5-2015

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

Kurt Rogler

Follow this and additional works at: https://surface.syr.edu/architecture_theses

Part of the Architecture Commons

Recommended Citation
https://surface.syr.edu/architecture_theses/306

This Thesis is brought to you for free and open access by the School of Architecture Dissertations and Theses at SURFACE. It has been accepted for inclusion in Architecture Senior Theses by an authorized administrator of SURFACE. For more information, please contact surface@syr.edu.
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.
Indoor Radiant Temperature Map

1 meter by 1 meter 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

Levels: 15 zones each

Level 1
Level 2
Level 3
Level 4
Level 5

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 m² 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.
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.
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.

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

**Resultant simulation**

Analysis Software
EnergyPlus, Radiance, Daysim, EvalGlare

Daylight Plugins for Grasshopper
Honeybee, Ladybug, DIVA, Archsim, UrbanDaylighting

Behavioral Cues
Environmental variables, Dynamic Systems, Occupants

Dynamic Systems
Technologies which respond to the analysis data

Behavioral Model
Data trees, which contain each “frame” of an action of a changing element

Parametric Model
Accumulation of inputs, flexible in accordance with destination software
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…

**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:

<table>
<thead>
<tr>
<th>Color key:</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.44°C</td>
<td>≤ 21.53°C</td>
</tr>
</tbody>
</table>

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.

No EDDS/Shaders - Actual Analysis

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

Static Instance of 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.

Dynamic/Responsive EDDS - Speculation
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.
Bibliography:


<table>
<thead>
<tr>
<th>Modeling and Analyzing Unpredictable Building Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-Time Whole Building Performance Impacts of Occupant Interaction with Dynamic Façade Systems</td>
</tr>
</tbody>
</table>

SuperJury Presentation
Spring 2015
Kurt Rogler
Advisor Bess Krietemeyer
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 facade technologies that deal with a broader range of architectural performance criteria.
Part 1:  
Project Background
Dynamic Glazing Systems

- Introduction
- Dynamic Facade Systems Examples
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions
Dynamic Glazing Systems
Example 1
The Arab World Institute by Jean Nouvel

- Introduction
- Dynamic Facade Systems
  Arab World Institute
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions
Dynamic Glazing Systems
Example 2
Syracuse Center of Excellence
by Toshiko Mori

- Introduction
- Dynamic Facade Systems Center of Excellence
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions
Dynamic Glazing Systems
Example 3
Homeostatic Facade System
by Decker Yeadon LLC

- Introduction
- Dynamic Facade Systems
  Homeostatic Facade System
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions
Dynamic Glazing Systems
Example 4
Electroactive Dynamic Display System (EDDS)
by the Center for Architecture Science and Ecology
Dynamic Glazing Systems
Example 4 Continued
EDDS details
Patent #: US 8,134,112 B2

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

- 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/Daylighting control
- Design variability
- Occupant interaction
- Much more...

Glass Substrate
Transparent Fixed
Electrodes
Transparent
Dielectric Layer
Adhesive Glue
Anchor Lines
Movable Electrode
Rolled Metalized Polymer
- possibility for multiple layers
Dynamic Glazing Systems
Example 4 Continued
EDDS visualization
Dynamic Glazing Systems
Example 4 Continued
Occupant Viewing & Privacy Screens

- Introduction
- Dynamic Facade Systems
  EDDS
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions
Dynamic Glazing Systems
Example 4 Continued
Occupant Interaction

- Introduction
- Dynamic Facade Systems
  EDDS
- Analysis Inputs
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions
EDDS default state

EDDS responding to an occupant

EDDS compensating for the previous response
The Traditional Building Analysis
C. Reinhart’s Daylighting Analysis Example

- Introduction
- Dynamic Facade Systems
- Traditional Analysis
  - Current Method Used
- The Method
- Software Used
- The Building Testbed
- Single Zone Analysis
- Multiple Zone Analysis
- Building Visualizations
- Conclusions