

Generative Design for HVAC System Selection

Sean Fruin

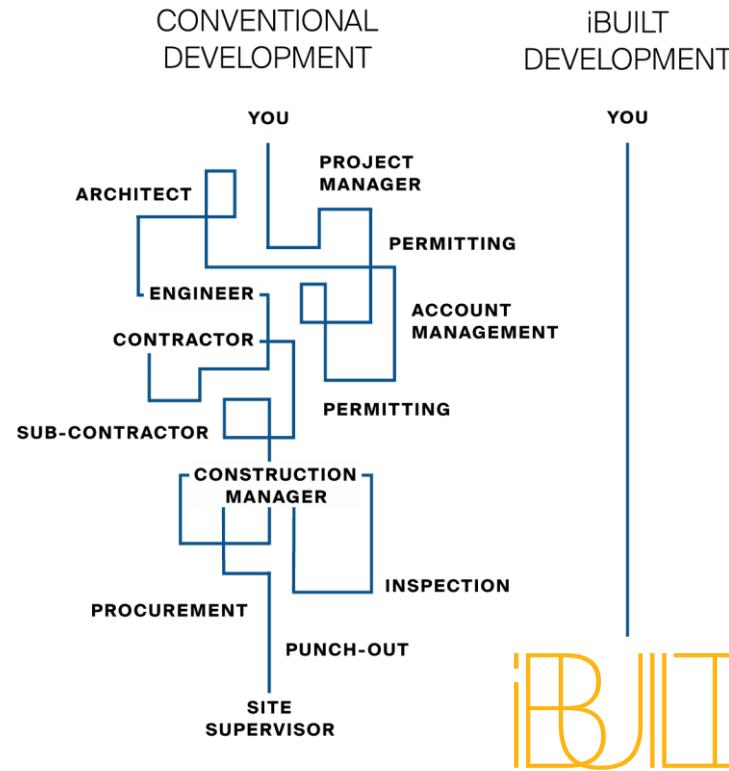
Director Of Design Technology | @SeanFruin

The Challenge

iBuilt Start Up

iBuilt

Rethinking Construction



Rethinking Construction – HVAC Goals

iBUILT
DEVELOPMENT

YOU

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

iBUILT



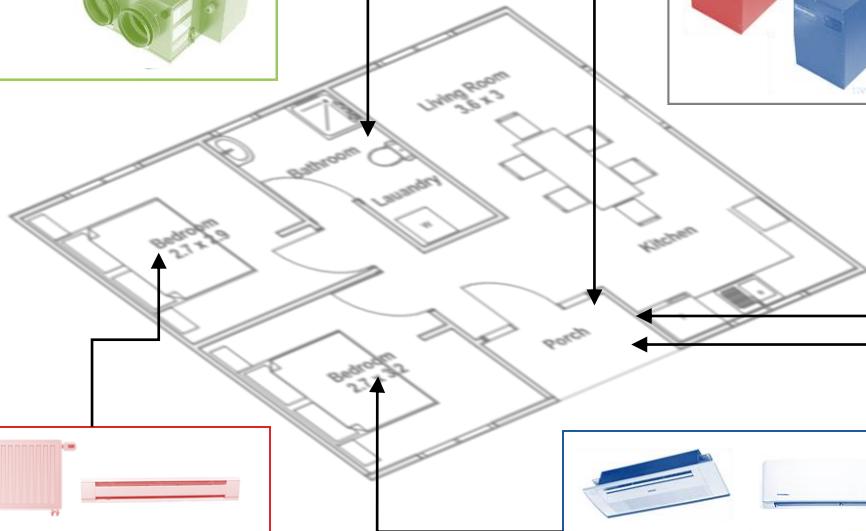
Rethinking Construction – Expectations

Universe of Alternatives HVAC System

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



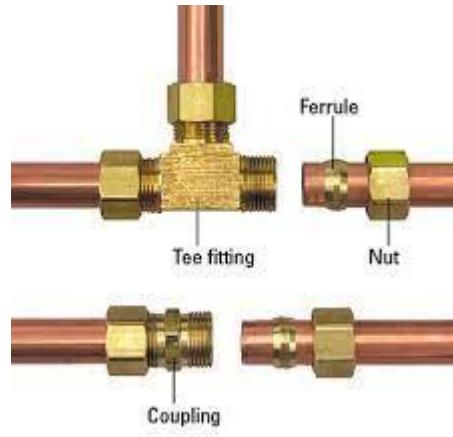
iBuilt - Rethinking Construction



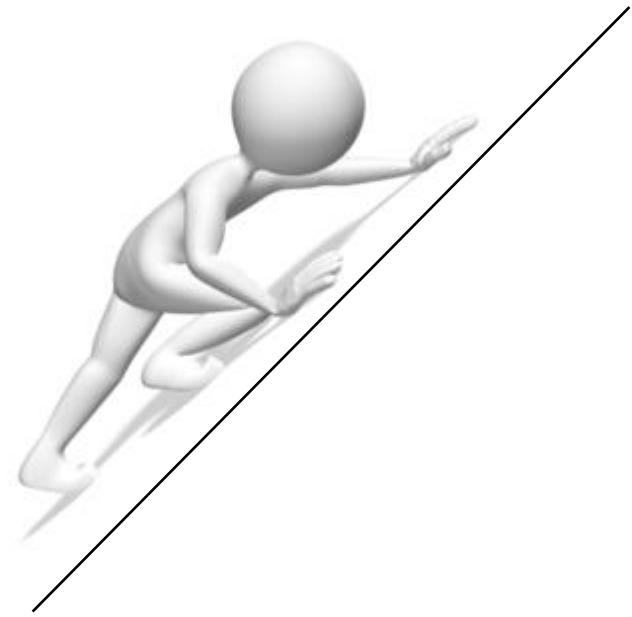
HVAC Alternatives -Infrastructure



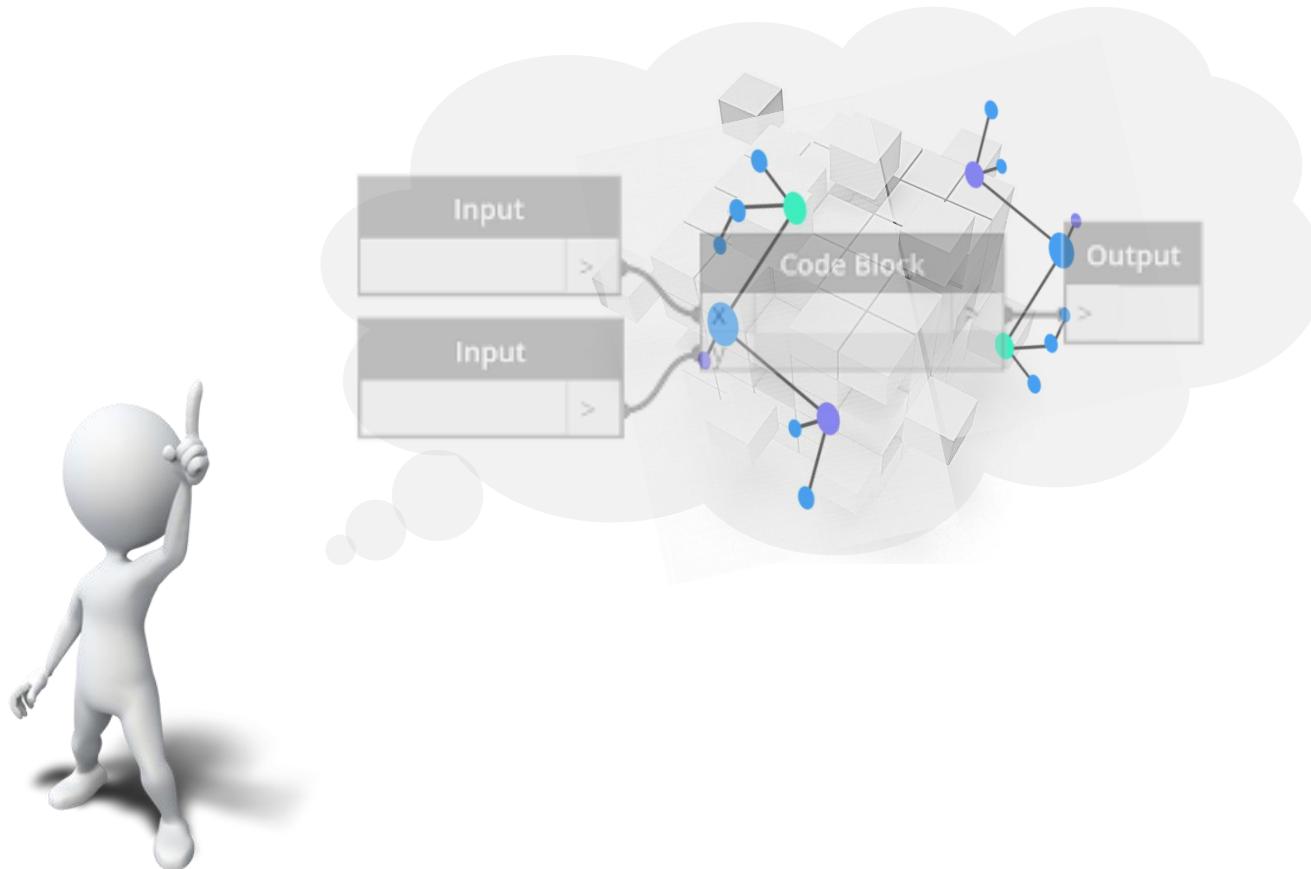
HVAC Fittings & Accessories



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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3. **Explore running Generative Design studies in Dynamo and Revit.**

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.”

