

Generative Design for HVAC System Selection

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The Challenge

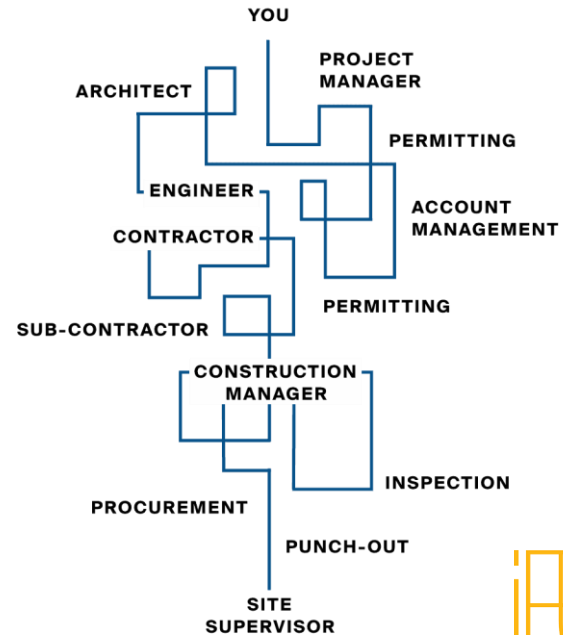
iBuilt Start Up

iBUILT

Rethinking Construction

CONVENTIONAL
DEVELOPMENT

iBUILT
DEVELOPMENT



iBUILT



Rethinking Construction – HVAC Goals

iBUILT
DEVELOPMENT

you

iBUILT

- 1. Procumbent First**
- 2. Easy Installation**
- 3. Cheap**
- 4. One Size Fits All**
- 5. Beautiful**

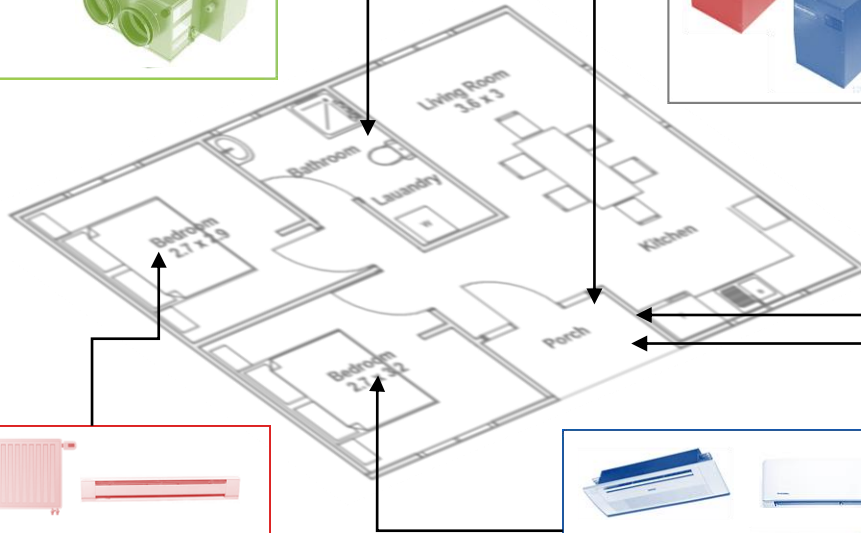
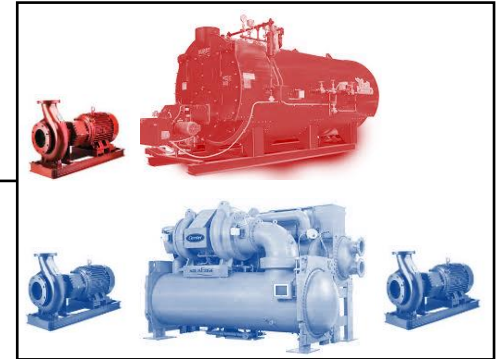
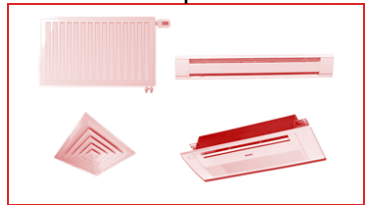


Universe of Alternatives HVAC System

- All Alternatives
- No Rules Of Thumb
- Calculate Cost
- Calculate Space Requirements



iBuild - Rethinking Construction



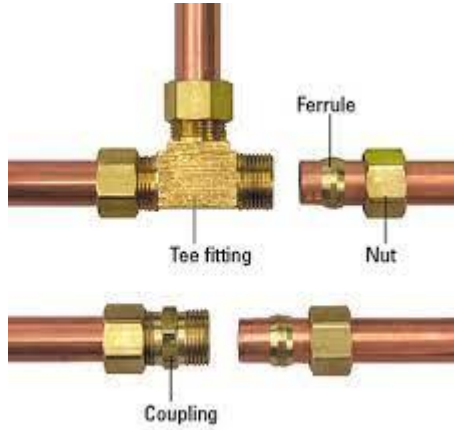
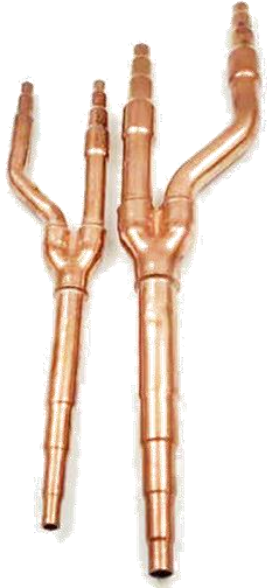
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HVAC Alternatives -Infrastructure



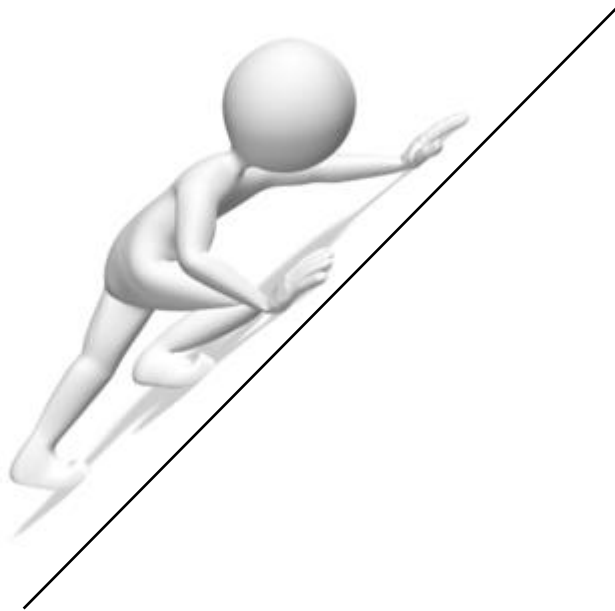
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HVAC Fittings & Accessories

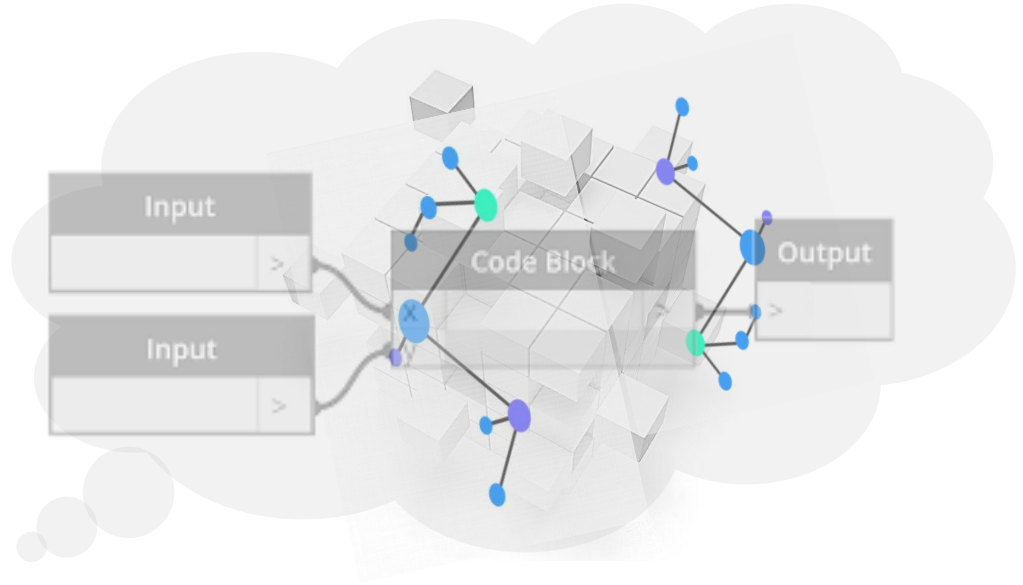


iBuilt

HVAC Alternatives Overload



HVAC System Selection With Generative Design



Learning Objectives

- 1. Get an understanding of what generative design is and where it can be utilized.**

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2. **Identify how to define rules and measure success for generative design analysis.**

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Learning Objectives

1. Get an understanding of what generative design is and where it can be utilized.
2. Identify how to define rules and measure success for generative design analysis.
3. Explore running Generative Design studies in Dynamo and Revit.
4. **Learn how to apply these techniques for MEP System design.**

Generative Design 101

What is Generative Design?



“Generative design is the combination of data, design logic, and algorithms that delivers methods for optimization.”

