5-2015

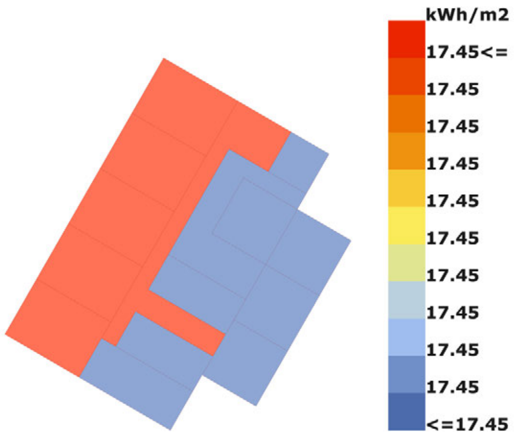
Energy Modeling and Implementation of Complex Building Systems, Pt. 2

Kurt Rogler

3. Zoomed-in Scale: Analyzed with E+

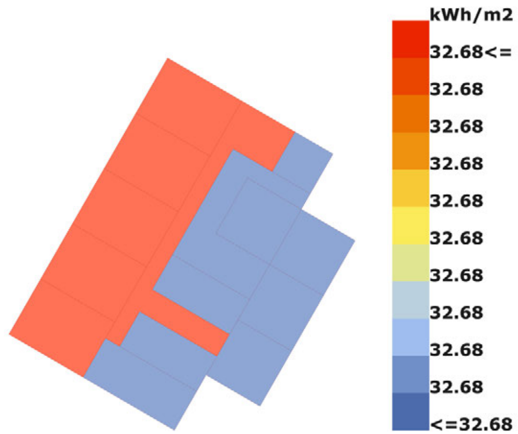
Seagram Building floor without context or EDDS.

Analyzing People/Systems:



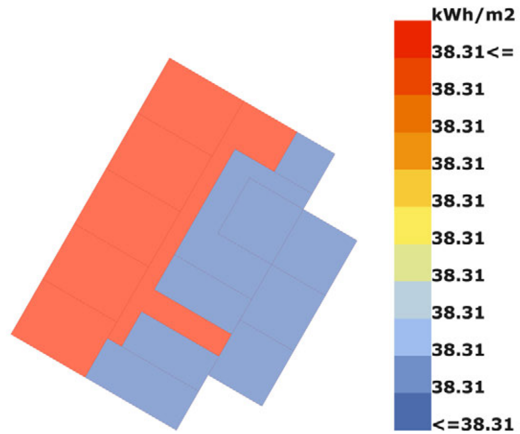
People Gains

The internal heat gains in each zone resulting from people (kWh).



Electric Equip. Energy Usage

The electric equipment energy needed for each zone in kWh.



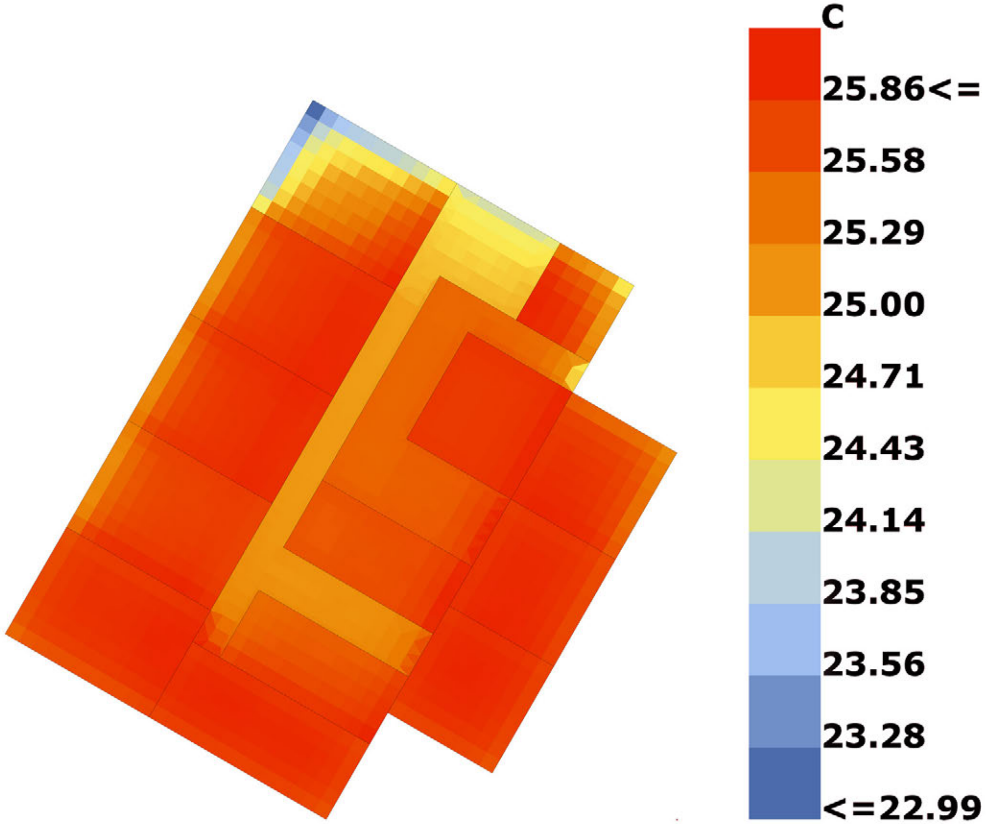
Electric Lighting Energy Usage

The electric lighting energy needed for each zone in kWh.

Seagram Building floor without context or EDDS.

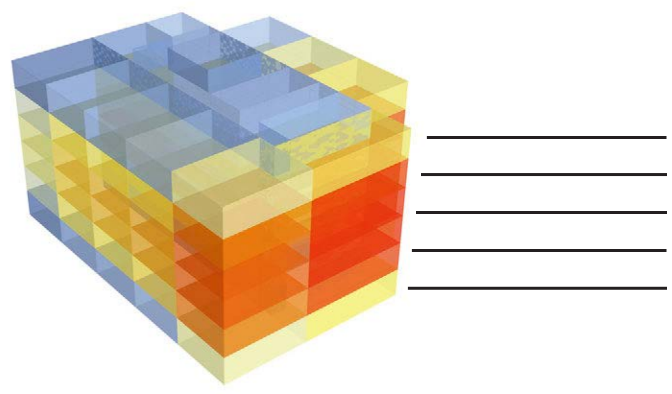
Indoor Radiant Temperature Map

1meter by 1meter grid of sensor points each provide a result post-analysis to be merged into an indoor radiant temperature map. Note the corridor penetrating the center of the building (with the least amount of area-to-glazing ratio). The cooler sensory points at the north corner of the building may be an anomaly, or an accurate representation of the cooler north-side zones.



3. Preliminary Results - No EDDS

Looking at the results of a section of the Seagram Building



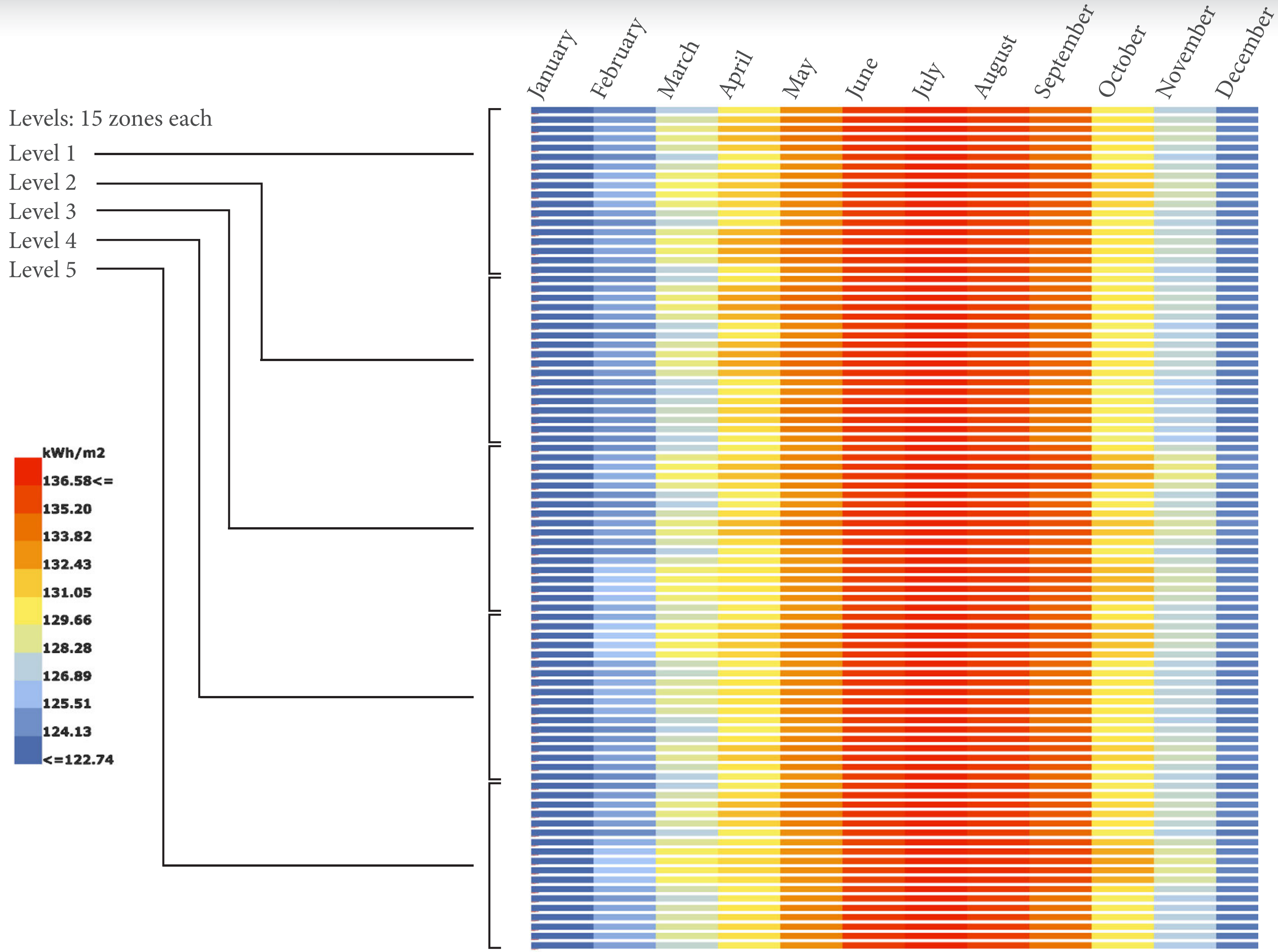
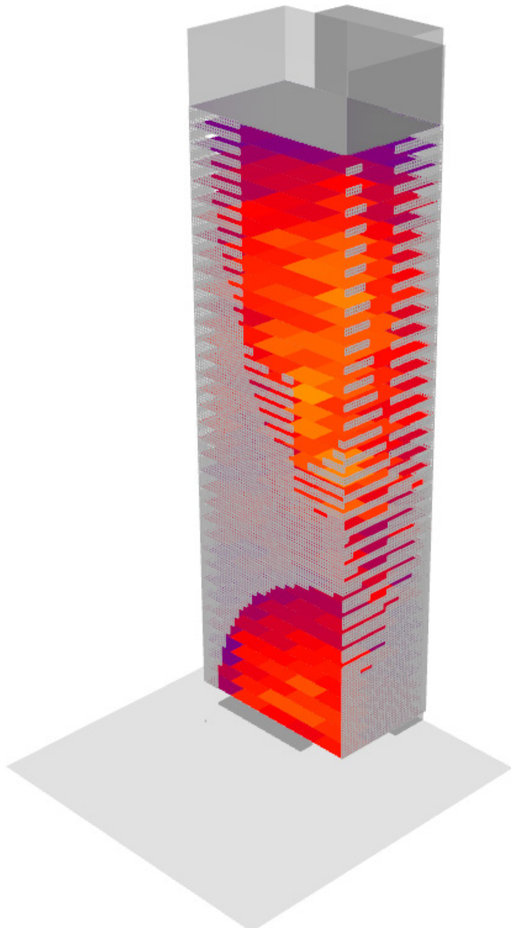


Diagram of results mapped out over time

EnergyPlus provides results on a zone-by-zone basis, with data for each zone representable for every hour of the year (in this case, an averaged total hourly thermal energy required per zone per m^2 per month per year).

4. Building & Zoomed-in Scale

Seagram Building and building section analyzed
with a static instance of EDDS implemented.