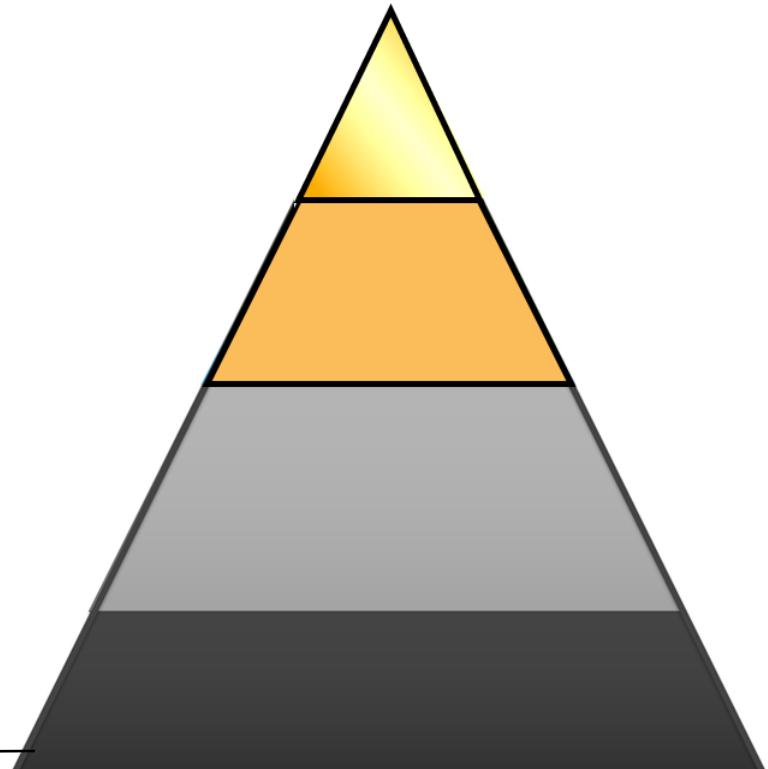
Sean Fruin

Generative Design 101

Autodesk Framework

Data

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



Generative Design 101

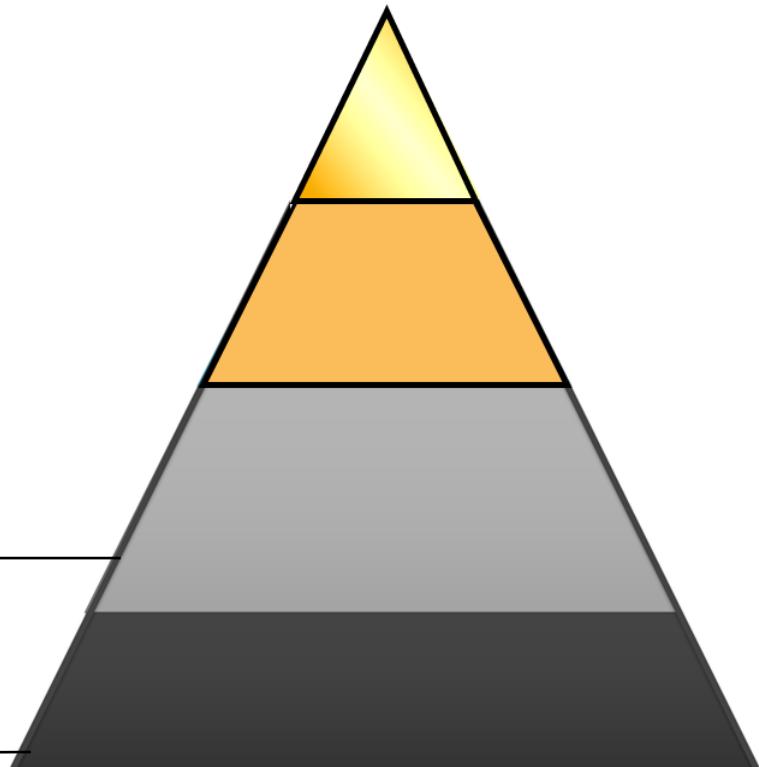
Autodesk Framework

Computational Design

Dynamo / Python / C#

Data

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



Generative Design 101

Autodesk Framework

Optioneering

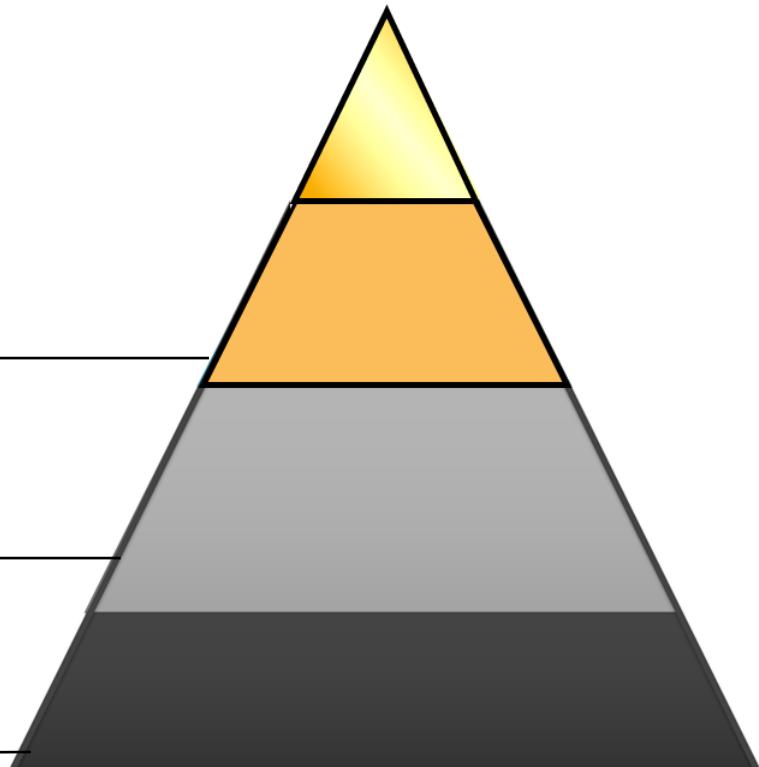
GD Dynamo / GD In Revit

Computational Design

Dynamo / Python / C#

Data

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



Generative Design 101

Autodesk Framework

Optimization

GD Dynamo / GD In Revit

Optioneering

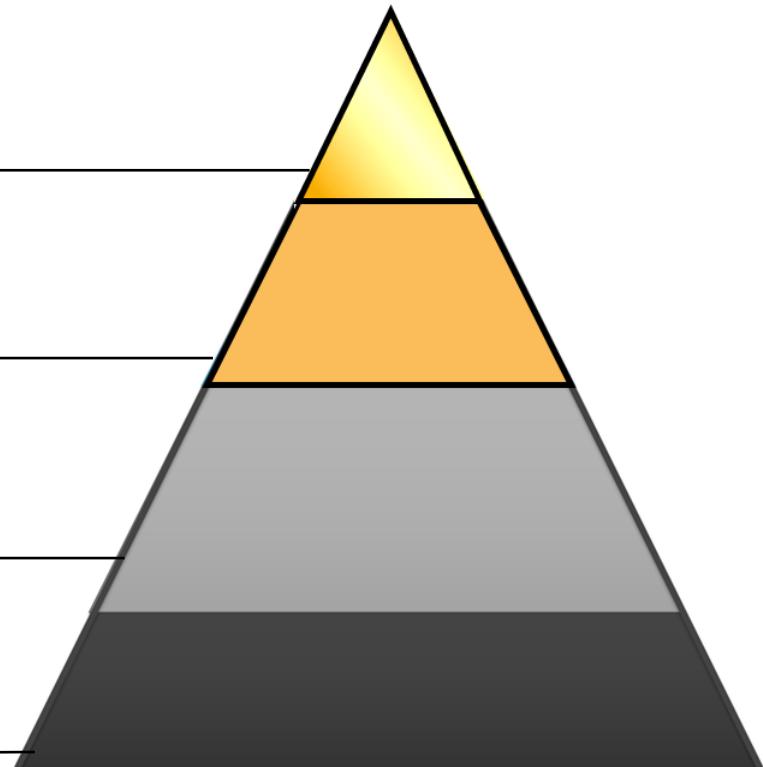
GD Dynamo / GD In Revit

Computational Design

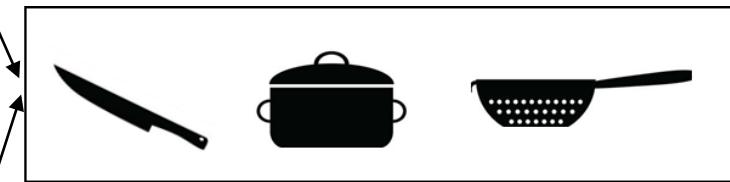
Dynamo / Python / C#

Data

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



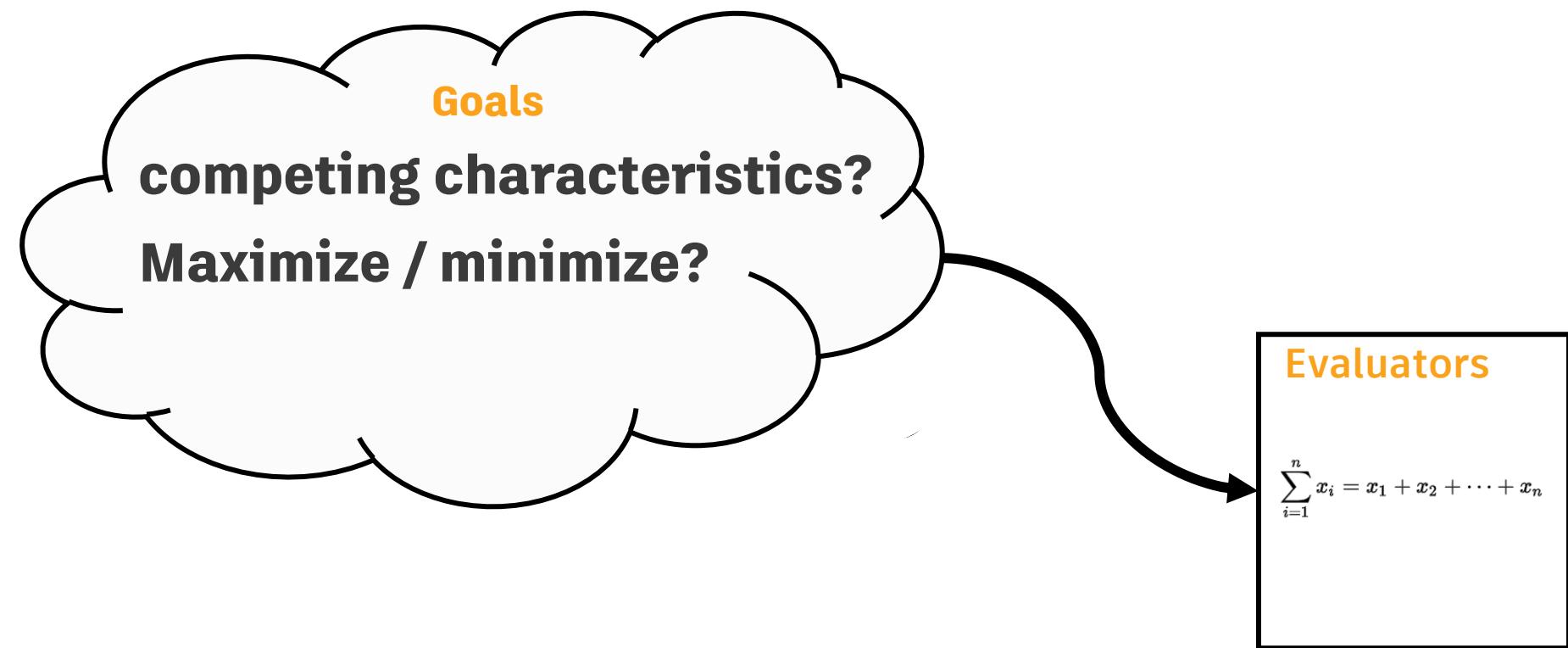
Algorithmic Thinking – Just Like Cooking



Score Sheet - Patrol:

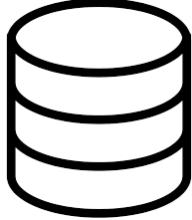
Criteria	Maximum Score	Actual Score
Planning	3	
Organization & Cooperation	3	
Clean-up	3	
Variety and Balance	3	
Preparation and Presentation	4	
Taste	5	
Initiative and Ambition	4	
Total	25	

