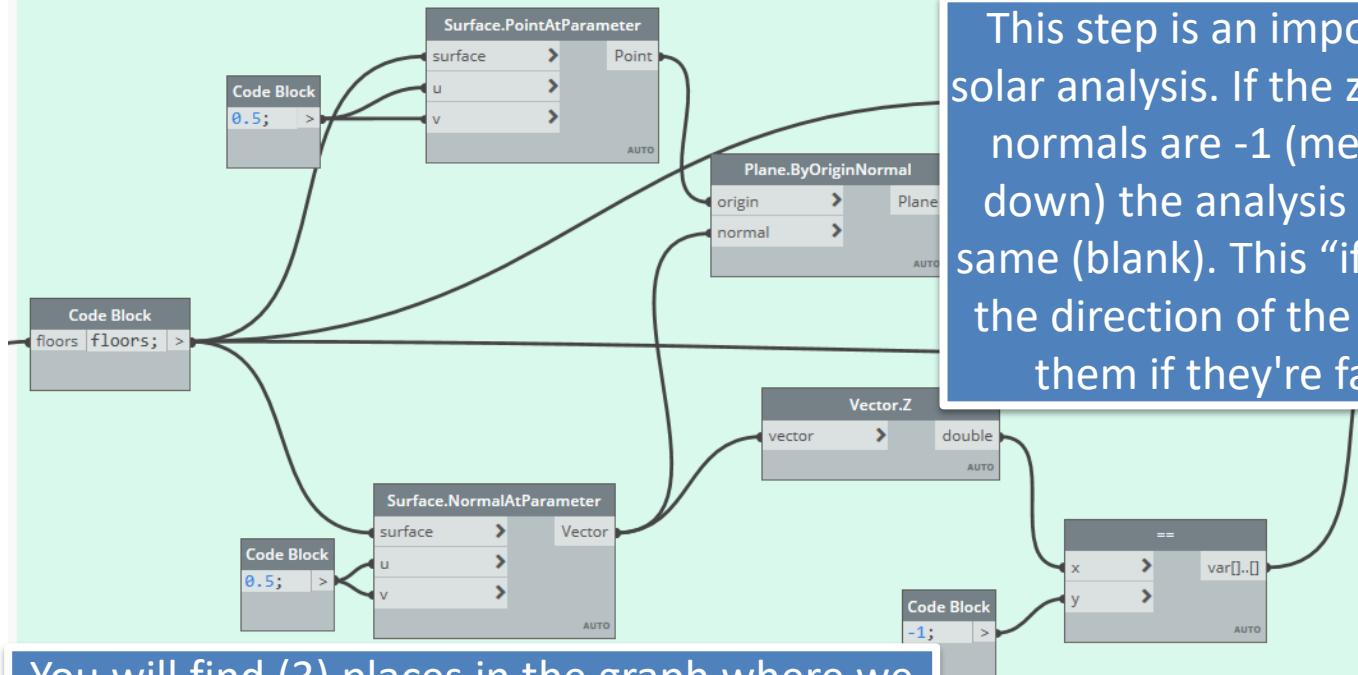
INTEGRATE:
Convert to Dynamo objects



Note the multiple “Data.Remember” nodes in the graph, these are needed to cache Revit data.

Solar Analysis: Surface Normal

ANALYZE: Direction of surrounding roofs



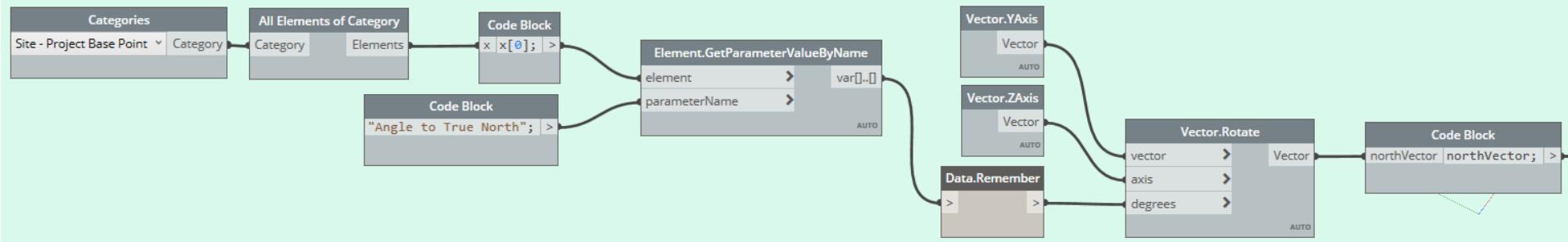
This step is an important when running solar analysis. If the z parameter of surface normals are -1 (meaning they're facing down) the analysis values will be all the same (blank). This "if" condition evaluates the direction of the surfaces and mirrors them if they're facing downwards.

You will find (3) places in the graph where we have to do this; roofs, ground plane, and floors

Find North, South, West, East

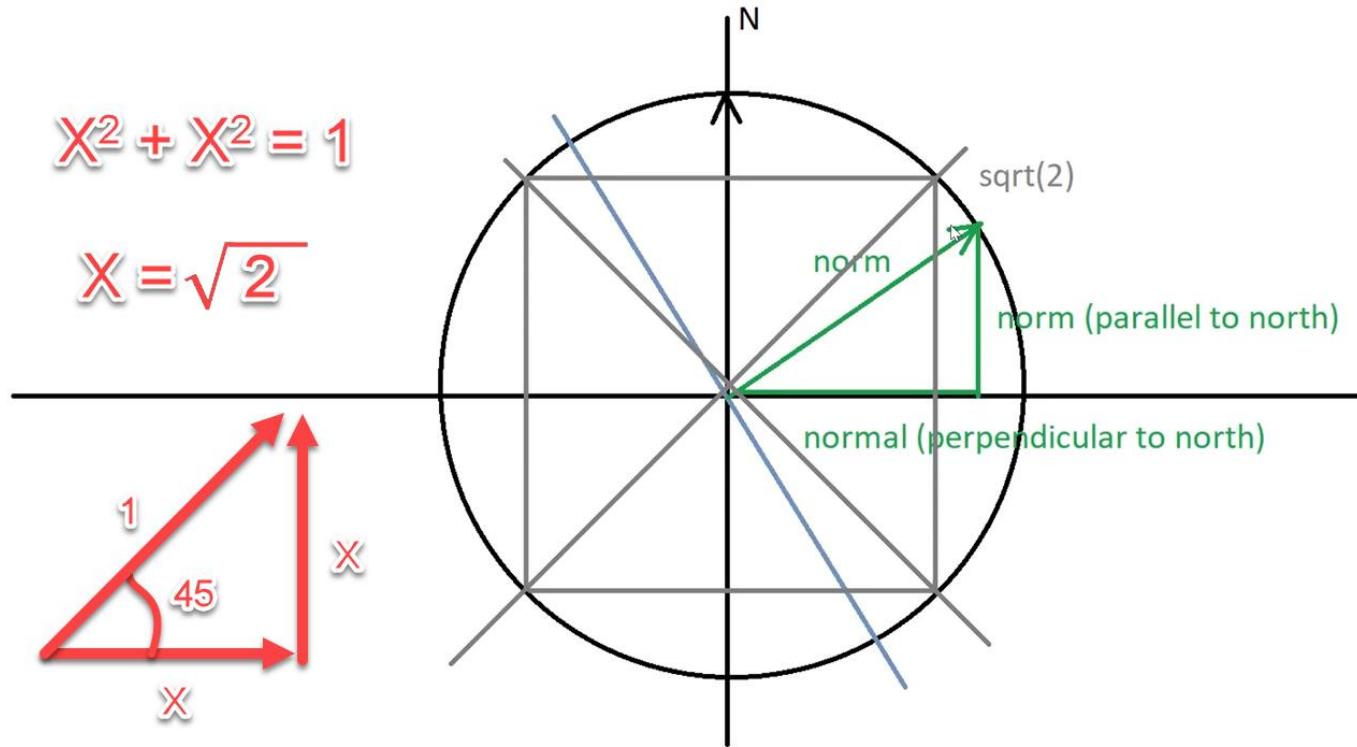
For the window to wall ratio (WWR) we had to analyze and define where north, south, west, and east was from the Revit model.