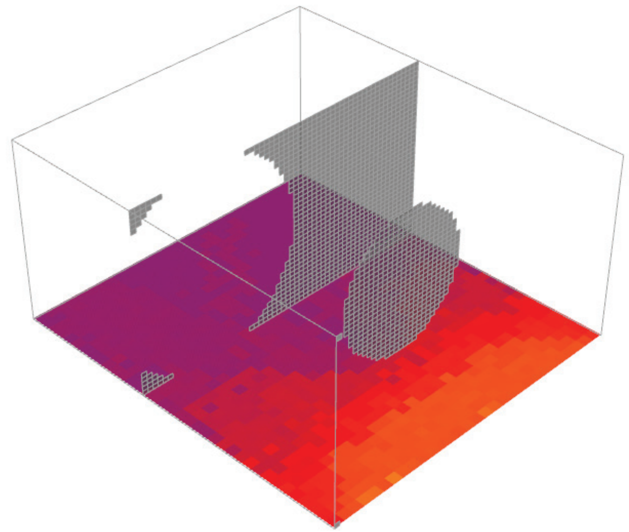


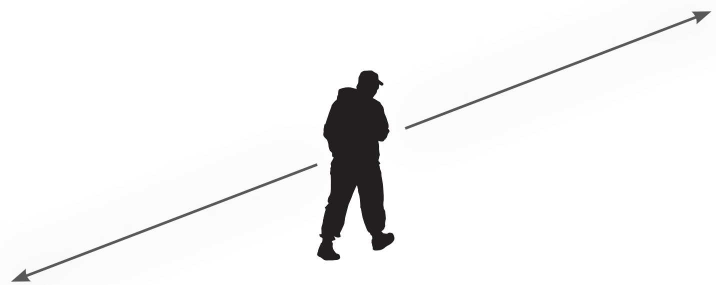
Building Scale Analysis

Seagram Building typical direct/diffuse daylighting levels analyzed without contextual influence. One instance of a non-moving EDDS facade is analyzed.

Zoomed-in Analysis

Test of daylighting analysis in a space with two EDDS-like partitions. Context and building are not taken into account. This study represents an instance of light diffusing around temporary or potentially moving EDDS obstructions.



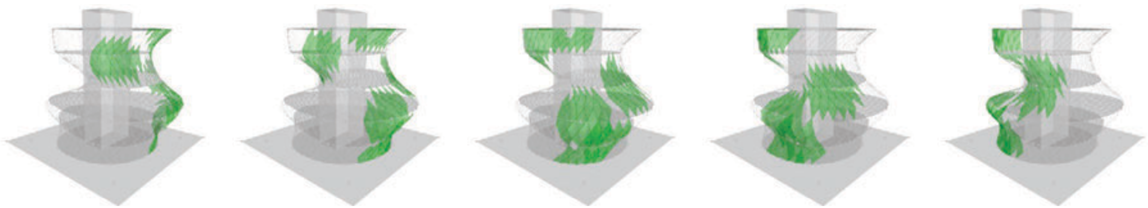


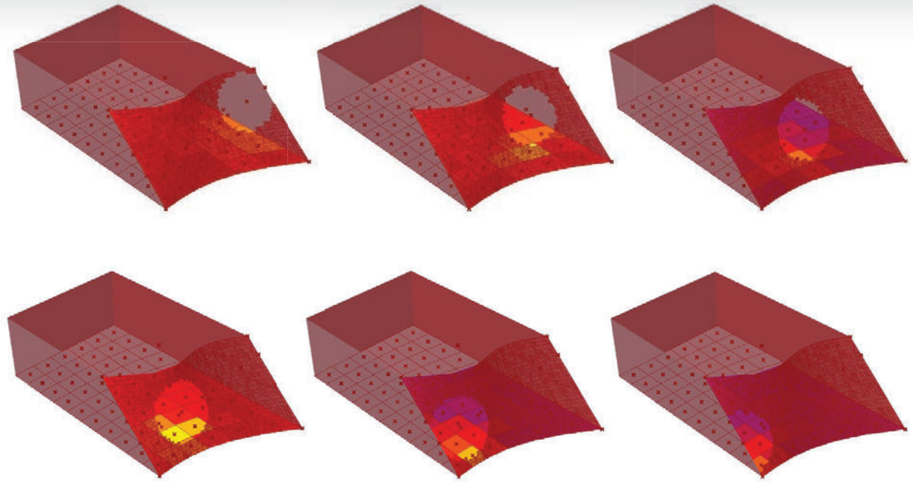
Behavioral Modeling - My Proposal

Part 5 looks at applying a dynamic system to a building and building section, and analyze each's impact on the space.

5. Building Scale & Zoomed-in Analysis

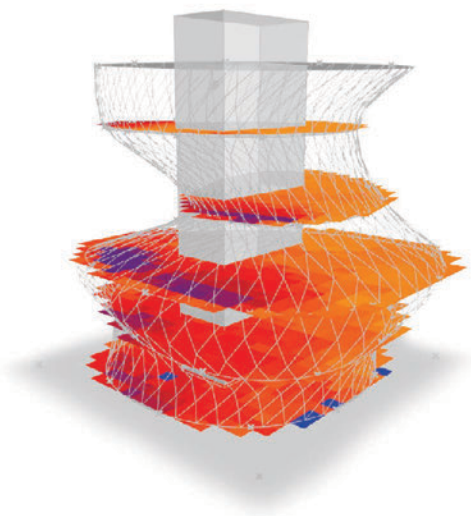
~~Seagram Building~~ Test building and zoomed-in model analyzed with a dynamic instance of EDDS implemented.





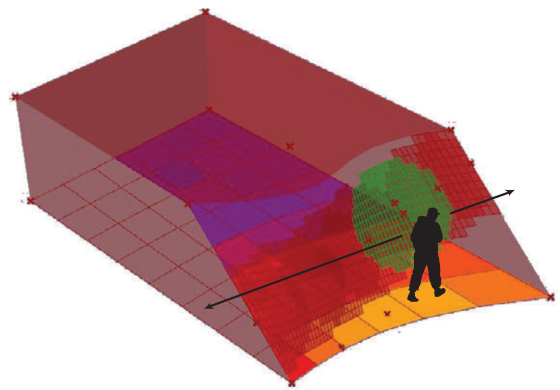
Building Scale Analysis

Composite analysis of 5 facade iterations, meant to simulate EDDS movement.



Zoomed-in Analysis

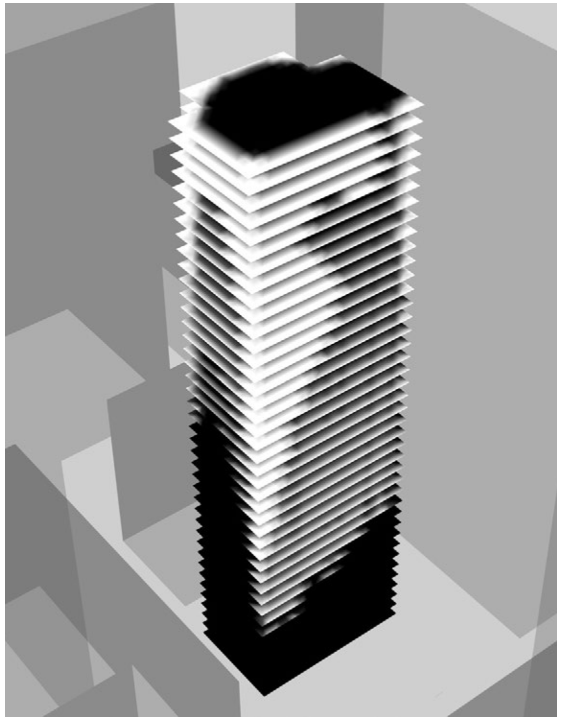
Behavior: Person walking in front of responsive EDDS facade. 7 points along the way compiled into a composite analysis.



Systematic Compensation Example 1
Building Scale

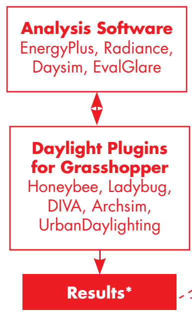
What could a dynamic system, such as EDDS compensate for in a space/building?

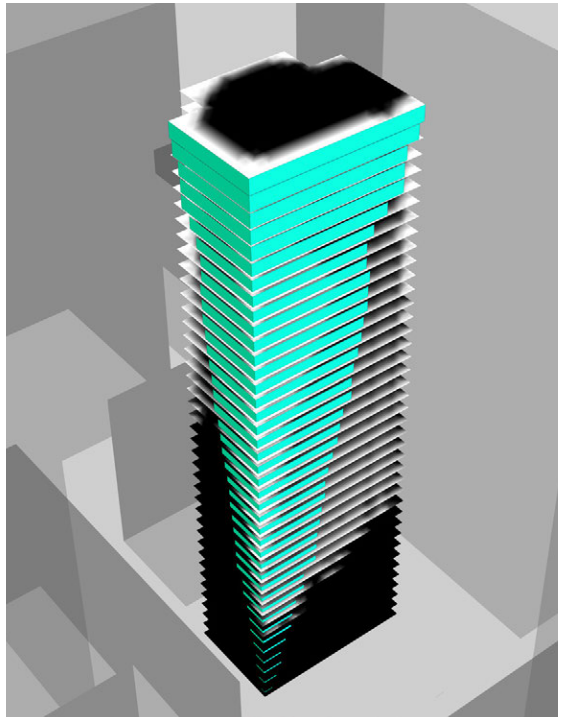
- Heat/Cooling/Lighting gains due to:
- Increase of Occupants
- Changing weather patterns
- An influx of machines in a space (computers etc)
- Changing thermal properties on nearby floors/ in nearby zones
- More…



Analysis with no EDDS

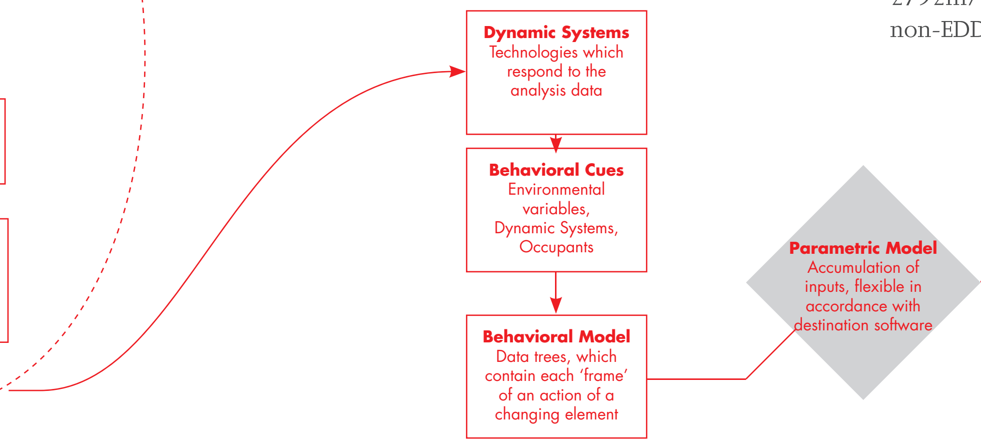
Results: Of the 54990 m2 floor area,
7142 m2 day-lit
Average 13.0% of floor is directly lit by sun

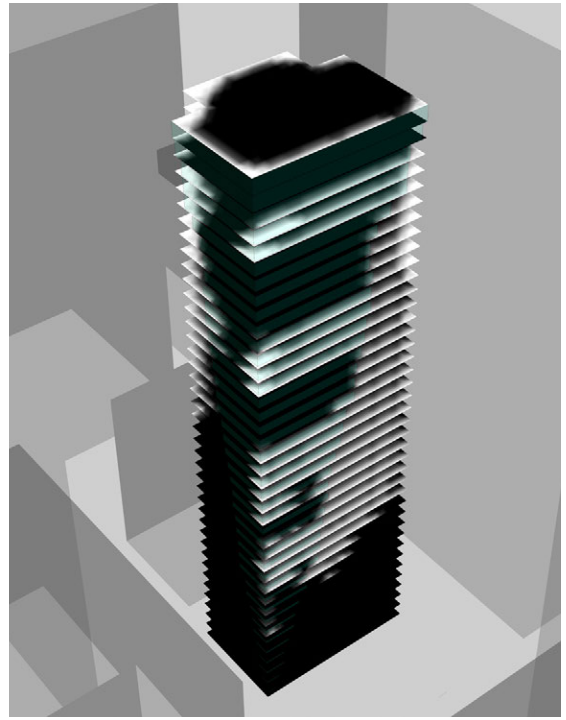




EDDS responding to areas of too much direct lighting

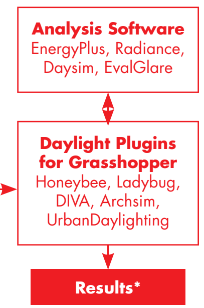
After the first simulation, the results are read and the new model rebuilds itself to accommodate the results: to lessen direct daylighting loads.





Resultant simulation

Results: Of the 54990 m2 floor area,
4351 m2 day-lit area
Average 7.9% of floor is directly lit by sun
2792m/60% direct daylighting decrease from non-EDDS analysis



Systematic Compensation Example 2
Zoomed-in Scale

What could a dynamic system, such as EDDS compensate for in a space/building?