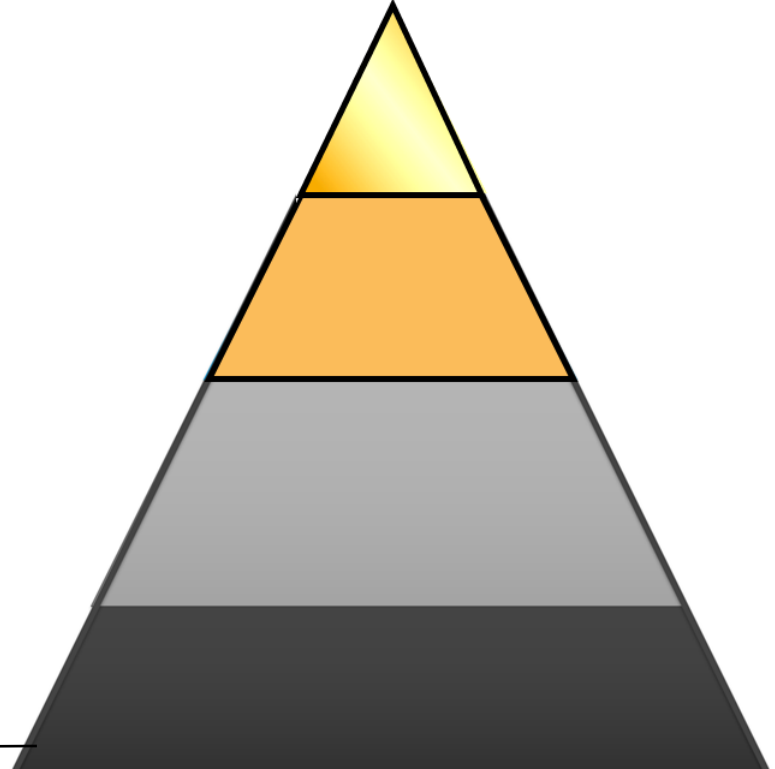
Sean Fruin

Generative Design 101

Autodesk Framework

Data

Revit / Excel / .csv / .jpg / .json

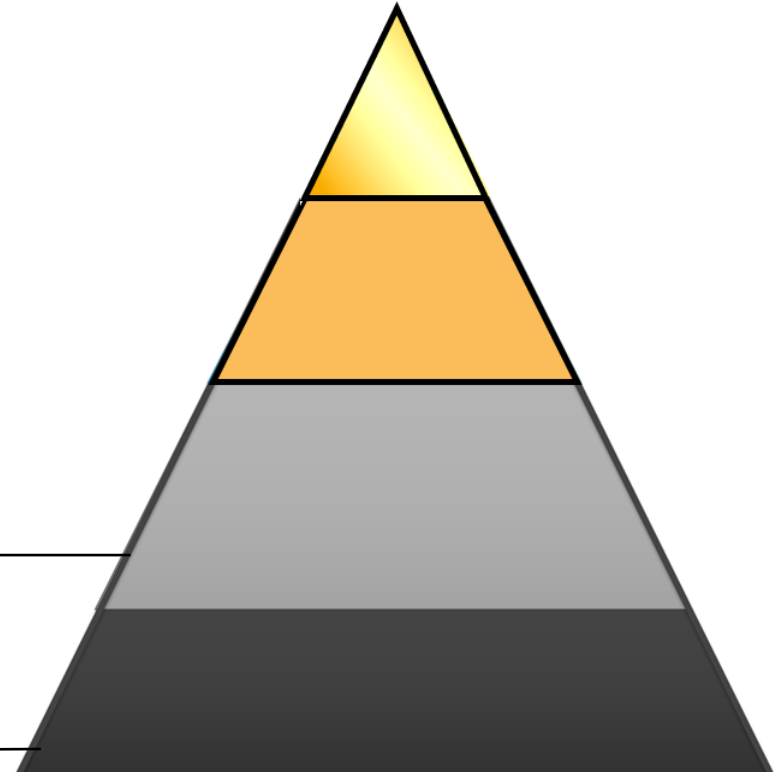


Computational Design

Dynamo / Python / C#

Data

Revit / Excel / .csv / .jpg / .json



Optioneering

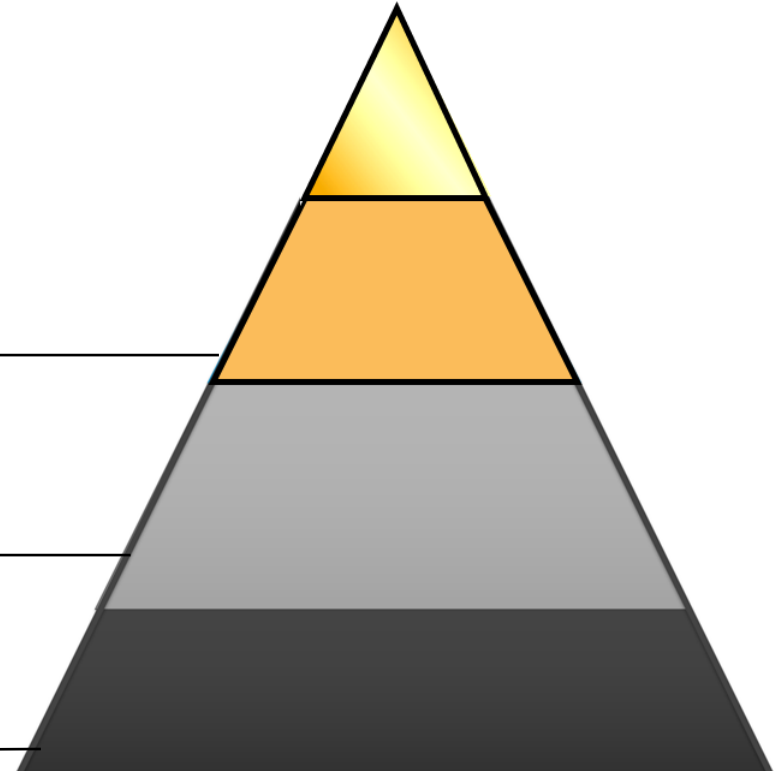
GD Dynamo / GD In Revit

Computational Design

Dynamo / Python / C#

Data

Revit / Excel / .csv / .jpg / .json



Optimization

GD Dynamo / GD In Revit

Optioneering

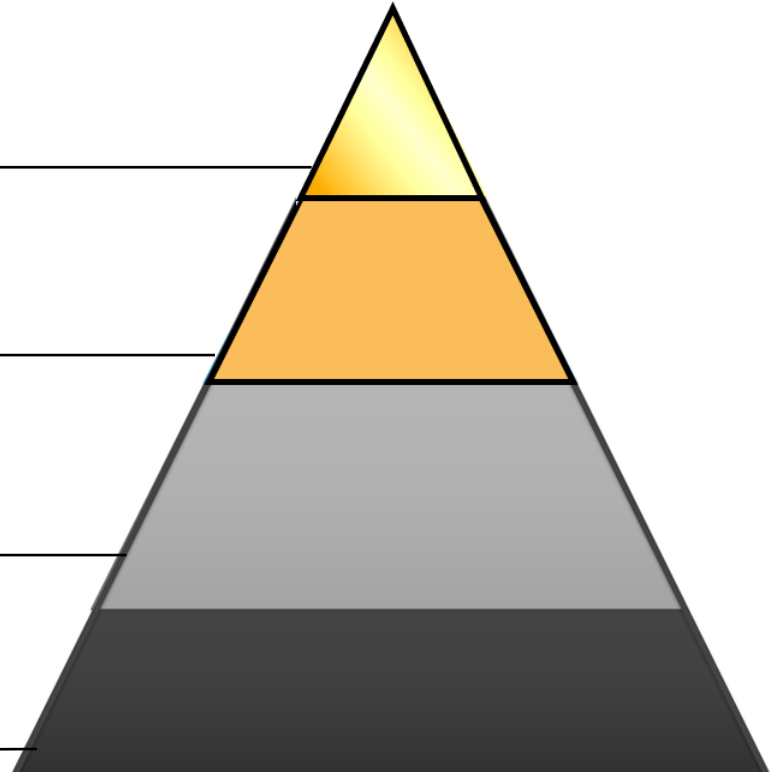
GD Dynamo / GD In Revit

Computational Design

Dynamo / Python / C#

Data

Revit / Excel / .csv / .jpg / .json



Algorithmic Thinking – Just Like Cooking



Score Sheet – Patrol:

Criteria	Maximum Score	Actual Score
Planning	3	
Organization & Cooperation	3	
Clean-up	3	
Variety and Balance	3	
Preparation and Presentation	4	
Taste	5	
Initiative and Ambition	4	
Total	25	

Step 1 – Formulate Goals

Goals

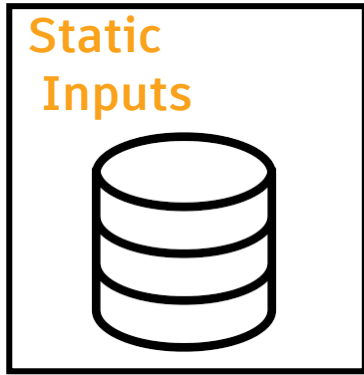
competing characteristics?

Maximize / minimize?

