Parametric Daylighting Tools

Leland Curtis
Dr. Richard Mistrick
Sarith Subramaniam
Reinhardt Swart

Parametric Daylighting Tools

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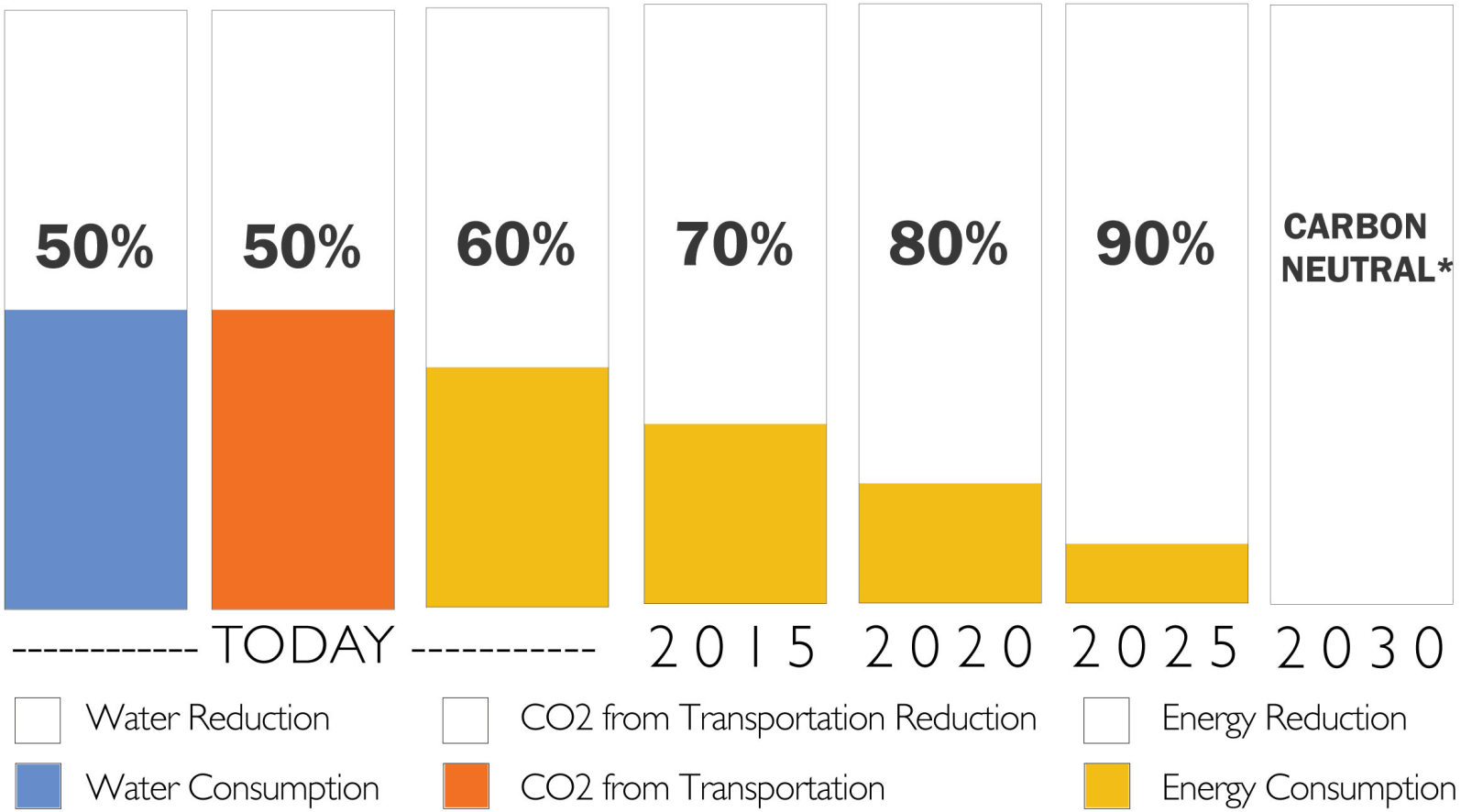
lighting design



The 2030 Challenge for Planning: New Buildings & Major Renovations

**Using no fossil fuel GHG-emitting energy to operate.*

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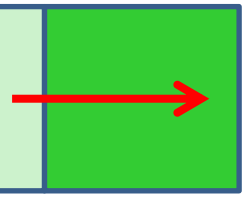
Schedule/Fee

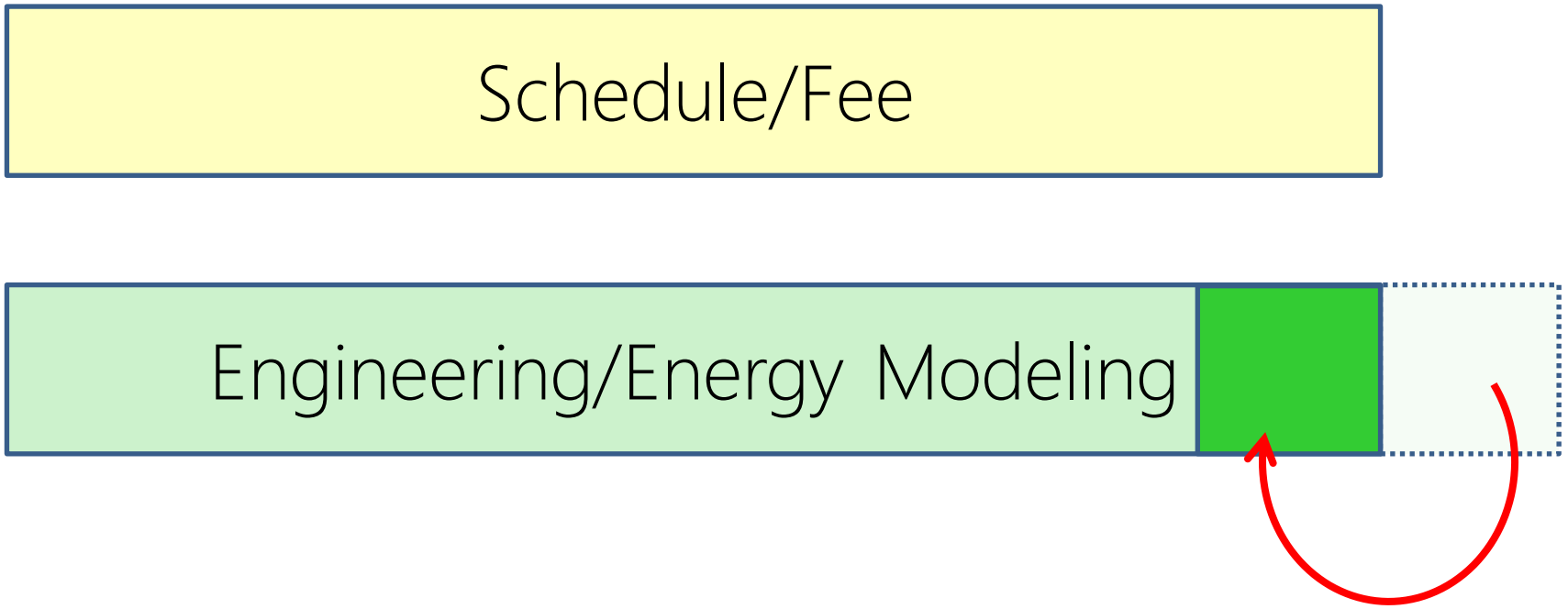
Engineering/Energy Modeling

Schedule/Fee

Engineering/Energy Modeling



Do more for less



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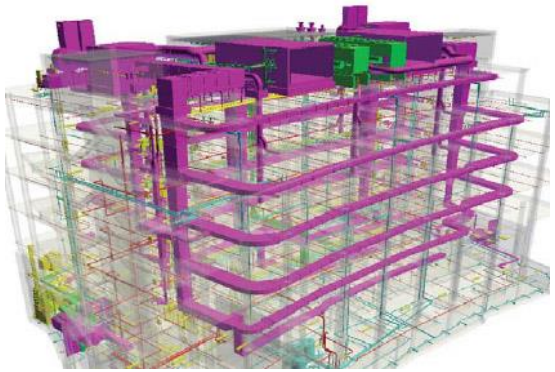
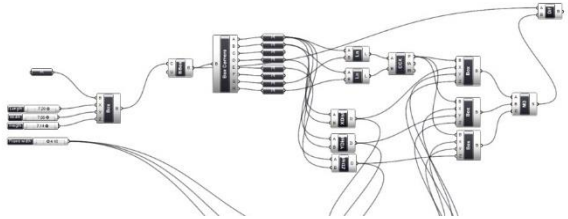
PAST

PAST - PRESENT



PRESENT - FUTURE



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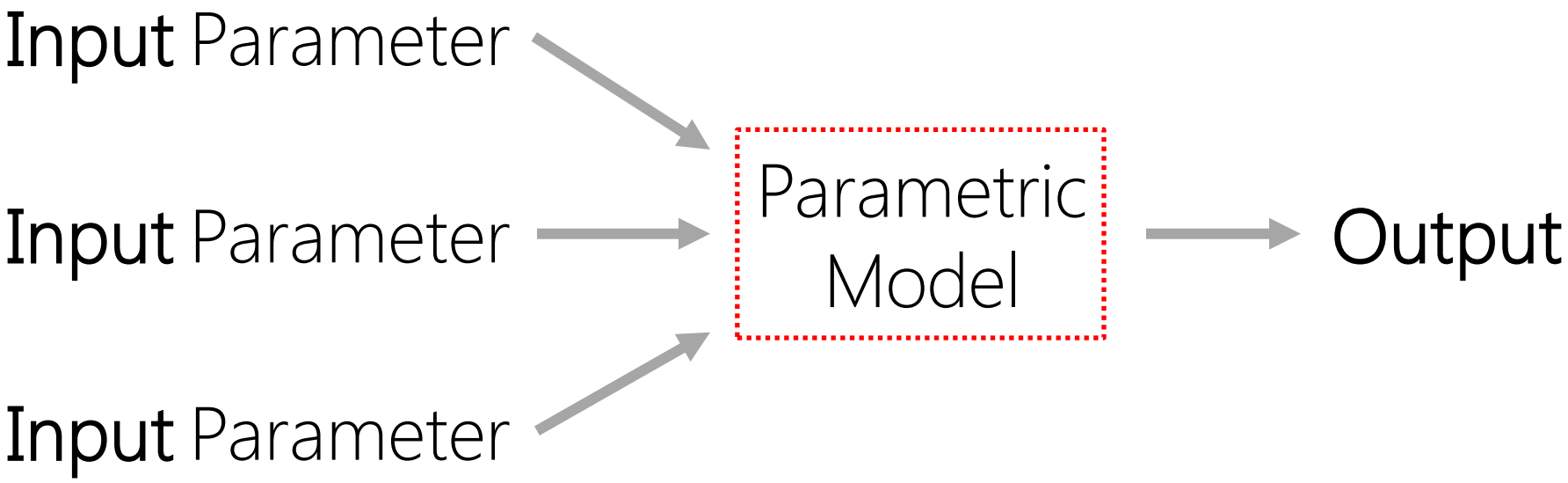
Parametric Model



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Parametric Modeling Programs

Rhino 5.0 grasshopper

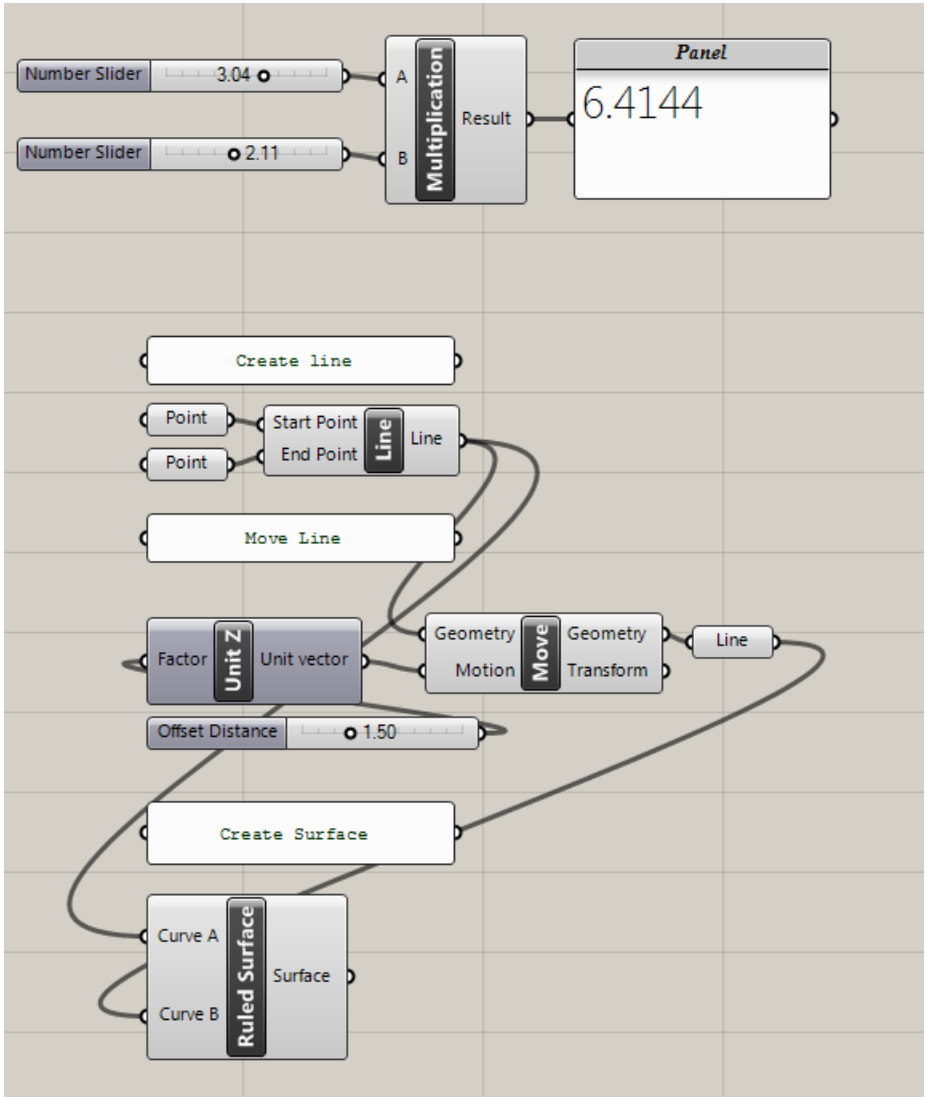
Ladybug

Honeybee

DIVA

AUTODESK REVIT

Dynamo



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Parametric Modeling Programs