- Heat/Cooling/Lighting gains due to:
- Increase of Occupants
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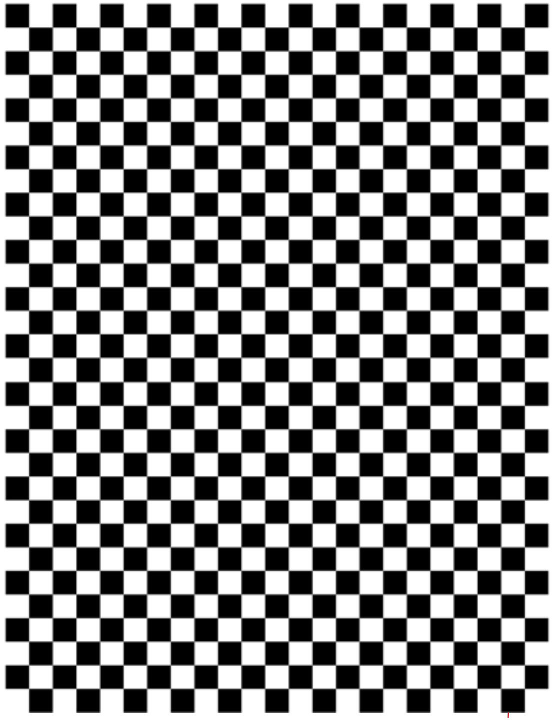
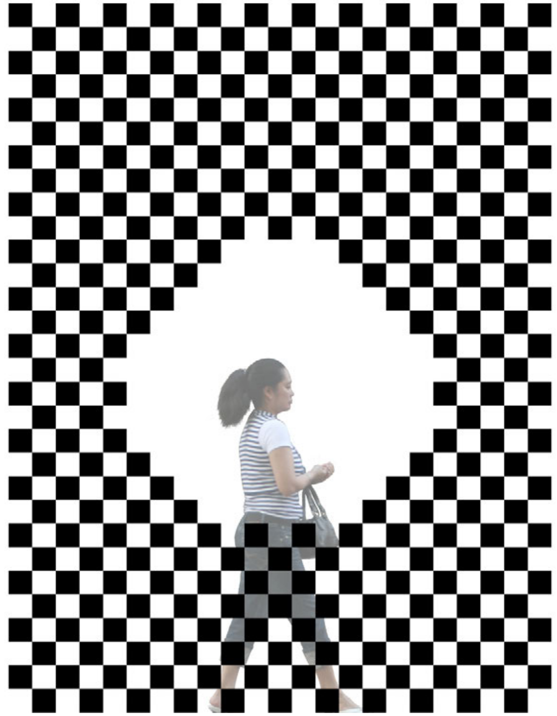
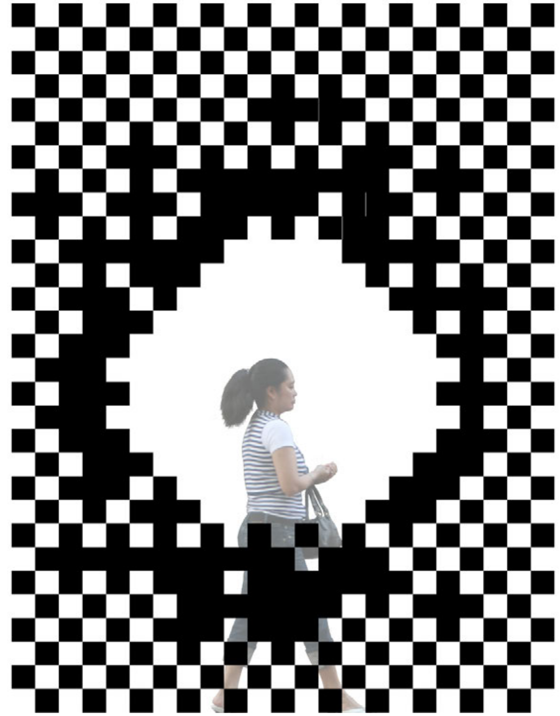
- An influx of machines in a space (computers etc)
- Changing thermal properties on nearby floors/ in nearby zones
- More…



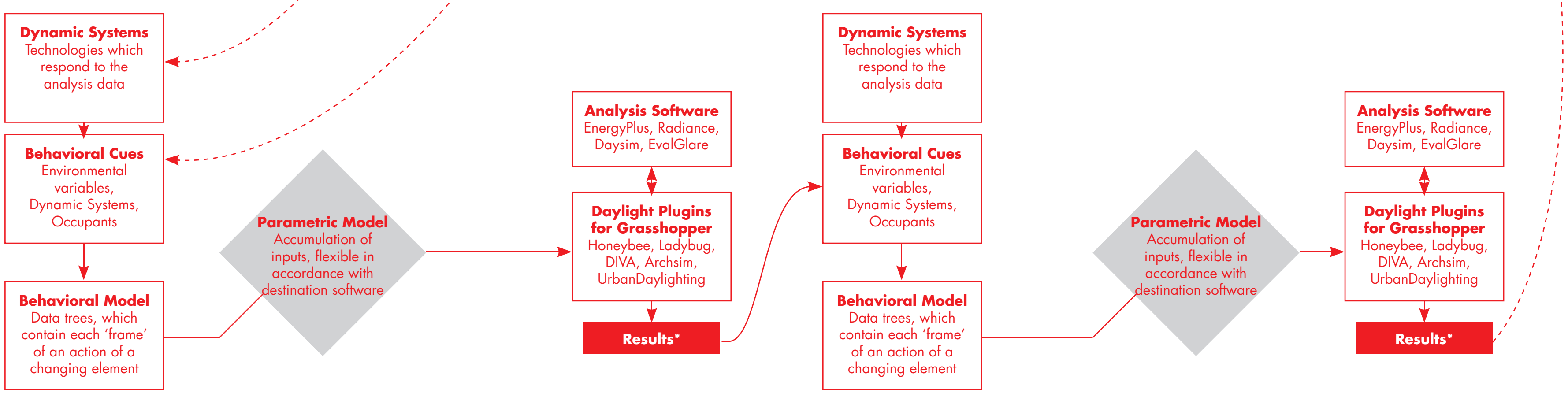
EDDS non-responsive pattern



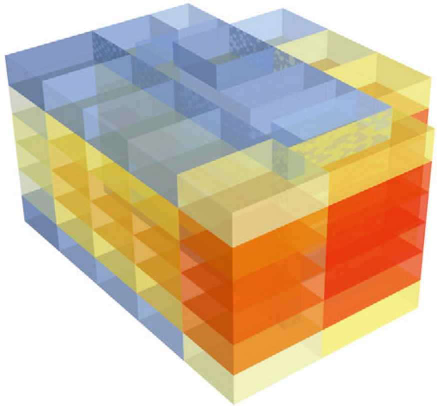
EDDS responding to an occupant



EDDS compensating for the previous response



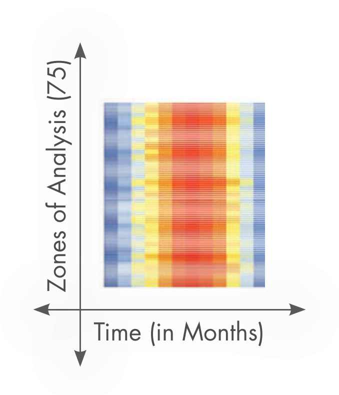
Analysis Speculation:

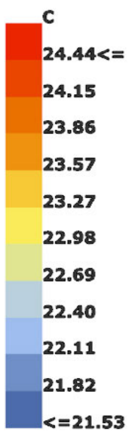


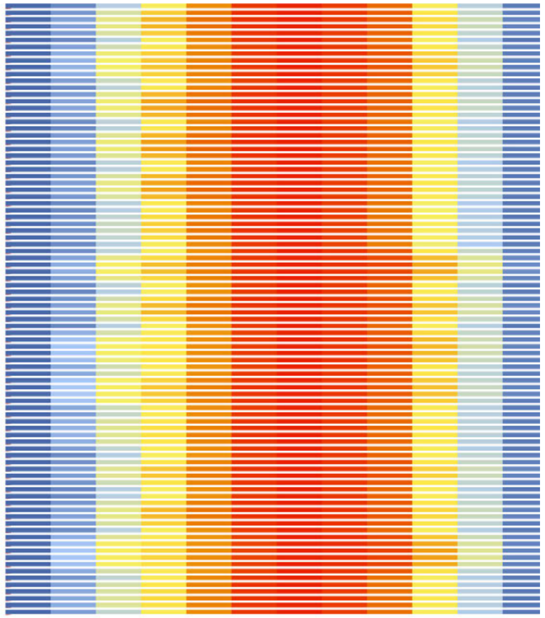
Example: Mean Radiant Temp Analysis

The mean radiant temperature of each zone (degrees Celsius).

Result diagram key: Color key:

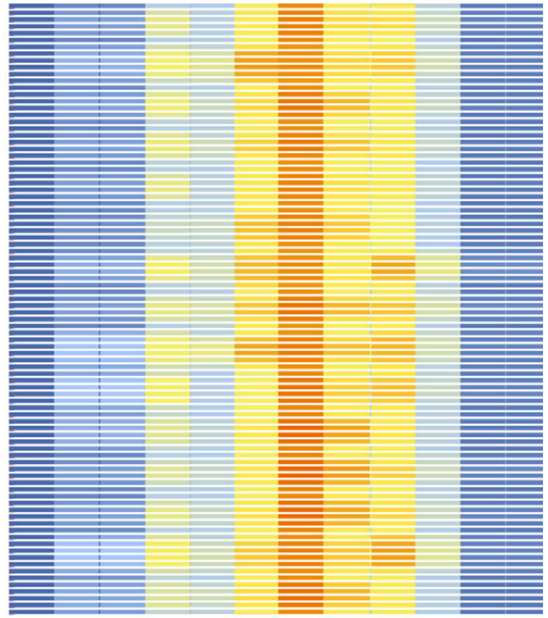






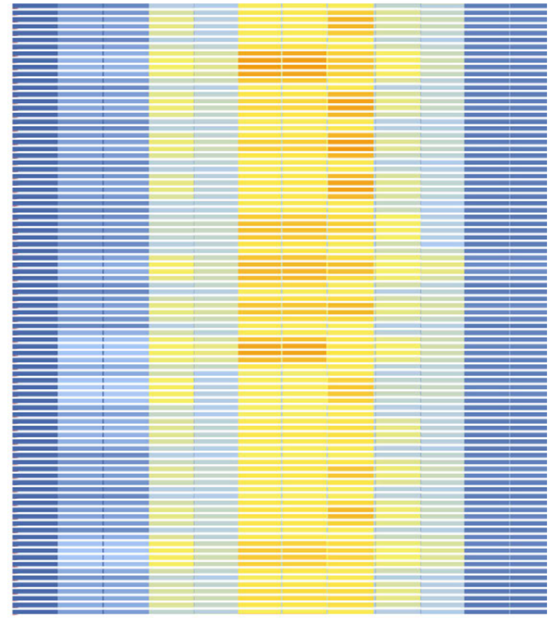
No EDDS/Shaders - Actual Analysis

A representation of the average radiant temperature in all zones over the span of a year (monthly values are determined from hourly results). Clearly the simulation shows that there is a rise in temperature during the summer months as is expected.



Static Instance of EDDS - Speculation

Implementing any shading device, including a static instance of EDDS, would result in a decrease of average radiant temperatures during the summer months.

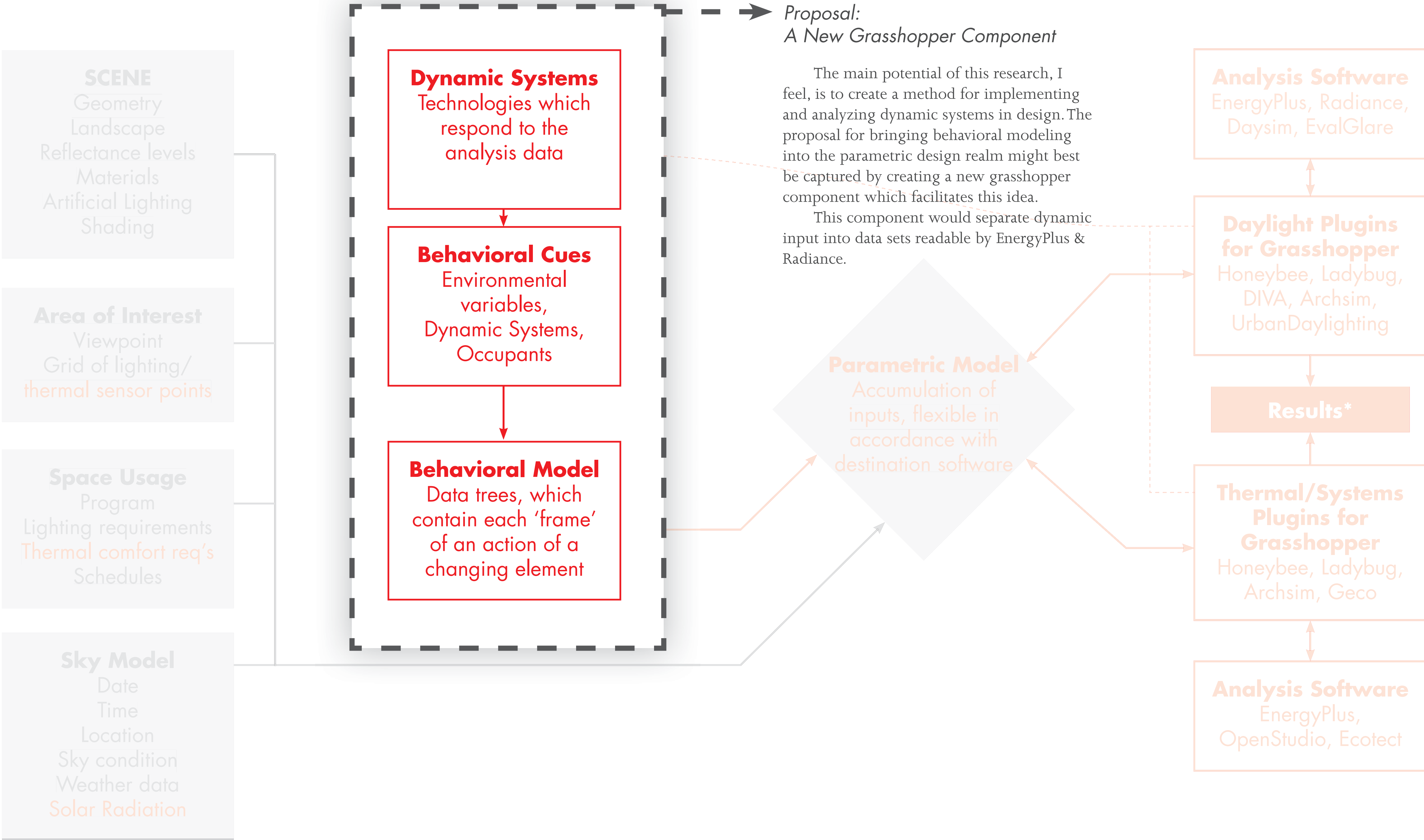


Dynamic/Responsive EDDS - Speculation

Moving beyond static shading devices, however, we get into the territory of responsive systems. I speculate an improvement in average temperature during summer months with the implementation of a fully dynamic EDDS system. In this case, EDDS would respond to occupant movement, other systems, environmental cues etc.