Evaluators

$$\sum_{i=1}^n x_i = x_1 + x_2 + \cdots + x_n$$

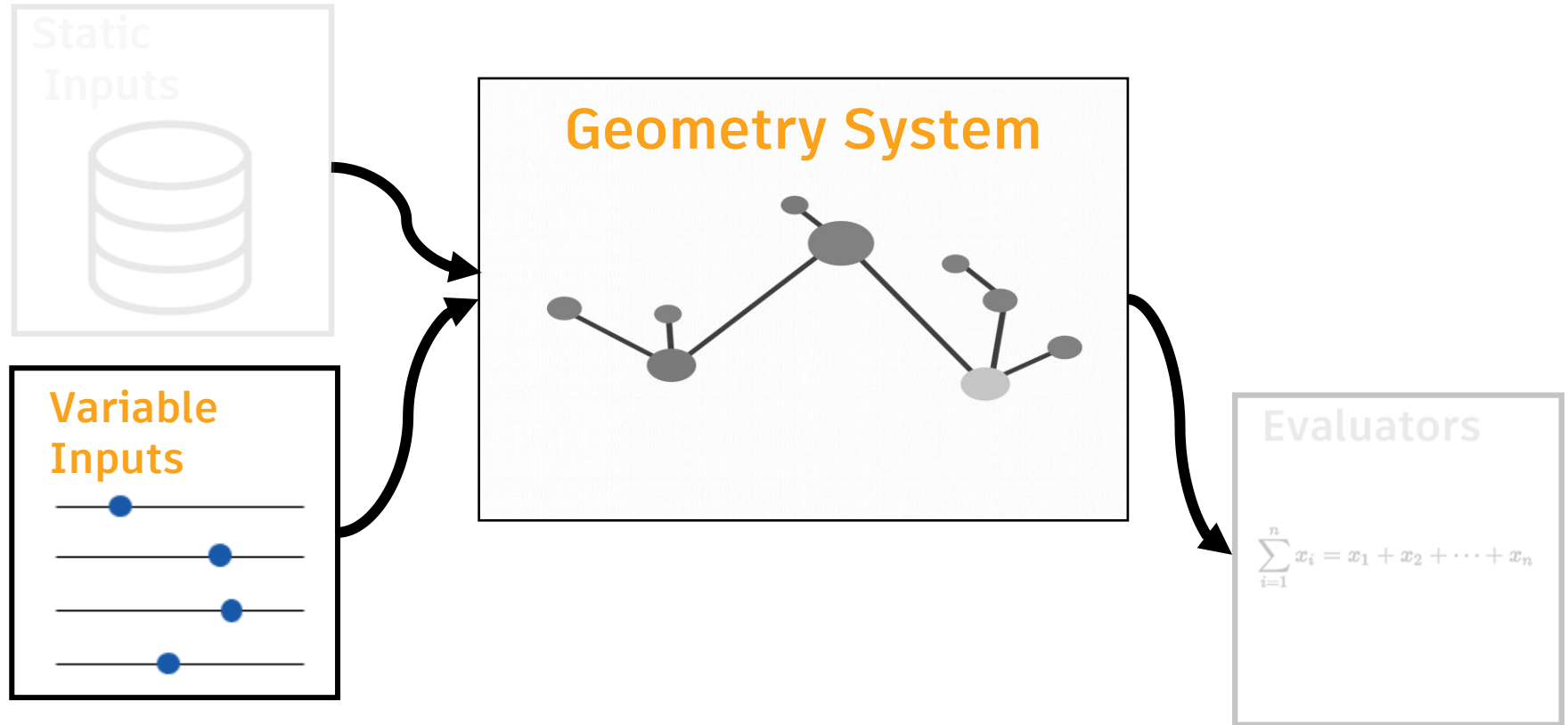
Step 2 – Data Collection



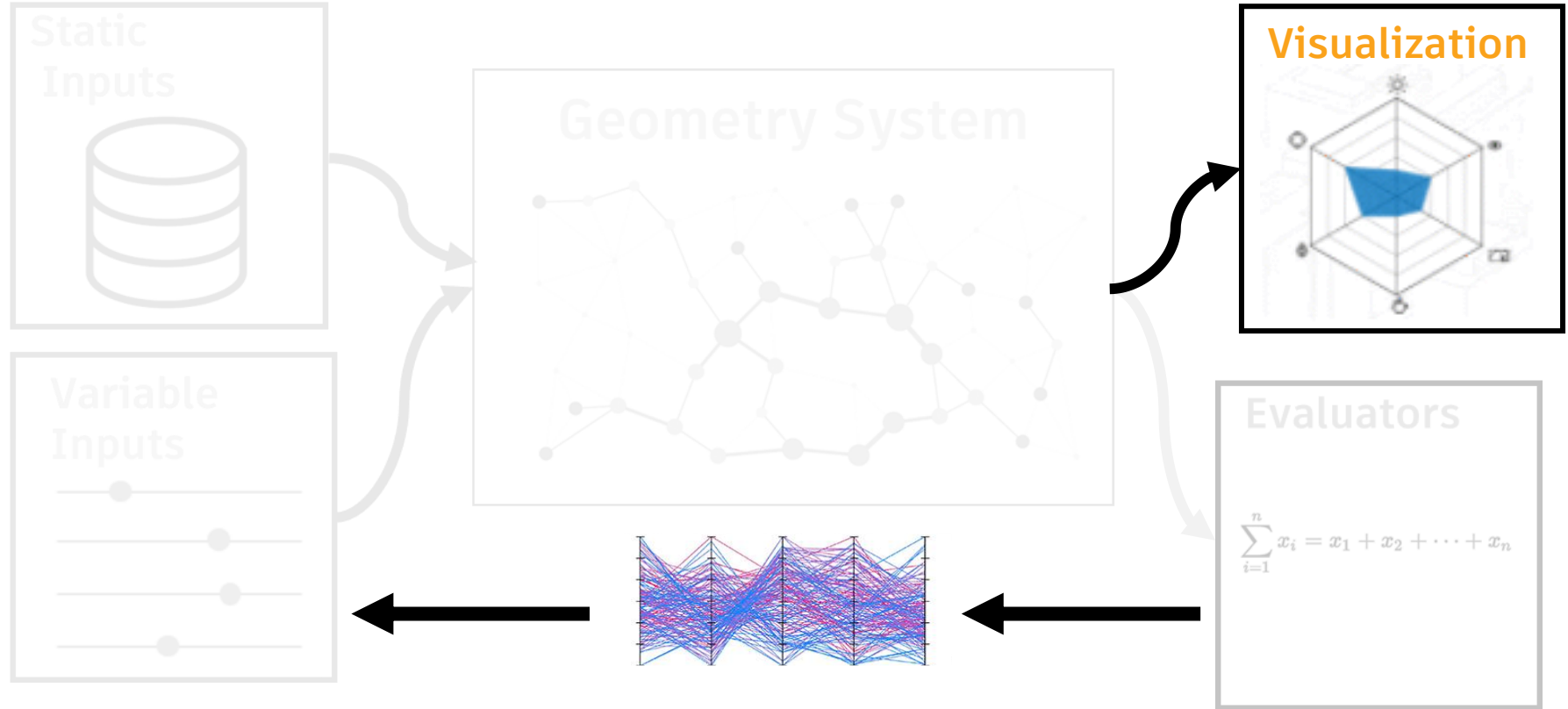
Evaluators

$$\sum_{i=1}^n x_i = x_1 + x_2 + \cdots + x_n$$

Step 3 – Objective Algorithms



Framework Flowchart – Step 3



Kart Optimization



Example – Mario Kart Optimization



Generative Design 101

Example – Mario Kart Optimization



SegaBlueSky Wed 17th May 2017

There's plenty of useful info here, but think the headers of 'best cart/characters/etc' are a bit of a misnomer as they don't really tell me which are best...don't really feel like I know any more now than I did before I read the article. It may give lots of stats but it doesn't do what the headline suggests, as it doesn't tell me how to put together a build. It just goes "here are some numbers, and really anything goes so just have fun and experiment" - which may be true, but it's not really instructional.

Too much data to understand



Zyrac Wed 17th May 2017

@DarkRula Definitely true that high-speed builds are less viable on 200cc, but the tricky thing is that unlike on Wii U, once your online rank is high enough you have to play both 150cc and 200cc, so you need to be able to handle both with what you're using.

Balance set up is key for all situation



SLIGEACH_EIRE Wed 17th May 2017

There is no ultimate setup. It's all about compromise and finding what suits you best personally. For what you'll gain in 1 stat you'll lose out on another.

Always lose One and gain one

Example – Mario Kart Goals



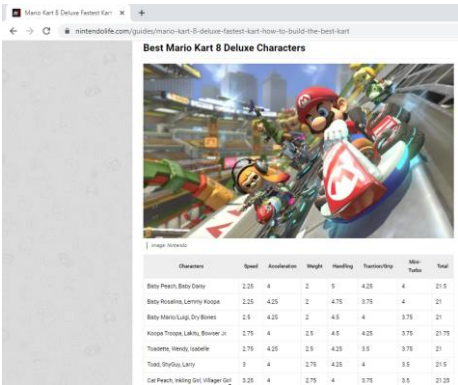
straight away?

fall off?