Step 1 – Formulate Goals



Step 2 – Data Collection

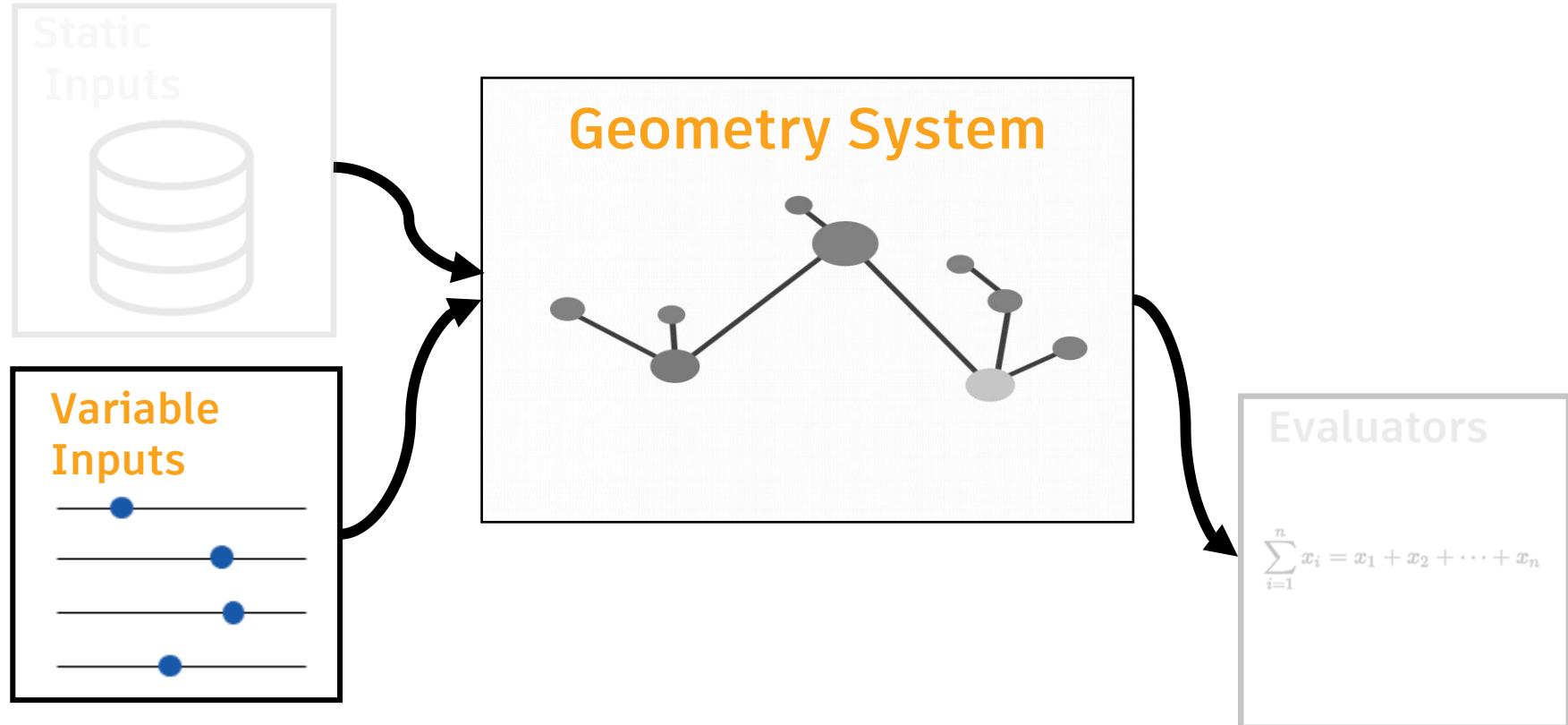
Static
Inputs



Evaluators

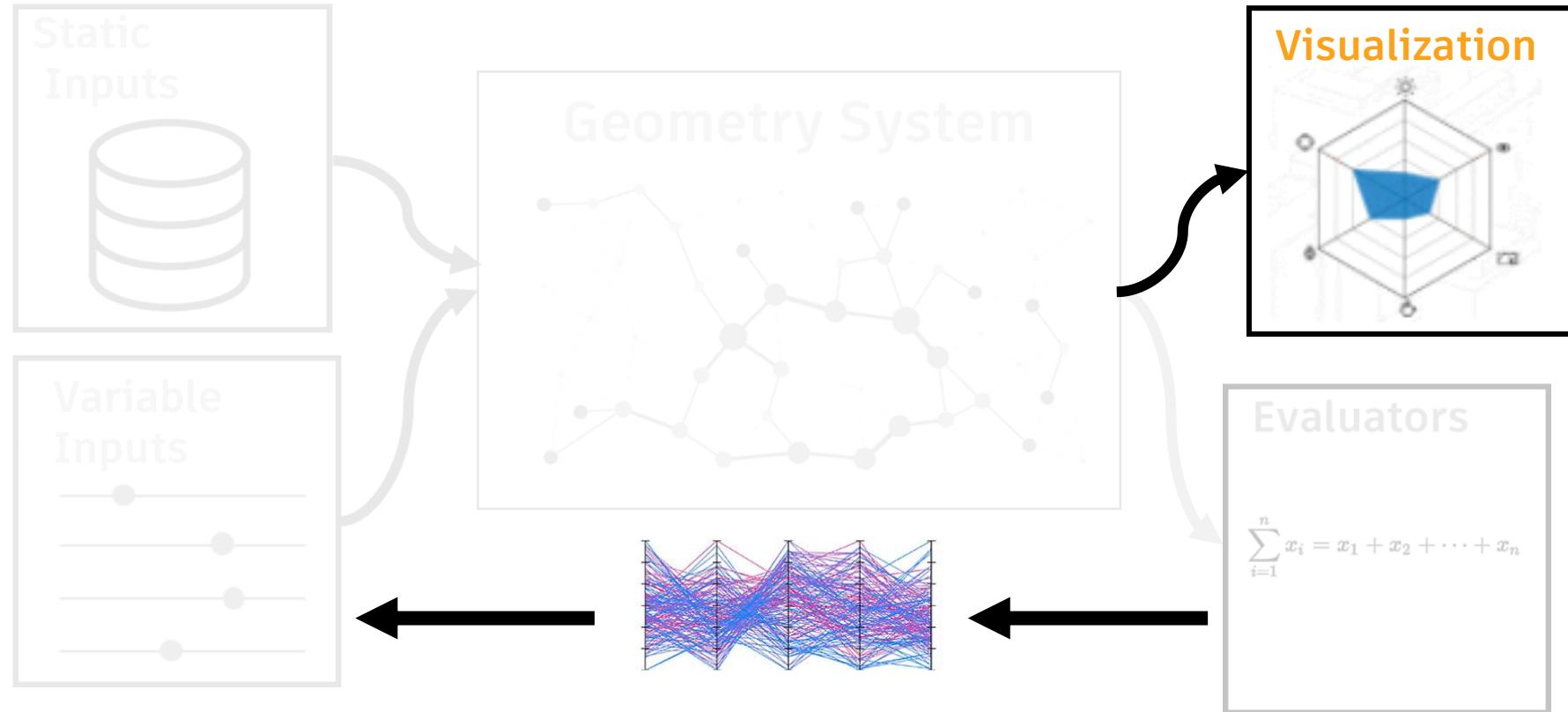
$$\sum_{i=1}^n x_i = x_1 + x_2 + \cdots + x_n$$

Step 3 – Objective Algorithms



Generative Design 101

Framework Flowchart – Step 3



Kart Optimization



Generative Design 101

Example – Mario Kart Optimization



Generative Design 101

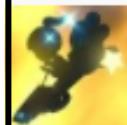
Example – Mario Kart Optimization



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



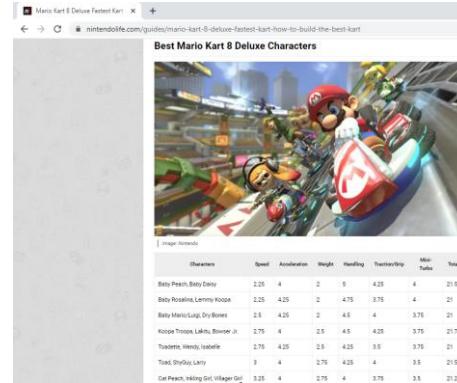
straight away?

fall off?

Can I stay on the track?

Generative Design 101

Example – Mario Kart Data Collection



Character	Speed	Acceleration	Weight	Handling	Traction	Mini-Turbo
Wario	4.75	3	4.25	2.75	3.25	2.75
Toadette	2.75	4.25	2.5	4.25	3.5	3.75
Toad	3	4	2.75	4.25	4	3.5
Inking Boy	3.5	3.75	3.25	3.75	3.25	3.5
Yoshi	3.5	3.75	3	3.75	3.75	3.5
Metal Mario	4.25	3.25	4.5	3.25	3.25	3
Mario	3.75	3.5	3.5	3.5	3.5	3.25
Luigi	3.75	3.5	3.5	3.75	3.25	3.25
King Boo	4	3.25	3.75	3.25	3.75	3.25
Koopa	2.75	4	2.5	4.5	4.25	3.75
Donkey Kong	4.5	3.25	4	3	3	3
Inking Girl	3.25	4	2.75	4	3.75	3.5
Bowser	4.75	3	4.5	2.5	3	2.75
Lemmy Koopa	2.25	4.25	2	4.75	3.75	4
Baby Peach	2.25	4	2	5	4.25	4
Dry Bones	2.5	4.25	2	4.5	4	3.75



Data.Remember

> >

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

Character



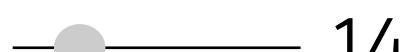
Kart



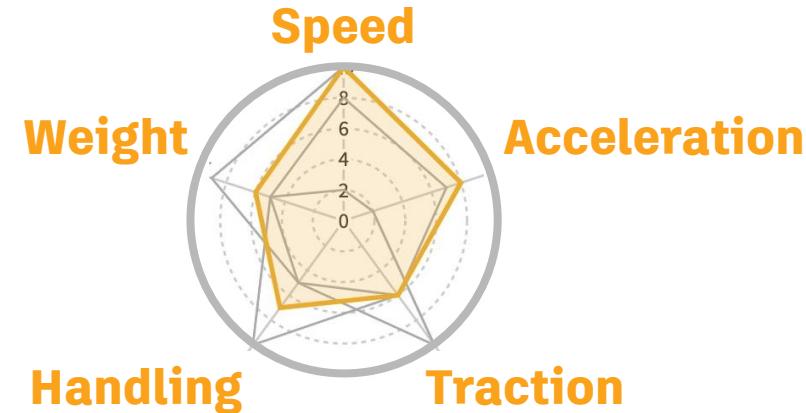
Tiers



Glider



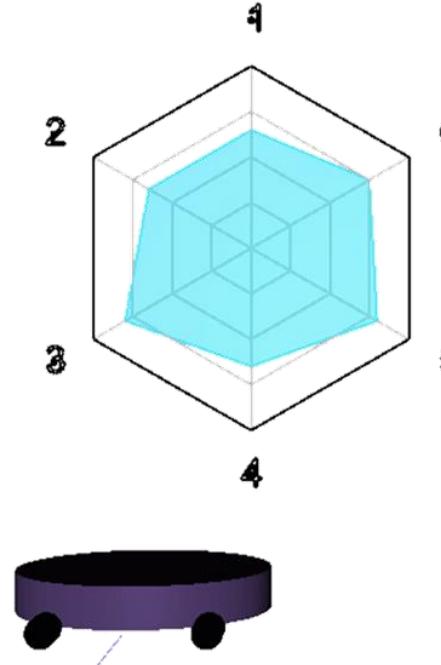
Evaluators



Generative Design 101

Example – Mario Kart Geometry System

Variables



Character - Inkling Girl

Kart - Koopa Clown

Glider - Super Glider

Tiers - Triforce Tires

1-Acceleration

2-Speed

3-Traction

4-Weight

5-Mini Turbo

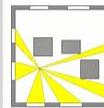
Select a study type

**Grid Object Placement**

Places elements in a rectangular grid pattern inside a room.

**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

 Charts
 Details

Mario Kart Optimization 002

 Mario Kart Optimization

Aug 20, 2021, 1:56 PM

10000/10000 ✓

Mario Kart Optimization 001

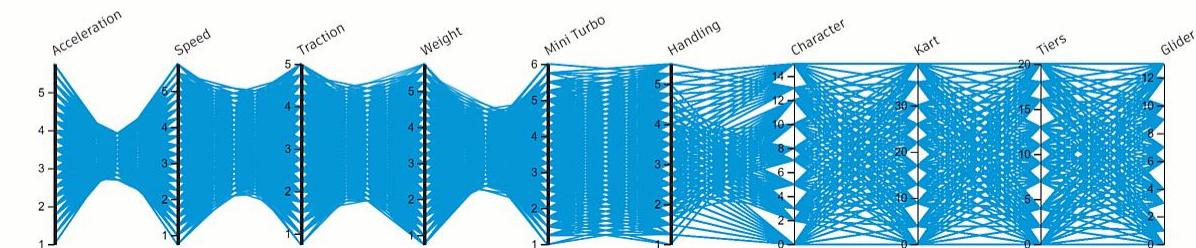
 Mario Kart Optimization

Aug 20, 2021, 1:51 PM

10/10 ✓

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

Value



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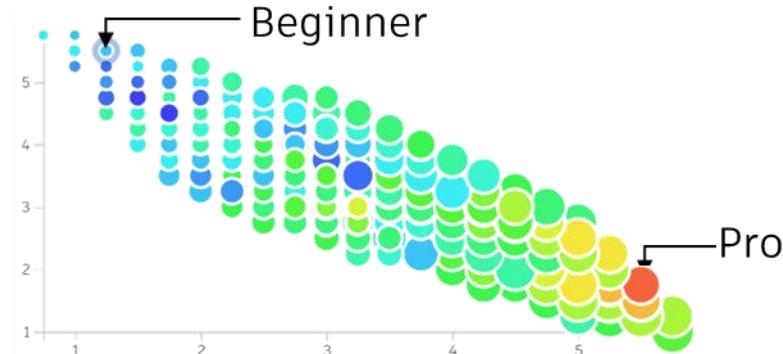


Y-Axis Acceleration

X-Axis Speed

Size Weight

Color Traction



SLIGEACH_EIRE

“Always lose One and gain one”

Generative Design 101

Value



SegaBlueSky

“Too much data to understand”