Rhino 5.0 grasshopper

Ladybug

Honeybee

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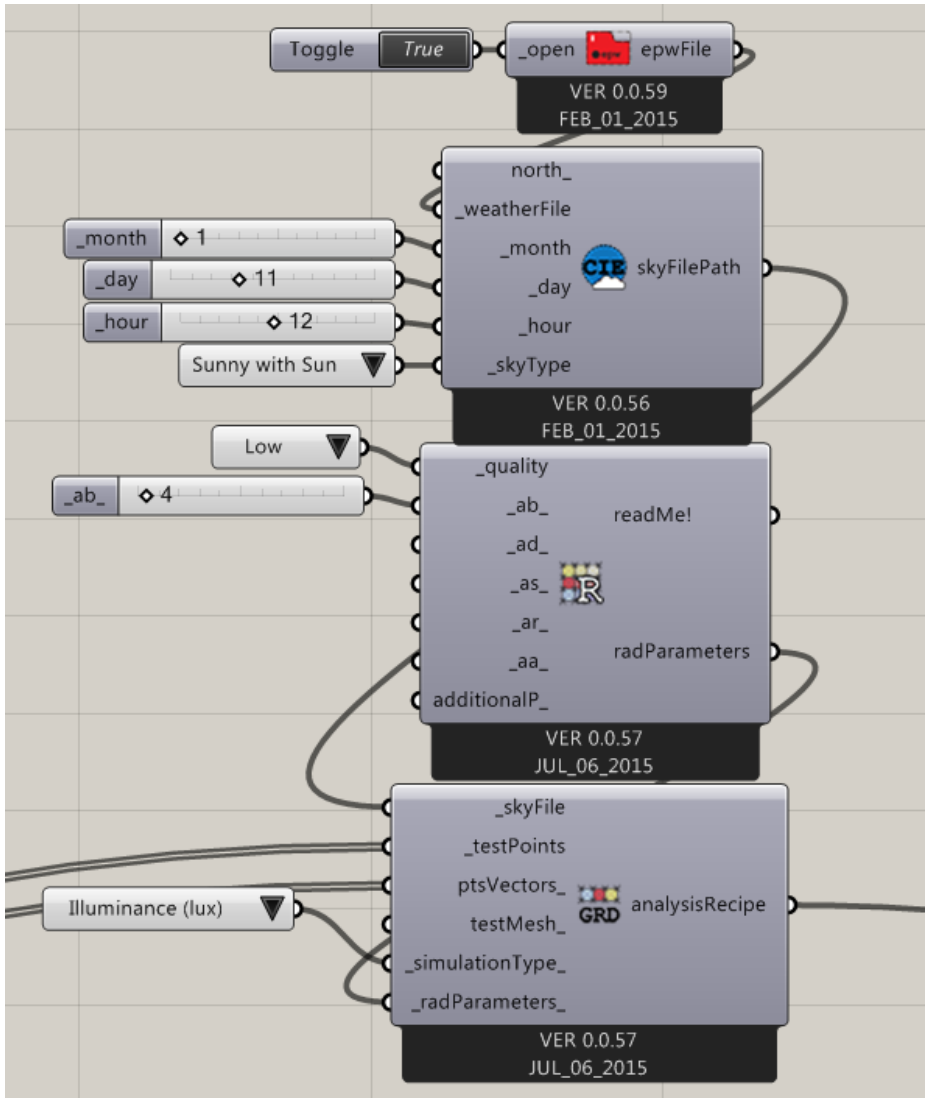

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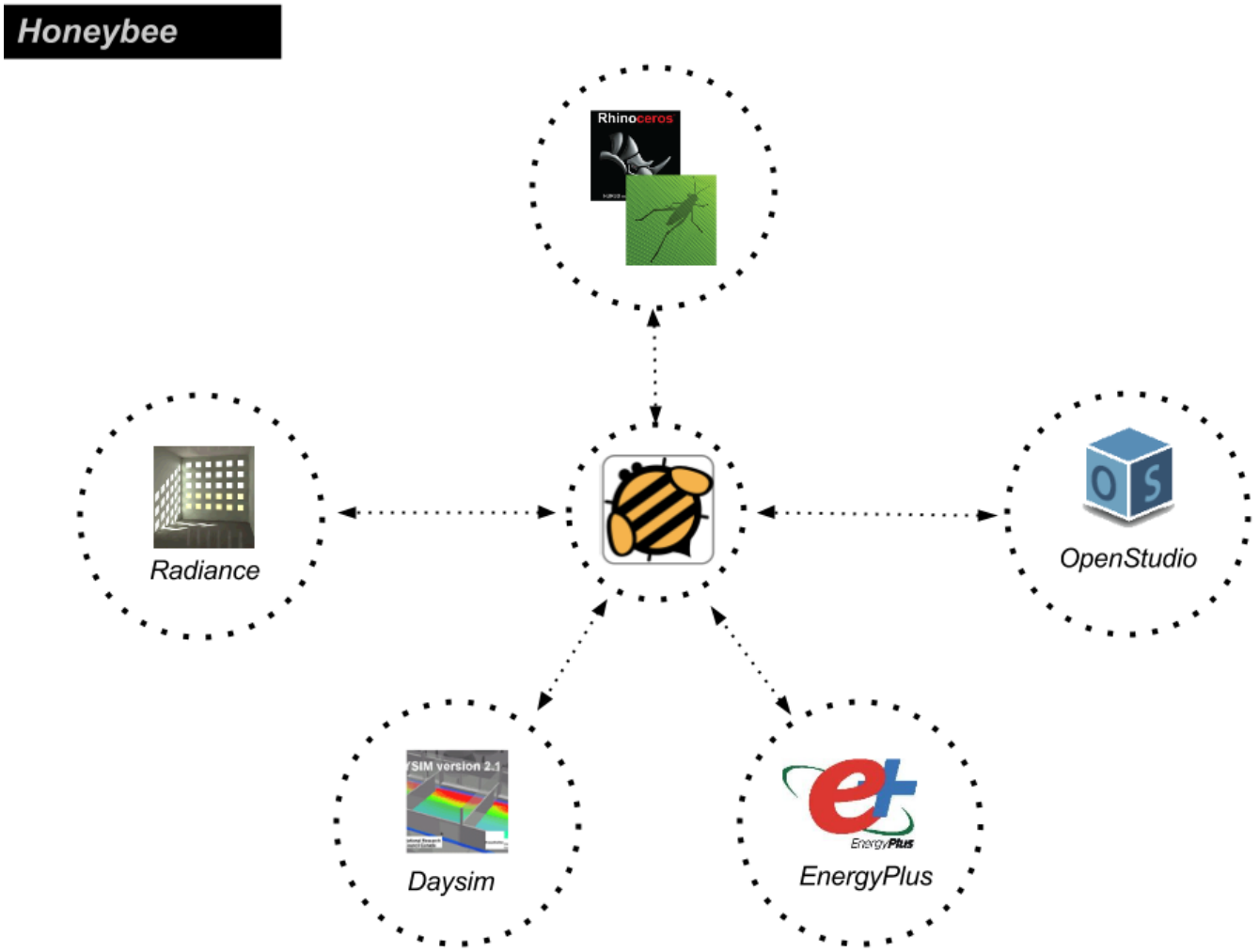
Grasshopper for Rhino

Honeybee: Developed by Mostapha Sadeghipour Roudasri

http://www.food4rhino.com/project/ladybug-honeybee?ufh



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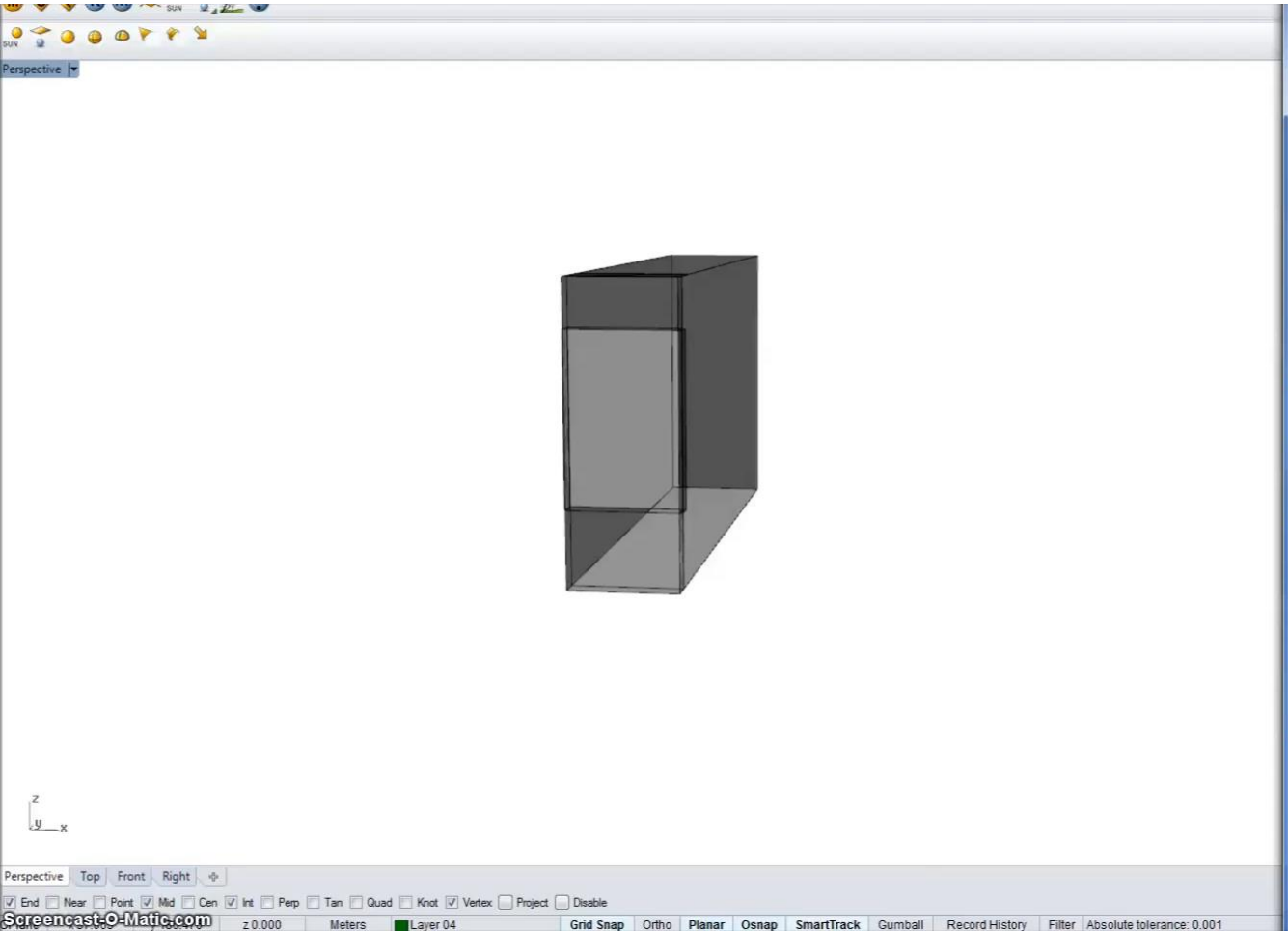
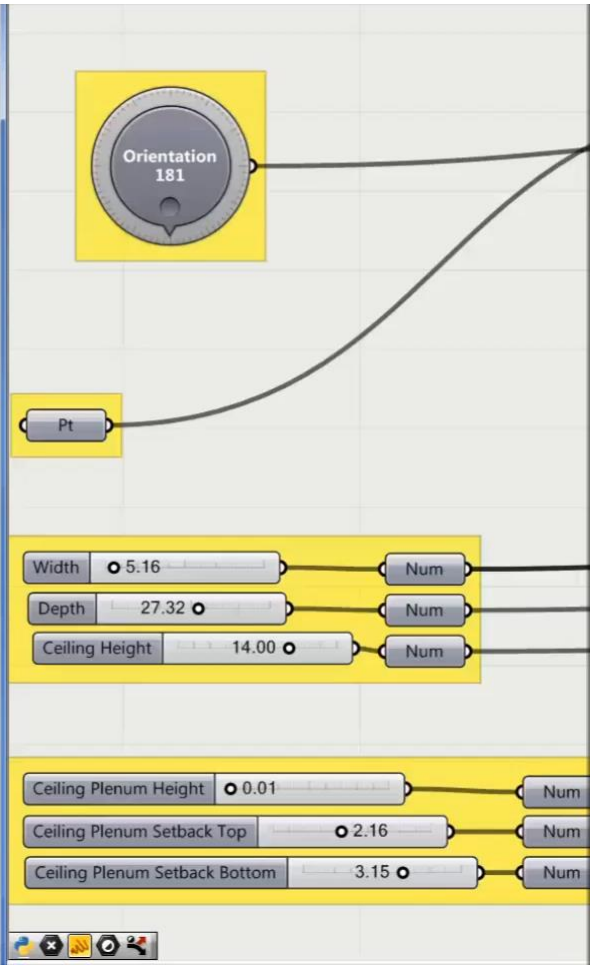
Automate Model Making





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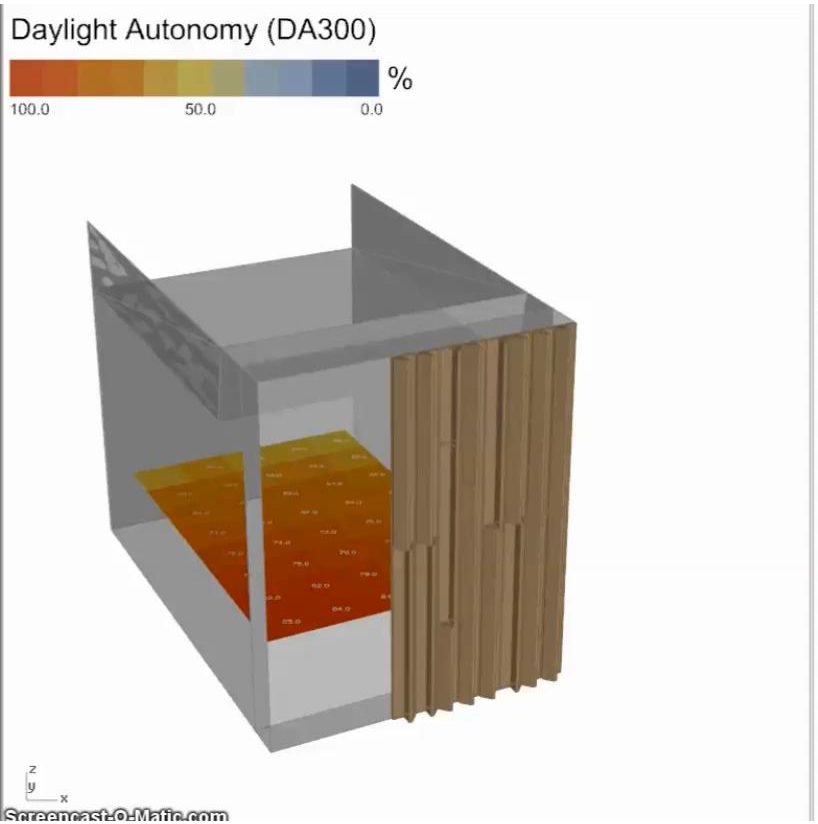
Calculate multiple iterations