ANALYZE: Finding the north vector from revit



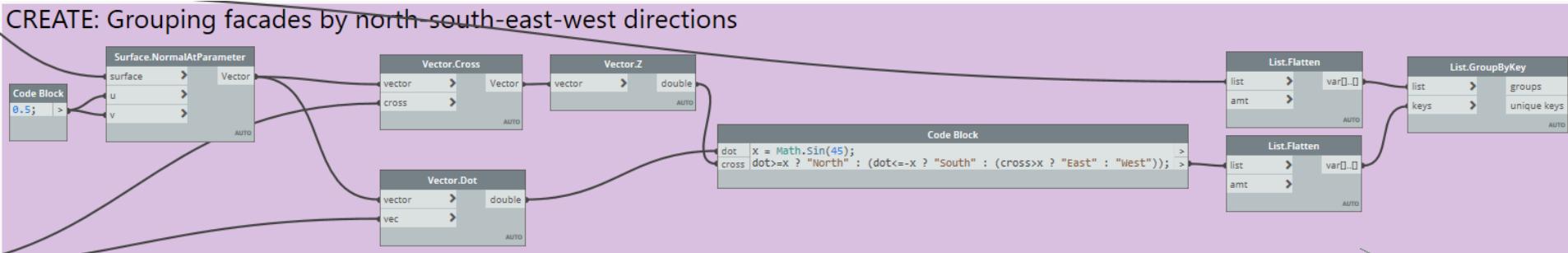
Grouping Facades for WWR

Using some math and a code block we were able to define and group each façade into north, south, west, and east for WWR.



Grouping Facades for WWR

The key is the code block to bring this together once we found where north was in the Revit model.

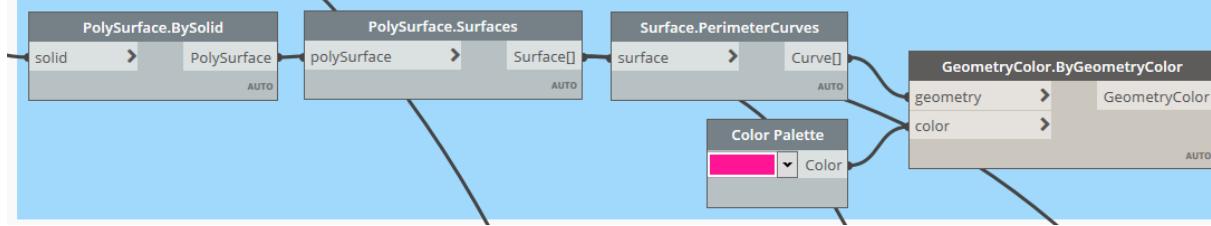


```
x = Math.Sin(45);
dot>=x ? "North" : (dot<=-x ? "South" : (cross>x ? "East" : "West"));
```

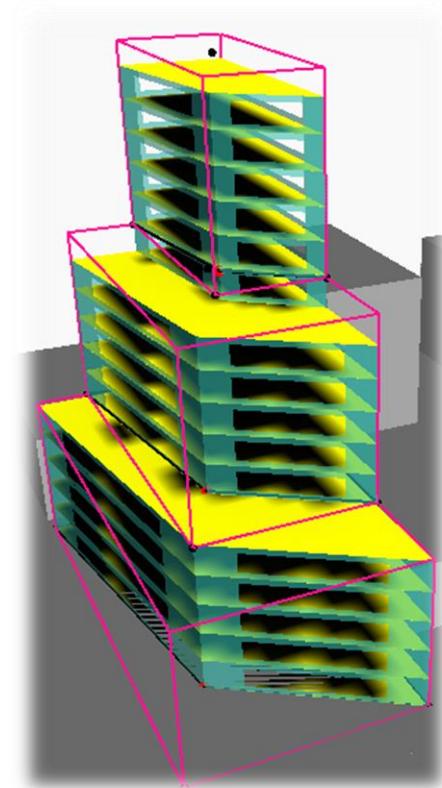
Parcel/Zoning Boundary

Note that the boundary representing the parcel area and zoning heights has a magenta color which can be changed

DISPLAY: Color zoning boundary

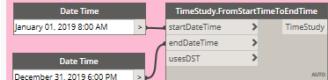


You will find several “Display” groups where you have control on display color



Solar Radiation: Site Study

INPUT: Entire Year



INPUT: Winter Solstice



INPUT: Summer Solstice



INPUT: Still: Solstices

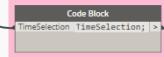


INPUT: Choose Date Time

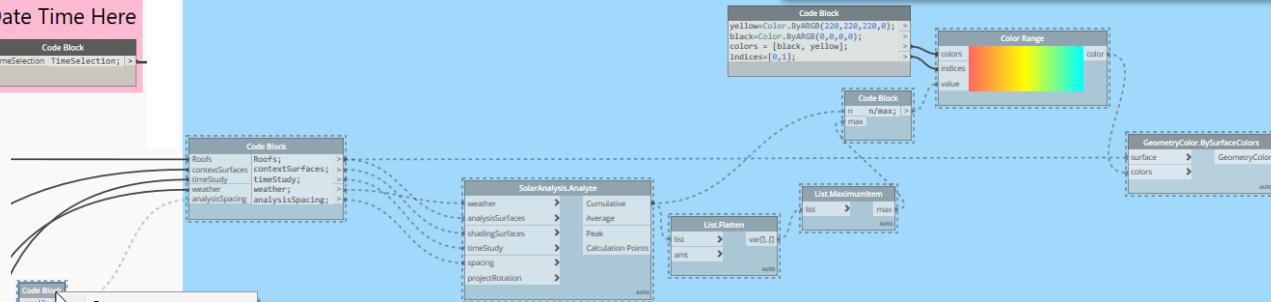


By default the Date/Time Input is set to "Entire Year" for Generative Design Analysis.

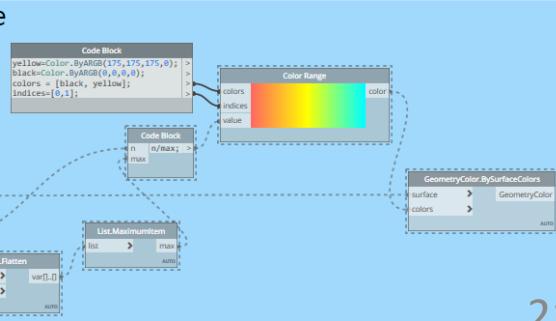
INPUT: Feed Date Time Here



DISPLAY: Solar analysis on site roof planes



DISPLAY: Solar analysis on site ground plane

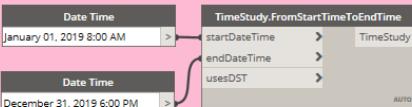


Right-click on the "Code Block" to uncheck "Freeze" and then run the graph again to see the new results

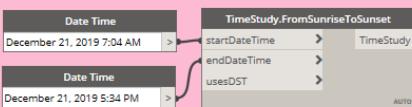
There are other options where you might want to do a "single" run inside Dynamo to see how the surrounding buildings are being affected.