Zyrac

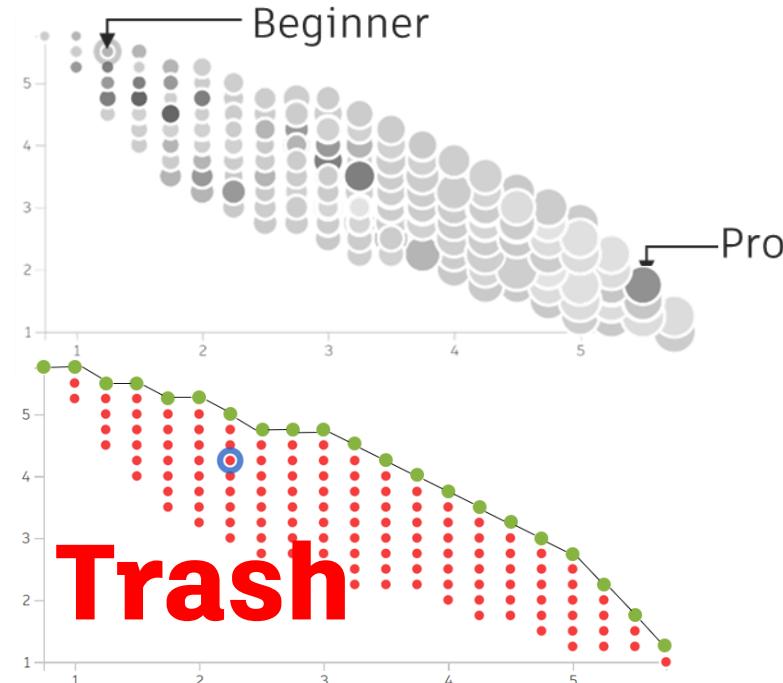
“Balance set up is key for all situation”

Y-Axis Acceleration

X-Axis Speed

Size Weight

Color Traction



SLIGEACH_EIRE

“Always lose One and gain one”