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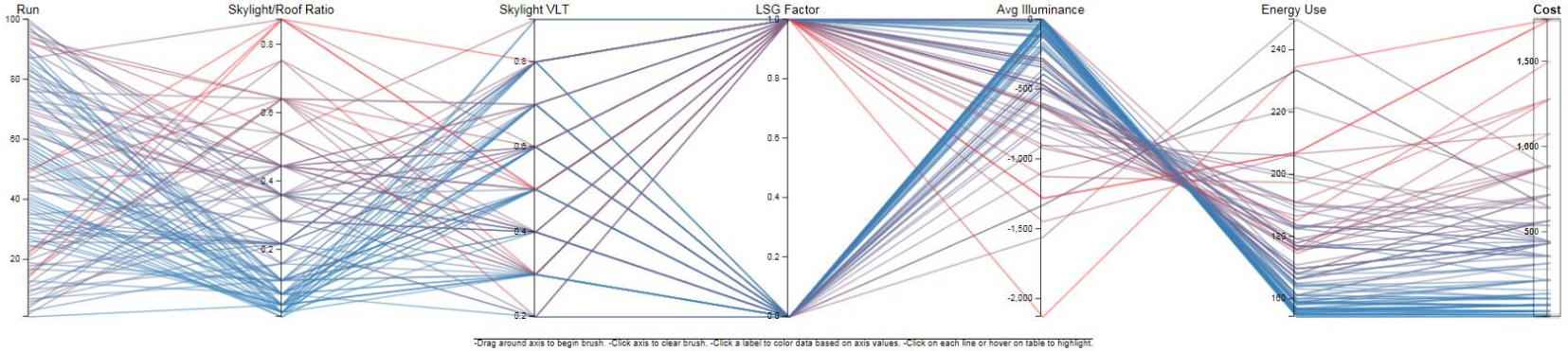
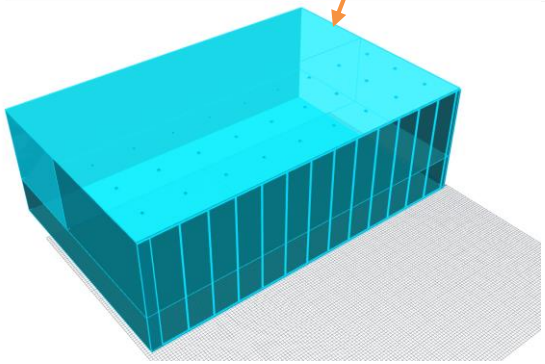
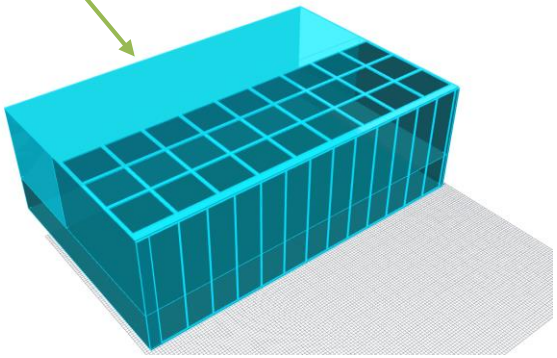
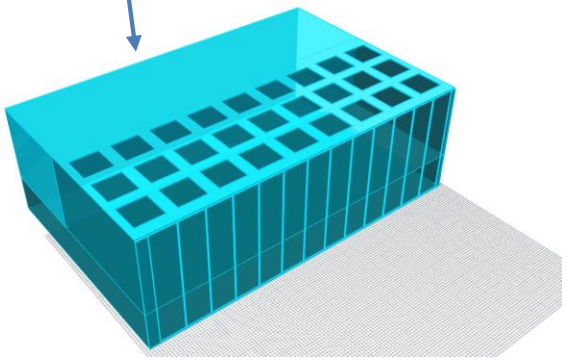
Analyze generated data



Run	Skylight/Roof Ratio	Skylight VLT	LSG Factor	Avg Illuminance	Energy Use	Cost
1	0.039889	0.9	1	-56.537976	156.547142	79.777638
2	0.445291	0.6	1	-760.107262	182.47522	890.582578
3	0.160091	0.5	0	-195.621825	165.031	160.090696
4	0.538901	0.3	0	-435.532341	183.120572	538.90062
5	0.360606	0.4	0	-390.65254	177.100414	360.605631
6	0.218005	0.8	1	-467.459841	169.841687	436.010669
7	0.1111	0.5	1	-124.417817	159.145912	222.199461
8	0.284844	0.4	1	-300.866429	166.641727	569.687292
9	0.445291	0.3	0	-355.416508	177.148346	445.291289
10	0.160091	0.7	1	-279.805238	164.002328	320.181392
11	0.360606	0.4	0	-391.006071	177.100414	360.605631







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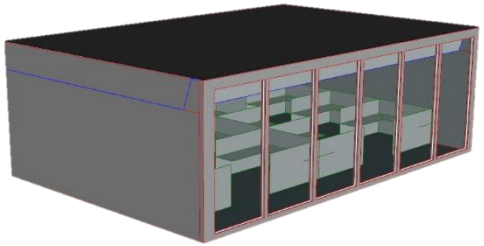
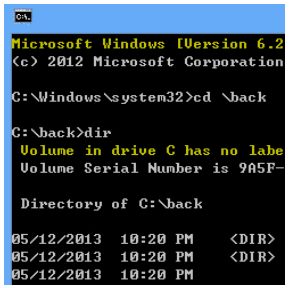
Validation Workflow

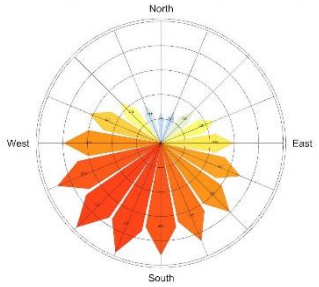
Model



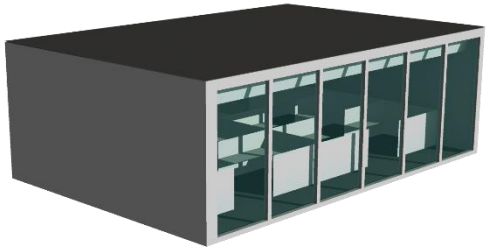
Calculate



Analyze



Design



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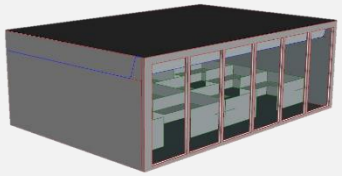
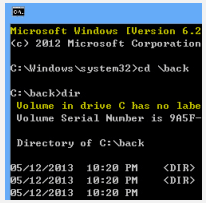
Parametric Workflow

Parametric Model

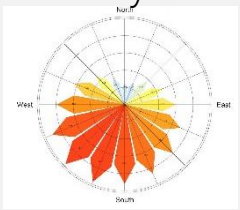
Model



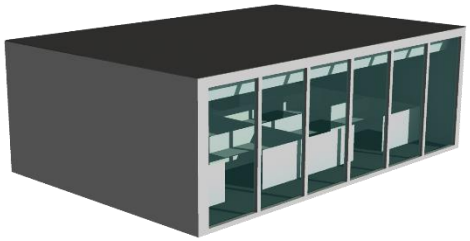
Calculate

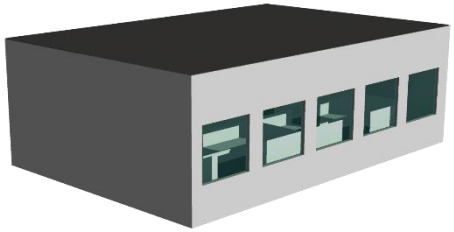


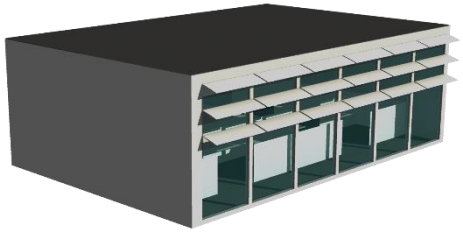
Analyze



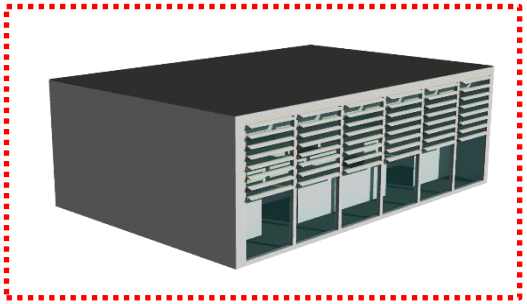
Iterative Analysis







Informed Design



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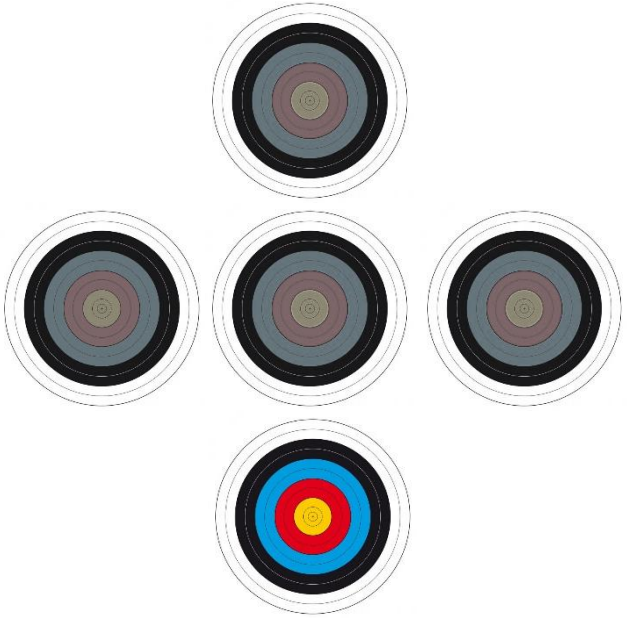
Explore



Optimize

DC Water Headquarters

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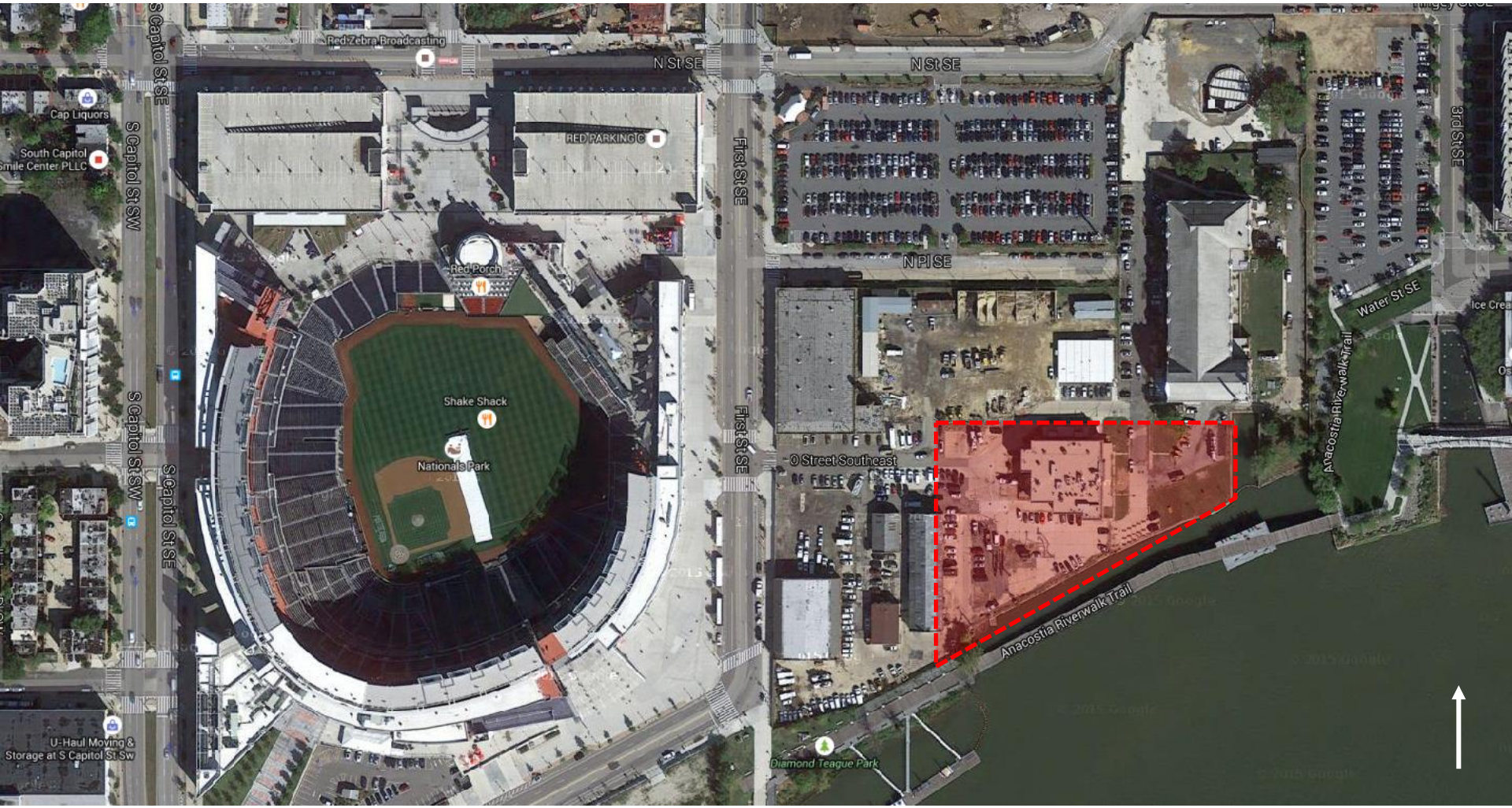
DC Water - Site