Solar Radiation: Site Study

Entire Year



Winter Solstice



Summer Solstice



Still: Solstices

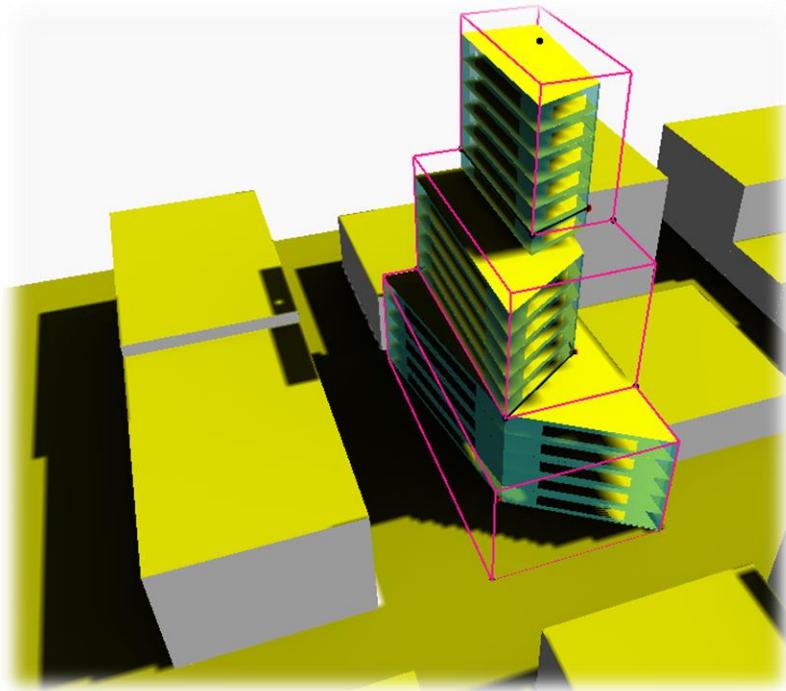


Choose Date Time



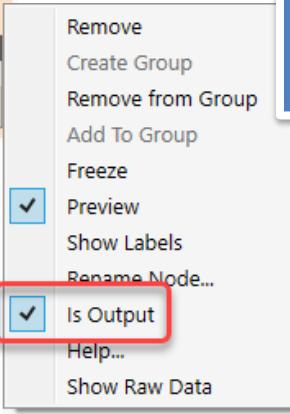
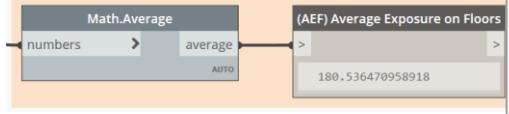
Using the previous slide as a basis and once you have a Generative Design “Optimized” this might be a good place to use the other date & time options to check site conditions.

Feed Date Time Here



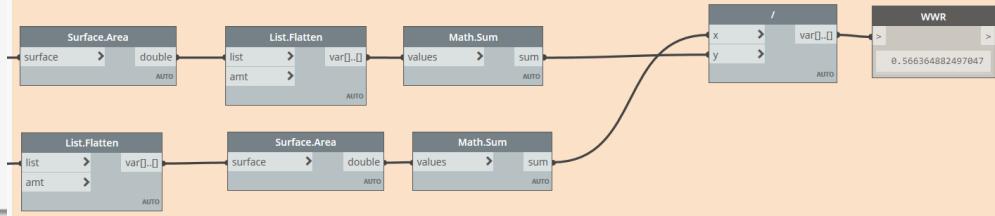
Outputs for Generative Design

OUTPUT - Exposure on Floors

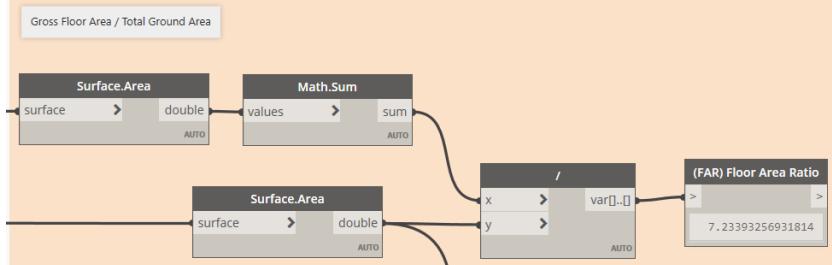


There are several Outputs that we are using to help us analyze the results. For Generative Design to see these you need to choose the option “Is Output”. Right-click on the node to get to this option.

OUTPUT - Compute Window to Wall Ratio for Entire Building



OUTPUT - Floor Area Ratio (FAR)

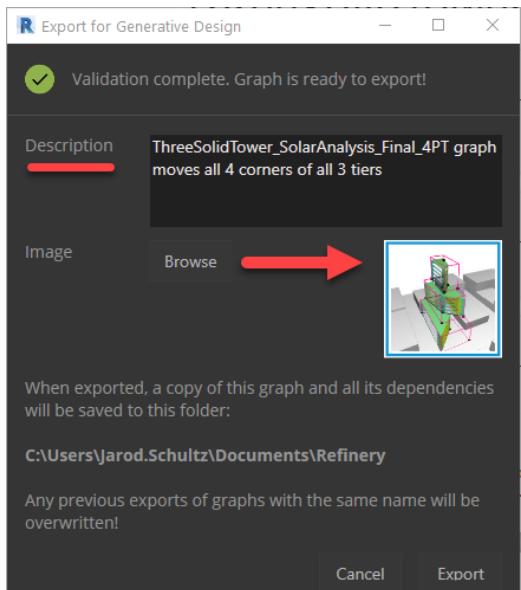
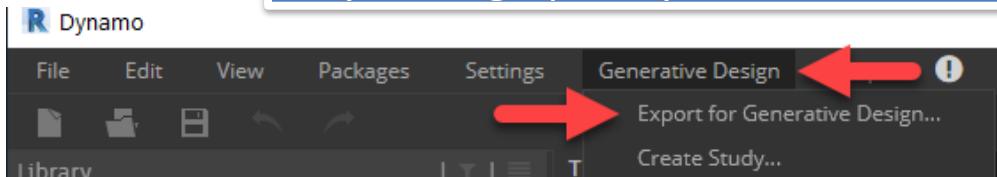


OUTPUT - Floor Space Index (FSI)

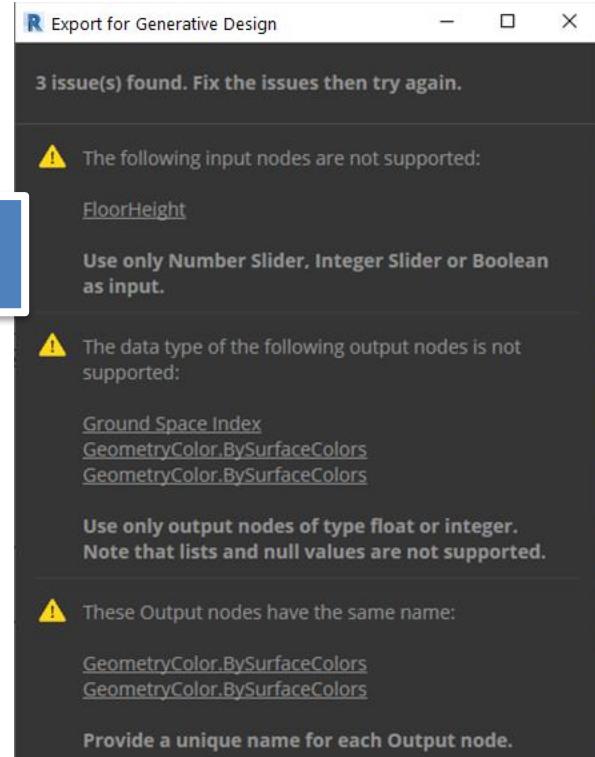
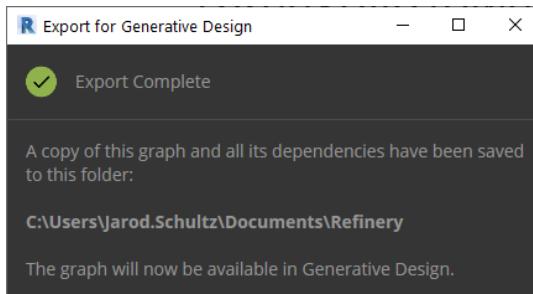


Export for Generative Design

On the Generative Design drop-down you need to “Export” the Dynamo graph. If you haven’t “Run” the graph it will tell you.