Moving Forward

I hope to further develop a method for analyzing and simulating complex building systems in architecture. This method for analysis and optimization would facilitate the efficient implementation of dynamic/advanced/sustainable technologies in all building typologies.



Proposal:
A New Grasshopper Component

The main potential of this research, I feel, is to create a method for implementing and analyzing dynamic systems in design. The proposal for bringing behavioral modeling into the parametric design realm might best be captured by creating a new grasshopper component which facilitates this idea.

This component would separate dynamic input into data sets readable by EnergyPlus & Radiance.

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Modeling and Analyzing Unpredictable Building Systems

Real-Time Whole Building Performance Impacts of Occupant Interaction with Dynamic Façade Systems

SuperJury Presentation
Spring 2015
Kurt Rogler
Advisor Bess Krietemeyer

Contention

Problems:

Current tools don't support analyzing unpredictable systems' effects on buildings.

Building performance analyses are usually centered around static resultant data and they don't necessarily account for unpredictable human behavior.

I contend:

By developing a new workflow that links energy analysis tools to parametric modeling tools which can represent human behavior, we can better design and implement new building façade technologies that deal with a broader range of architectural performance criteria.

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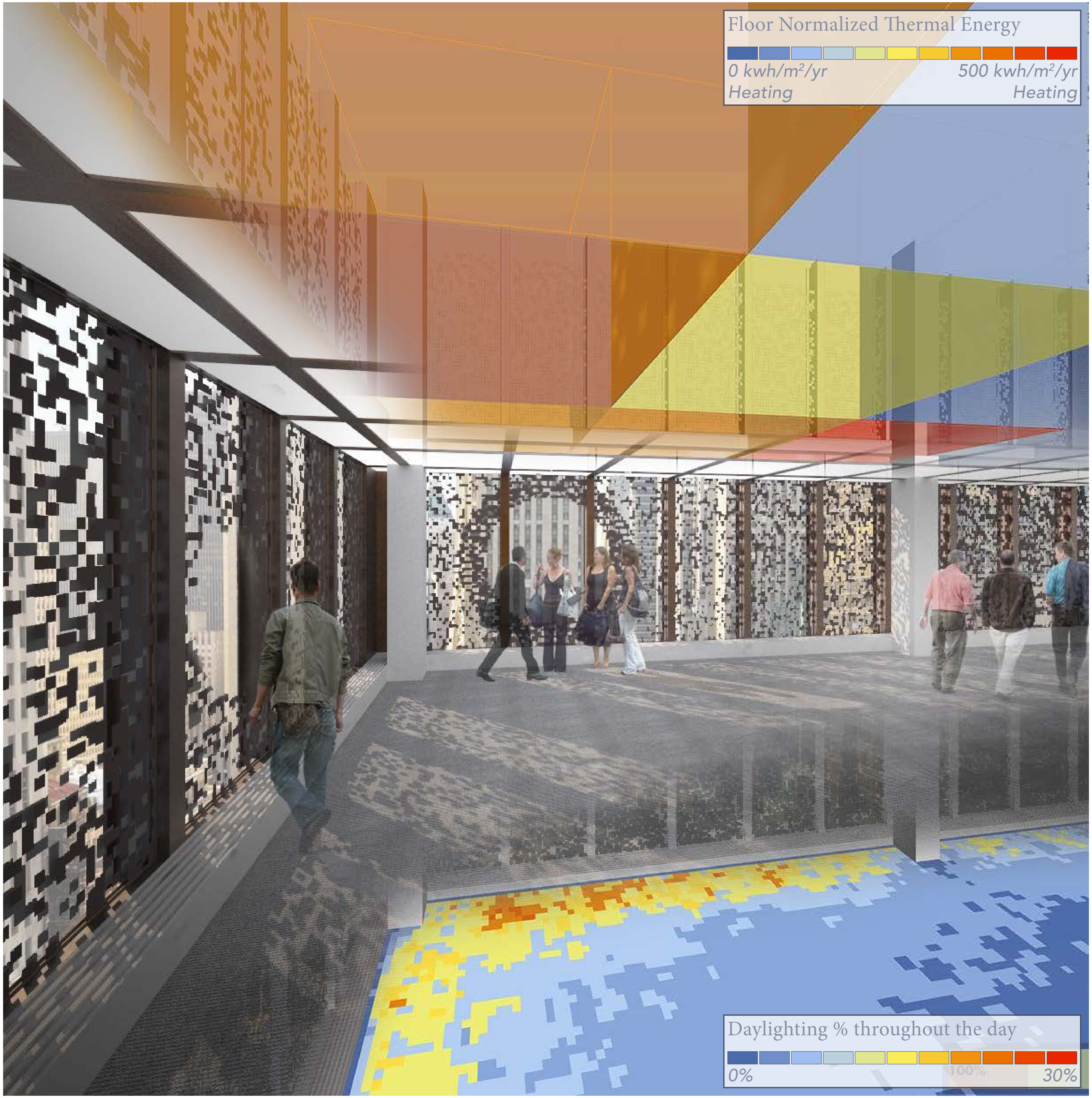
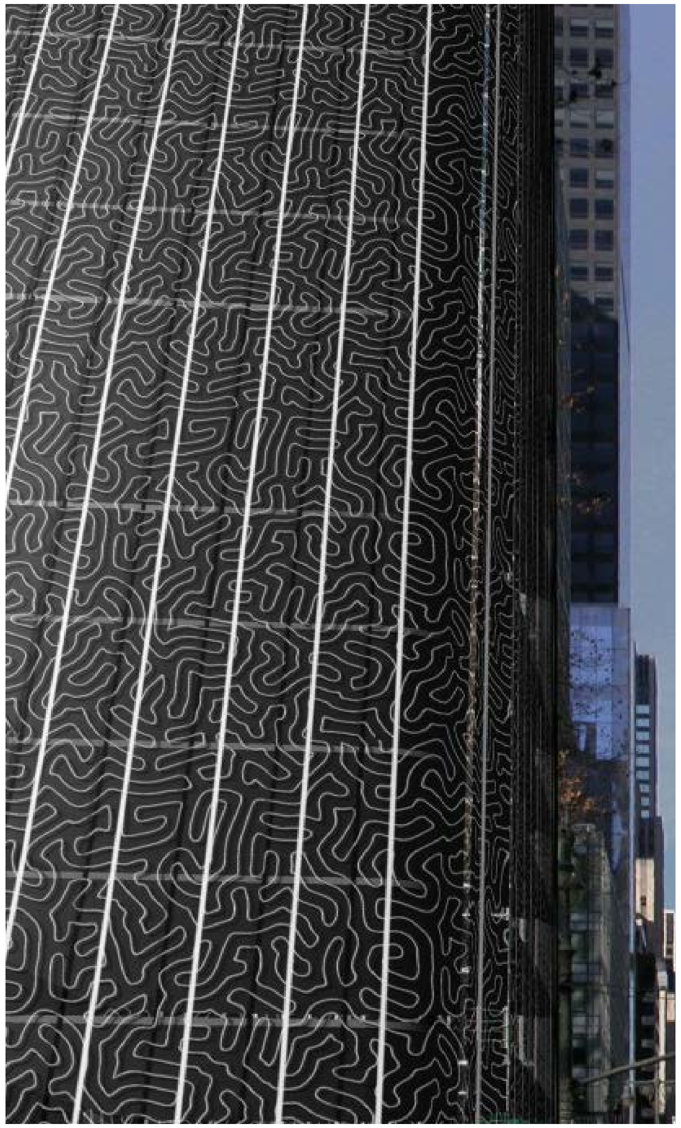
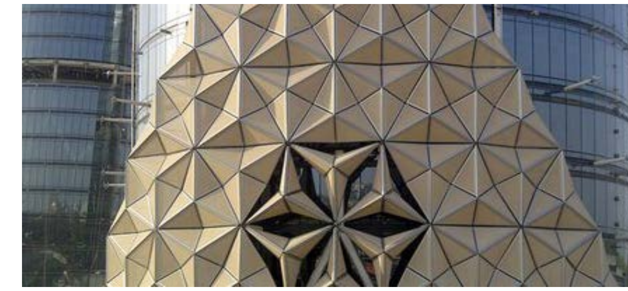
  - Contention
- Dynamic Facade Systems
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions