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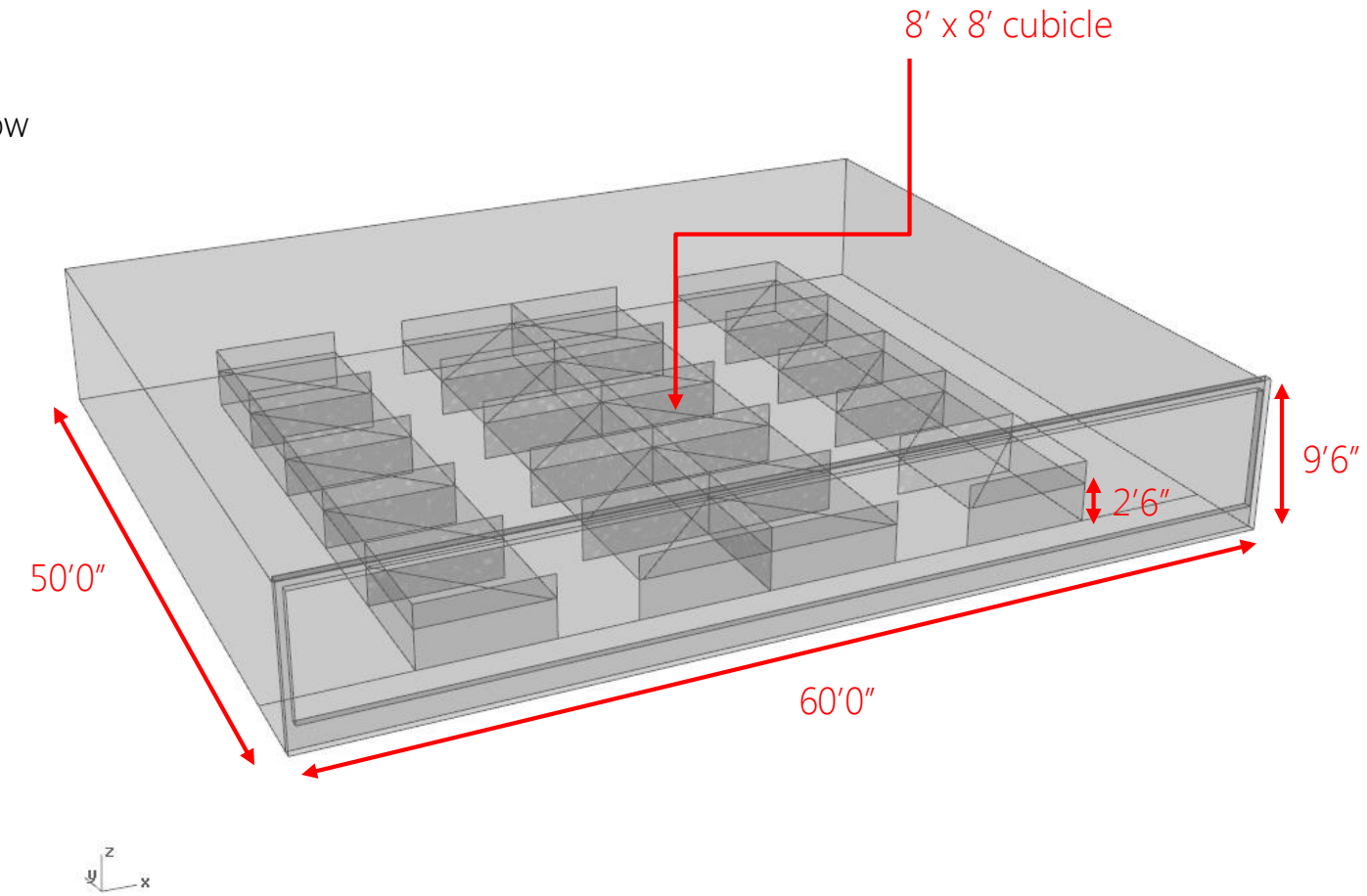
Iterative Parametric Daylighting Model

Conditions:
80% refl ceiling
50% refl wall
67% VLT window



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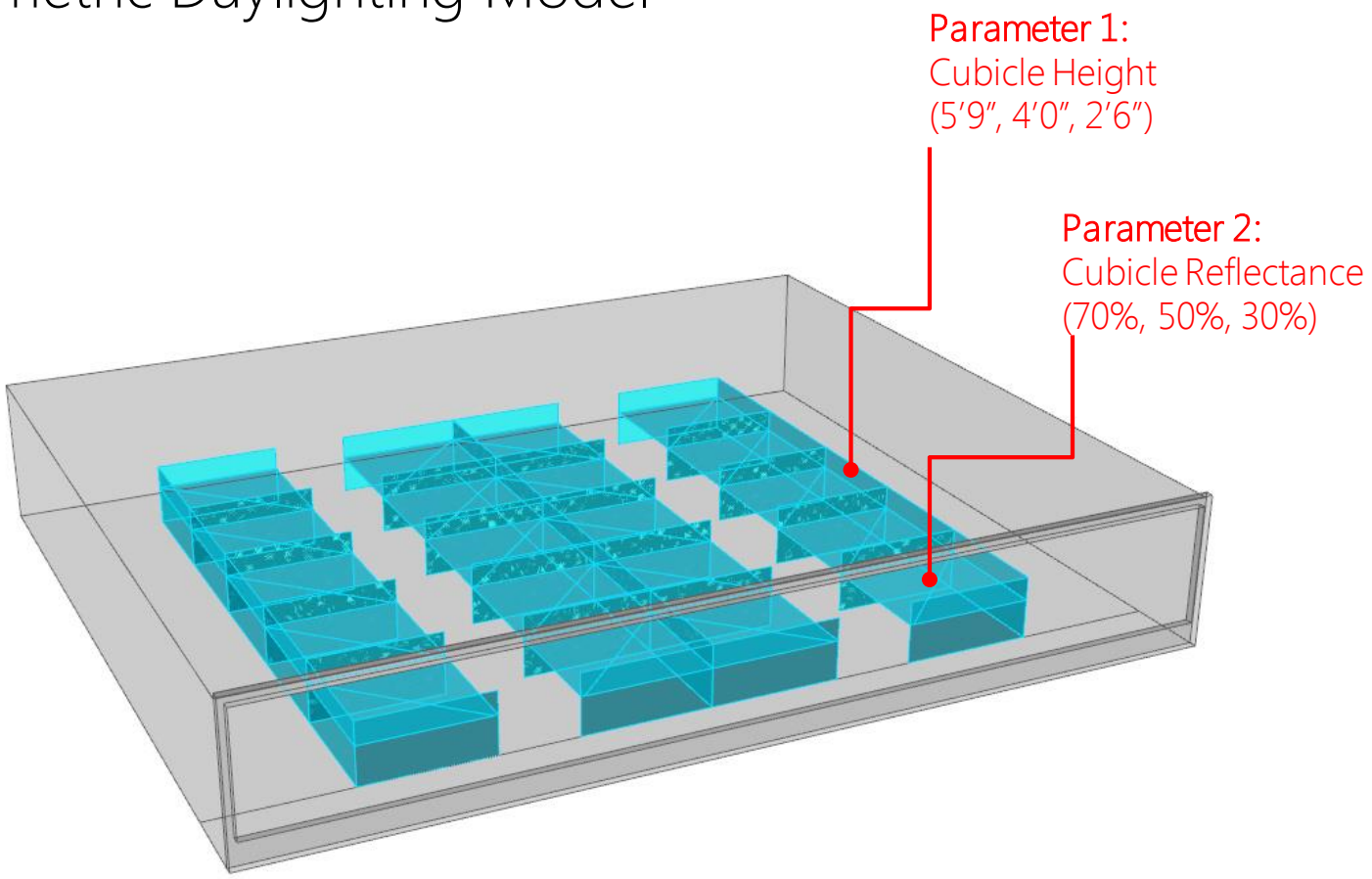
Iterative Parametric Daylighting Model



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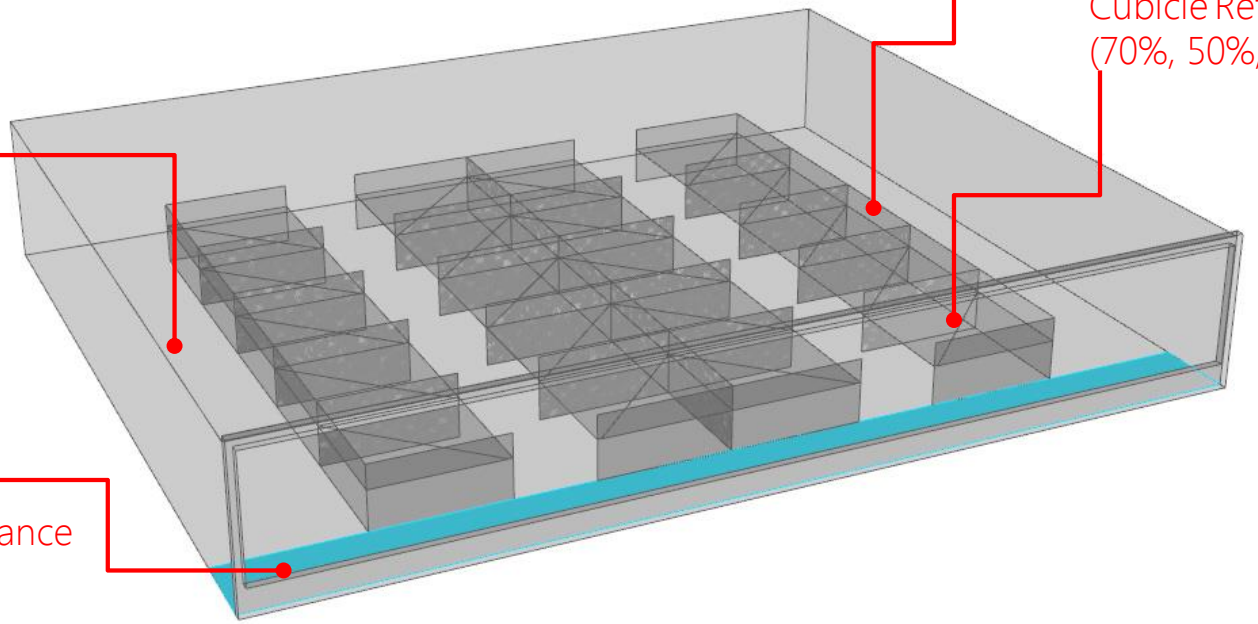
Iterative Parametric Daylighting Model

Parameter 1:
Cubicle Height
(5'9", 4'0", 2'6")

Parameter 2:
Cubicle Reflectance
(70%, 50%, 30%)

Parameter 3:
Inner Floor Reflectance
(20%, 10%)

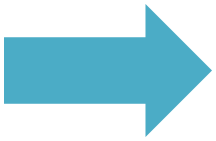
Parameter 4:
Outer Floor Reflectance
(35%, 20%, 10%)



Iterative Parametric Daylighting Model

Input Parameters:

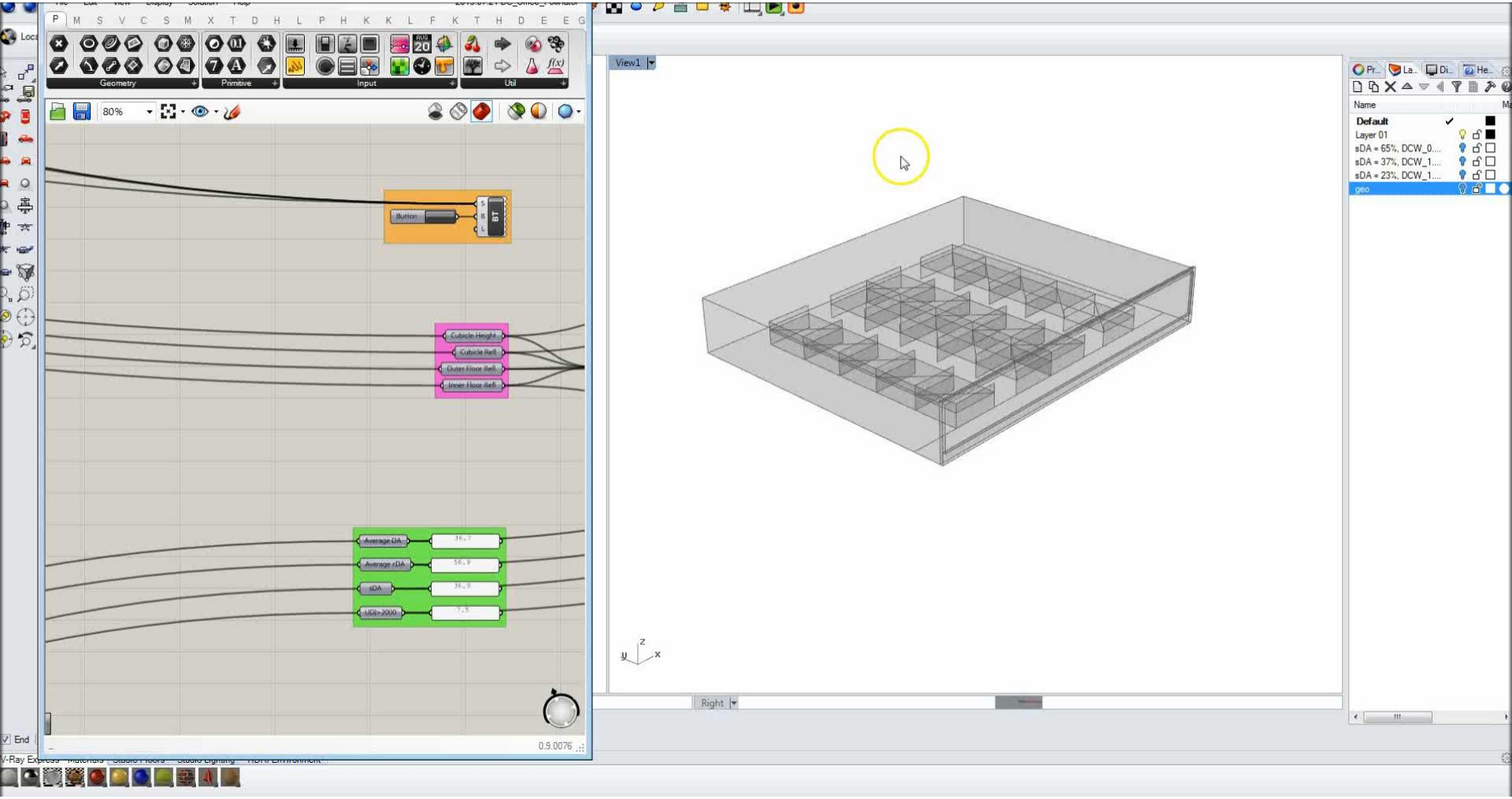
Cubicle Height
Cubicle Reflectance
Inner Floor Reflectance
Outer Floor Reflectance



Output Metrics:

Avg DA_{300lux}
Avg cDA_{300lux}
sDA_{300lux}
UDI > 2000lux

Iterative Parametric Daylighting Model



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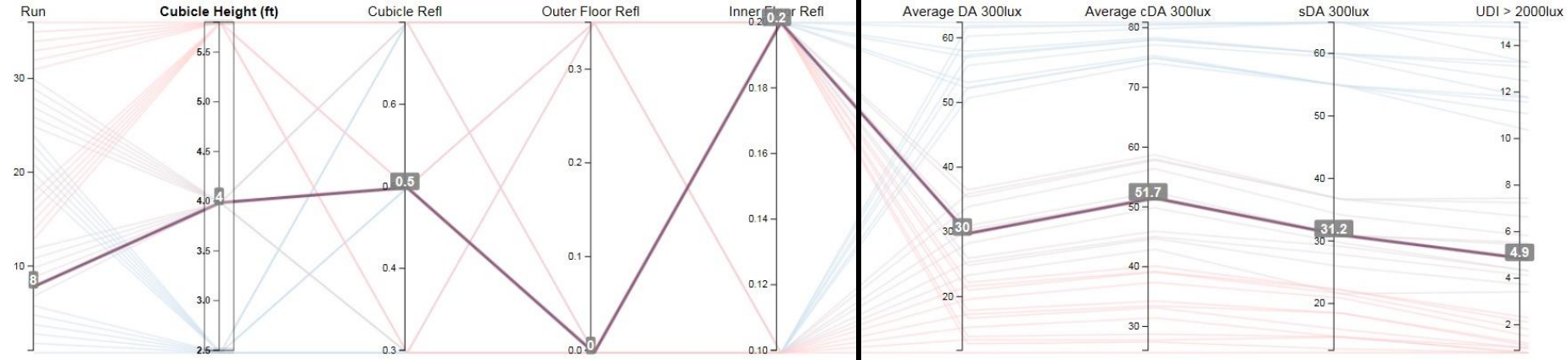
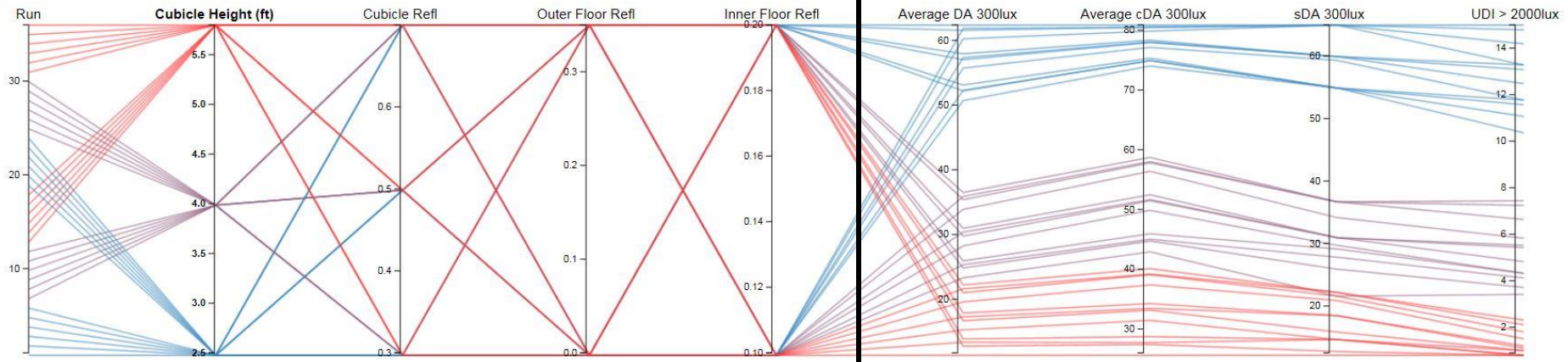
Analysis of all possible combinations of input parameters