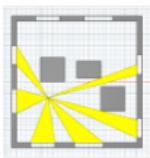
Any “Errors” will
need to be fixed.



Create New Generative Design Study

Choose “Create Study” and select your exported Dynamo graph.

Create Study



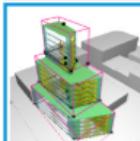
Maximize Window Views

Generates various viewpoints. Calculates scores that represent the quality of views to the outside from those points.



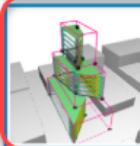
Three Box Massing

Generates simple massing models by varying the heights and relative positions of three boxes. Calculates surface area and volume.



ThreeSolidTower_SolarAnalysis...

ThreeSolidTower_SolarAnalysis_Final_2PT graph moves only the south 2 corners of all 3 tiers



ThreeSolidTower_SolarAnalysis...

ThreeSolidTower_SolarAnalysis_Final_4PT graph lets all 4 corners of all 3 tiers move



Workspace Layout

Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.

Select Optimize from the drop-down.

Create Study ThreeSolidTower_SolarAnalysis_Final_4PT

Study Name

Method

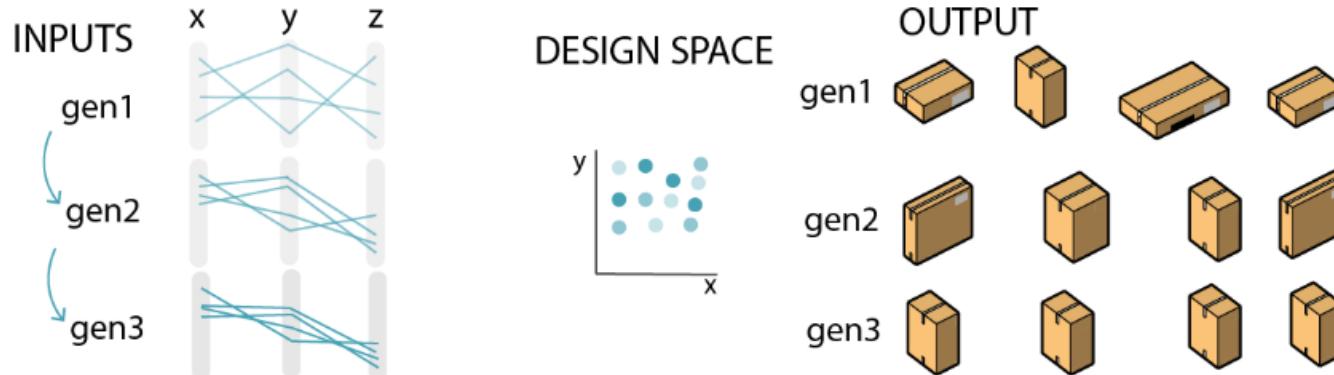
Which inputs should vary?

<input checked="" type="checkbox"/> Middle Corner Selection	0 to 3
<input checked="" type="checkbox"/> Middle Corner Adjustment	0.1 to 1
<input checked="" type="checkbox"/> Base Corner Adjustment	0.1 to 1
<input checked="" type="checkbox"/> Base Corner Selection	0 to 3
<input checked="" type="checkbox"/> Top Corner Adjustment	0.1 to 1
<input checked="" type="checkbox"/> Top Corner Selection	0 to 3
<input checked="" type="checkbox"/> WWR East (%)	5 to 95
<input checked="" type="checkbox"/> WWR North (%)	5 to 95
<input checked="" type="checkbox"/> WWR West (%)	5 to 95
<input checked="" type="checkbox"/> WWR South (%)	5 to 95

Optimize Method

Throughout this workflow we are focused on the “Optimize” method for our Generative Design study to help us find the best building design that maximum indoor daylight and PV potential.

During an optimization of a Generative Design study it will evolve the design based on the evaluator's outputs. The optimization process works by running multiple generations of a design, each generation will use the input configuration from previous generations, and from that, optimize the new design options.



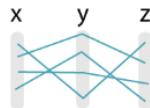
Generative Design is using the NSGA-II algorithm
https://www.youtube.com/watch?v=SL-u_7hlqjA

Other Methods

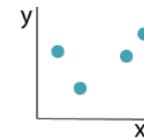
Even though we used optimized for our method you might want to also experiment with;
“Randomize”, “Cross Product,” and “Like This.”

Randomize

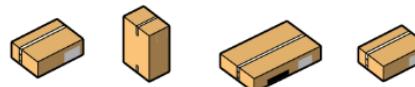
INPUTS



DESIGN SPACE

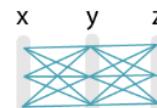


OUTPUT

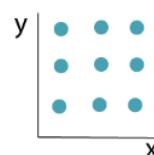


Cross Product

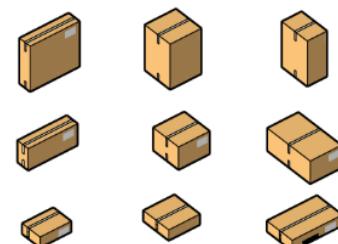
INPUTS



DESIGN SPACE



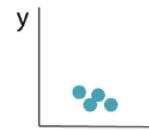
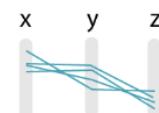
OUTPUT



INPUTS

DESIGN SPACE

OUTPUT



Like This

Learn More: <http://tinyurl.com/s5q5kzg>

Which Inputs should Vary

Note the “Variable Inputs” are listed and showing the values that were set for minimum and maximum in the node.

Create Study ThreeSolidTower_SolarAnalysis_Final_4PT

Study Name

Method

Which inputs should vary?

<input checked="" type="checkbox"/> Middle Corner Selection	0 to 3
<input checked="" type="checkbox"/> Middle Corner Adjustment	0.1 to 1
<input checked="" type="checkbox"/> Base Corner Adjustment	0.1 to 1
<input checked="" type="checkbox"/> Base Corner Selection	0 to 3
<input checked="" type="checkbox"/> Top Corner Adjustment	0.1 to 1
<input checked="" type="checkbox"/> Top Corner Selection	0 to 3
<input checked="" type="checkbox"/> WWR East (%)	5 to 95
<input checked="" type="checkbox"/> WWR North (%)	5 to 95
<input checked="" type="checkbox"/> WWR West (%)	5 to 95
<input checked="" type="checkbox"/> WWR South (%)	5 to 95

For this run we will leave all of them selected.

What are the Goals

Note the “Outputs” are listed and Generative Design is asking which ones need to be considered as a goal.

Which outputs should be used as goals?

- WWR
 - Minimize
 - Maximize
- (AEF) Average Exposure on Floors
 - Minimize
 - Maximize
- (AER) Average Exposure on Roof
 - Minimize
 - Maximize
- (FAR) Floor Area Ratio
 - Minimize
 - Maximize
- (FSI) Floor Space Index

For this run change the options to what you see here. Even though FSI is not checked it will still be analyzed and the output values calculated.

Any Outputs need to be Constrained

If the initial minimum and maximum values from the nodes need to be constrained further, you can make this adjustment here.

Which outputs should be constrained?

- WWR
- (AEF) Average Exposure on Floors
- (AER) Average Exposure on Roof
- (FAR) Floor Area Ratio
- (FSI) Floor Space Index

For this run we are leaving all of them unchecked.

Generation Settings

We need to set the Population Size, Generations, and Seed.