Y-Axis Acceleration

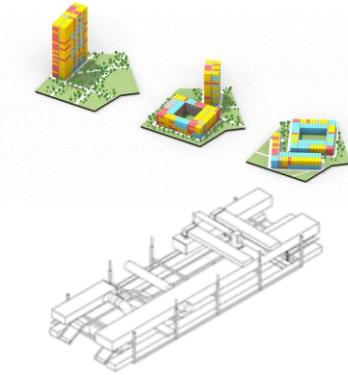
X-Axis Speed

Size Default

Color Default

Generative Design HVAC System Selection

Foundation For Automation



No Data Drops



Standardized Design Process

Procurement First

Automation

HVAC System Selection Evaluators

Goals – Find The Best Combination

Cheap

Easy Installation

Tight Space

Requirements

One Size Fits All

Beautiful

Material Cost

Field Labor Cost

Factory Labor Cost

Unit Mechanical Area

Unit Horizontal Area

Main Horizontal Area

Shaft Vertical Area

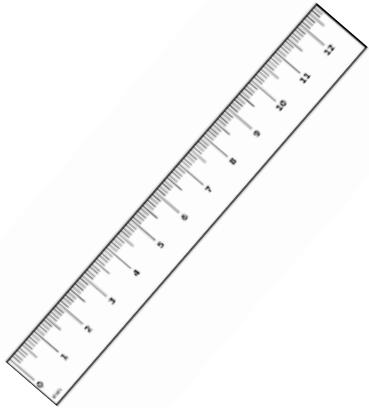
Plant Area

Plant Weight

Architecture Aesthetics

Generative Design – HVAC System Selection

Evaluators – Labor Cost



X

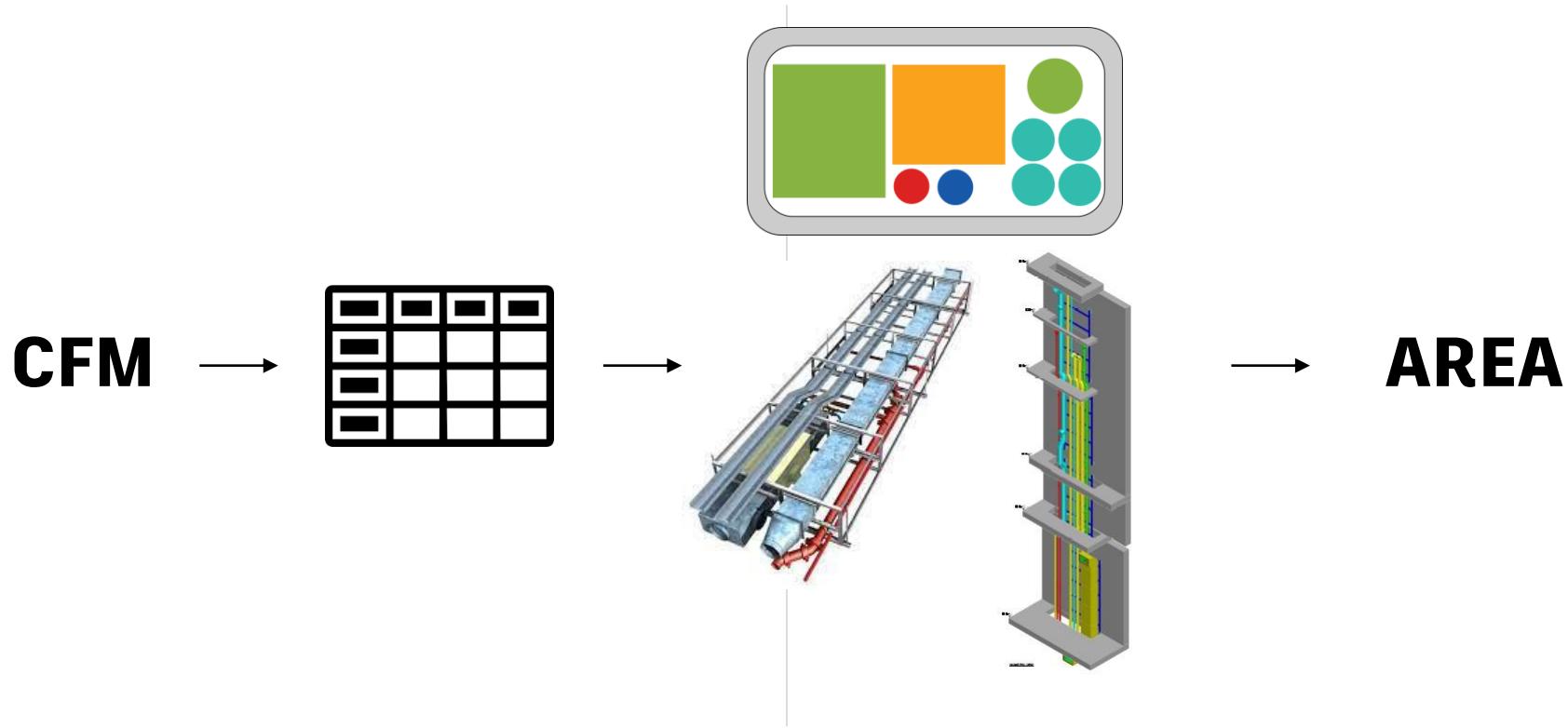


X



Generative Design – HVAC System Selection

Evaluators – Areas



Generative Design – HVAC System Selection

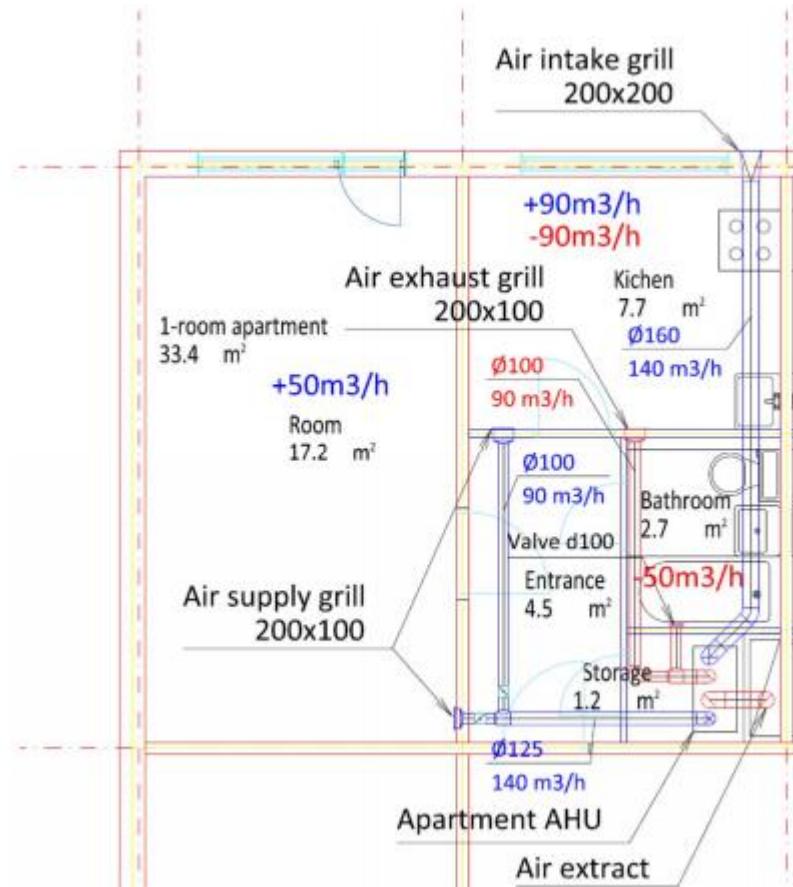
Evaluators – Energy

HVAC System Selection Static Inputs

Generative Design – HVAC System Selection

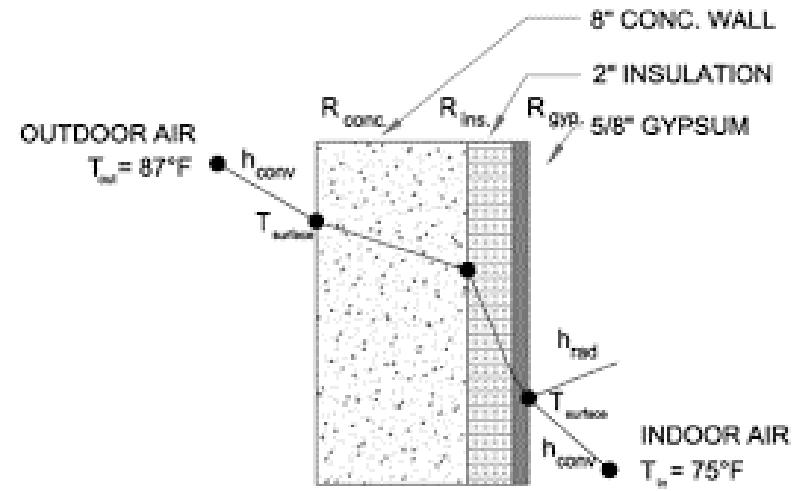
Static Inputs – System Definitions

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

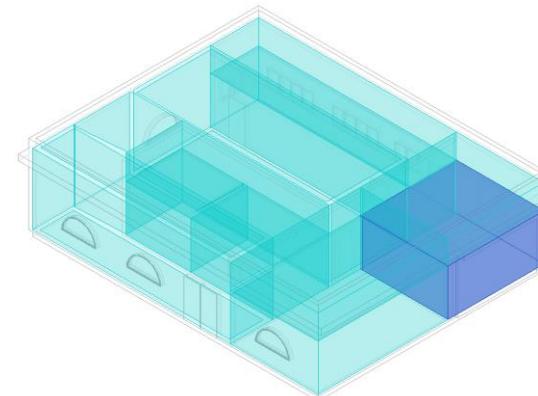
Static Inputs – Heating & Cooling Loads



Min - Schedule: Analytical Spaces Schedule

<Analytical Spaces Schedule>

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

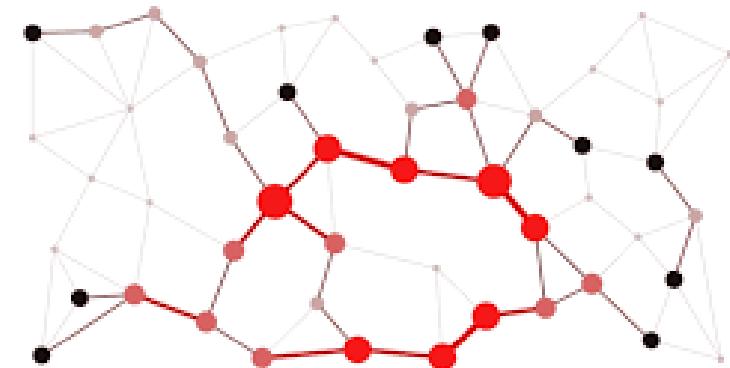
Generative Design – HVAC System Selection