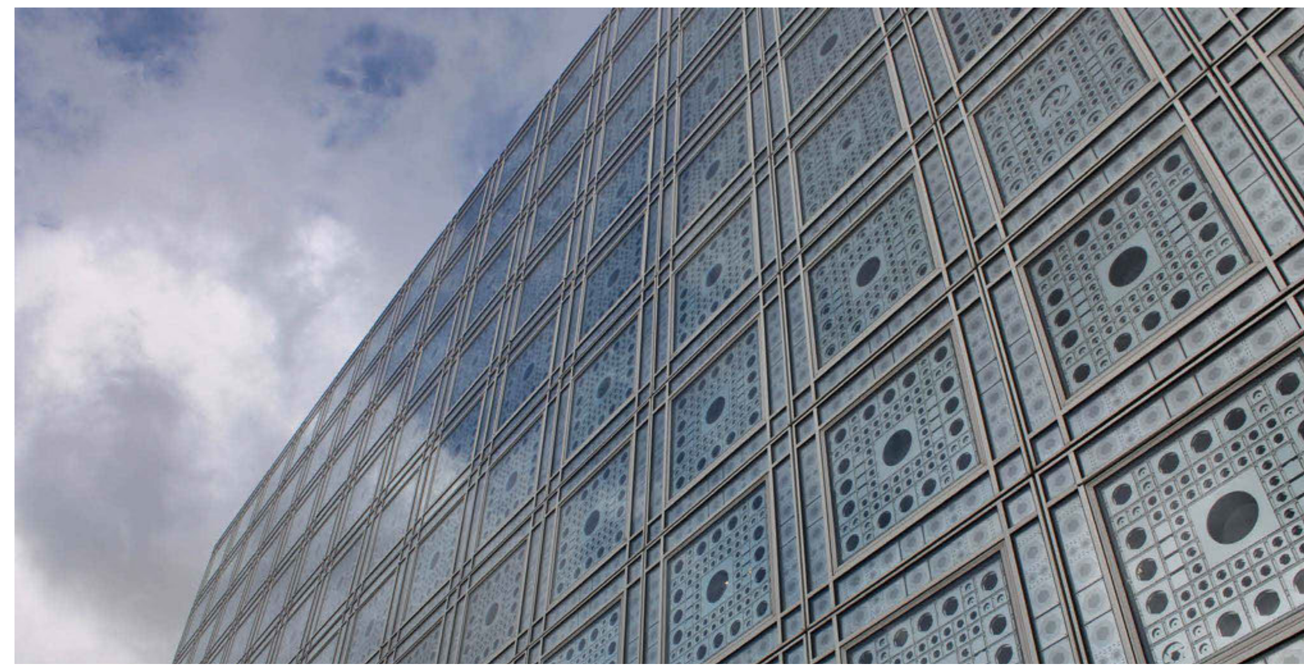


Part 1:
Project Background

Dynamic Glazing Systems







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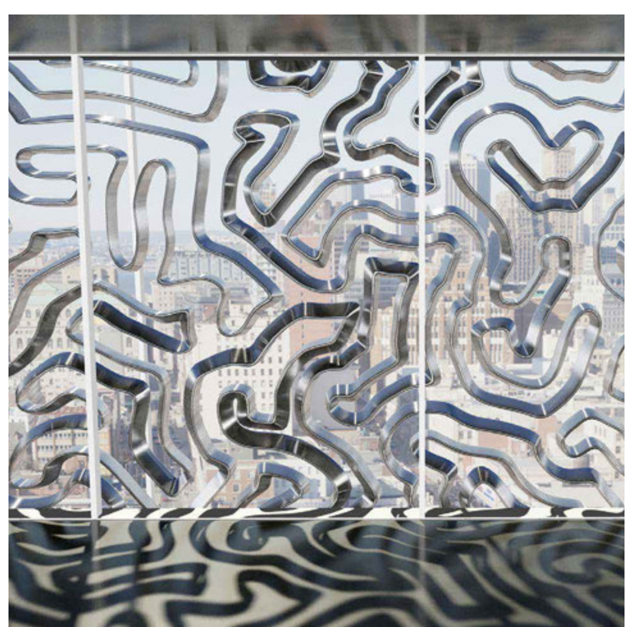
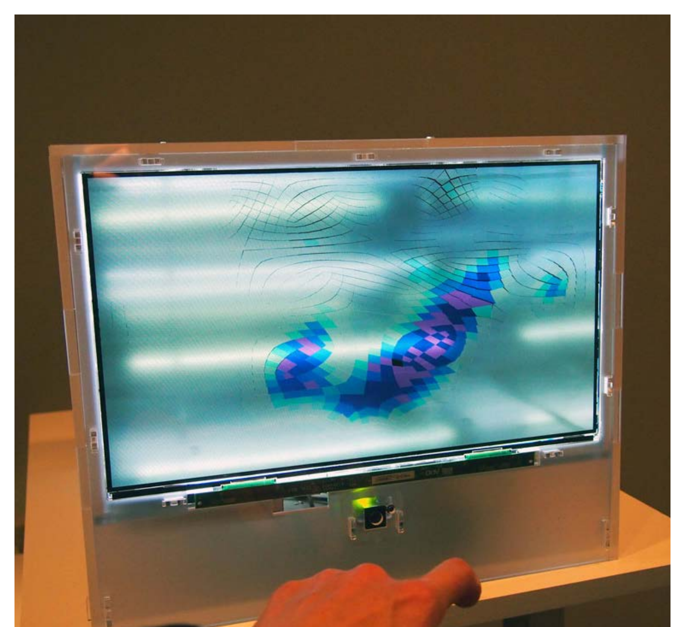
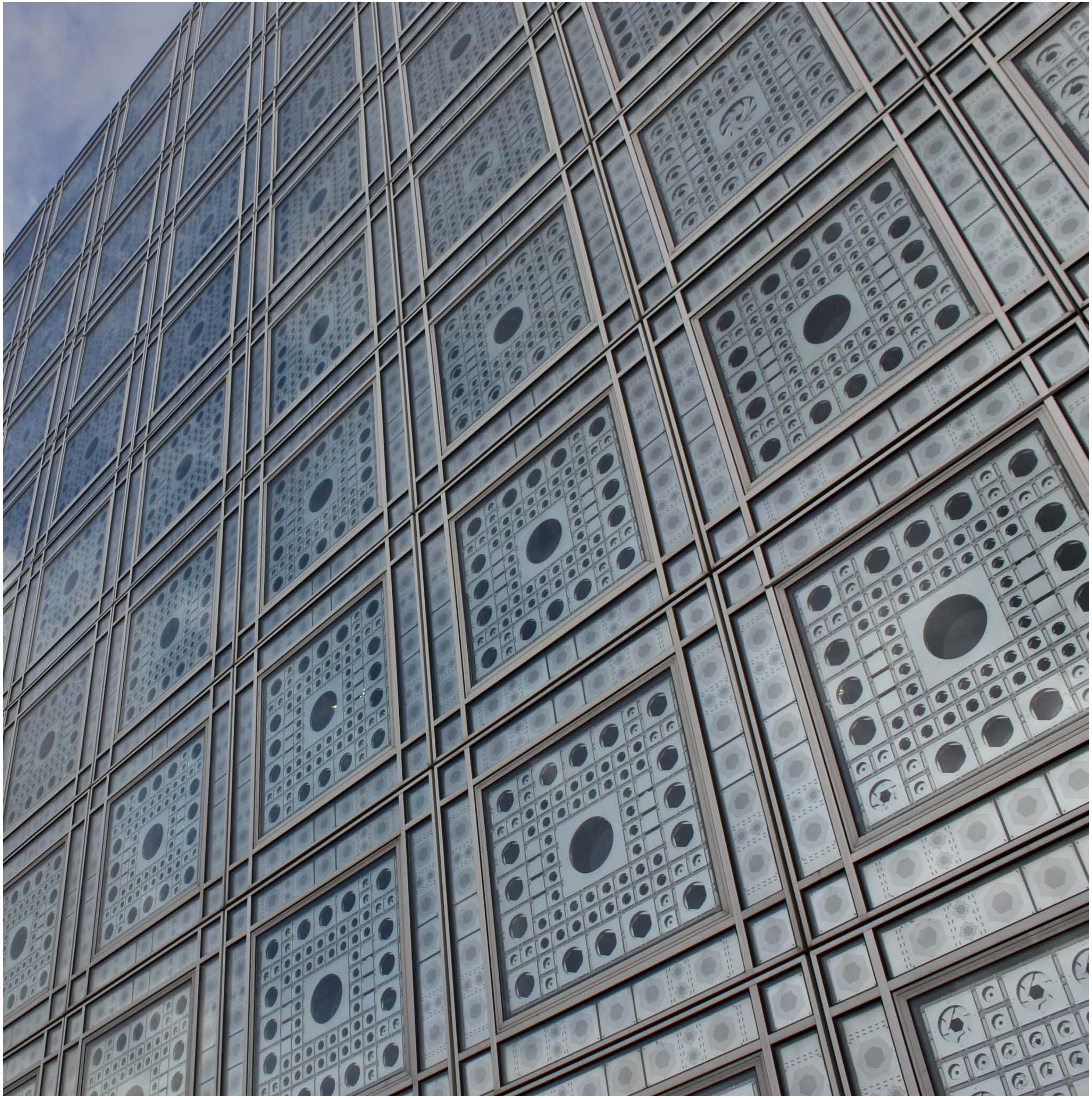




Dynamic Glazing Systems Example 1

The Arab World Institute
by Jean Nouvel



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Dynamic Glazing Systems Example 2

Syracuse Center of Excellence by Toshiko Mori

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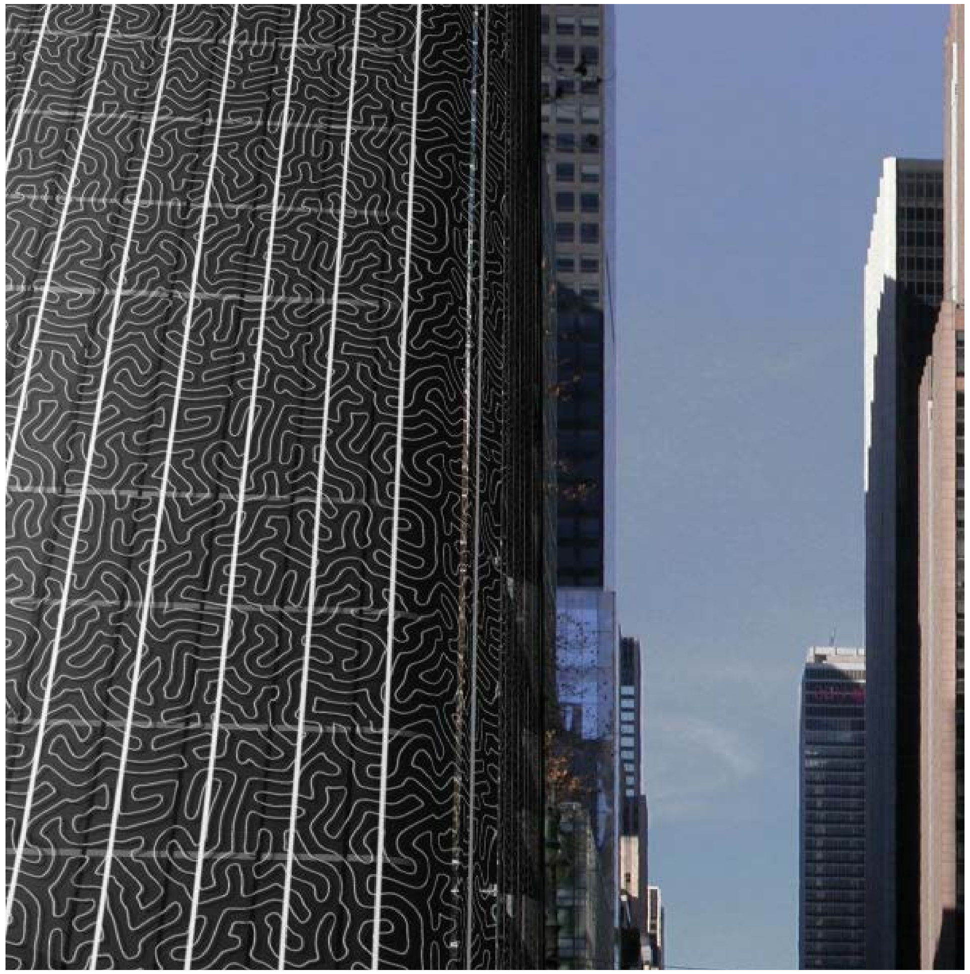
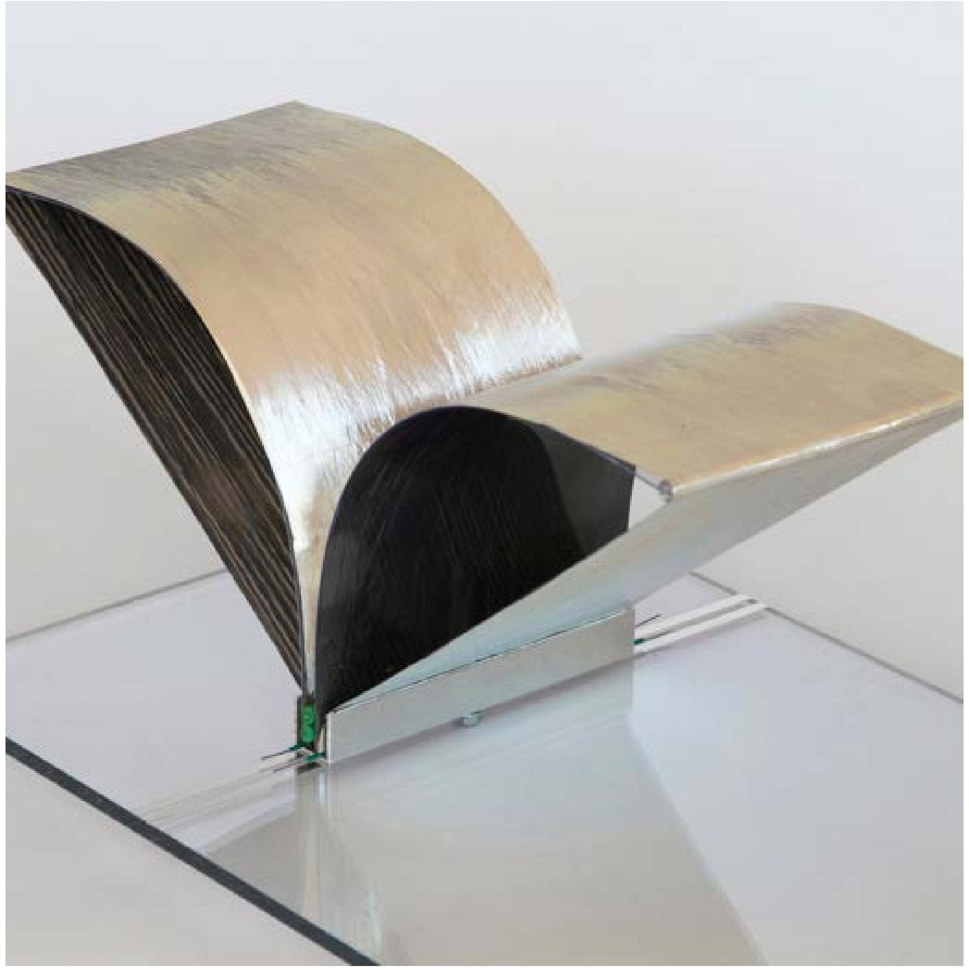
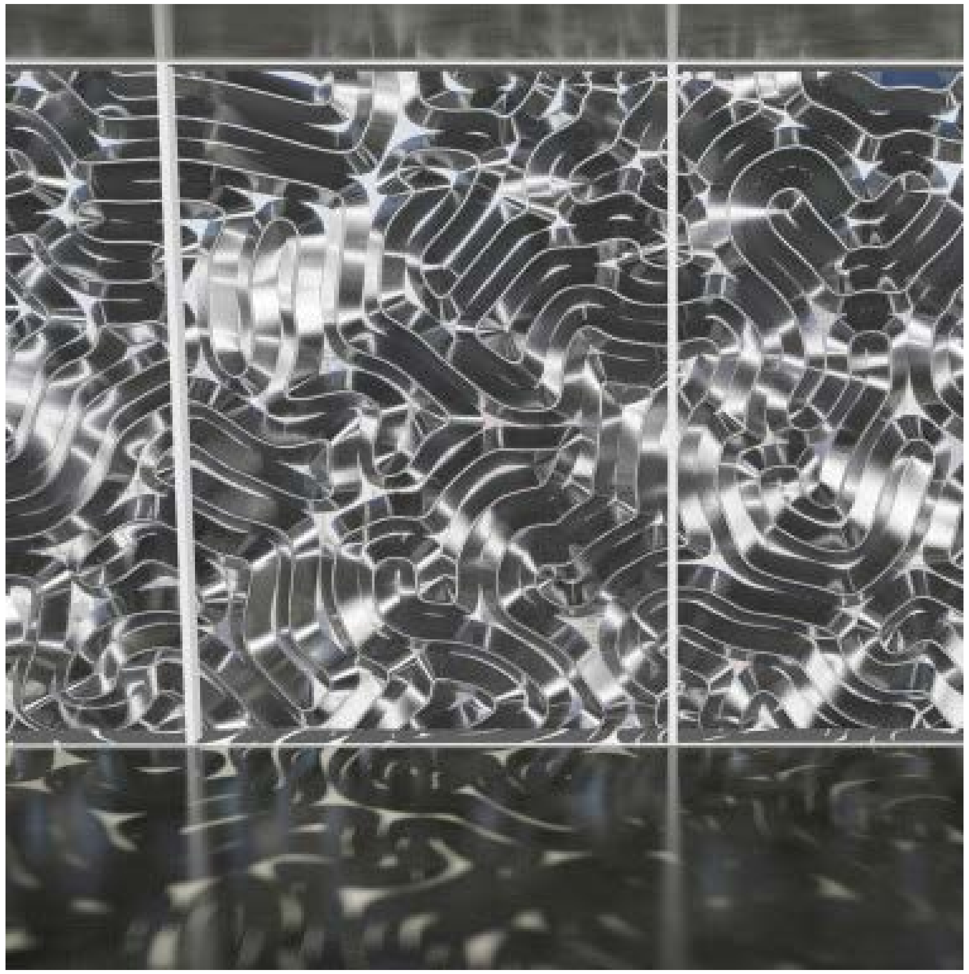
Dynamic Glazing Systems Example 3