Single option selected showing input parameter values



All iterations displayed



Input Parameters

Output Metrics

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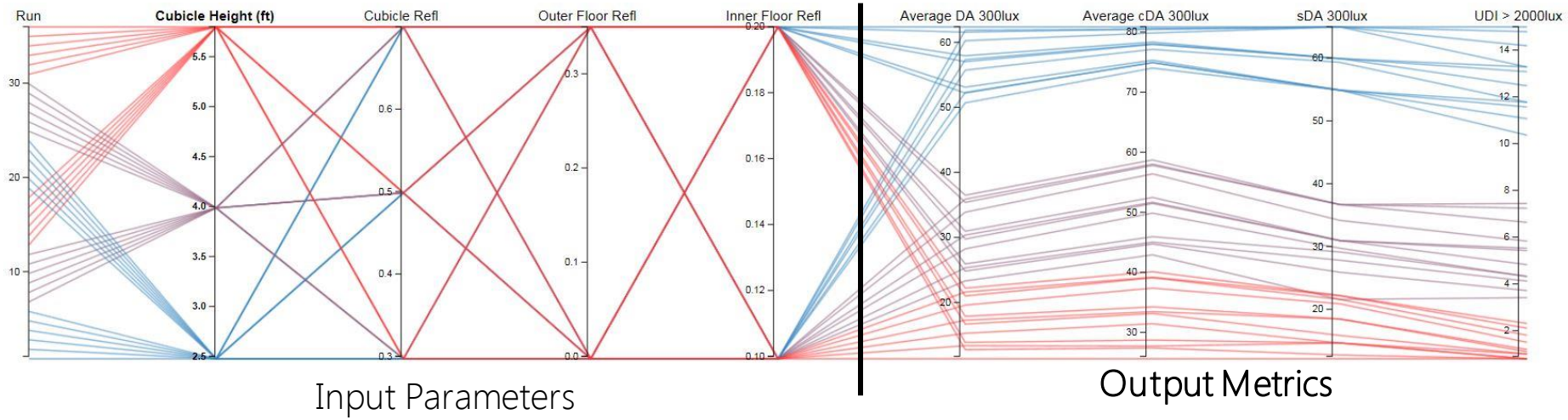
Analysis of all possible combinations of input parameters

All options shown: 30" cubicle=blue, 48" cubicle=purple, 69" cubicle=red



Input Parameters

Output Metrics

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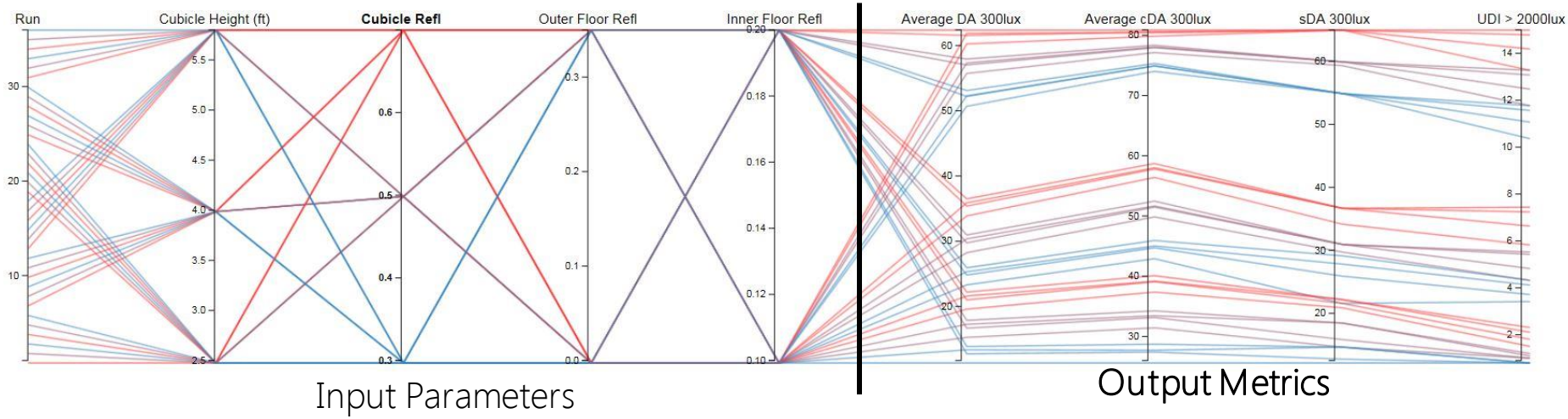
Analysis of all possible combinations of input parameters

All options shown: 30% cubicle LRV=blue, 50% cubicle LRV=purple, 70%" cubicle LRV=red



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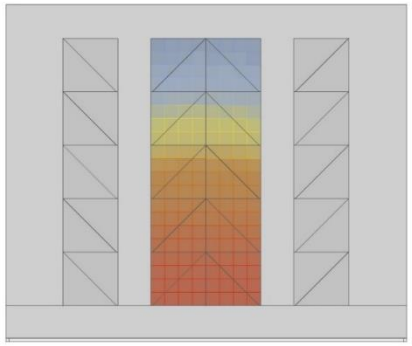
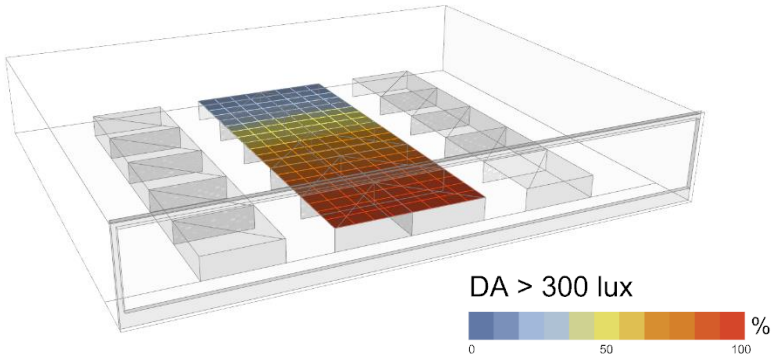
Effect of cubicle design and materials on daylight levels

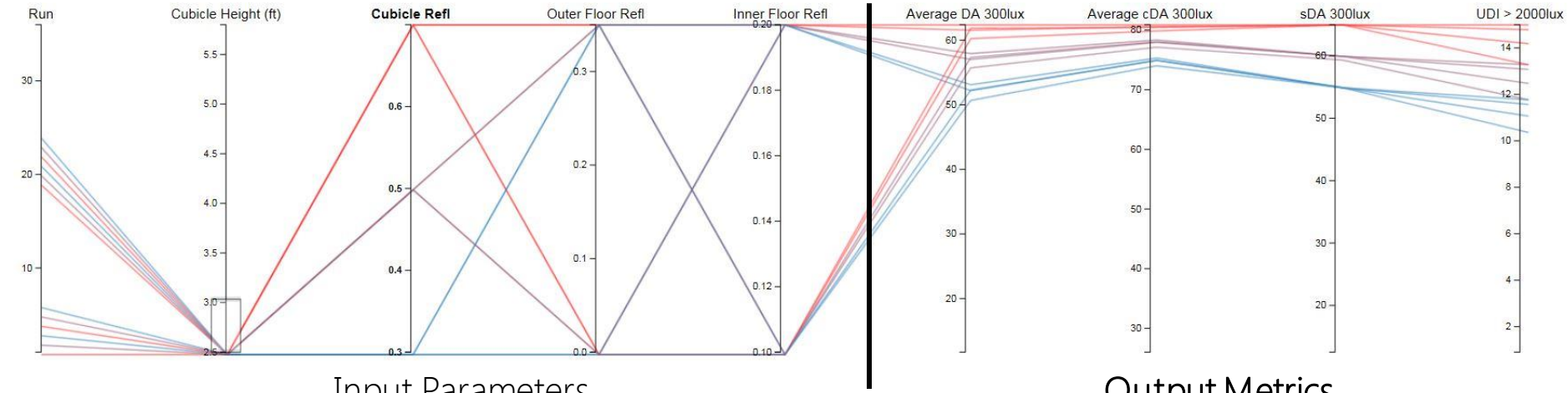
30" cubicle height

- sDA_{300lux} = 65%
- DA_{300lux} avg = 62%
- cDA_{300lux} avg = 81%
- $UDI_{>2000lux}$ avg = 14%





30" cubicles shown: 30% cubicle LRV=blue, 50% cubicle LRV=purple, 70%" cubicle LRV=red



Input Parameters

Output Metrics

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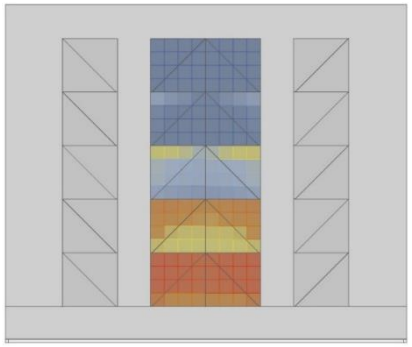
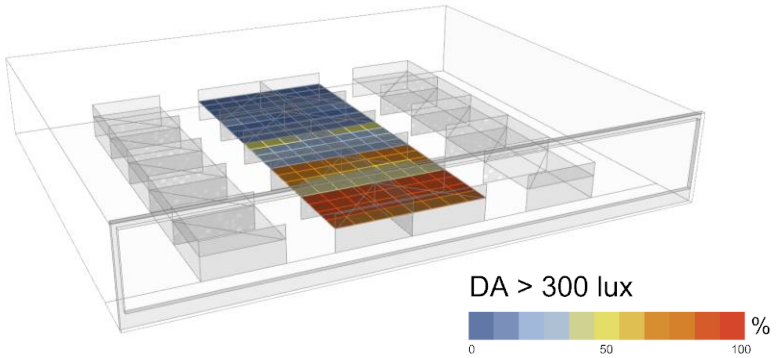
Effect of cubicle design and materials on daylight levels

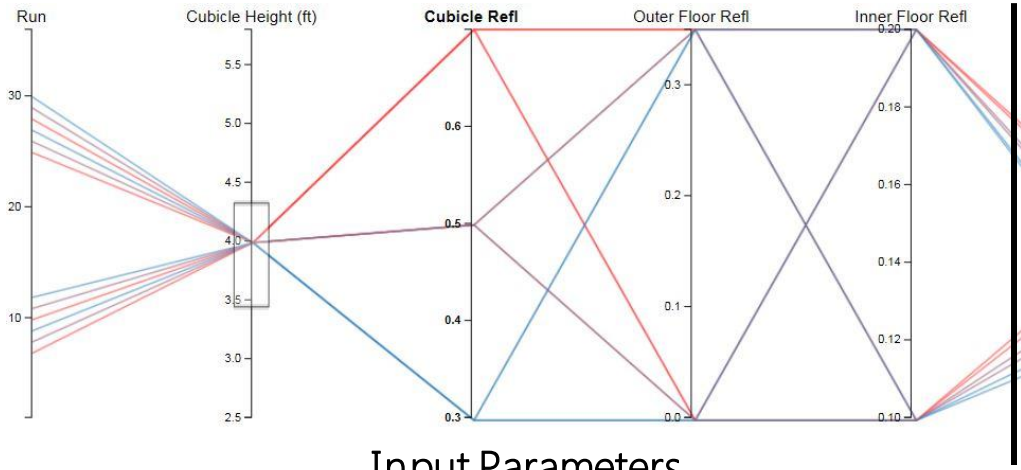
48" cubicle height

- sDA_{300lux} = 37%
- DA_{300lux} avg = 36%
- cDA_{300lux} avg = 58%
- $UDI_{>2000lux}$ avg = 7%





48" cubicles shown: 30% cubicle LRV=blue, 50% cubicle LRV=purple, 70%" cubicle LRV=red



Input Parameters

Output Metrics

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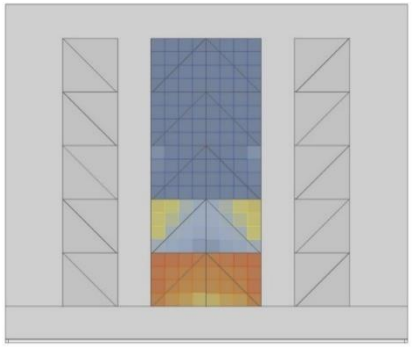
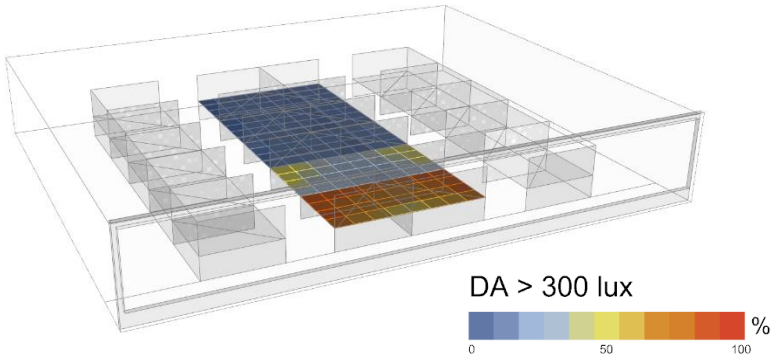
Effect of cubicle design and materials on daylight levels