Can I stay on the track?

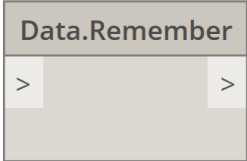
Generative Design 101

Example – Mario Kart Data Collection



The screenshot shows a spreadsheet application with the following data:

	A	B	C	D	E	F	G	H
	Characters	Speed	Acceleration	Weight	Handling	Traction	Mini-Turbo	
1	Wario	4.75	3	4.25	2.75	3.25	2.75	
2	Toadette	2.75	4.25	2.5	4.25	3.5	3.75	
3	Toad	3	4	2.75	4.25	4	3.5	
4	Inkling Boy	3.5	3.75	3.25	3.75	3.25	3.5	
5	Yoshi	3.5	3.75	3	3.75	3.75	3.5	
6	Metal Mario	4.25	3.25	4.5	3.25	3.25	3	
7	Mario	3.75	3.5	3.5	3.5	3.5	3.25	
8	Luigi	3.75	3.5	3.5	3.75	3.25	3.25	
9	King Boo	4	3.25	3.75	3.25	3.75	3.25	
10	Koopa	2.75	4	2.5	4.5	4.25	3.75	
11	Donkey Kong	4.5	3.25	4	3	3	3	
12	Inkling Girl	3.25	4	2.75	4	3.75	3.5	
13	Bowser	4.75	3	4.5	2.5	3	2.75	
14	Lemmy Koopa	2.25	4.25	2	4.75	3.75	4	
15	Baby Peach	2.25	4	2	5	4.25	4	
16	Dry Bones	2.5	4.25	2	4.5	4	3.75	



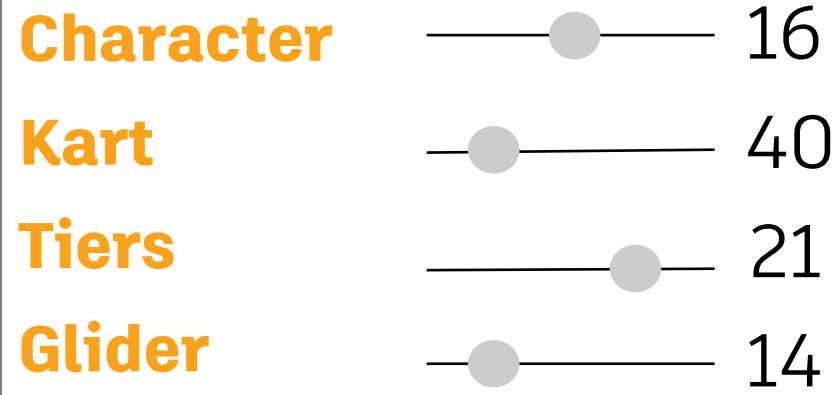
Dictionary

- ▶ Tiers List
- ▶ Karts List
- ▶ Gliders List
- ▶ Characters List
 - 0 Dictionary
 - Acceleration 3
 - Traction 3.25
 - Mini-Turbo 2.75
 - Speed 4.75
 - g 200
 - b 0
 - r 255
 - Characters Wario
 - Weight 4.25
 - Handling 2.75
 - 1 Dictionary
 - Acceleration 4.25

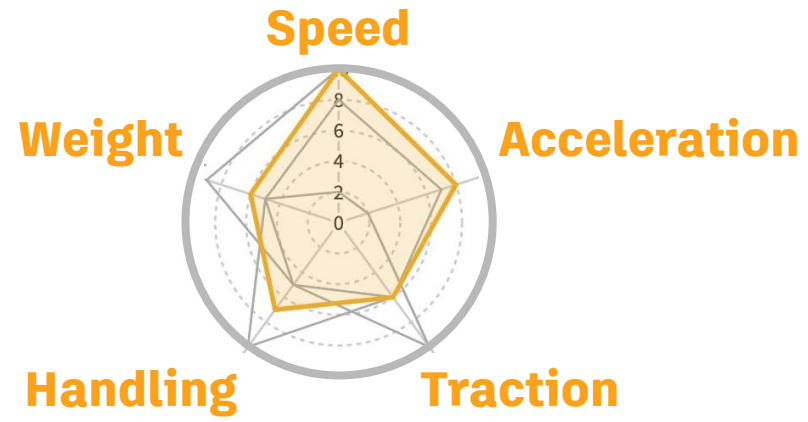
Generative Design 101

Example – Mario Kart Optimization

Variable



Evaluators



Generative Design 101

Example – Mario Kart Geometry System

Variables

Character *Renamed*

11

Kart *Renamed*

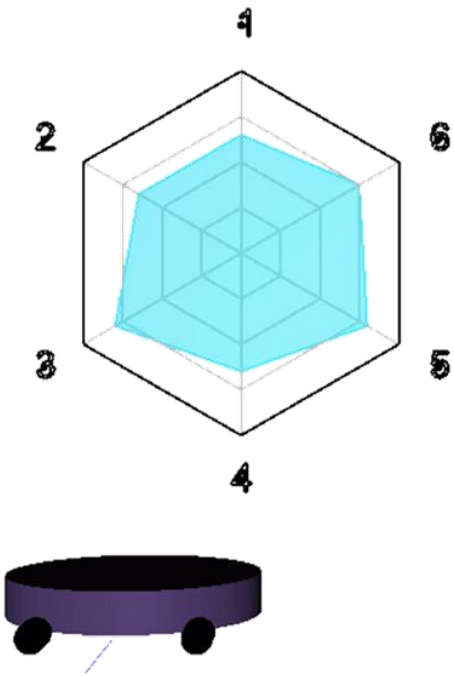
27

Glider *Renamed*

0

Tiers *Renamed*

11



Character - Inkling Girl
Kart - Koopa Clown
Glider - Super Glider
Tiers - Triforce Tires

1-Acceleration
2-Speed
3-Traction
4-Weight
5-Mini Turbo

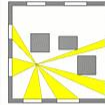
Select a study type

**Grid Object Placement**

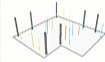
Places elements in a rectangular grid pattern inside a room.

Kart Optimization**Mario Kart Optimization**

Mario Kart 8 Deluxe Fastest KART - How To Build The Best Kart

**Maximize Window Views**

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

**Randomize Object Placement**

Creates clusters of elements inside a selected room.

**Stepped Grid Object Placement**

Places elements in a stepped grid pattern inside a room.

**Three Box Massing**

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

**Workspace Layout**

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

[How do I add study types?](#)Cancel

Studies



Filter list by study type

All

Mario Kart Optimization 002

Mario Kart Optimization

Aug 20, 2021, 1:56 PM 10000/10000 ✓

Mario Kart Optimization 001

Mario Kart Optimization

Aug 20, 2021, 1:51 PM 10/10 ✓

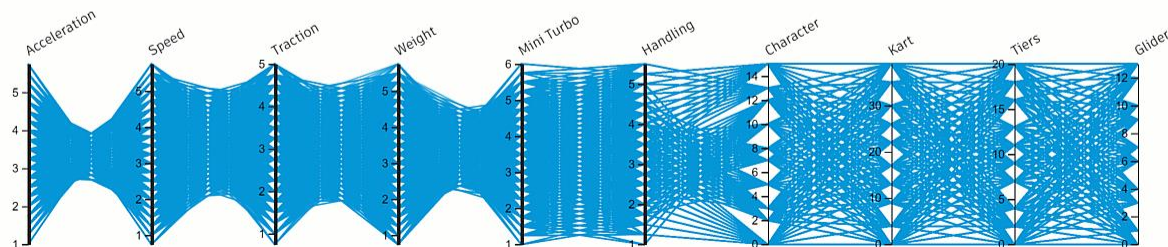
Mario Kart Optimization 002



Acceleration	Speed ↑	Traction	Weight	Mini Turbo	Handling	Character
5.750	0.750	3.750	0.750	5.750	5.500	13
5.750	0.750	3.750	0.750	5.750	5.500	13
5.750	0.750	3.500	1.0	5.750	5.500	13
5.750	0.750	3.750	0.750	5.750	5.500	13
5.750	0.750	3.500	1.0	5.750	5.500	13
5.750	0.750	3.750	0.750	5.750	5.500	13



Select an outcome to see details

 Enable filters ☒ Click and drag over axes to add filters

Create Study

✓ 10000 of 10000

Select an outcome

Open in Dynamo

Generative Design 101

Value



SegaBlueSky

**“Too much data
to understand”**



Zyrac

**“Balance set up is
key for all situation”**



SLIGEACH_EIRE

**“Always lose One
and gain one”**

Generative Design 101

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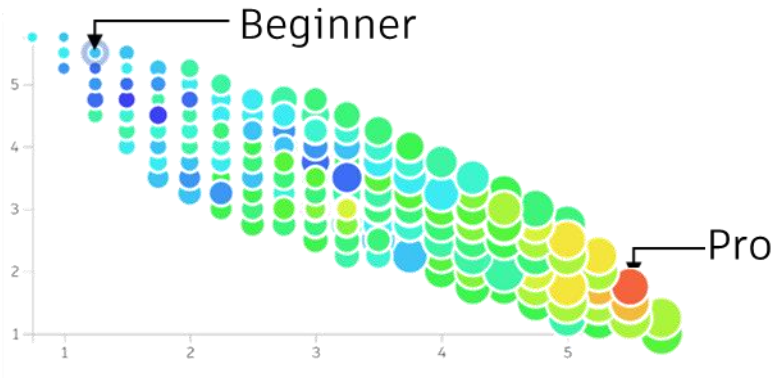