Homeostatic Facade System
by Decker Yeadon LLC







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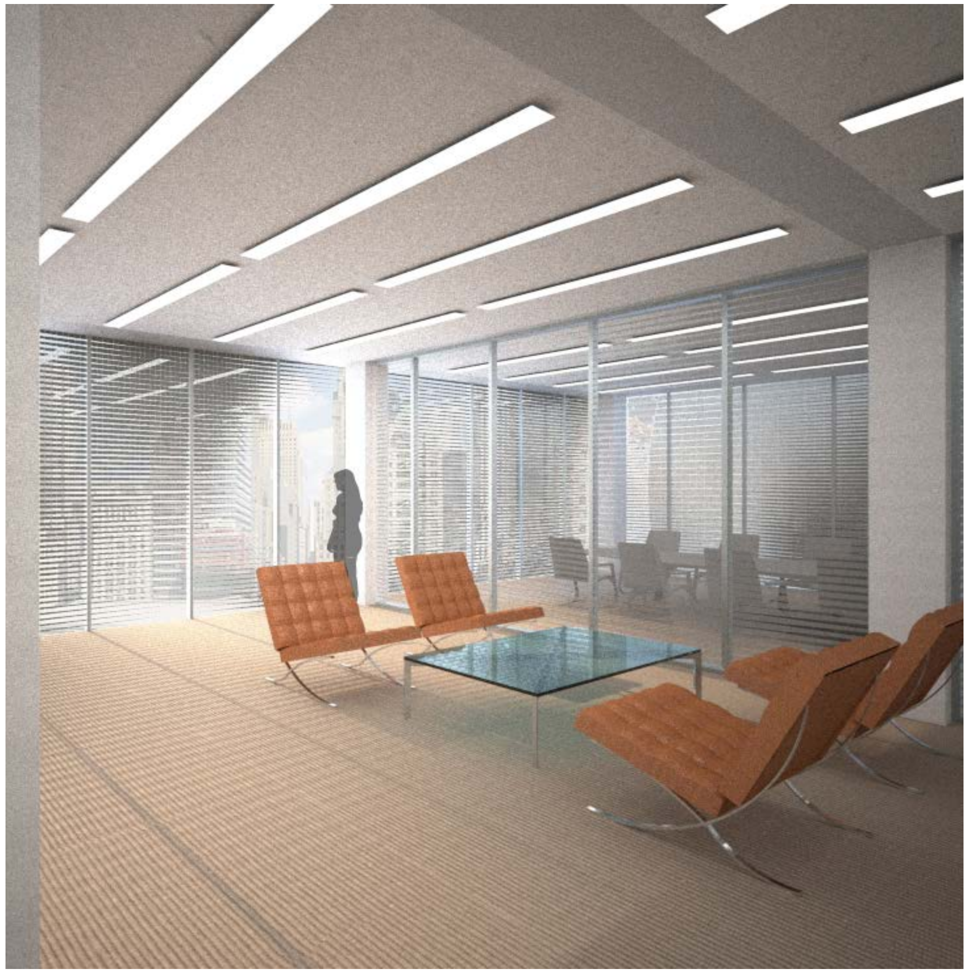
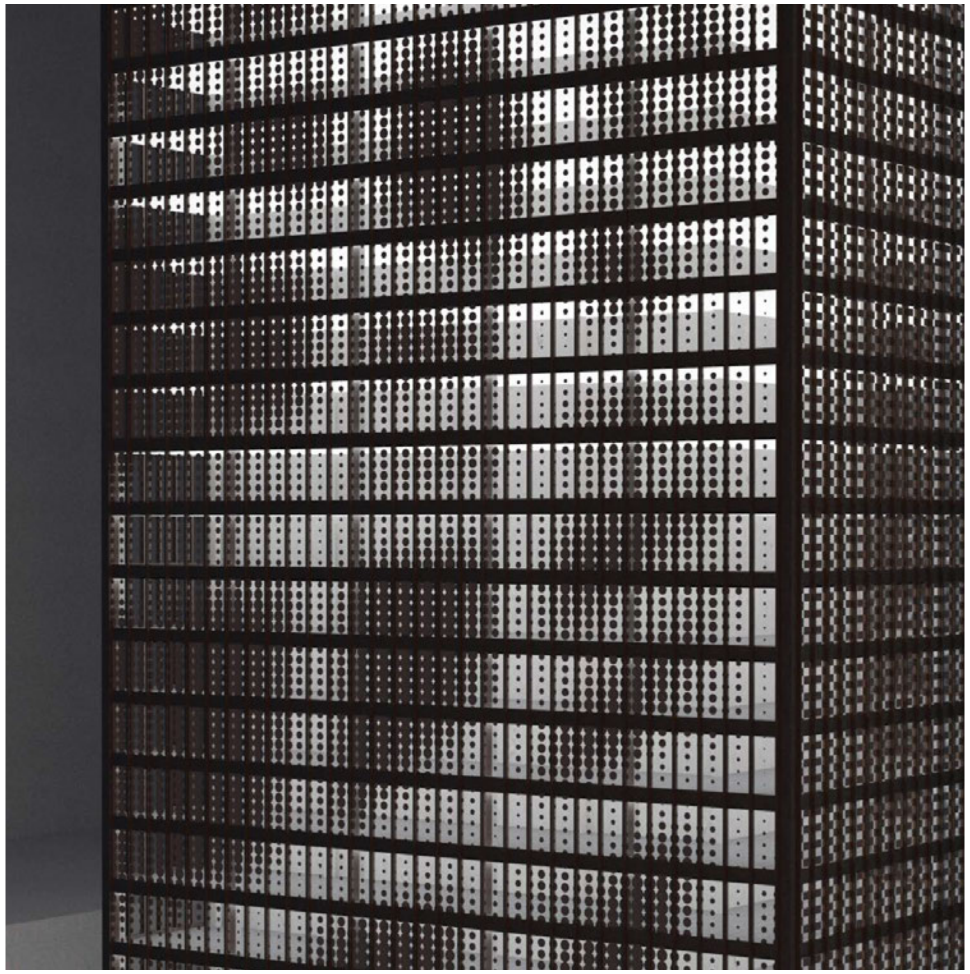
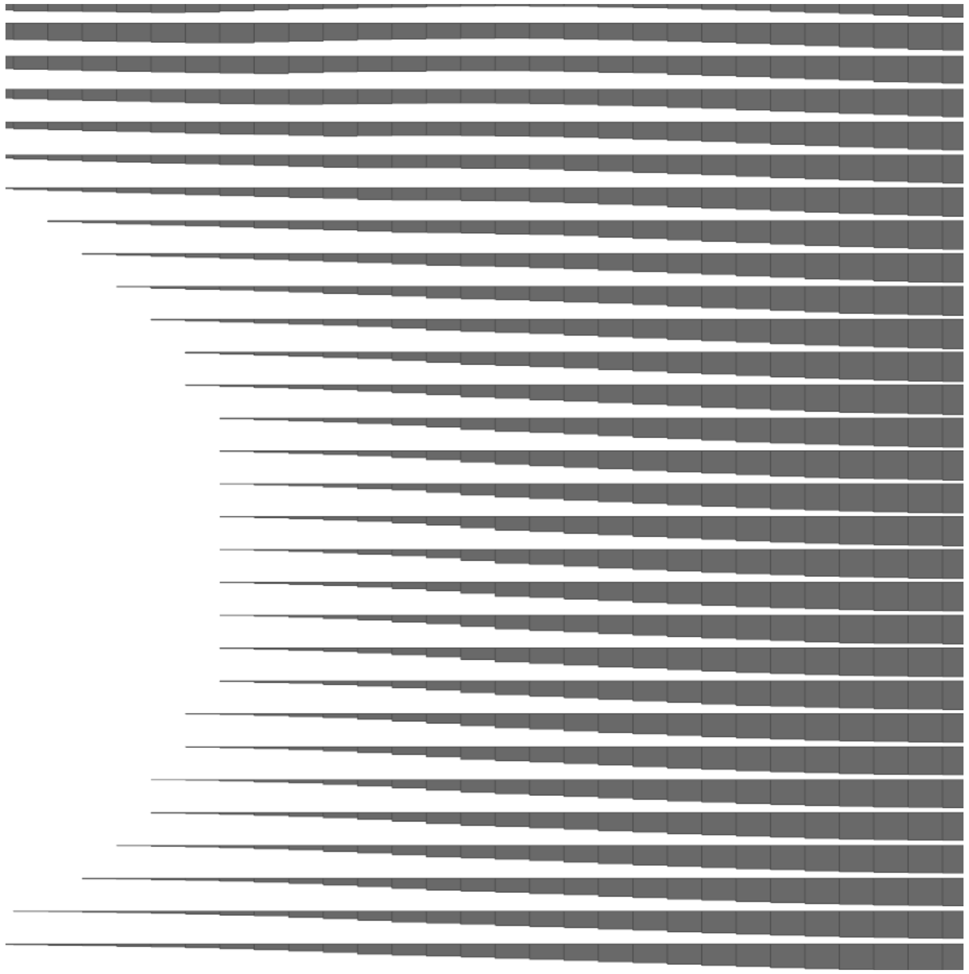
Dynamic Glazing Systems Example 4

Electroactive Dynamic Display System (EDDS) by the Center for Architecture Science and Ecology







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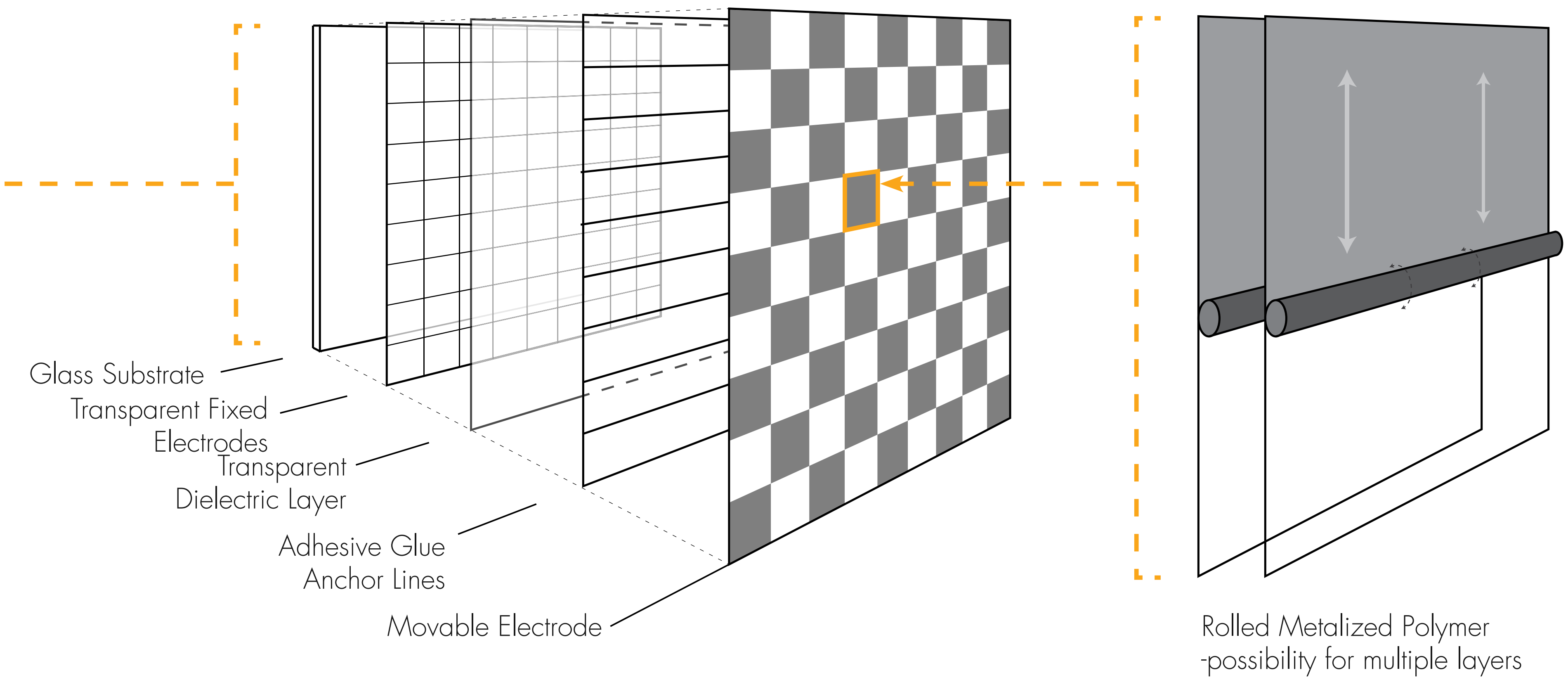
Dynamic Glazing Systems
Example 4 Continued