For the first run use these settings so it gives you multiple options but finishes quickly.

Generation Settings

Population Size	<input type="text" value="8"/>
Generations	<input type="text" value="4"/>
Seed	<input type="text" value="1"/>

Issues

No issues. Ready to generate results!

- Population Size: represents the number of options that will be created in each generation.
- Generations: Each new generation is a range of options that falls between the two best designs of the previous generation
- Seed number initializes the randomization. It doesn't add 'more' randomness, it just starts the randomness differently each time you change the number

Choose “Generate” to start the process.

Generative Design Interface

1 Note “AEF” on the graph and the corresponding first option is currently selected.

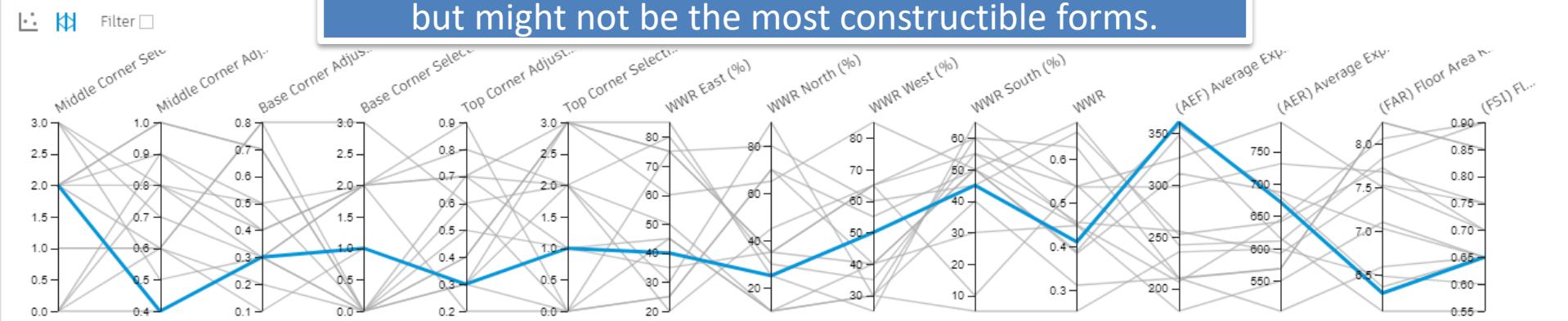
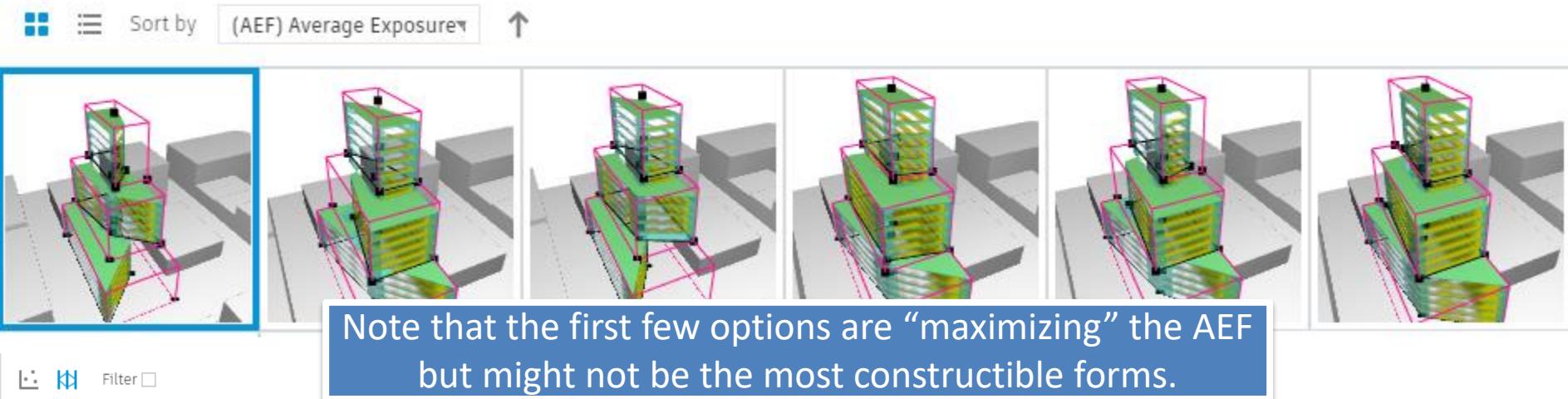
2 Switch the output to “Parallel Coordinates”

3 For this example we want to focus on “Average Exposure of Floor” (AEF) so change the “Sort By” option.

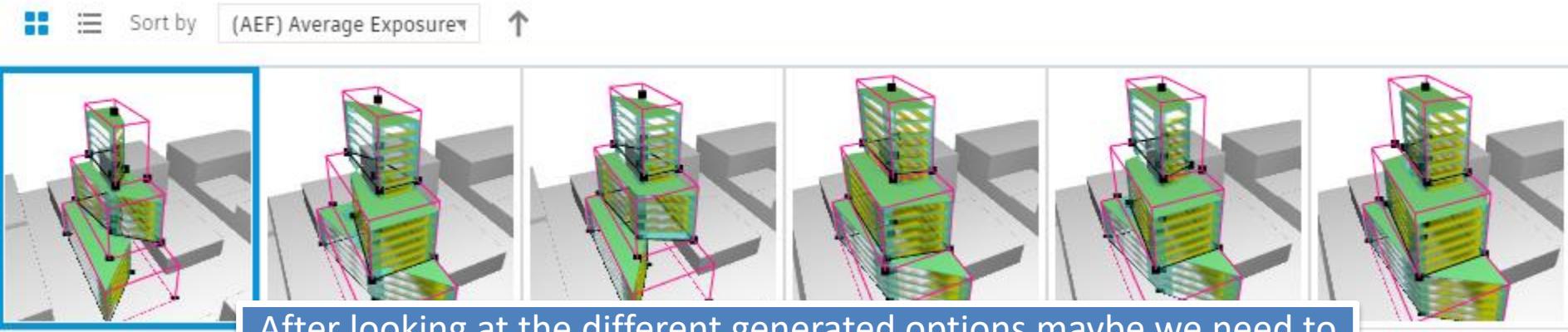
The screenshot shows the Generative Design interface with the following details:

- Studies:** A list of studies including "ThreeSolidTower_SolarAnalysis_Final_4PT 001" (selected), "ThreeSolidTower_SolarAnalysis_Final_4PT 002", and "ThreeSolidTower_SolarAnalysis_Final_4PT 003".
- Sort by:** The dropdown is set to "(AEF) Average Exposure".
- Parallel Coordinates Plot:** Shows relationships between various parameters like Middle Corner Selection, WWR, and AEF.
- Detailed Study View:** Shows "ThreeSolidTower_SolarAnalysis_Final_4PT 001" with a 3D model, a 2D floor plan, and a table of outputs and inputs.

