2015 Radiance Workshop, Philadelphia
How we use Radiance to guide design teams to the right decisions before they even start…

08.18.2015
Wait, who’s making the decisions here?

Navigating value engineering, cost estimates, the diminishing role of designers in building projects, and the growing influence of design build contractors...
Why Early Daylighting Simulation is Critical to Integrated, High Performance Building Design

Things Radiance and Daylighting Practitioners Can Integrate with High Performance Building Design:

- The measurement and simulation of optically complex shading materials
- Elegant shading device design
- Evaluating the impact of dynamic glazing
- Optimizing automated interior shade fabrics and controls
- Applying complex performance metrics like Spatial Daylight Autonomy to low and net zero energy buildings
- Successfully deploying new glazing technologies in façade design
Why Early Daylighting Simulation is Critical to Integrated, High Performance Building Design

<table>
<thead>
<tr>
<th>Things Radiance and Daylighting Practitioners Can Integrate with High Performance Building Design:</th>
<th>Things I’ve Heard Cost Estimators Mark as Prohibitively Expensive in pre-Schematic, Concept Phases of Projects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The measurement and simulation of optically complex shading materials</td>
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<td>- “LEED”</td>
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<td>- Successfully deploying new glazing technologies in façade design</td>
<td>- Daylight re-directing film</td>
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01. You Can Have 100% Glass on Your West Façade, But...
Glazing Specifications, Implications and Shared Goals

All double pane low-e IGU's with clear glass are not created equal

- **Viracon VE-12M**
  - VLT = 0.70 / SHGC = 0.38

- **PPG Solarban 70xl**
  - VLT = 0.64 / SHGC = 0.28

- **Saint Gobain Cool-Lite Extreme 60/28 II**
  - VLT = 0.59 / SHGC = 0.25
Building Performance: Thermal and Visual Experience, Architecture and Engineering Decisions

Glazing Specifications, Implications and Shared Goals

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Glazing Specifications + Design Day Mean Radiant Temperature

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Façade Elements: Annual Insolation

Understanding the Efficacy of Fixed Shading Options

Total radiation from the sun and sky falling on the building skin

West Façade + No External Shading
West Façade + 9" West Façade Fins
West Façade + 30" West Façade Fins
Façade Elements + Design Day Mean Radiant Temperature

PPG Solarban 70xl
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Façade Elements + Design Day Mean Radiant Temperature

PPG Solarban 70xl
VLT = 0.64 / SHGC = 0.28

PPG Solarban 70xl + 50% WWR
VLT = 0.64 / SHGC = 0.28
Façade Design: Experiential Impacts

Thermal Impacts, Visual Impacts, Energy Impacts, Aesthetic Impacts, Cost Impacts...

Viracon VE-12M
- EUI: 83
- Tonnage: 680
- System Cost: $816,000
- $/sf: 3.6

PPG Solarban 70xl
- EUI: 72
- Tonnage: 580
- System Cost: $696,000
- $/sf: 3.1

Saint Gobain CLEX 60/28 II
- EUI: 65
- Tonnage: 530
- System Cost: $636,000
- $/sf: 2.8

PPG Solarban 70xl + 9" West Façade Fins
- EUI: 65
- Tonnage: 570
- System Cost: $684,000
- $/sf: 3.0

PPG Solarban 70xl + 30" West Façade Fins
- EUI: 65
- Tonnage: 570
- System Cost: $684,000
- $/sf: 3.0

PPG Solarban 70xl + 50% WWR
- EUI: 55
- Tonnage: 430
- System Cost: $516,000
- $/sf: 2.3
02. What Would Dynamic Glass Be Like on My Building?
Dynamic Glazing: Perception Shifts Over a Typical Day

Exterior Façade Under Clear Sunny Skies

Dynamic IGU With Clear Inboard Pane

Dynamic IGU

Clear IGU

Dynamic IGU

Clear IGU

Dynamic IGU

Clear IGU

Dynamic IGU

Clear IGU

PPG Clear 1/4”
Electrochromic Coating
View Clear 1/4” Tint Level 01

PPG Clear 1/4”
Solutran 70M Low-E Coating
PPG Clear 1/4”