Geometry System Foundation

Clustering / Grouping

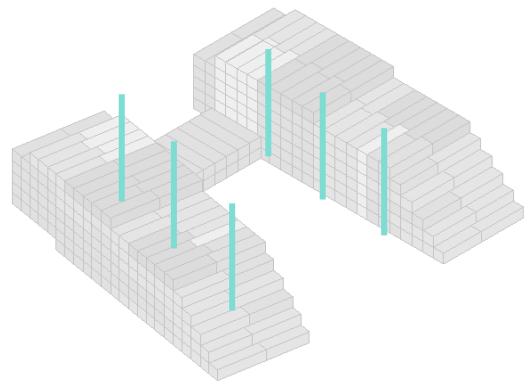


Graph Theory

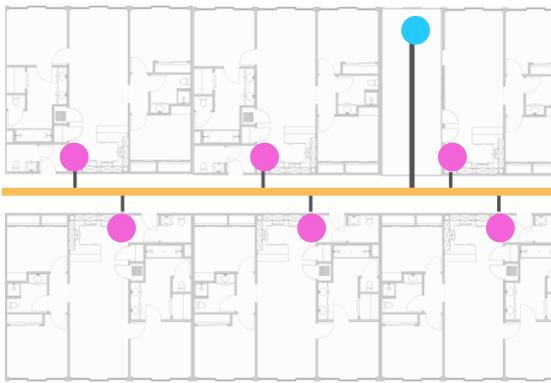


Geometry System – The Graph

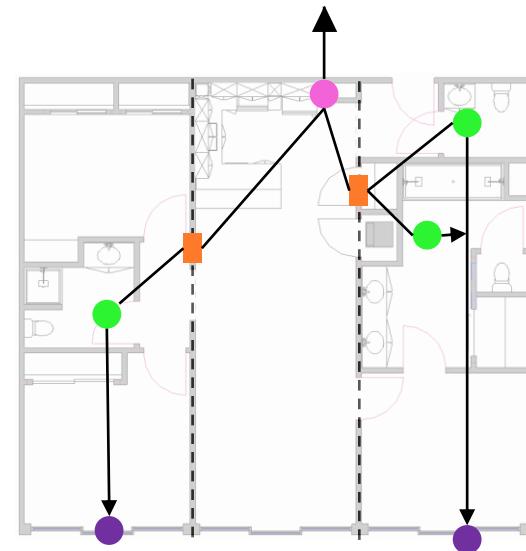
Shafts



Mains



Units



Shaft Edge

Shaft Edge

Exterior Node

Unit Node

Unit Hub

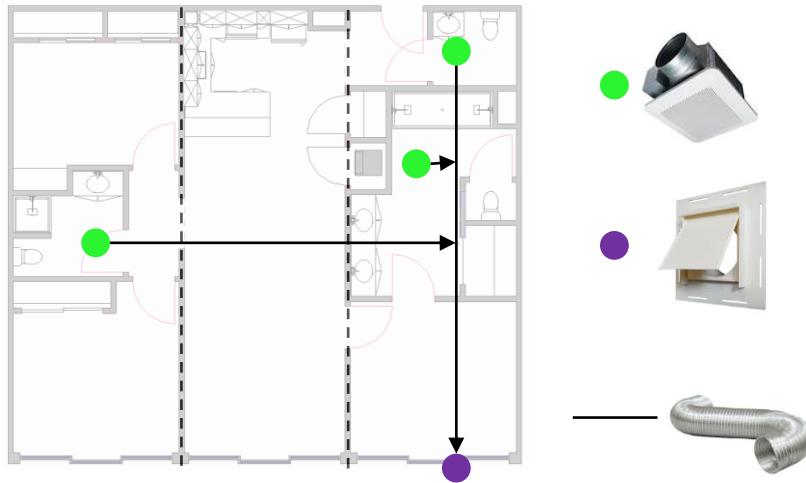
Exhaust Node

Shaft Node

Shaft Node

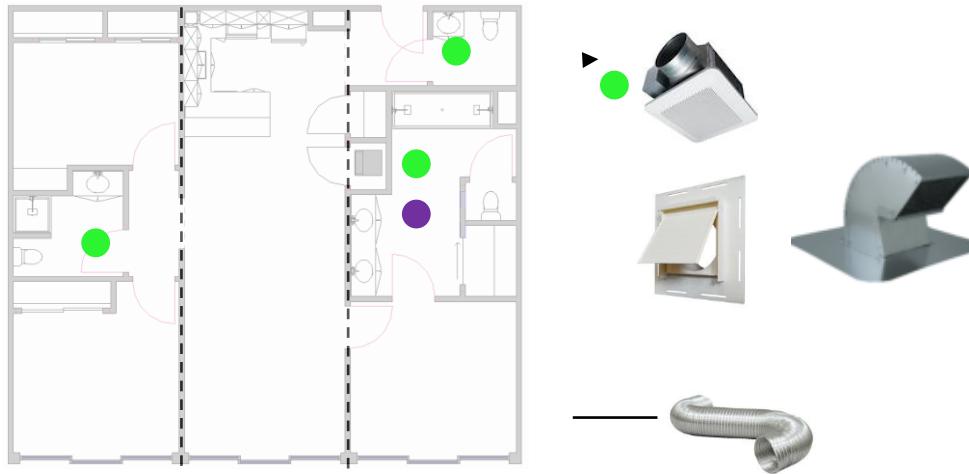
Unit Exhaust

Bathroom Exhaust Fan to wall



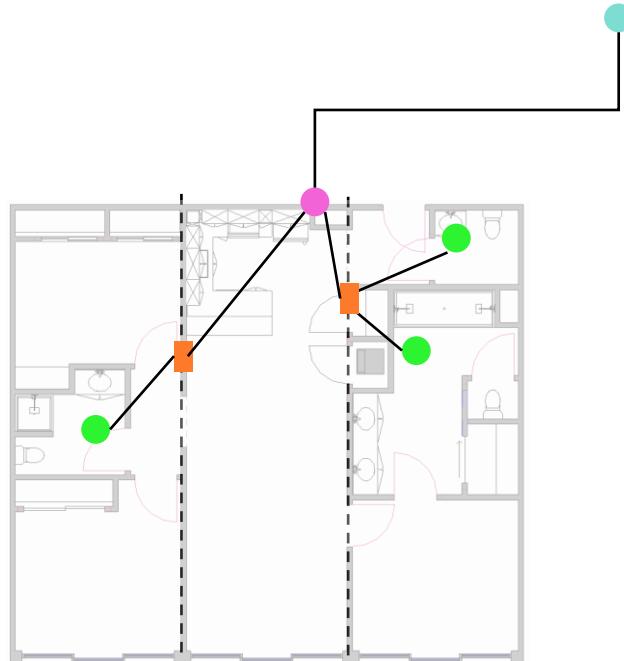
Unit Exhaust

Bathroom Exhaust Fan to roof



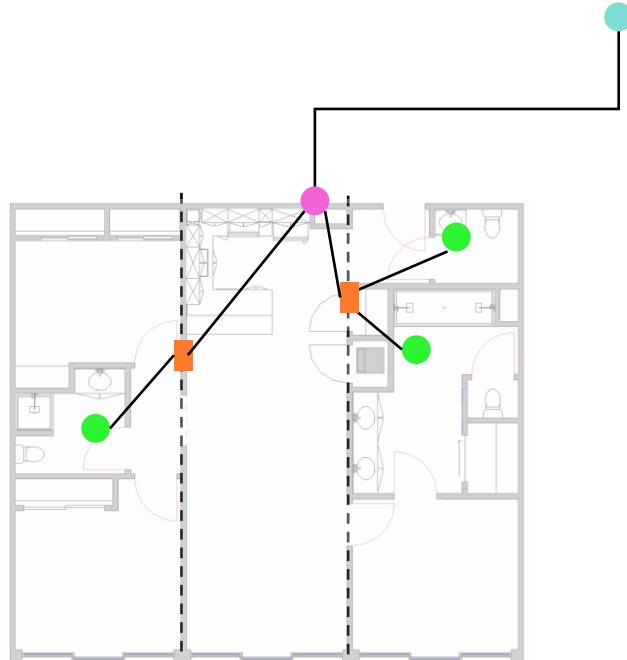
Unit Cooling

Centralized Bathroom Exhaust Fan



Unit Cooling

Centralized Bathroom Energy Heat Recover

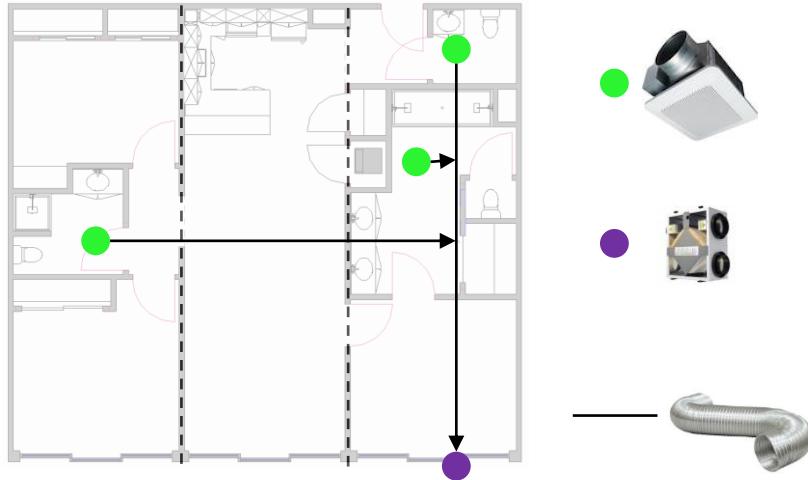


renewaire he-2x