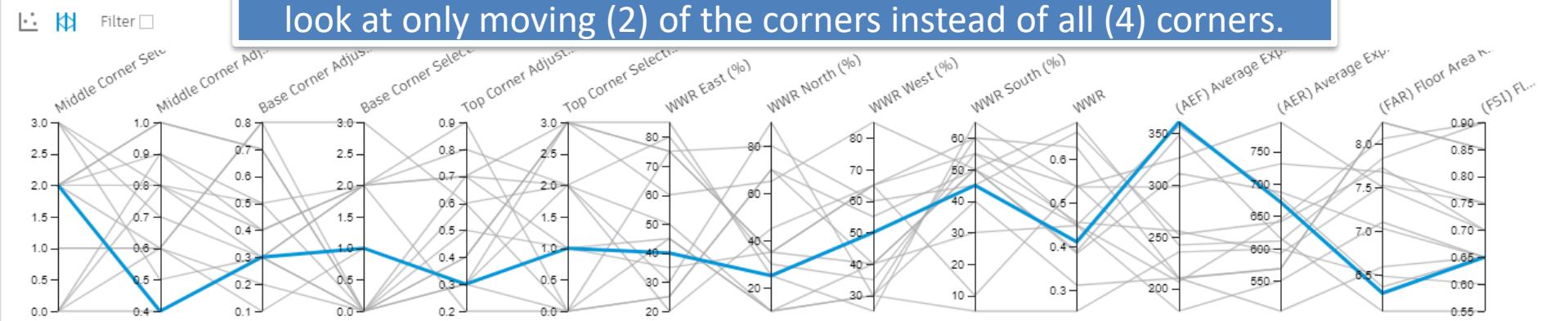
Generative Design Options



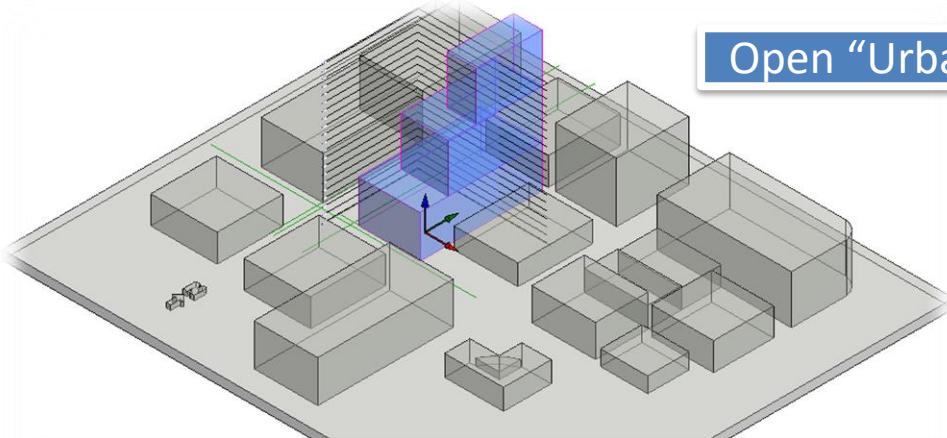
Generative Design Options



After looking at the different generated options maybe we need to look at only moving (2) of the corners instead of all (4) corners.

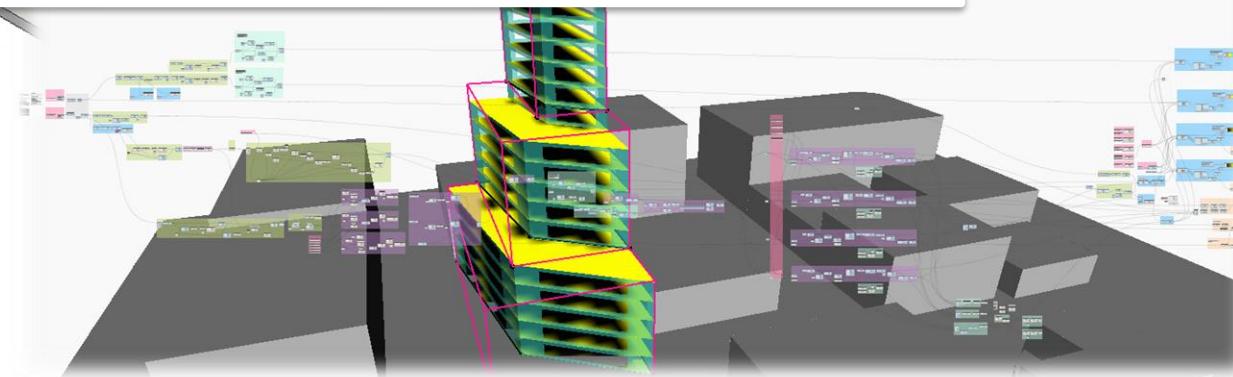


Next Sequence



Open “UrbanContextWithPark_2020_Final_1.rvt”

Open “ThreeSolidTower_SolarAnalysis_Final_2PT.dyn” and pick Run



Export to Generative Design

Like before, on the Generative Design drop-down you need to “Export” the Dynamo graph. If you haven’t “Run” the graph it will tell you.

The screenshot illustrates the process of exporting a Dynamo graph to Generative Design. It shows the Dynamo ribbon with the 'Generative Design' tab selected, and a red arrow pointing to the 'Export for Generative Design...' option. Below, a 'Library' window shows validation results and an image preview, with a red arrow pointing to the 'Browse' button. A central callout box states: "Any ‘Errors’ will need to be fixed." To the right, the 'Export for Generative Design' dialog box displays error messages related to unsupported input and output node types, as well as duplicate output node names. The bottom part of the dialog shows a summary of the export completion and the path where the graph was saved.

Dynamo

File Edit View Packages Settings Generative Design

Export for Generative Design...

Create Study...

R Export for Generative Design

Validation complete. Graph is ready to export!

Description

ThreeSolidTower_SolarAnalysis_Final_2PT graph moves only the south 2 corners of all 3 tiers

Image

Browse

When exported, a copy of this graph and all its dependencies will be saved to this folder:
C:\Users\Jarod.Schultz\Documents\Refinery

Any previous exports of graphs with the same name will be overwritten!

Cancel Export

Any “Errors” will need to be fixed.

R Export for Generative Design

3 issue(s) found. Fix the issues then try again.

⚠ The following input nodes are not supported:
FloorHeight
Use only Number Slider, Integer Slider or Boolean as input.

⚠ The data type of the following output nodes is not supported:
Ground Space Index
GeometryColor.BySurfaceColors
GeometryColor.BySurfaceColors
Use only output nodes of type float or integer.
Note that lists and null values are not supported.

⚠ These Output nodes have the same name:
GeometryColor.BySurfaceColors
GeometryColor.BySurfaceColors
Provide a unique name for each Output node.

R Export for Generative Design

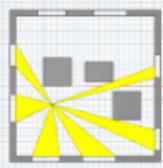
Export Complete

A copy of this graph and all its dependencies have been saved to this folder:
C:\Users\Jarod.Schultz\Documents\Refinery

The graph will now be available in Generative Design.

Run New Generative Design Study

Create Study



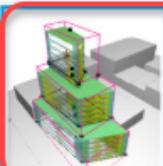
Maximize Window Views

Generates various viewpoints. Calculates scores that represent the quality of views to the outside from those points.



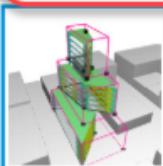
Three Box Massing

Generates simple massing models by varying the heights and relative positions of three boxes. Calculates surface area and volume.



ThreeSolidTower_SolarAnalysis_2PT

ThreeSolidTower_SolarAnalysis_Final_2PT graph moves only the south 2 corners of all 3 tiers



ThreeSolidTower_SolarAnalysis_4PT

ThreeSolidTower_SolarAnalysis_Final_4PT graph lets all 4 corners of all 3 tiers move



Workspace Layout

Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.

Choose “Create Study” and select your exported Dynamo graph.

Create Study

ThreeSolidTower_SolarAnalysis_Final_2PT

Study Name

ThreeSolidTower_SolarAnalysis_Final_2PT 002

Method

Optimize

Which inputs should vary?

<input checked="" type="checkbox"/> Middle Corner Selection	1 to 2
<input checked="" type="checkbox"/> Middle Corner Adjustment	0.5 to 1
<input checked="" type="checkbox"/> Base Corner Adjustment	0.5 to 1
<input checked="" type="checkbox"/> Base Corner Selection	1 to 2
<input checked="" type="checkbox"/> Top Corner Adjustment	0.5 to 1
<input checked="" type="checkbox"/> Top Corner Selection	1 to 2
<input checked="" type="checkbox"/> WWR East (%)	5 to 95
<input checked="" type="checkbox"/> WWR North (%)	5 to 95
<input checked="" type="checkbox"/> WWR West (%)	5 to 95
<input checked="" type="checkbox"/> WWR South (%)	5 to 95

Select Optimize from the drop-down.