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PPG Clear 1/4”
Solutran 70M Low-E Coating
PPG Clear 1/4”

September 21, 12:00pm

September 21, 1:00pm

September 21, 2:00pm

September 21, 4:00pm

Dynamic Glass

Clear Glass

Dynamic Glass

Clear Glass

Dynamic Glass

Clear Glass

Dynamic Glass

Clear Glass

Dynamic Glass

Clear Glass

Dynamic Glass

Clear Glass

VLT: 0.58
SHGC: 0.46

VLT: 0.63
SHGC: 0.28

VLT: 0.40
SHGC: 0.29

VLT: 0.63
SHGC: 0.28

VLT: 0.20
SHGC: 0.16

VLT: 0.63
SHGC: 0.28

VLT: 0.03
SHGC: 0.09

VLT: 0.63
SHGC: 0.28
Dynamic Glazing: Perception Shifts Over a Typical Day

Exterior Façade Under Clear Sunny Skies

Dynamic IGU With Colored Inboard Pane

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<tr>
<th>Time</th>
<th>Dynamic Glass</th>
<th>Clear Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 21, 12:00pm</td>
<td>VLT: 0.44, SHGC: 0.42</td>
<td>VLT: 0.63, SHGC: 0.26</td>
</tr>
<tr>
<td>September 21, 1:00pm</td>
<td>VLT: 0.31, SHGC: 0.26</td>
<td>VLT: 0.63, SHGC: 0.28</td>
</tr>
<tr>
<td>September 21, 2:00pm</td>
<td>VLT: 0.16, SHGC: 0.15</td>
<td>VLT: 0.63, SHGC: 0.28</td>
</tr>
<tr>
<td>September 21, 4:00pm</td>
<td>VLT: 0.02, SHGC: 0.08</td>
<td>VLT: 0.63, SHGC: 0.28</td>
</tr>
</tbody>
</table>
Daylighting Examples: Interior Luminous Environment

Interior View Looking West, September 21 at 4:30pm, Clear Sunny Skies

No Interior Shades
Daylighting Examples: Interior Luminous Environment

Interior View Looking West, September 21 at 4:30pm, Clear Sunny Skies

Dynamic Glass Tinted to 4%
Daylighting Examples: Interior Luminous Environment

Interior View Looking West, September 21 at 4:30pm, Clear Sunny Skies

Automated Fabric Shades Deployed
03. Daylighting and Shading for a Better Building, and it’s Cheaper!
Annual Insolation Study / Normative Building Without Shade Structure

Cumulative Direct Solar Radiation Falling on Building Skin

West Façade Reference Image

South Façade Reference Image

West Façade Annual Radiation on the Building Skin

South Façade Annual Radiation on the Building Skin

kWh/m²
Annual Insolation Study / High Performance Building With Shade Structure

Cumulative Direct Solar Radiation Falling on Building Skin

West façade Reference Image

South façade Reference Image

West façade Annual Radiation on the Building Skin

South façade Annual Radiation on the Building Skin

~ 65% Reduction in Solar Radiation Striking the West Glass

~ 90% Reduction in Solar Radiation Striking the South Glass
Annual Direct Sun Penetration Comparison Animation

High Performance Building with Shade Structure + Light Courts

Normative Building Without Shade Structure
Typical Daylight Conditions / Normative Building Without Shade Structure

September 21, 12:00pm, Clear Sunny Skies

Rendered Perspective

Illuminance Diagram, Light Levels in Footcandles

Falsecolor Luminance Map, Brightness
Typical Daylight Conditions / High Performance Building With Shade Structure + Light Courts

September 21, 12:00pm, Clear Sunny Skies

Rendered Perspective

Falsecolor Luminance Map, Brightness

Illuminance Diagram, Light Levels in Footcandles
Energy Performance Impact of Shade Canopy

- Reduced Envelope Surface Temperatures > **Higher Likelihood of Consistent Occupant Thermal Comfort**