SLIGEACH_EIRE

“Always lose One and gain one”



Y-Axis	Acceleration
X-Axis	Speed
Size	Weight
Color	Traction



Generative Design 101

Value



SegaBlueSky

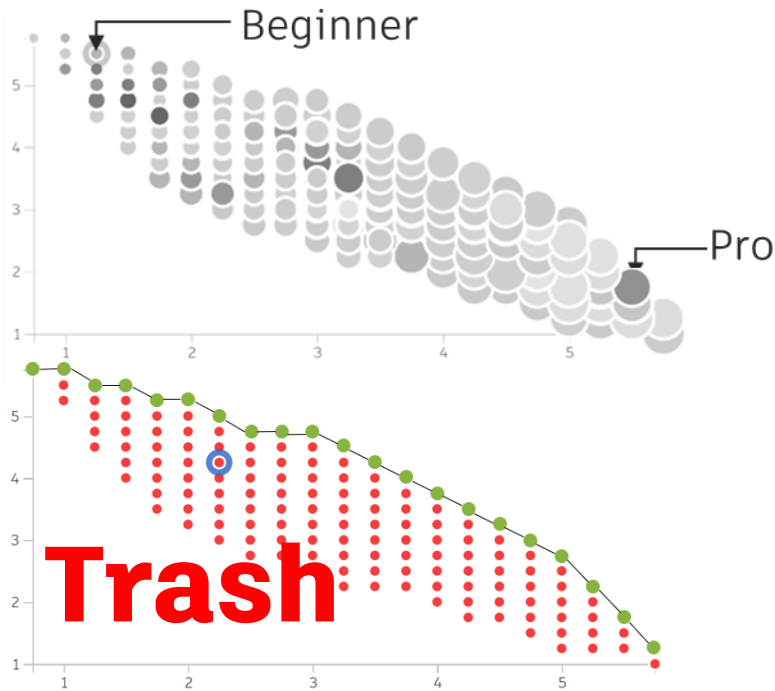
“Too much data to understand”



Zyrac

“Balance set up is key for all situation”


Y-Axis	Acceleration
X-Axis	Speed
Size	Weight
Color	Traction



SLIGEACH_EIRE

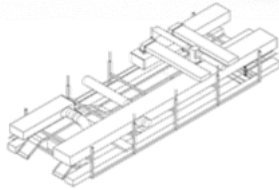
“Always lose One and gain one”

Y-Axis	Acceleration
X-Axis	Speed
Size	Default
Color	Default



Generative Design HVAC System Selection

Foundation For Automation



Base/Panel Length X Width
Curb Cap Size
Impeller Diameter
Roof Opening Width x Roof Opening Length
Base Height
Damper Width x Damper Height
Height
Weight
Overall Diameter

No Data Drops

Standardized Design Process

Procurement First

Automation

HVAC System Selection Evaluators

Generative Design – HVAC System Selection

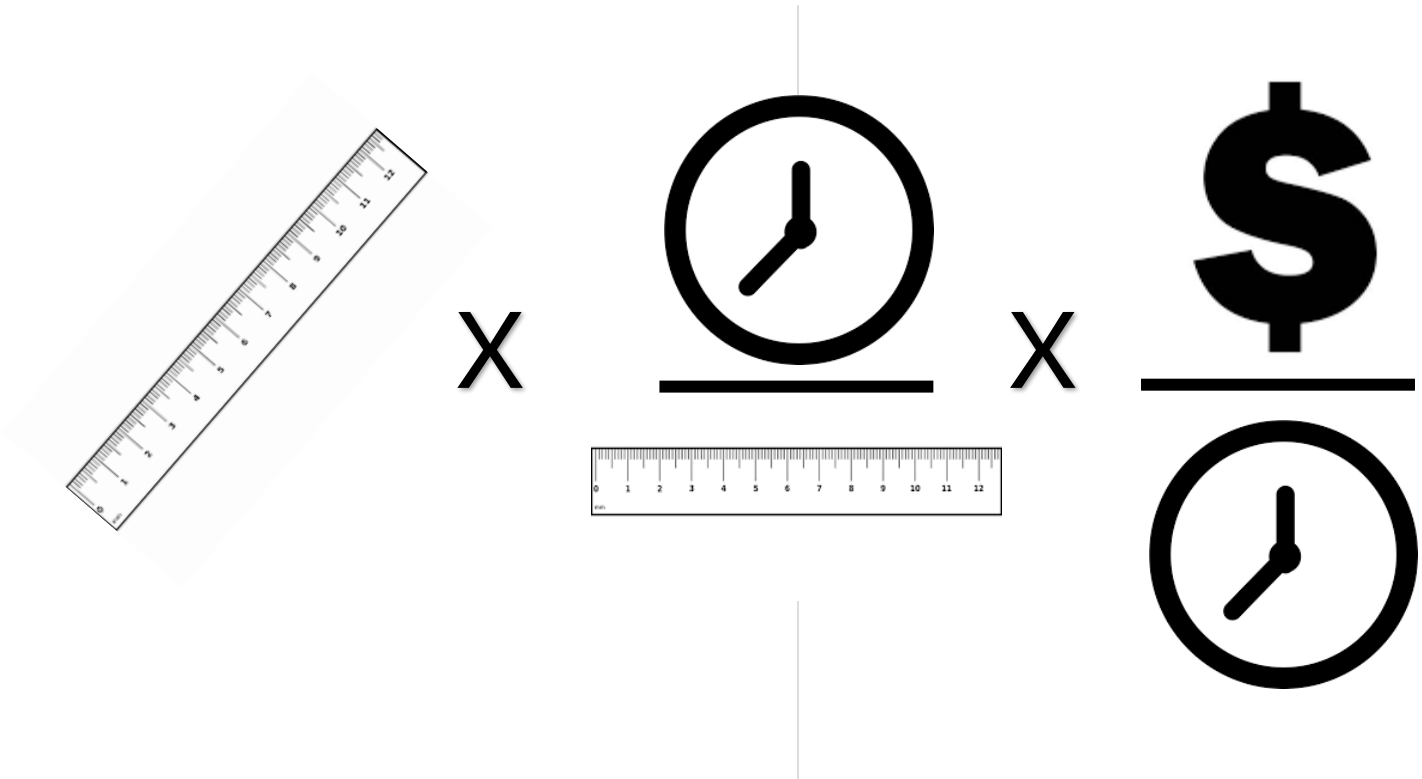
Goals – Find The Best Combination



Material Cost
Field Labor Cost
Factory Labor Cost
Unit Mechanical Area
Unit Horizontal Area
Main Horizontal Area
Shaft Vertical Area
Plant Area
Plant Weight
Architecture Aesthetics

Generative Design – HVAC System Selection

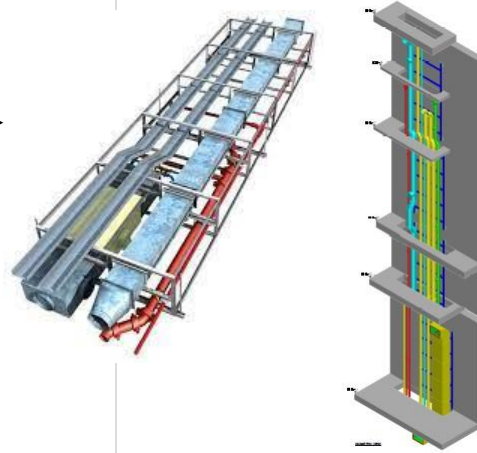
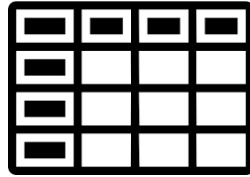
Evaluators – Labor Cost