Note the “Corner Selection” is showing (2) options instead of the (4) as before. We also changed the “Adjustment” limits.

For this run we will leave all of them selected.

What are the Goals

Note the “Outputs” are listed and Generative Design is asking which ones need to be considered as a goal.

Which outputs should be used as goals?

- WWR
 - Minimize
 - Maximize
- (AEF) Average Exposure on Floors
 - Minimize
 - Maximize
- (AER) Average Exposure on Roof
 - Minimize
 - Maximize
- (FAR) Floor Area Ratio
 - Minimize
 - Maximize
- (FSI) Floor Space Index

For this run change the options to what you see here. Even though FSI is not checked it will still be analyzed and the output values calculated.

Generation Settings

- Population Size: 8
- Generations: 4
- Seed: 1

Issues

No issues. Ready to generate results!

Cancel Generate

For the first run use these settings so it gives you multiple options but finishes quickly.

Choose “Generate” to start the process.

Generative Design Interface

1 Note “AEF” on the graph and the corresponding first option is currently selected.

Switch the output to “Parallel Coordinates”

2

3

For this example we want to focus on “Average Exposure of Floor” (AEF) so change the “Sort By” option.

Generative Design

Studies to show All

Studies: ThreeSolidTower_SolarAnalysis_Final_4PT 001, ThreeSolidTower_SolarAnalysis_Final_4PT 002, ThreeSolidTower_SolarAnalysis_Final_4PT 003, ThreeSolidTower_SolarAnalysis_Final_4PT 004

Dec 12, 2019, 10:37 AM 4/4 ✓

ThreeSolidTower_SolarAnalysis_Final_4PT 001, ThreeSolidTower_SolarAnalysis_Final_4PT 002, ThreeSolidTower_SolarAnalysis_Final_4PT 003, ThreeSolidTower_SolarAnalysis_Final_4PT 004

Dec 12, 2019, 10:19 AM 4/4 ✓

ThreeSolidTower_SolarAnalysis_Final_4PT 001

Sort by (AEF) Average Exposure ↑

Outputs

WWR	0.410
(AEF) Average Exposure on Floors	360.752
(AER) Average Exposure on Roof	671.454
(FAR) Floor Area Ratio	6.286
(FSI) Floor Space Index	0.650

Inputs

Middle Corner Selection	2
Middle Corner Adjustment	0.400
Base Corner Selection	0.300
Base Corner Adjustment	1
Top Corner Selection	0.300
Top Corner Adjustment	1
WWR East (%)	40
WWR North (%)	25
WWR West (%)	50
WWR South (%)	45
(AEF) Average Exposure	350
(AER) Average Exposure	750
(FAR) Floor Area Ratio	0.90
(FSI) Floor Space Index	0.60

Create Study

4 of 4

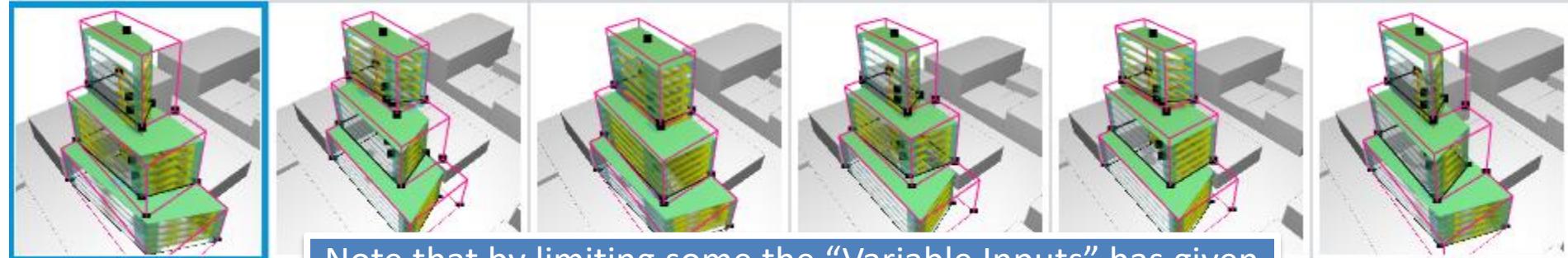
Open in Dynamo

39 A

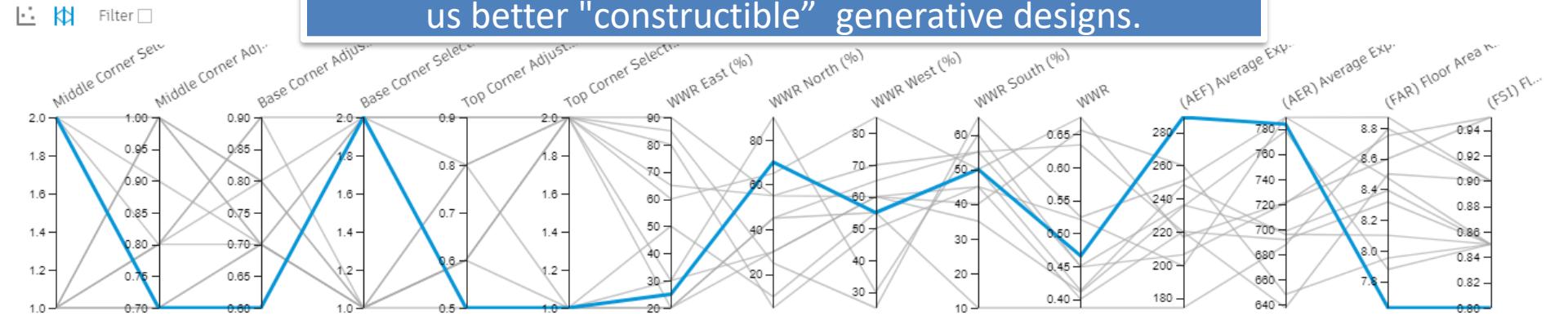
Generative Design Options



Sort by
(AEF) Average Exposure



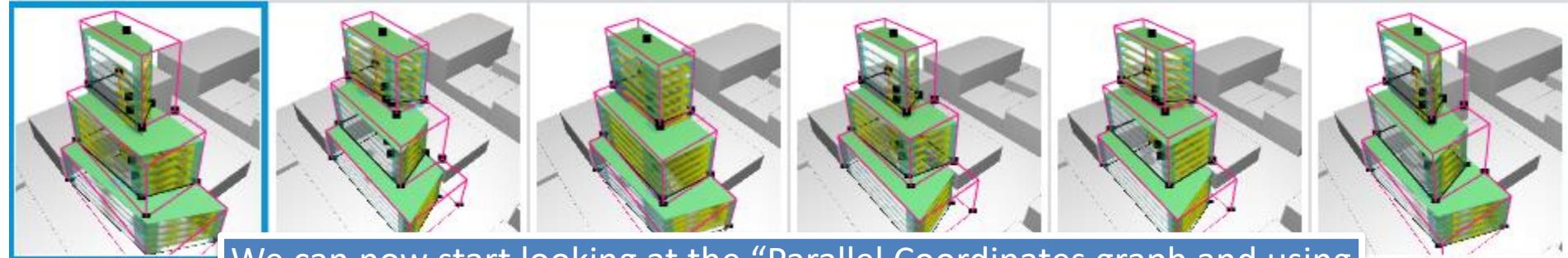
Note that by limiting some the “Variable Inputs” has given us better “constructible” generative designs.