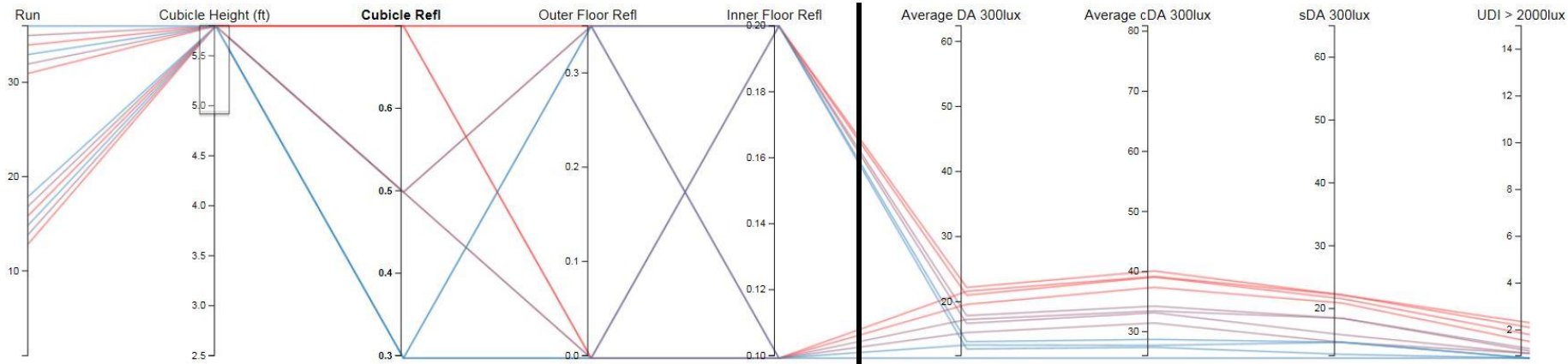
69" cubicle height

- sDA_{300lux} = 23%
- DA_{300lux} avg = 23%
- cDA_{300lux} avg = 40%
- $UDI_{>2000lux}$ avg = 3%





69" cubicles shown: 30% cubicle LRV=blue, 50% cubicle LRV=purple, 70%" cubicle LRV=red

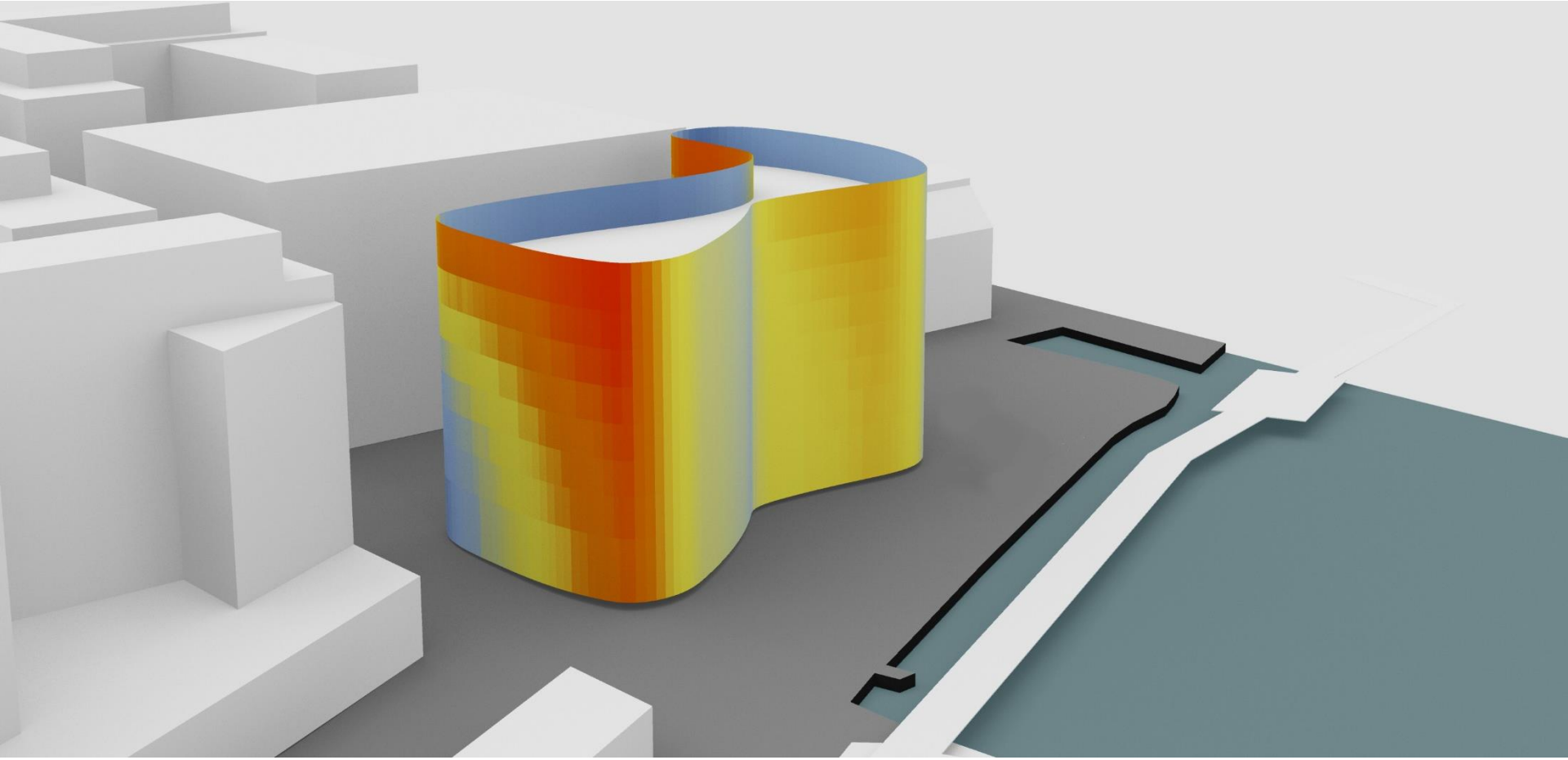


Input Parameters

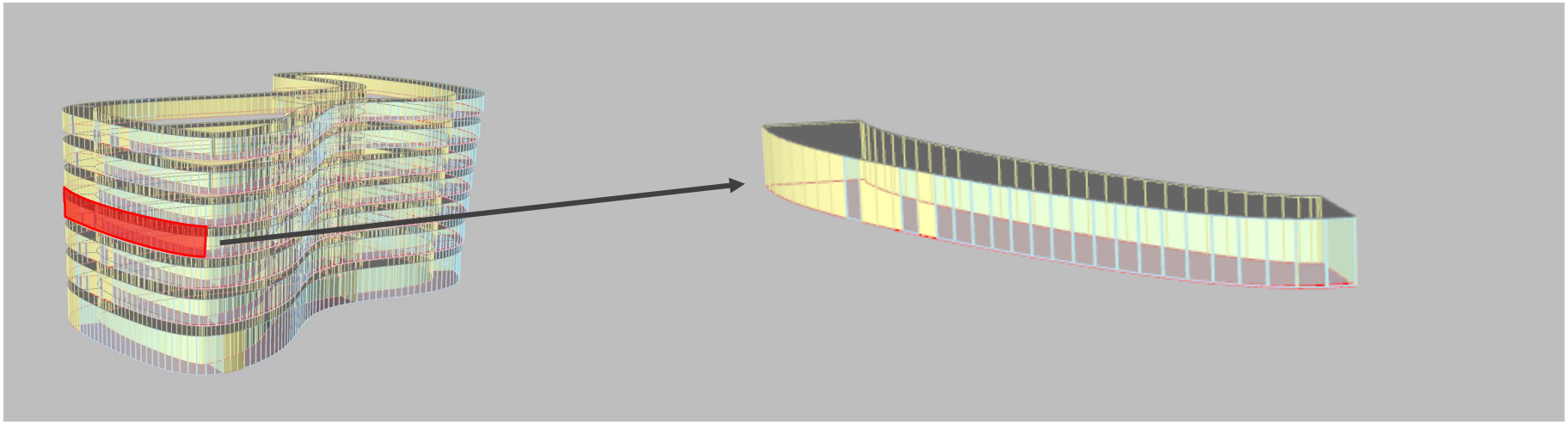
Output Metrics

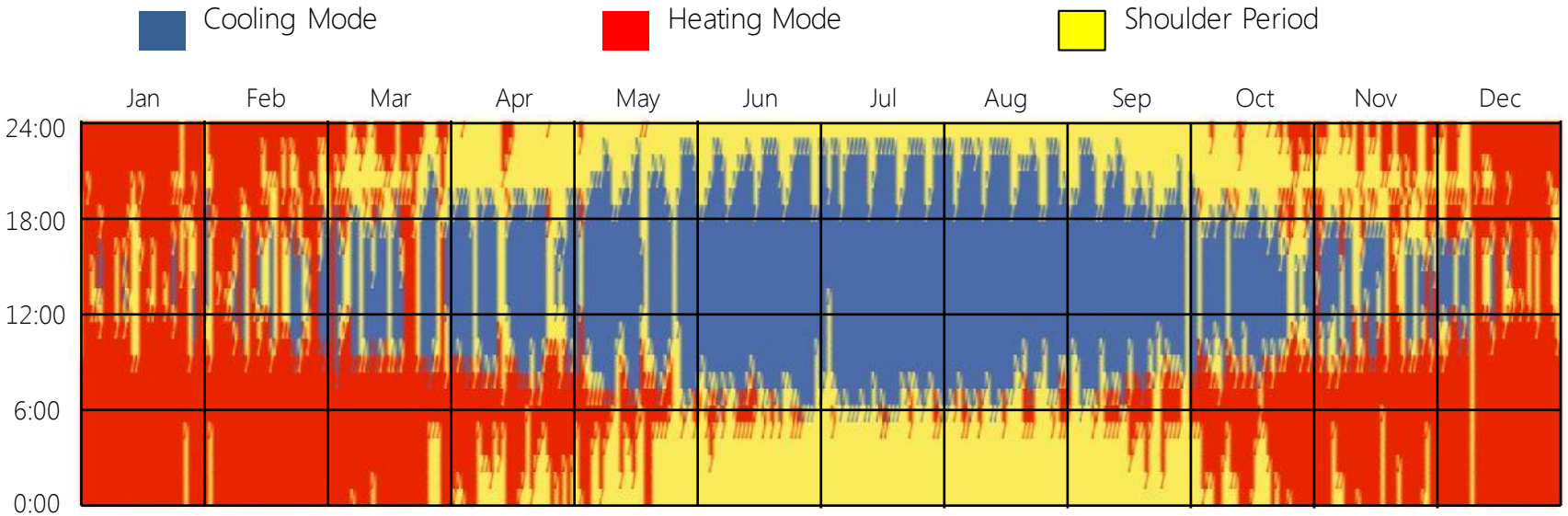
SMITHGROUP JJR lighting design

Solar Gain Analysis



Solar Gain Analysis





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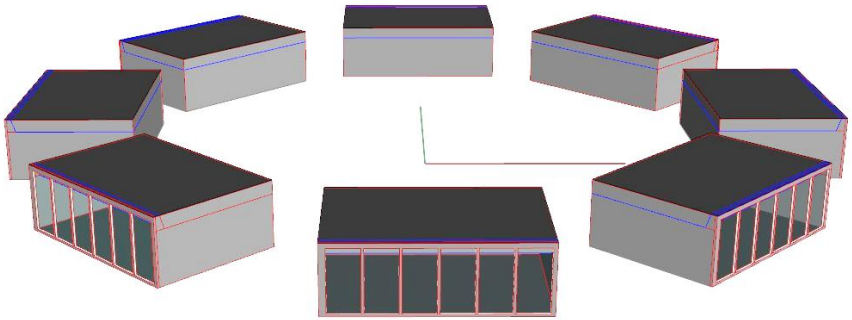
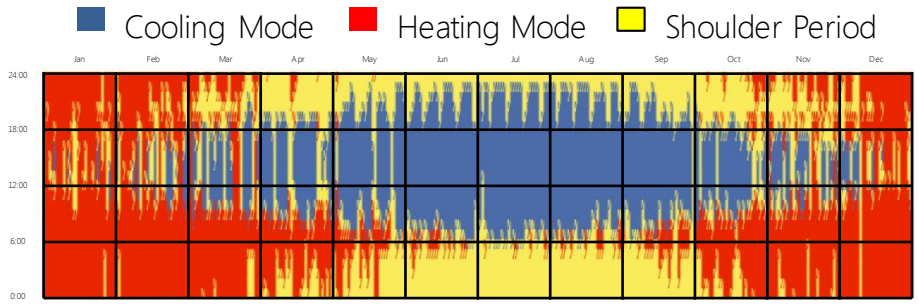
Solar Gain Analysis





GenCumulativeSky

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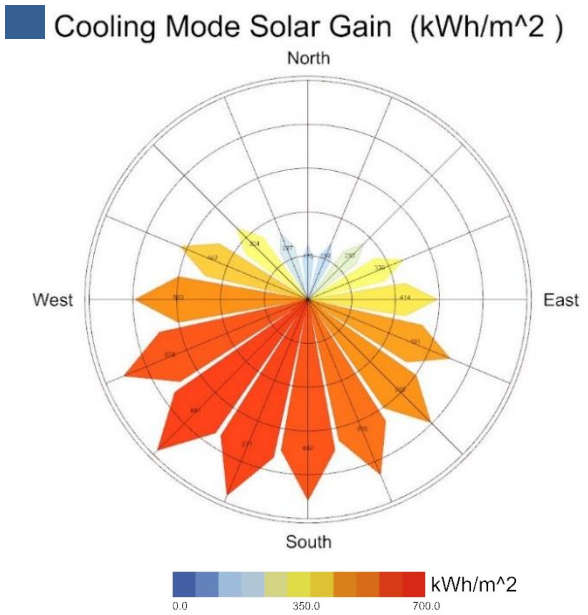
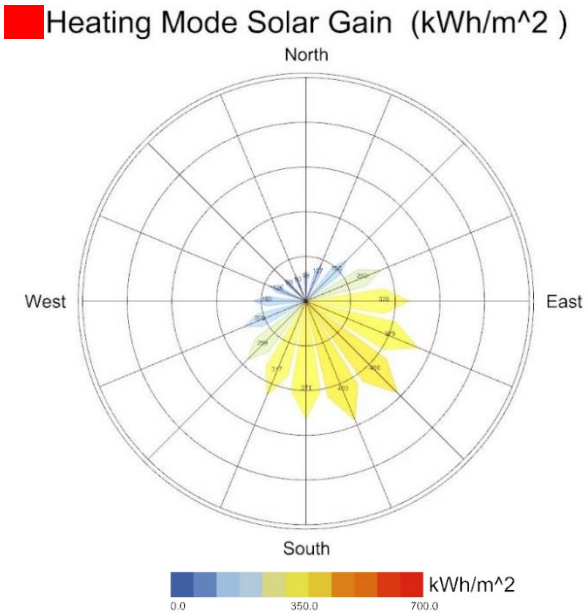
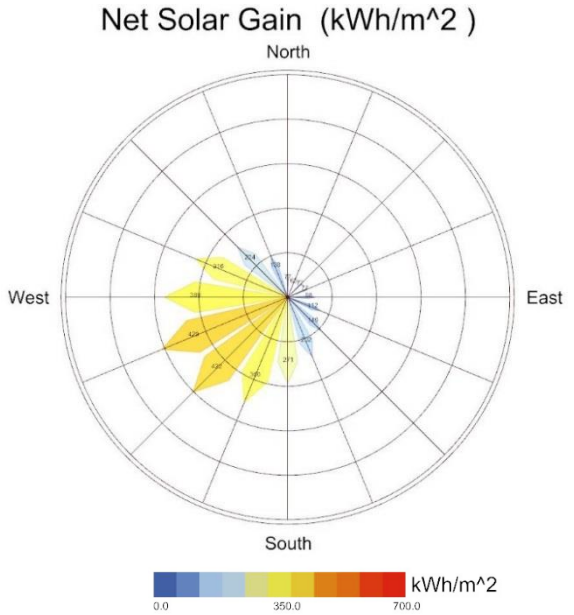
Solar Gain Analysis