Generative Design – HVAC System Selection

Evaluators – Areas

CFM



AREA



Generative Design – HVAC System Selection

Evaluators – Energy

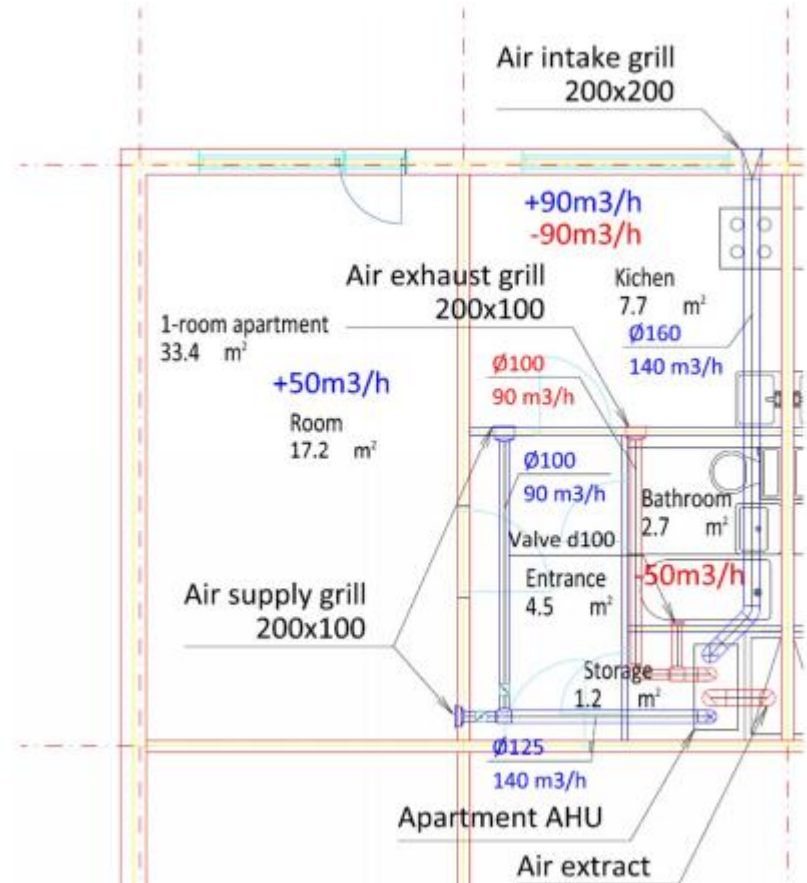
HVAC System Selection

Static Inputs

Generative Design – HVAC System Selection

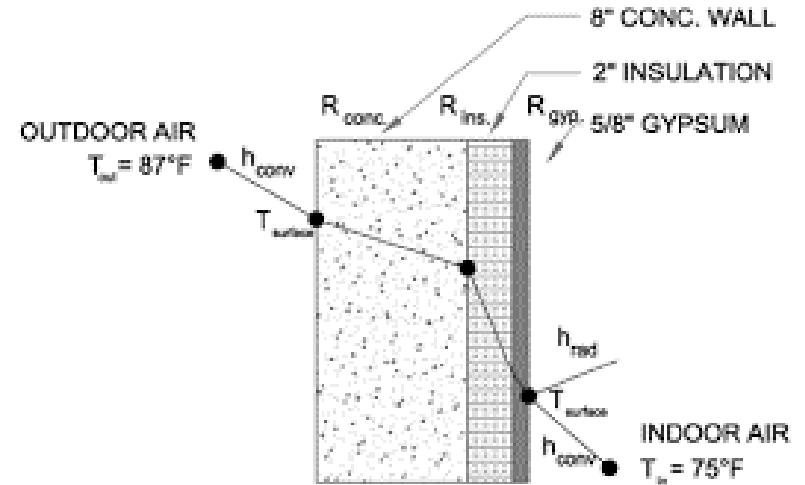
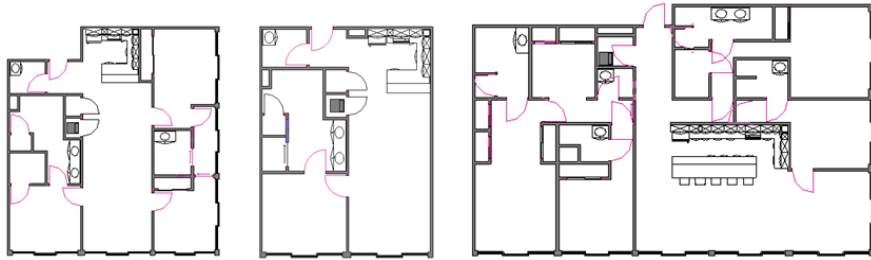
Static Inputs – System Definitions

Name	Size	Units	Quantity	Average price in EU for one unit (EUR)
AHU (140 m ³ /h)	-	Pcs.	1	1800.00
Air intake grill	200x200 mm	Pcs.	1	40.00
Extract air roof hood	Ø160 mm	Pcs.	1	200.00
Air supply grill	200x100 mm	Pcs.	2	17.00
Air exhaust grill	200x100 mm	Pcs.	1	17.00
Air exhaust valve	Ø100	Pcs.	1	5.00
Duct	Ø160 mm	m	10	1.50
Duct	Ø125 mm	m	4	1.20
Duct	Ø100 mm	m	7	0.90
Silencers	Ø100 mm/ L=1000mm	Pcs.	4	75.00
Total cost with 20 % added				2900.00



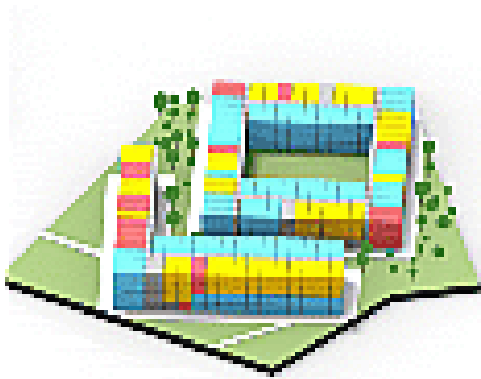
Generative Design – HVAC System Selection

Static Inputs – APT Layouts & Thermal Properties

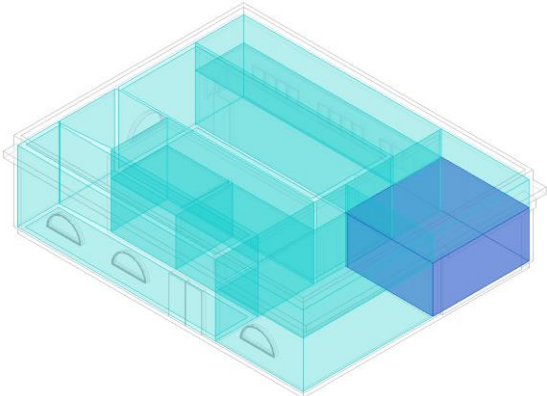


Generative Design – HVAC System Selection

Static Inputs – Heating & Cooling Loads



<Analytical Spaces Schedule>										
A	B	C	D	E	F	G	H	I	J	K
Room Name	Space Type	Heating Set Point			Air Changes per Hour	Latent Heat Gain per person	Outdoor Airflow	Peak Latent Cooling Load	Peak Cooling Load	Peak Heating Load
			Area	Volume						
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
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





HVAC System Selection Geometry System

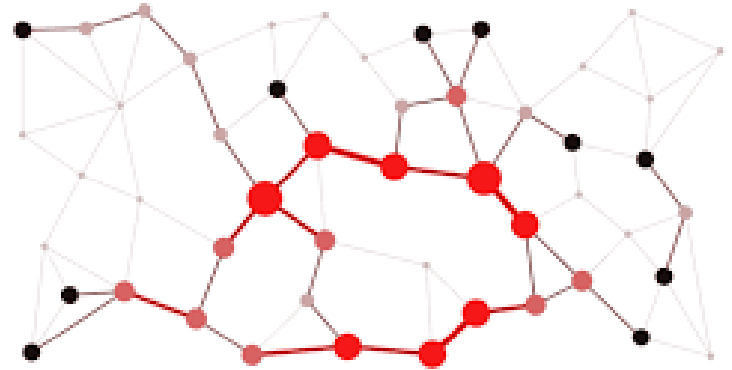
Generative Design – HVAC System Selection

Geometry System Foundation

Clustering / Grouping



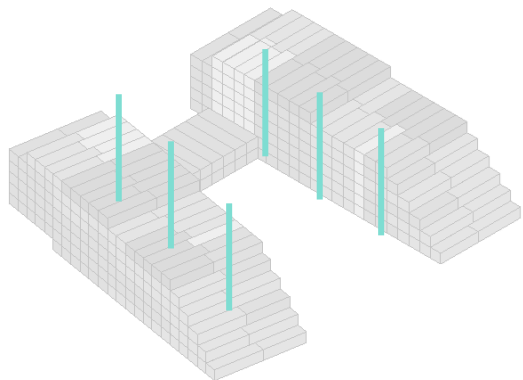
Graph Theory



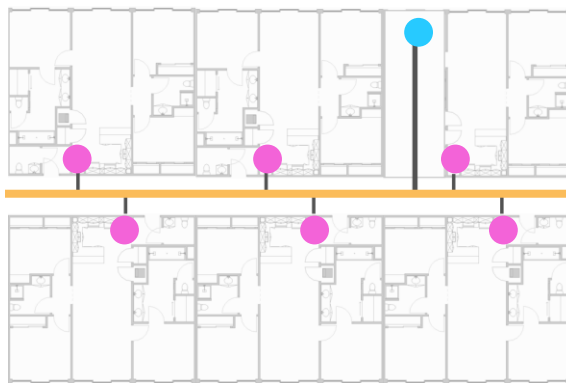
Generative Design – HVAC System Selection