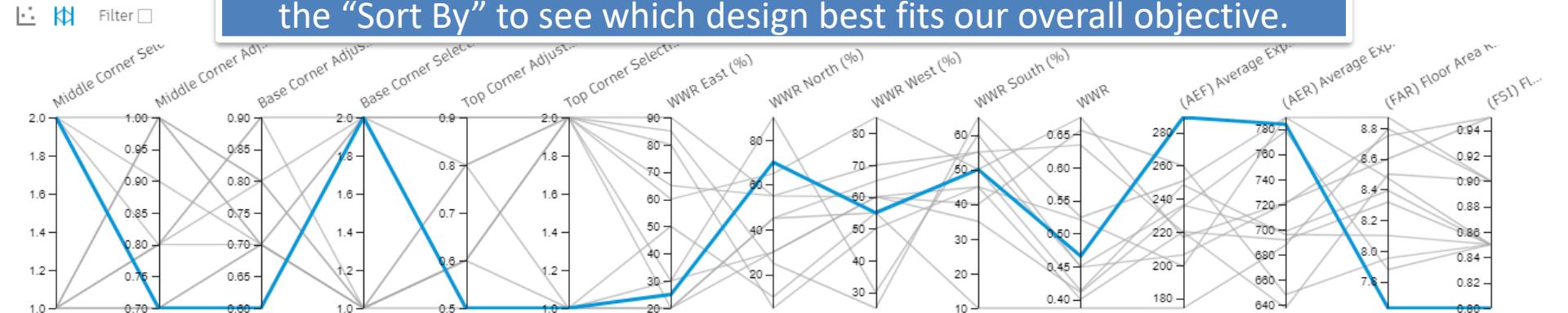
Generative Design Options

Sort by

(AEF) Average Exposure

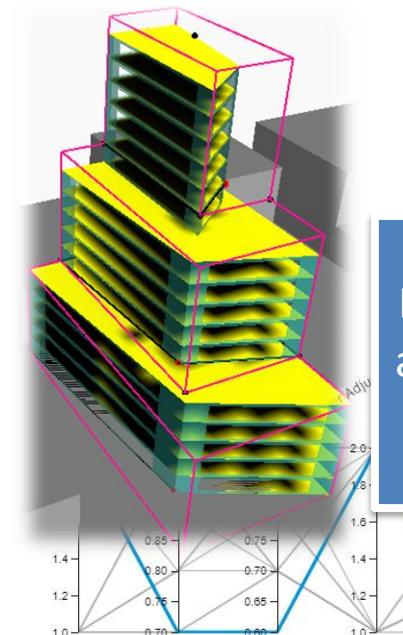
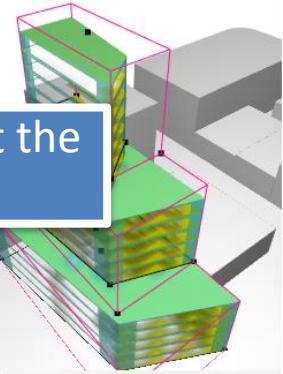


We can now start looking at the “Parallel Coordinates graph and using the “Sort By” to see which design best fits our overall objective.



Generative Design back to Dynamo

Once you decide on a design option you can use the “Open in Dynamo” button at the bottom right to export those “unique” settings back into Dynamo to save it.



It might ask about opening the Dynamo graph if it isn't current and you will need to use Run to see the new updates to the model in Dynamo.

Studies

Studies to show All

ThreeSolidTower_SolarAnalysis_Final_2PT 001

Sort by (AEF) Average Exposure ↑

ThreeSolidTower_SolarAnalysis_Fin...
ThreeSolidTower_SolarAnalysis_Final...
Dec 12, 2019, 10:37 AM 4/4 ✓

Outputs

WWR	0.466
(AEF) Average Exposure on Floors	289.039
(AER) Average Exposure on Roof	783.752
(FAR) Floor Area Ratio	7.627
(FSI) Floor Space Index	0.800

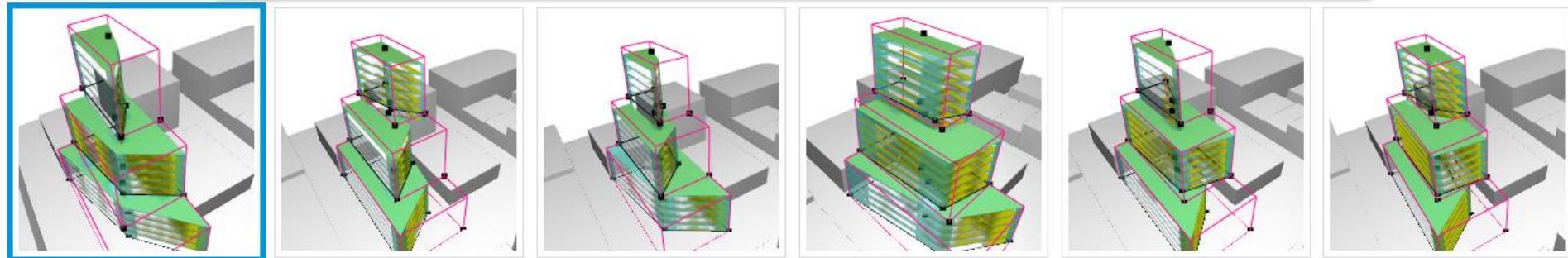
Inputs

Middle Corner Selection	2
Middle Corner Adjustment	0.700
Base Corner Adjustment	0.600
Base Corner Selection	2
Top Corner Adjustment	0.500
Top Corner Selection	1
WWR East (%)	25
WWR North (%)	70
WWR West (%)	55
WWR South (%)	50

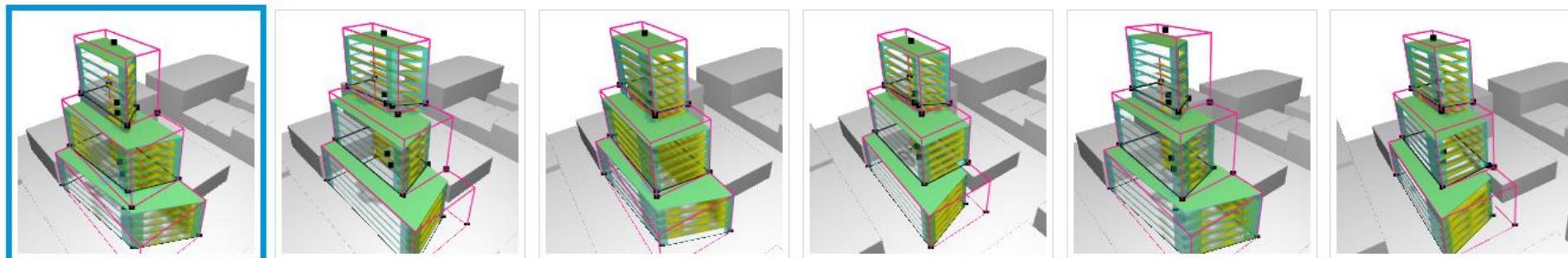
Open in Dynamo

Note that we did change the limit for the Corner Adjustment and below are examples of the differences that we discovered

Corner Adjustment with minimum set to 0.1 and maximum set to 1.0



Corner Adjustment with minimum set to 0.5 and maximum set to 1.0



Additional Learning Resources

- Getting Started with Dynamo:
 - <https://primer.dynamobim.org/>
- Dynamo Questions, inspiration:
 - <https://forum.dynamobim.com/>
- Design Script:
 - https://dynamobim.org/wp-content/uploads/forum-assets/colin-mccroneautodesk-com/07/10/Dynamo_language_guide_version_1.pdf
 - http://designscript.io/DesignScript_user_manual_0.1.pdf
 - <https://github.com/Amoursol/dynamoDesignScript>
- Refinery Sites:
 - <https://www.autodesk.com/solutions/refinery-beta>
 - <https://refineryprimer.dynamobim.org/>
- Generative Design education:
 - <https://medium.com/generative-design>



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