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 residential for many years to attempt to reduce energy loss by 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 offering 40 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.

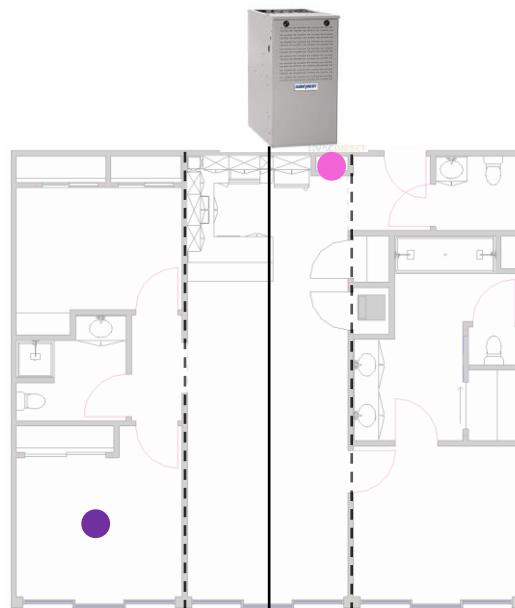
The systems can be further upgraded to use an ERV core that assists in transferring moisture between the exhaust and fresh air which results in reduced cost for moisture control and ventilation in the home.

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 residential applications. The Unilux exhaust 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

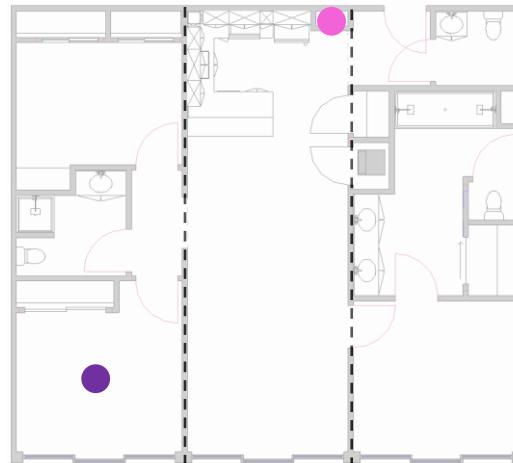


Unit Ventilation

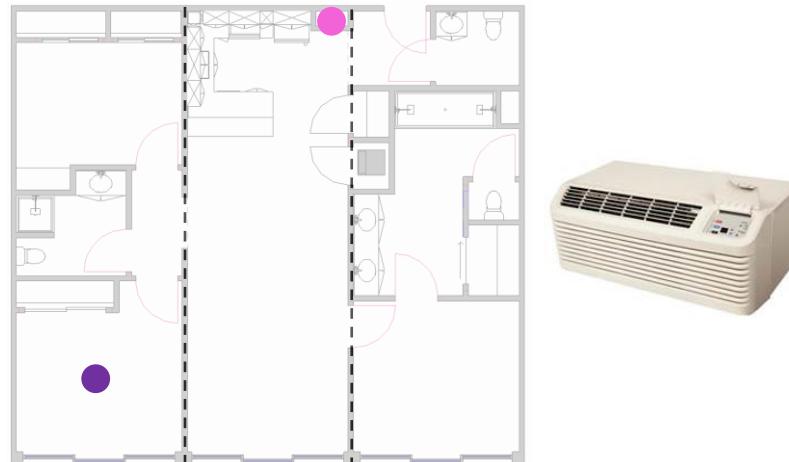
AHU – Duct Directly To Out side



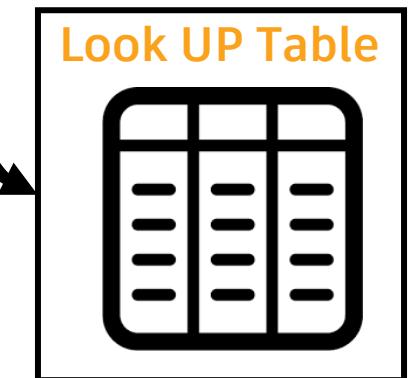
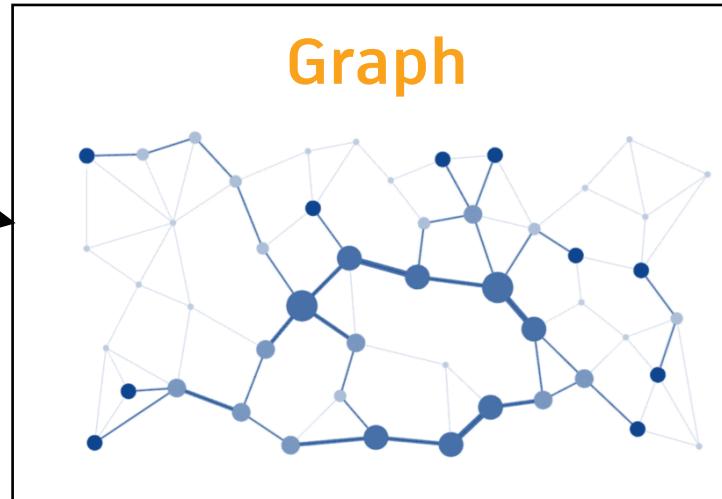
Unit Ventilation Grill