Geometry System – The Graph

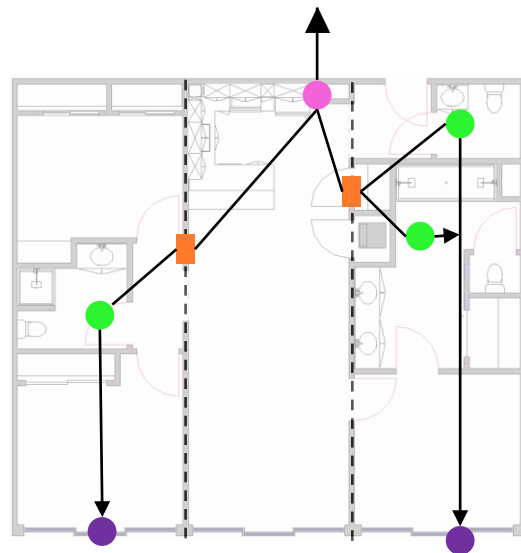
Shafts











Mains



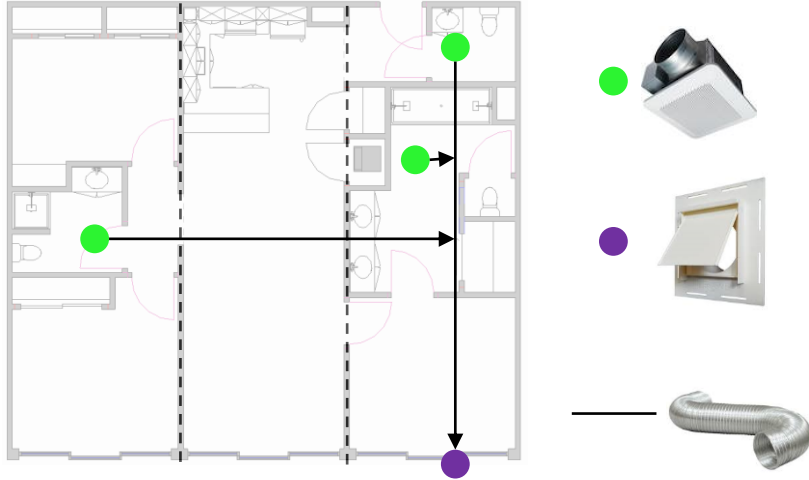
Units



- | | | | |
|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
|  Shaft Edge |  Exterior Node |  Unit Hub |  Shaft Node |
|  Shaft Edge |  Unit Node |  Exhaust Node |  Shaft Node |

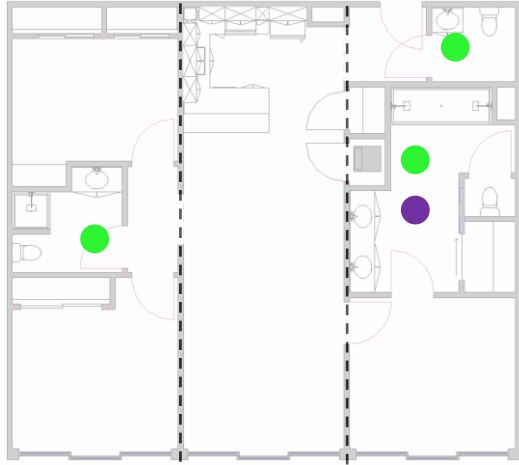
Unit Exhaust

Bathroom Exhaust Fan to wall



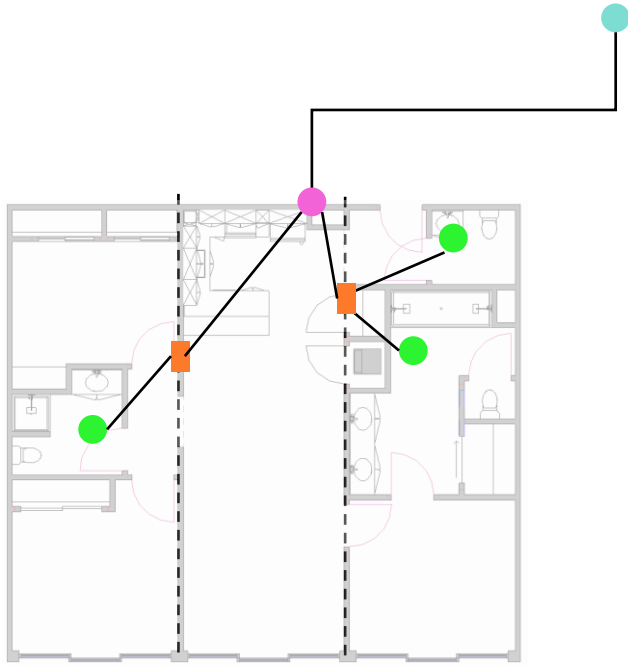
Unit Exhaust

Bathroom Exhaust Fan to roof



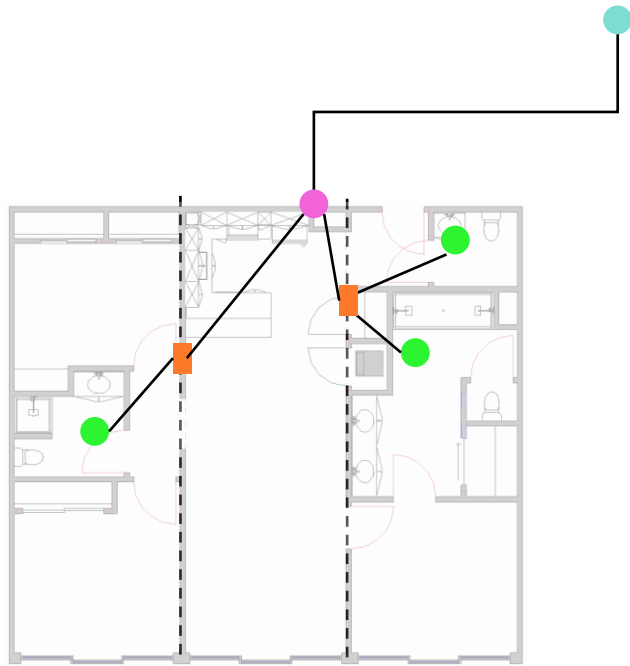
Unit Cooling

Centralized Bathroom Exhaust Fan



Unit Cooling

Centralized Bathroom Energy Heat Recover

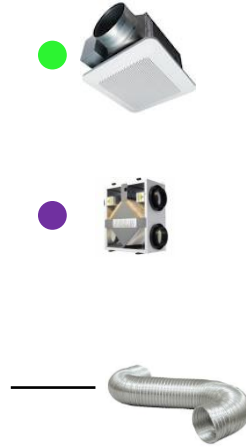
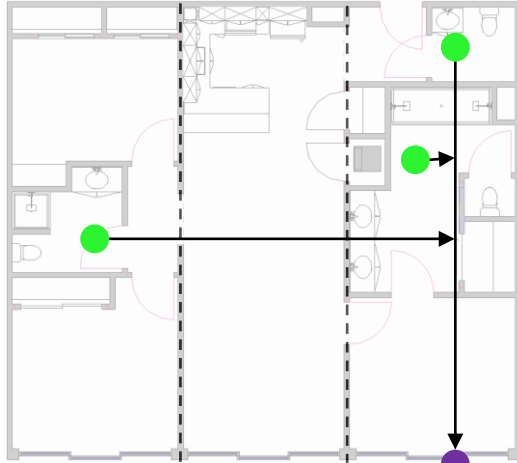


renewaire he-2x



Unit Exhaust

Bathroom Exhaust Fan to wall



designed for efficiency and Performance

In response to customer demand, Unilux has developed a patented vertical stack fan coil system which includes an integrated heat/energy recovery ventilation system (HRV or ERV).

Heat recovery ventilation (HRV) products have been used in residences for many years to introduce fresh air to homes while minimizing the loss of energy. An HRV takes stale air from the home and brings fresh air into the living space, using a heat transfer core to minimize the energy loss — using inside air to heat or cool the outside air, most often transferring 60 to 70 percent of the energy to the fresh air. This results in less energy use and more rapid cooling and heating where the outside and inside temperatures are significantly different.

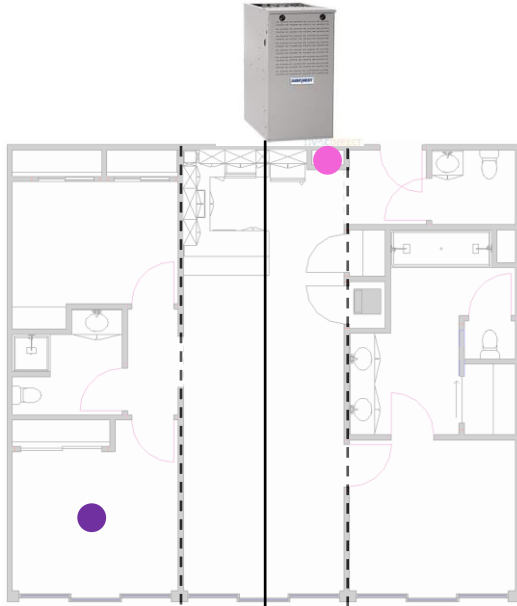
The systems can be further upgraded to use an ERV core that assists in transferring moisture between the exhaust and fresh air which results in reduced cost for moisture control and added comfort inside the home.