EDDS details

Patent #: US 8,134,112 B2



- Contained within an IGU
- Switches (rolls) easily
- Default position is up
- Low cost to fabricate/operate
- ~\$10-\$80 per ft² (electrochromic glass is \$100+ per ft²)
- High voltage, low current system

Accommodates:

- Solar tracking
- Glare/Daylighing control
- Design variability
- Occupant interaction
- Much more...

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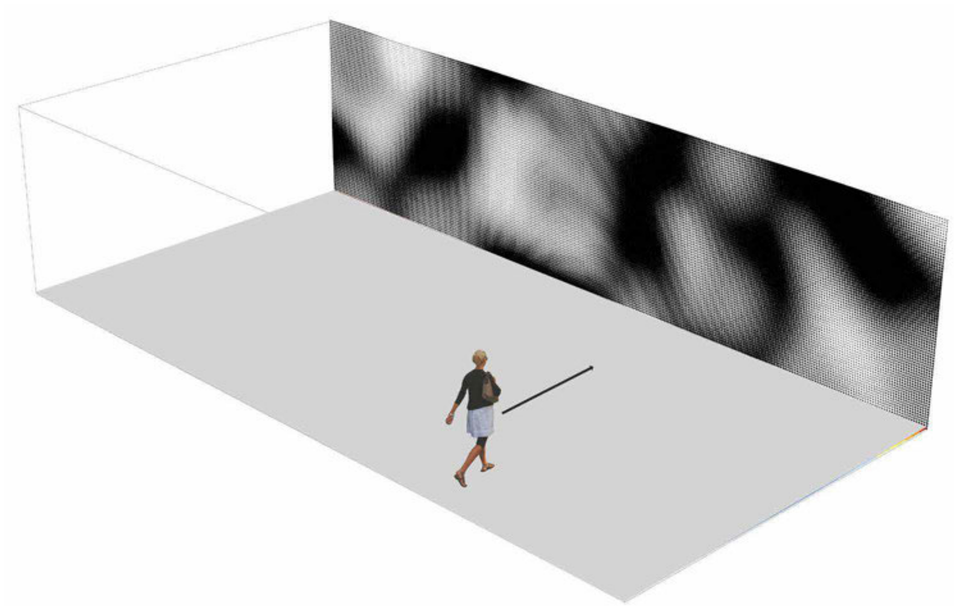
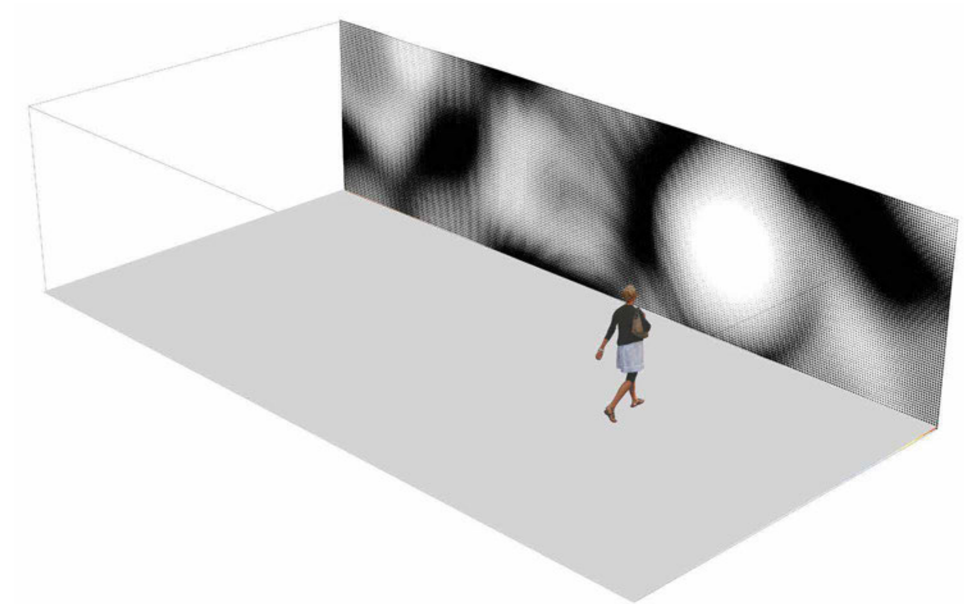
Dynamic Glazing Systems Example 4 Continued

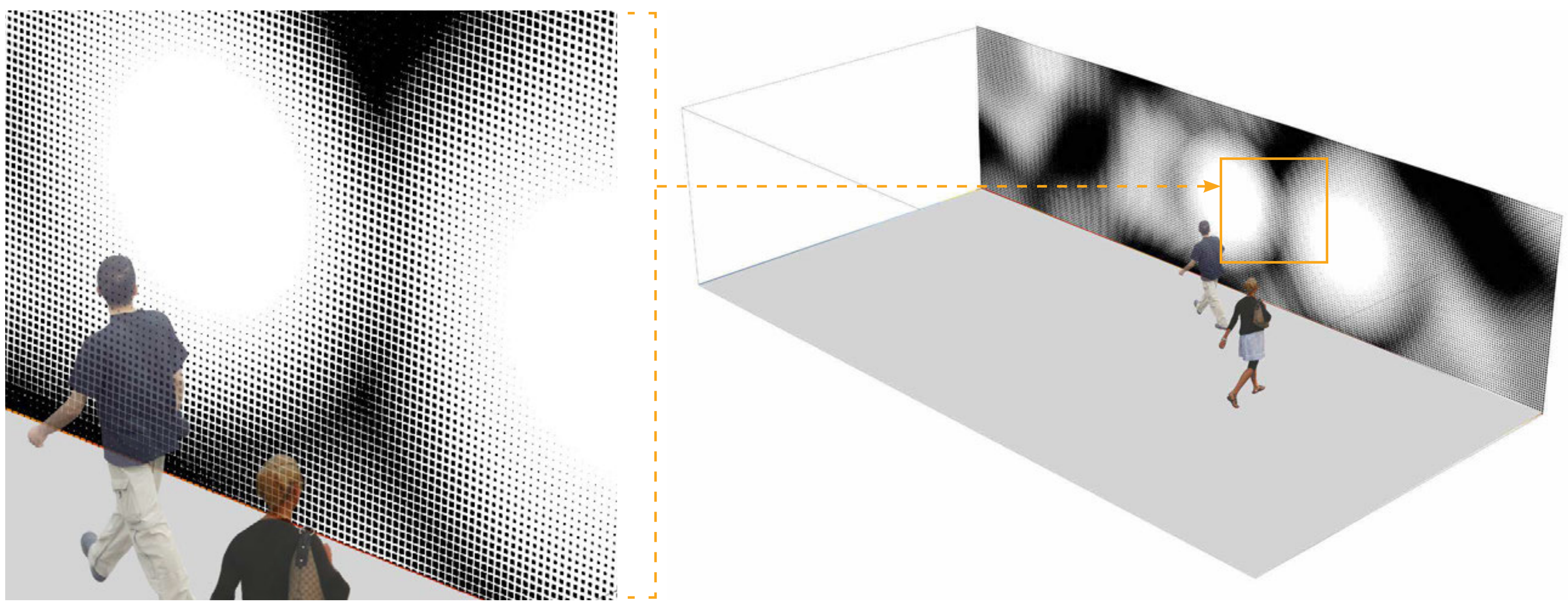
EDDS visualization

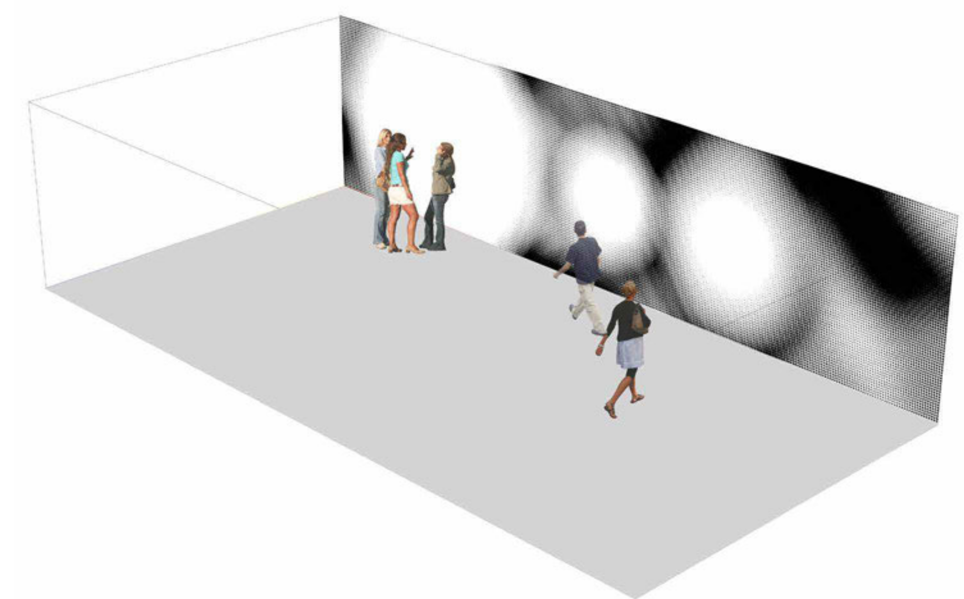
Dynamic Glazing Systems
Example 4 Continued

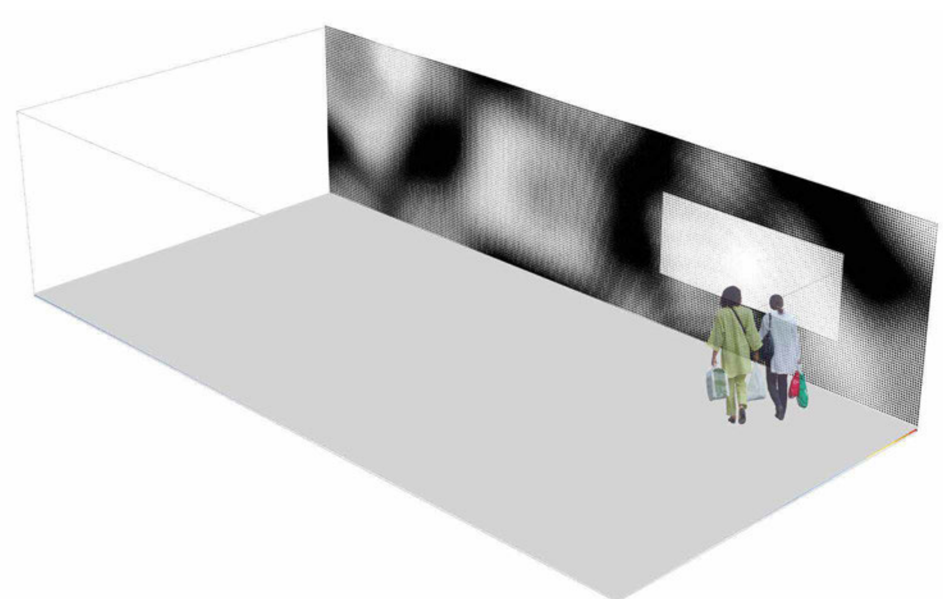
Occupant Viewing & Privacy Screens

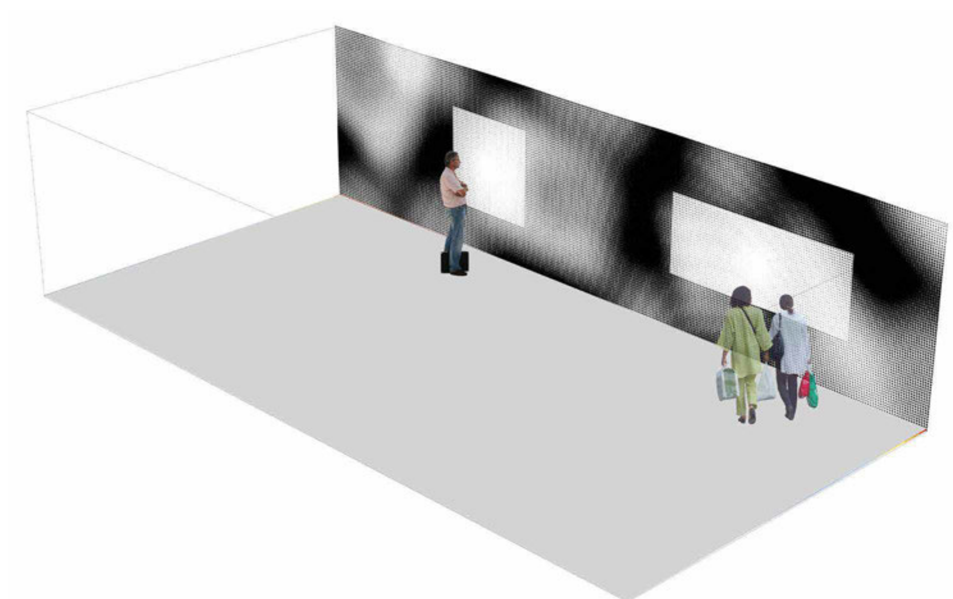












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Dynamic Glazing Systems
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Occupant Interaction