Unit Ventilation Grill



Geometry System - Algorithms

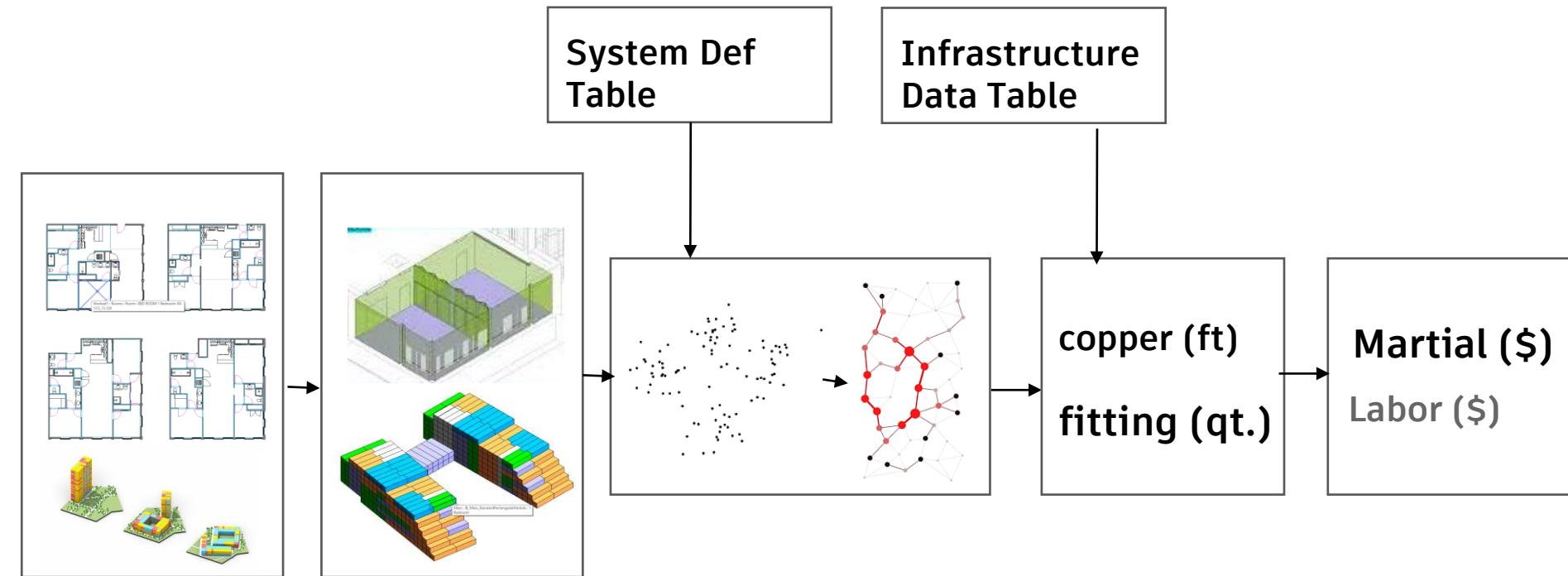


Geometry System - Variable

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

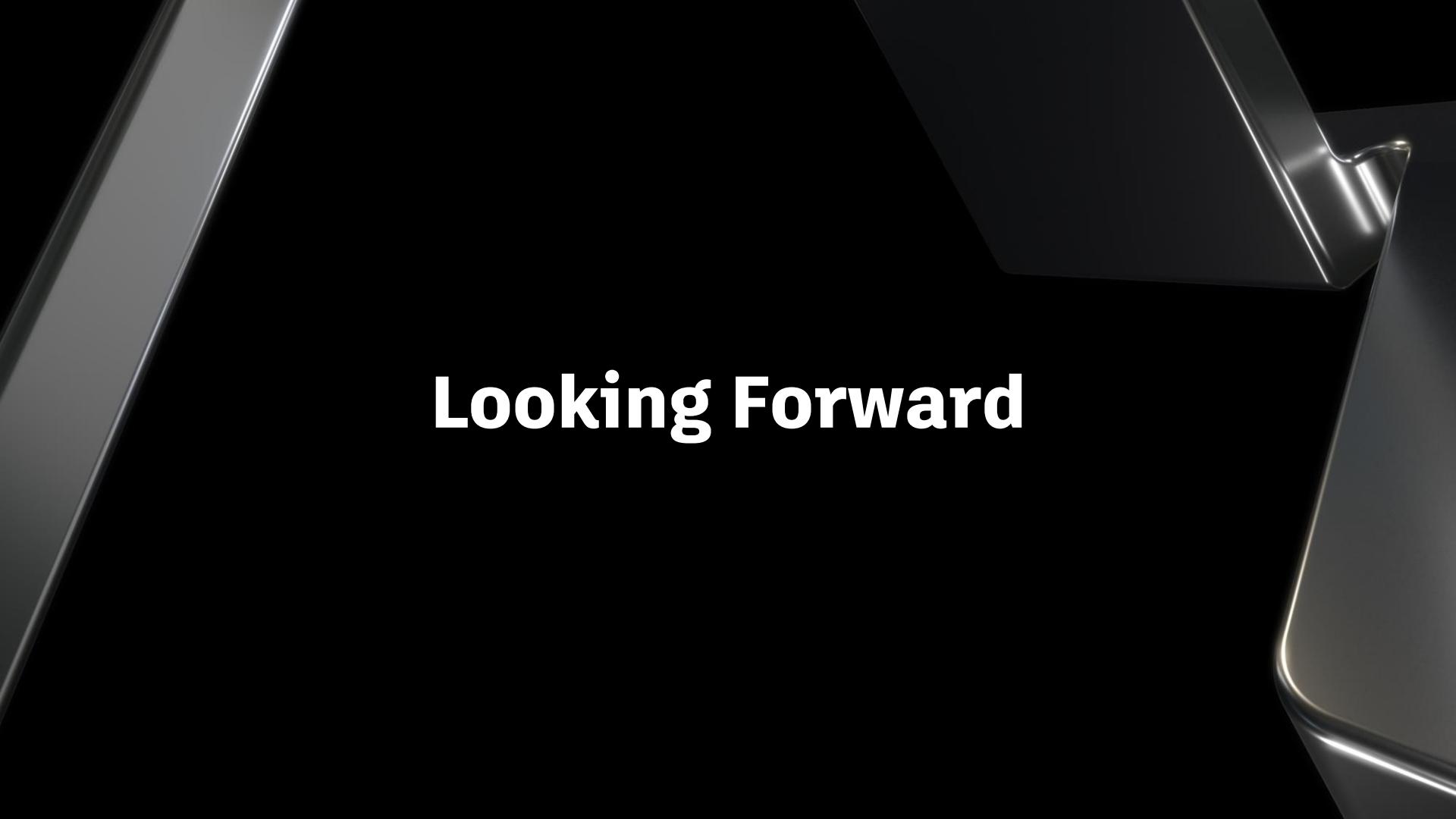
Generative Design – HVAC System Selection

Geometry System - Overview



HVAC System Selection Dynamo & Revit Implementation

Q & A Demo

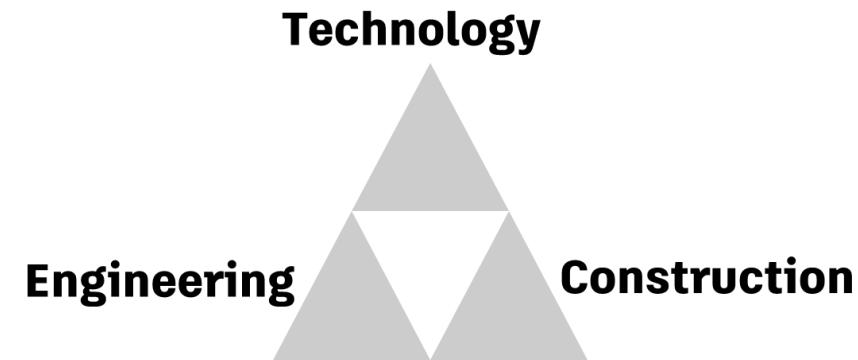


Looking Forward

Generative Design – HVAC System Selection

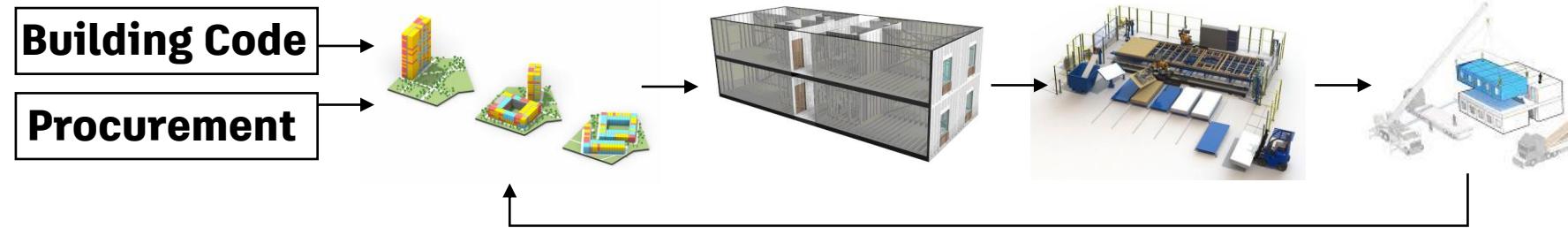
Final Thoughts

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



Final Thoughts

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





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