Often in high rise construction each unit will have a stand-alone HRV to exchange air, as well as a Vertical Stack Fan Coil product to provide heating and cooling. Unilux's integrated HRV/ERV vertical fan coil, provides a complete solution for all HVAC requirements. The Unilux solution integrates with bathroom and other exhaust systems in the home to provide an all encompassing heating and ventilation solution. Unilux's patented design incorporates multiple dampers and temperature sensors to ensure

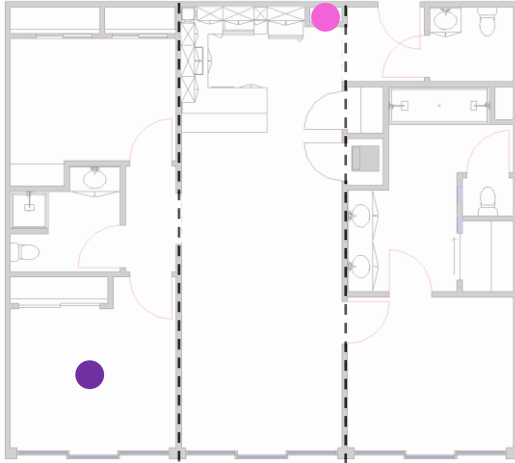
The HRV or ERV option is available across the entire Unilux product line from 300 cfm to 1200 cfm and in a 2 pipe or 4 pipe configuration.
U.S. Patent No. 8929826
CDN Patent No. 2766405

Unit Ventilation

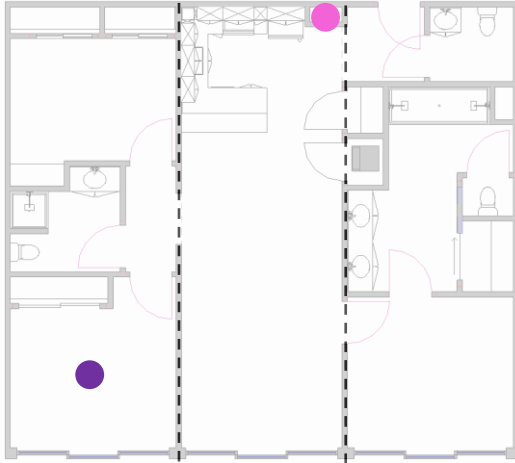
AHU – Duct Directly To Out side



Unit Ventilation Grill



Unit Ventilation Grill



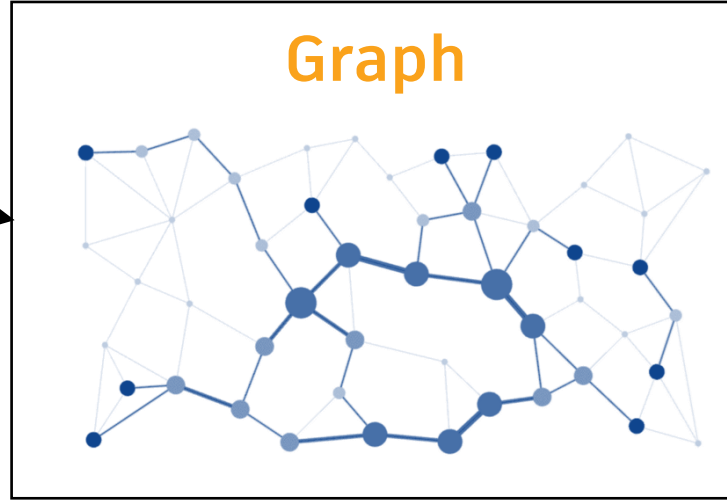
Generative Design – HVAC System Selection

Geometry System - Algorithms

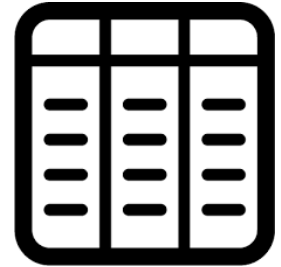
Clustering



Graph



Look UP Table



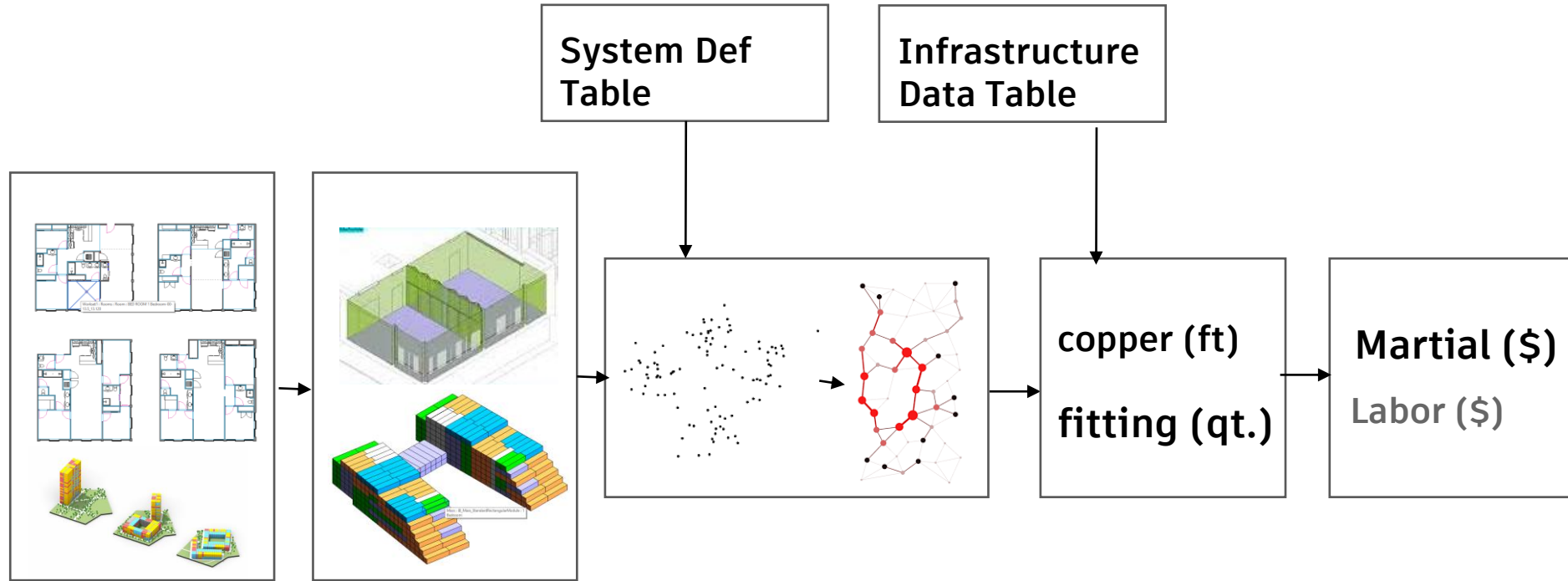
Generative Design – HVAC System Selection

Geometry System - Variable

Shaft Counts
System Types
Ventilation Plants Counts
Heating Plant Counts
Cooling Plant Count
Coupling Types
Unit Fitting Types

Generative Design – HVAC System Selection

Geometry System - Overview



HVAC System Selection Dynamo & Revit Implementation

Q & A Demo

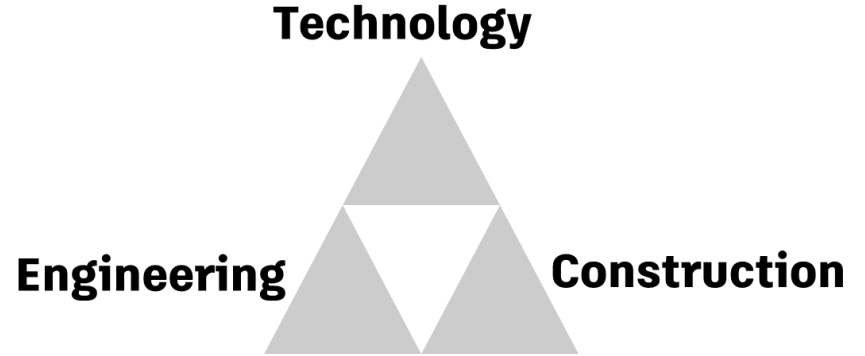


Looking Forward

Generative Design – HVAC System Selection

Final Thoughts

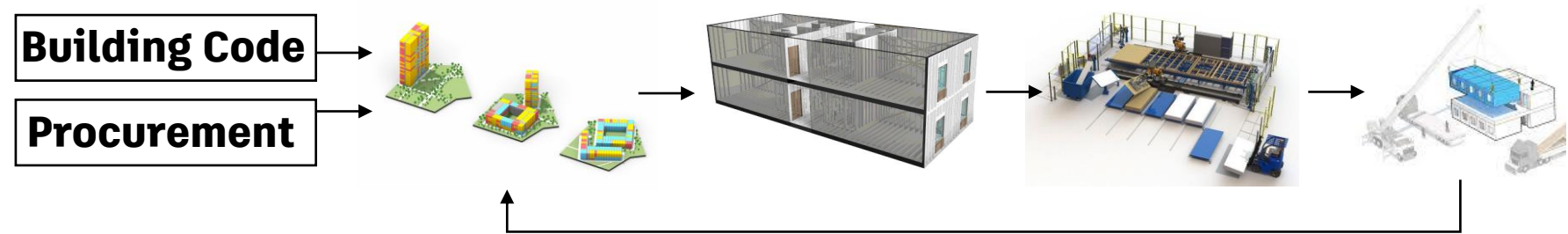
Discover unexpected novel designs
Navigate trade-offs between high performing designs
Sketch goals-constraints rather than form
Co-design between human and computer



Generative Design – HVAC System Selection

Final Thoughts

“Most people overestimate what they can do in one year and underestimate what they can do in ten years.”



The background features four abstract, dark, metallic-looking geometric shapes in the corners, resembling stylized computer monitors or architectural elements. They are arranged symmetrically, with two in the top corners and two in the bottom corners, all pointing towards the center.

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