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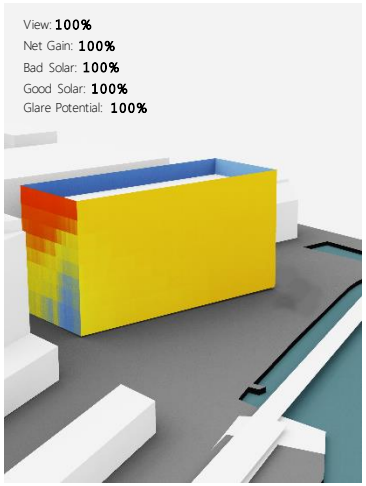
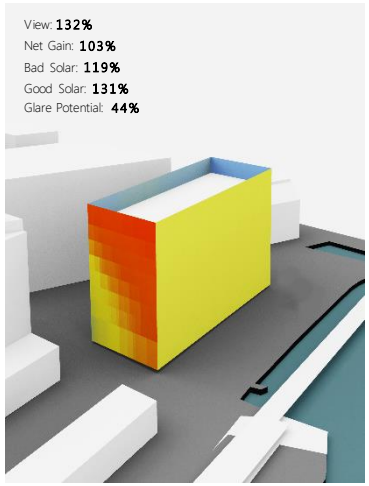
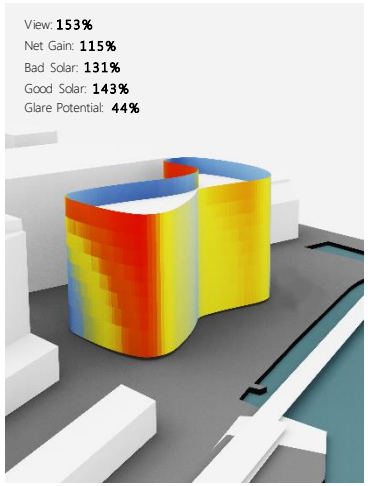
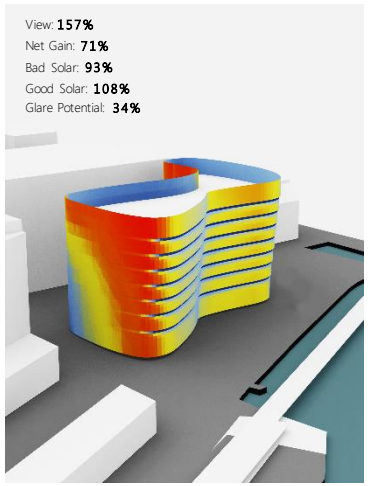
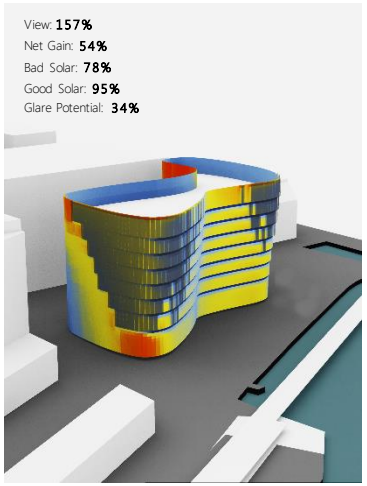
Solar Gain Analysis











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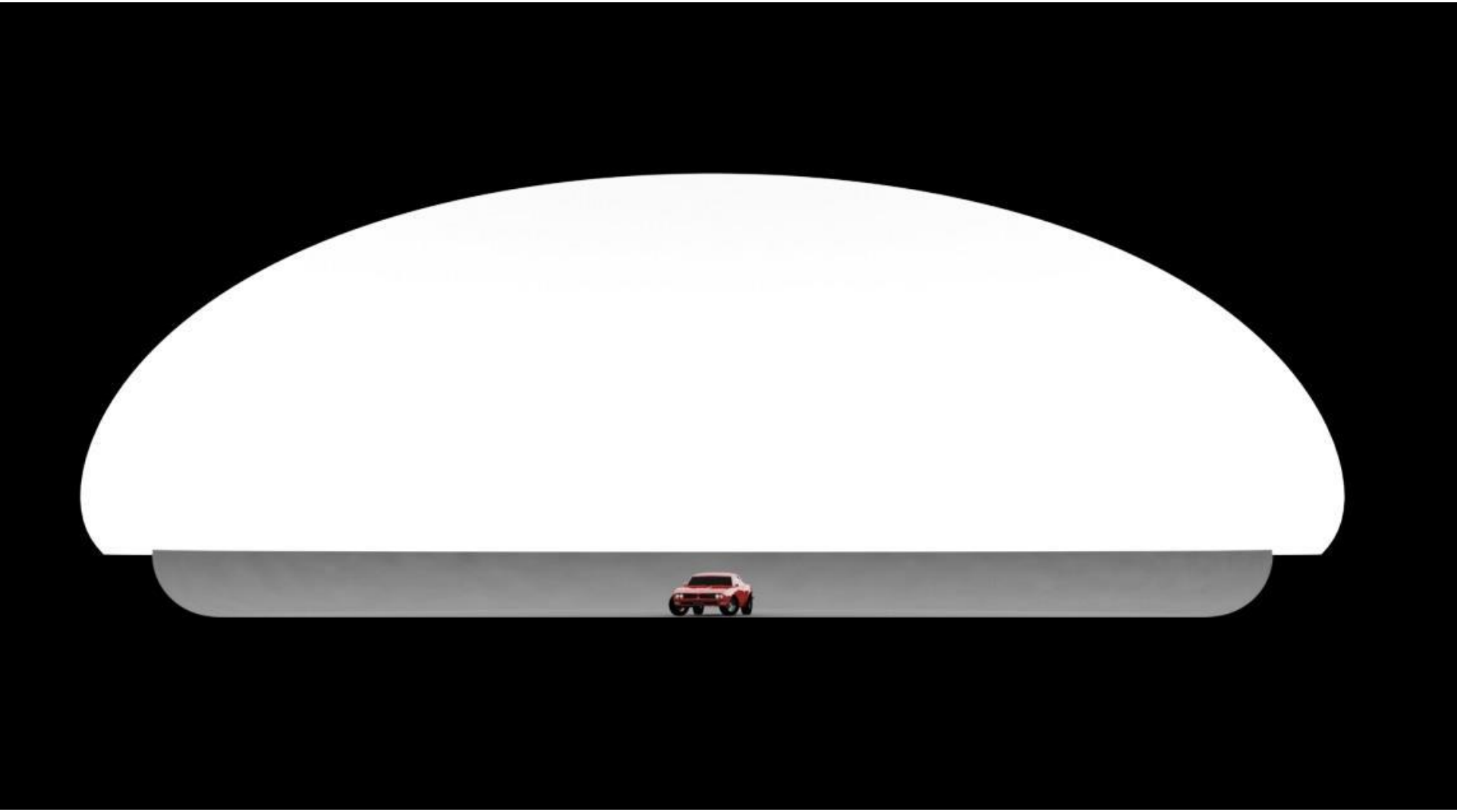
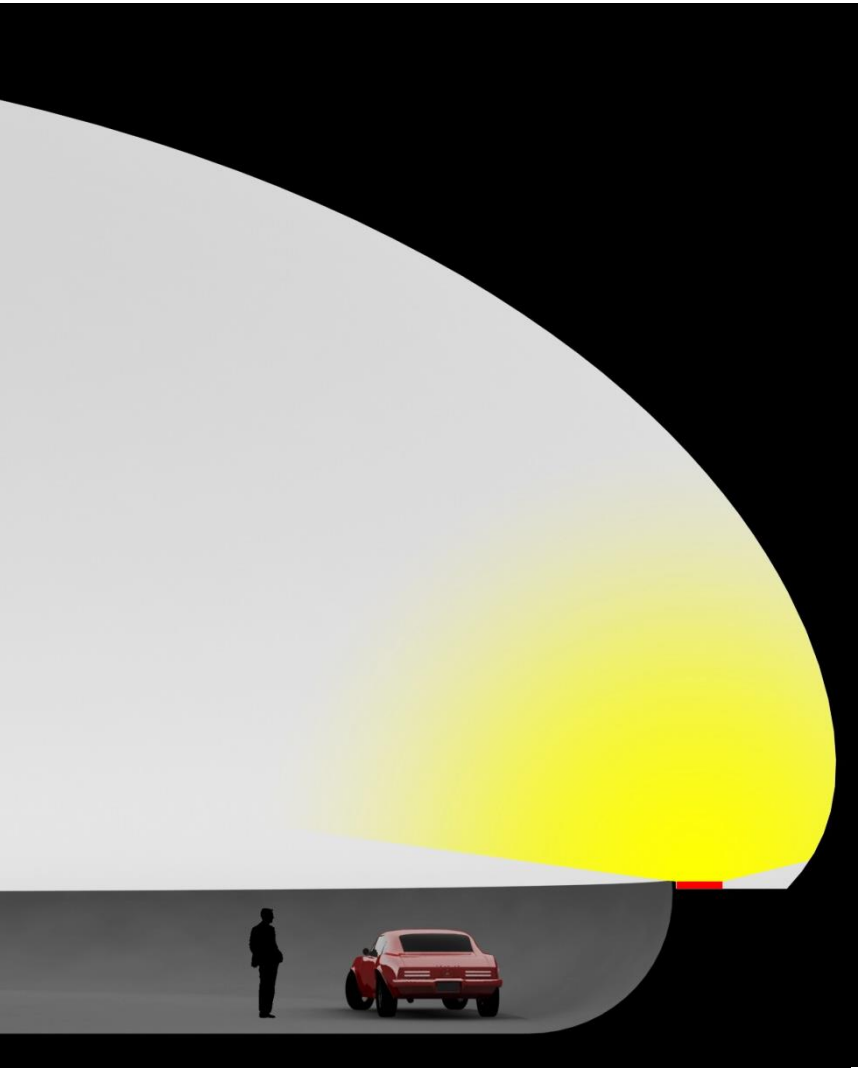
Solar Gain Analysis

PATAC Dome



PATAC Dome



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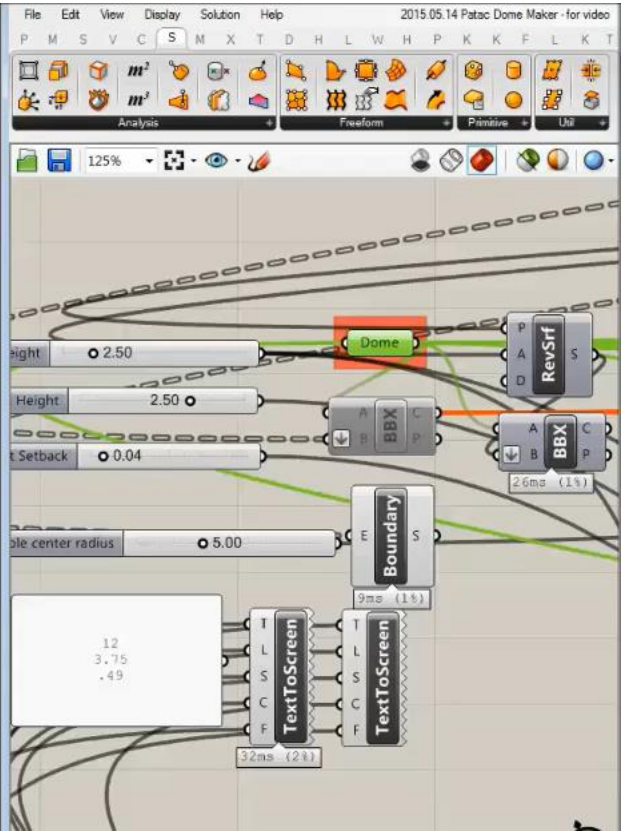
PATAC Dome



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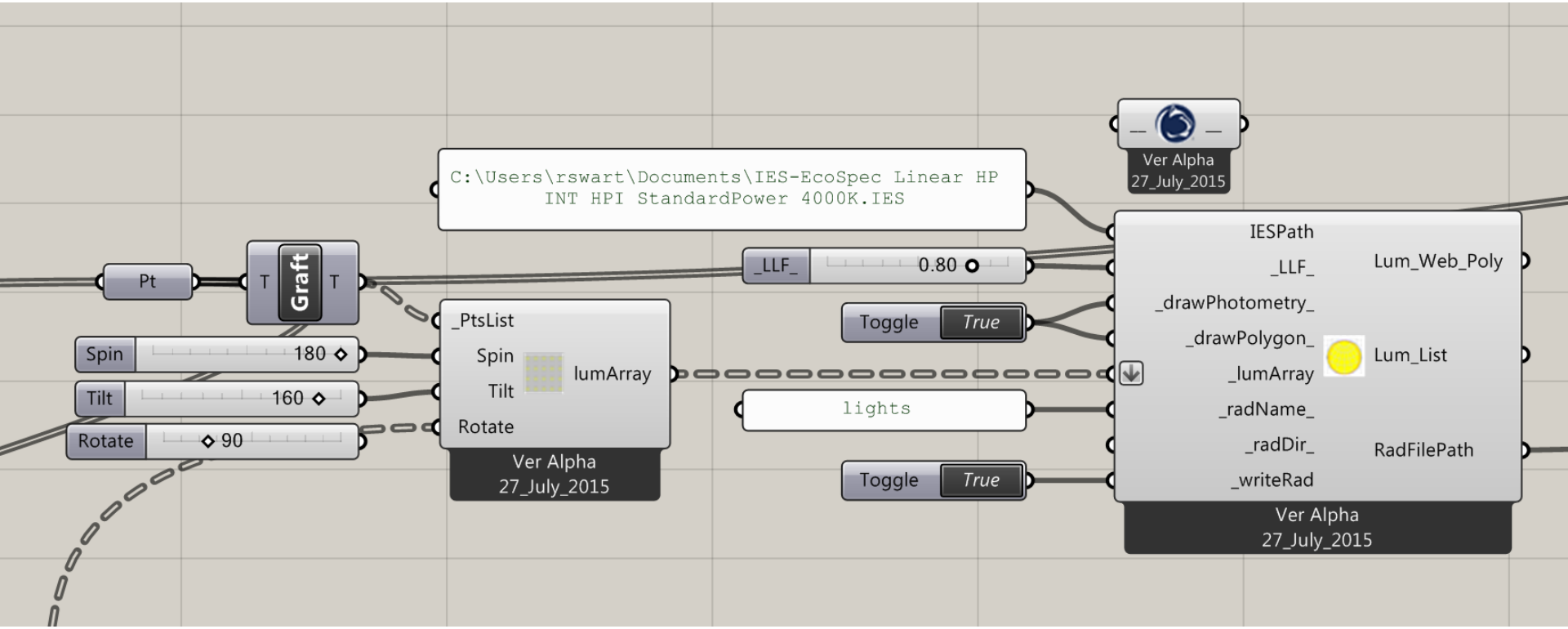
PATAC Dome