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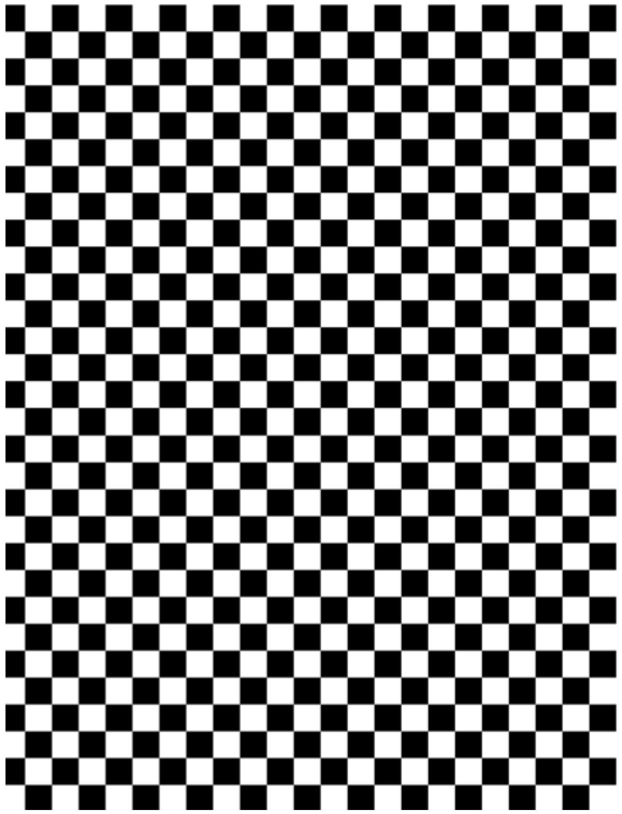
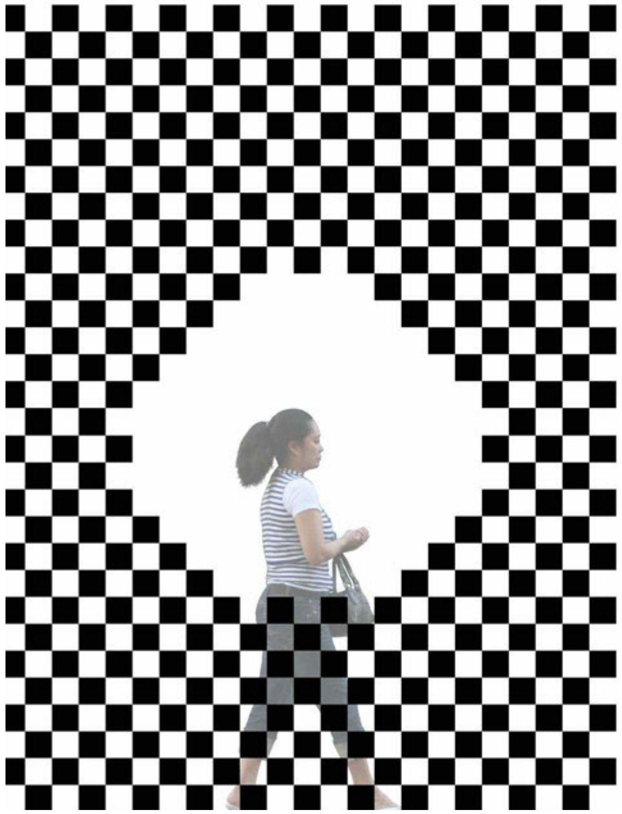
Dynamic Glazing Systems
Example 4 Continued

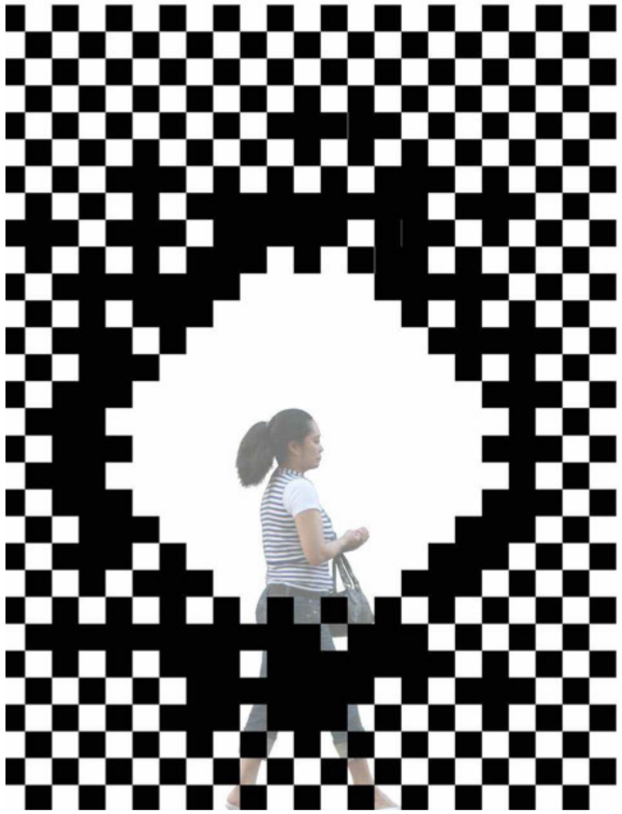
System Compensation



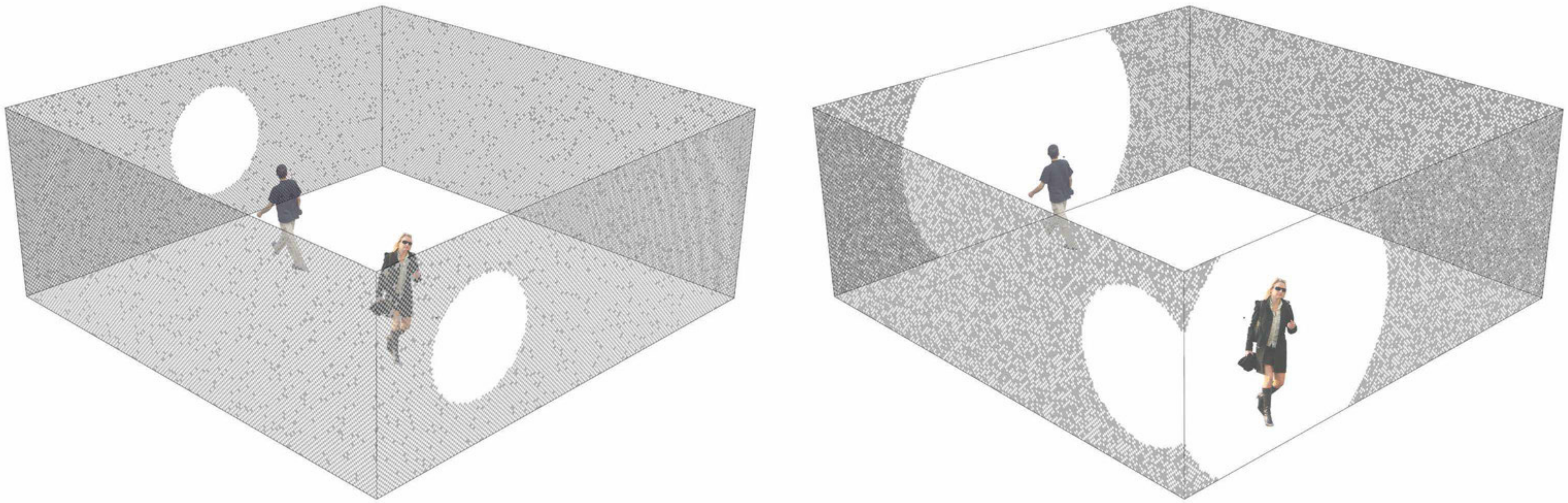
EDDS default state



EDDS responding to an occupant



EDDS compensating for the previous response



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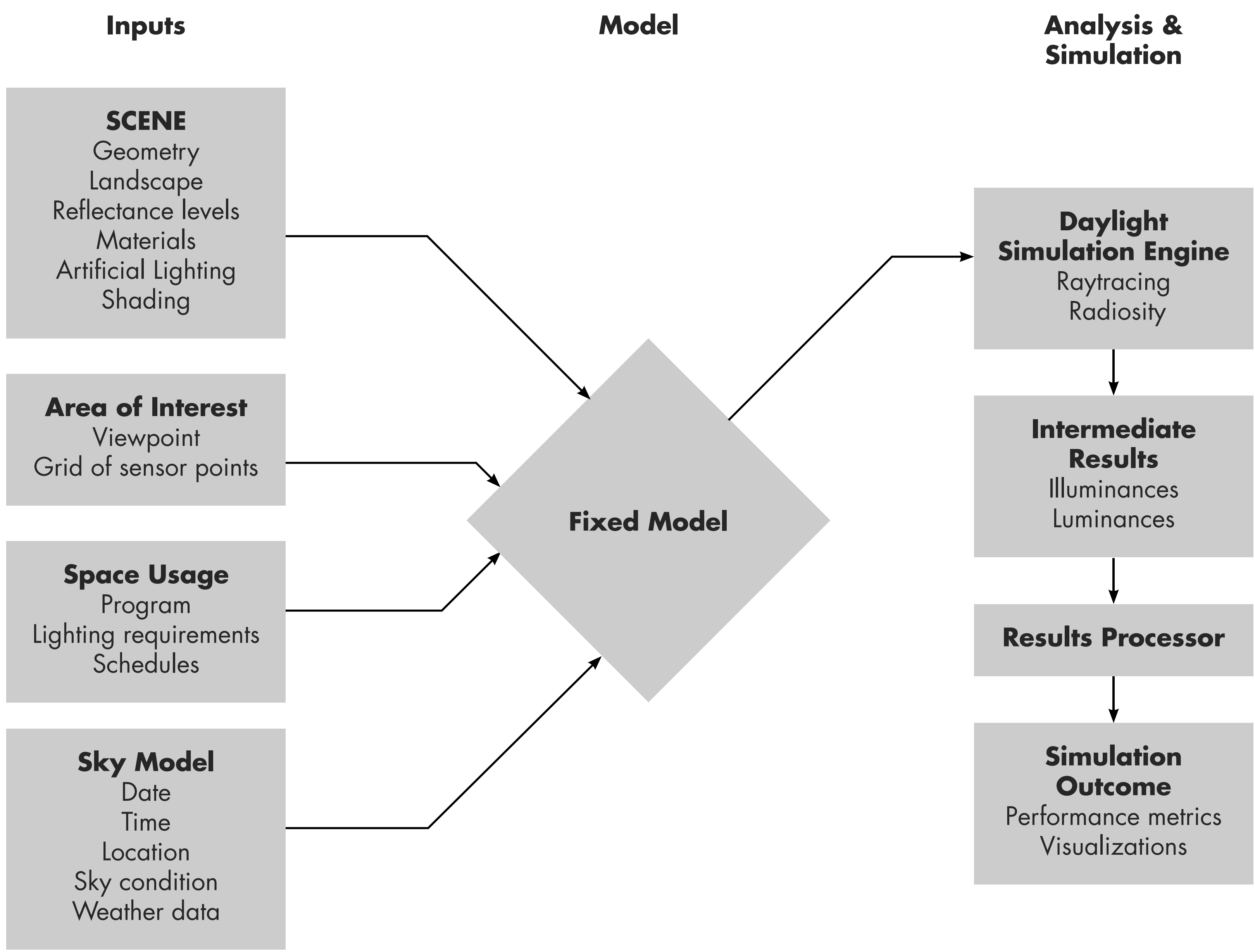
The Traditional Building Analysis

C. Reinhart's Daylighting Analysis Example



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