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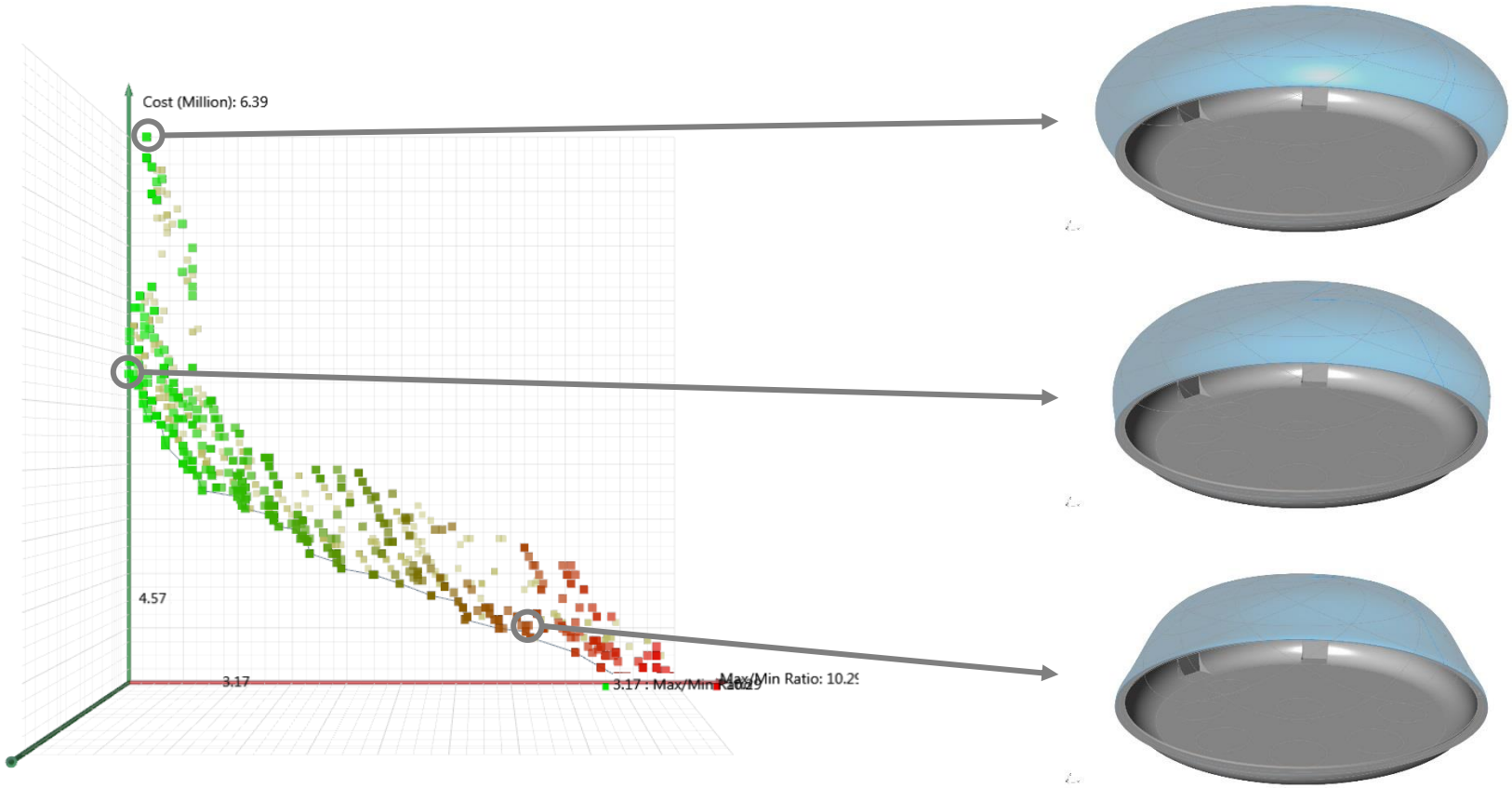

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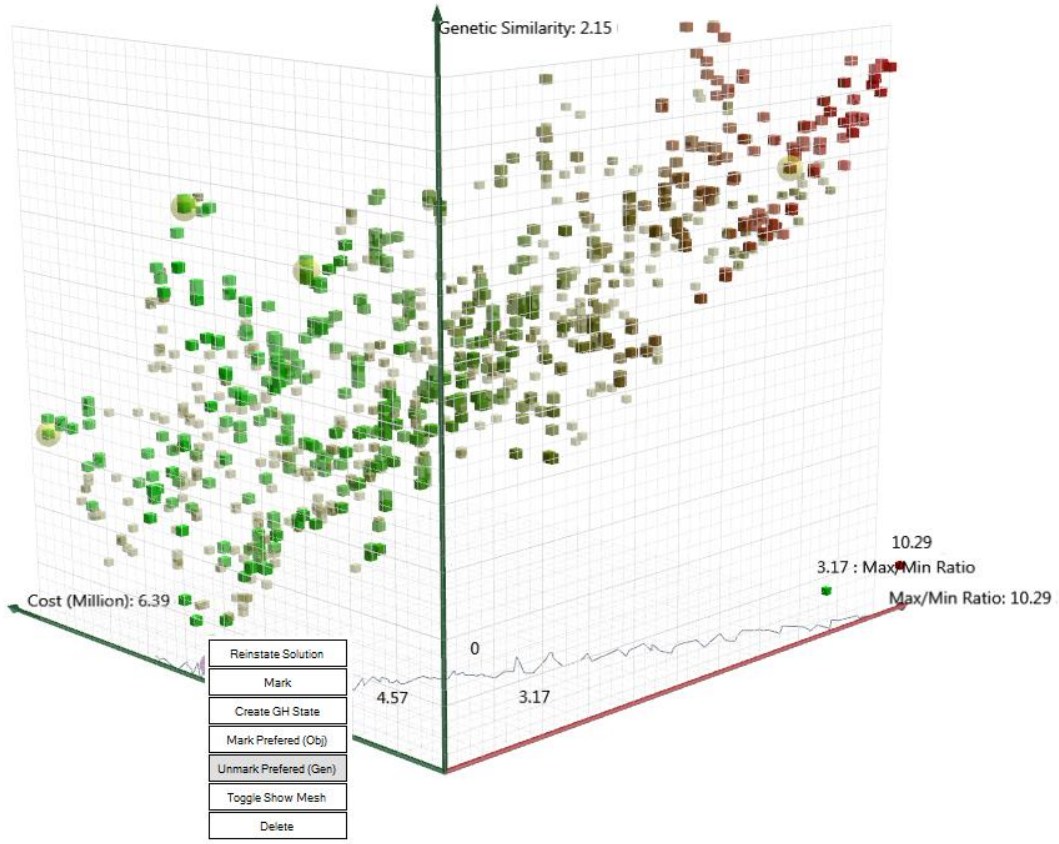
PATAC Dome



Use z-axis to study runs with similar genomes (parameters) to the one selected

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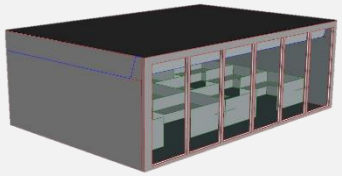
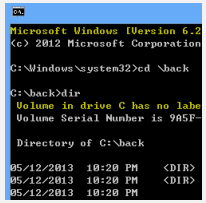
Parametric Workflow

Parametric Model

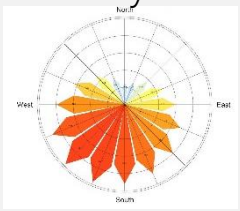
Model



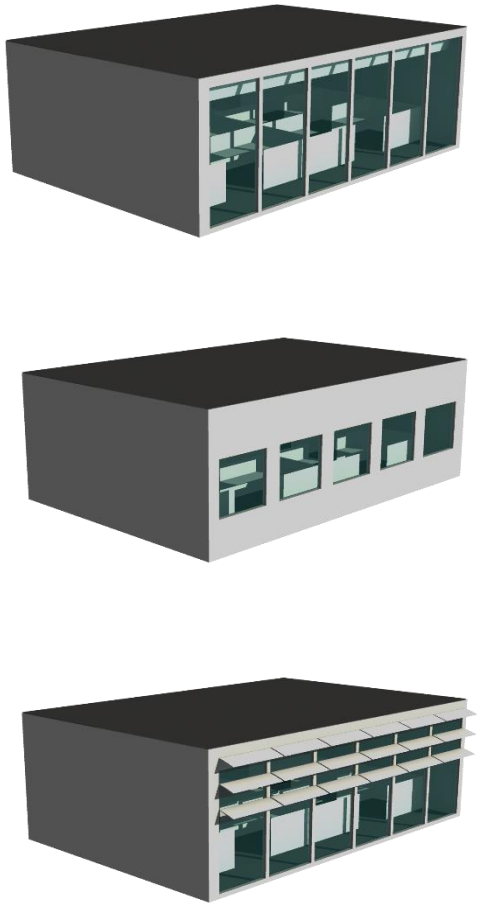
Calculate



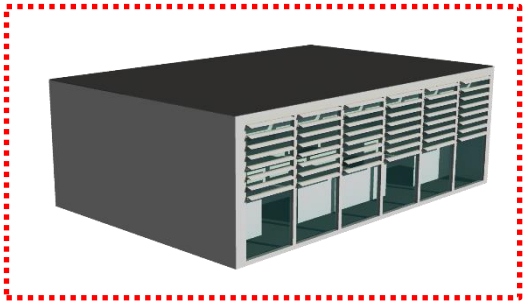
Analyze



Iterative Analysis



Informed Design



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Engaging Radiance for a parametric workflow

Parametric Model

- 3 and 5-phase calculation approaches could simplify and accelerate analyses.
- Parametric modeling could compute BTDFs and apply them as needed. Libraries of BTDFs may also be useful
- Better integration with energy modeling programs
- Expanded shade control capabilities

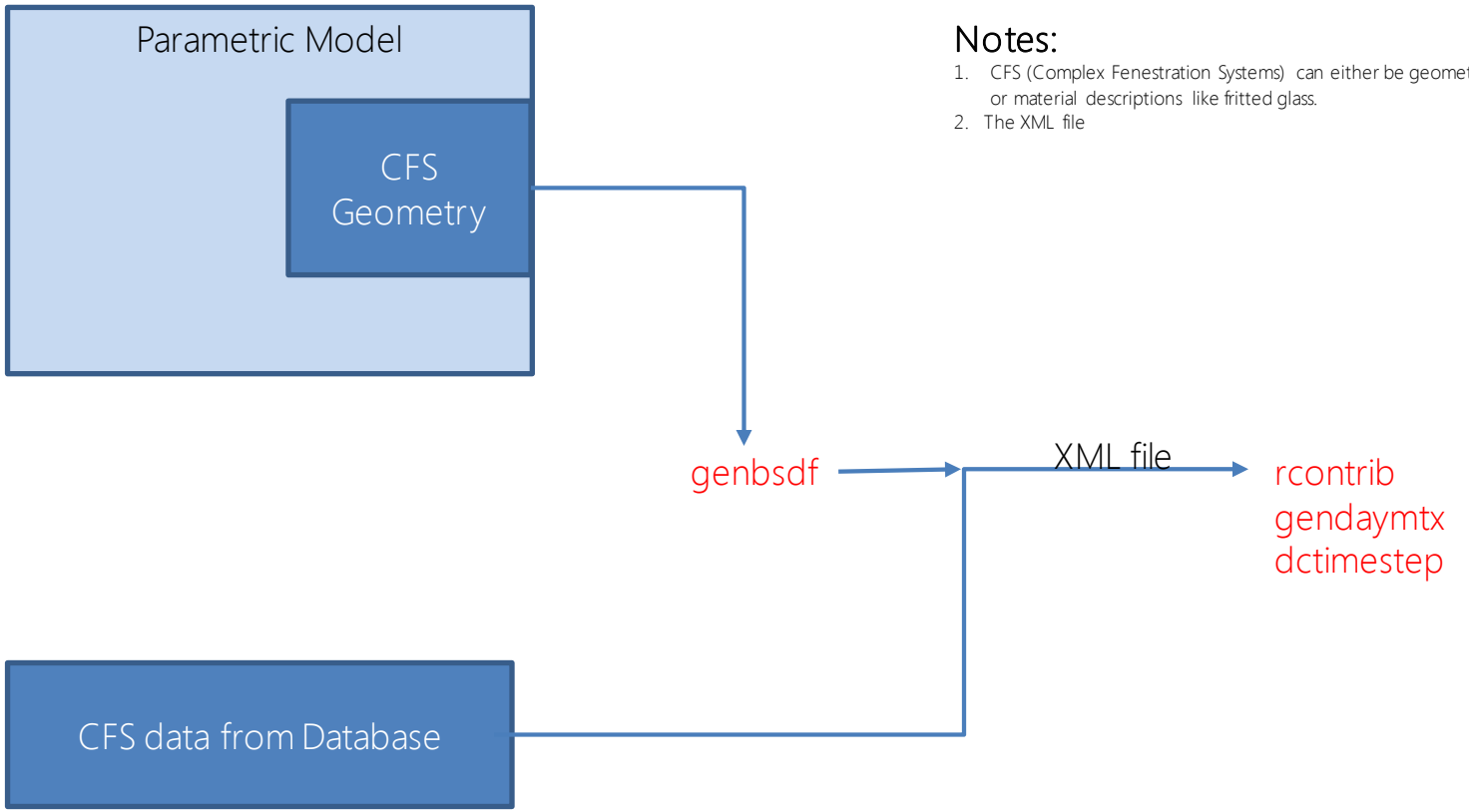
Iterative Analysis

- Reduce calculation times
- Reduce redundant calculations

Informed Design

- Design Team workflows need better integrate engineering and design.
- Allocation more fee to conceptual and schematic stages of design.
- Education

Incorporating BTDFs



Notes:

1. CFS (Complex Fenestration Systems) can either be geometric elements like blinds or material descriptions like fritted glass.
2. The XML file

3 Phase and 5 Phase integration

I_{3ph} = VTDS

View Matrix : Calculate if room geometry is changed
Transmission Matrix: Calculate if glazing or shading system is changed
Daylight Matrix: Calculate if building orientation or external geometry is altered.
Sky Matrix: Calculate if sky model is changed

In a parametric workflow each run of calculations is likely to have a one or more variable parameters with rest of the details remaining constant. Redundancy can be minimized by calculating the matrices on a need basis.

For example, if different shading systems are being evaluated, View Matrix, Daylight Matrix and Sky Matrix will remain the same for each run and only Transmission Matrix needs to be calculated in each time.