- Lower Cooling Loads Enable Radiant with DOAS, Opposed to Typical VAV with Reheat > **Simpler System with Lower Maintenance Costs**

- Reduction in Annual Energy Use > **Annual Cost Savings**

- Smaller Mechanical System > **First Cost Savings**
Peak Solar Reduction due to Shading

Reduced solar gains make radiant cooling possible, without shading air system required. Improvements in the envelope reduce solar gains. Reductions in solar gains reduces HVAC System size and complexity.
HVAC System Selection and Envelope Loads

People, Lights, Plug Loads

Envelope Thermal Performance

Natural Ventilation
Thermal Mass

Displacement

Radiant Floors

Radiant Ceiling

Radiant Floor & Ceiling

Radiant Panels

VAV Reheat / Fan Coils

Cooling Capacity, Btu/sf
Cost Transfer Approach

Improvements in the envelope reduce solar gains, which reduce the size and cost of HVAC Systems.
Energy Performance Cost Savings, High Performance Building vs Normative Building Without Shade Structure

Lower annual energy use, higher likelihood of achieving ZNE

**ANNUAL ENERGY COST**

- **VAV System with No Shading**
- **Radiant System with Shading and Lightwell**

$68,000 Annual Savings

**FIRST COST TRANSFER :: MECHANICAL SYSTEMS**

- **VAV with Reheat, Air Cooled with Boiler**
- **Radiant with DOAS and Air Cooled Chiller**

$395,000 One Time Savings
04. Sometimes it Only Takes One Simulation
Daylighting Retrofit Example: Existing Conditions

Section Perspective

Falsecolor Luminance Map, Surface Brightness
Daylighting Retrofit Example: Concept Design Moves

Section Perspective

Falsecolor Luminance Map, Surface Brightness

![Graph showing surface brightness levels](image-url)
Daylight Autonomy Studies, Existing Conditions

Annual, Climate Based Calculation
Given a work plane illuminance target, how many occupied hours can function with no electric lighting
Daylight Autonomy Studies, Proposed Scheme

Annual, Climate Based Calculation

Given a work plane illuminance target, how many occupied hours can function with no electric lighting
05. Transparency?
Glazing Specifications

Translating Concept Ideas to Reality

Guardian SNX 62/27 + Neutral 78/65

Viracon VNE13-63 + VE-85

PPG Solarban 72 + Solarban 72

PPG Solarban 72 + Solarban 60

PPG Solarban 72 + Sungate 400

PPG Single Pane Starphire (For Reference Only)

\[ \text{VLT} = 0.56 \]
\[ \text{SHGC} = 0.24 \]
\[ U\text{-Value} = 0.16 \]
\[ \text{Front Face VLR} = 0.13 \]

\[ \text{VLT} = 0.59 \]
\[ \text{SHGC} = 0.26 \]
\[ U\text{-Value} = 0.16 \]
\[ \text{Front Face VLR} = 0.14 \]

\[ \text{VLT} = 0.55 \]
\[ \text{SHGC} = 0.26 \]
\[ U\text{-Value} = 0.15 \]
\[ \text{Front Face VLR} = 0.16 \]

\[ \text{VLT} = 0.56 \]
\[ \text{SHGC} = 0.27 \]
\[ U\text{-Value} = 0.15 \]
\[ \text{Front Face VLR} = 0.15 \]

\[ \text{VLT} = 0.61 \]
\[ \text{SHGC} = 0.27 \]
\[ U\text{-Value} = 0.17 \]
\[ \text{Front Face VLR} = 0.16 \]

\[ \text{VLT} = 0.91 \]
\[ \text{SHGC} = 0.89 \]
\[ U\text{-Value} = 1.03 \]
\[ \text{Front Face VLR} = 0.08 \]
Glazing Specifications

Translating Concept Ideas to Reality

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Viracon VNE13-63 + VE-85

PPG Solarban 72 + Solarban 72

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PPG Single Pane Starphire (For Reference Only)
Guardian SNX 62/27 + Neutral 78/65

Visualizing Glass Types
Viracon VNE13-63 + VE 85

Visualizing Glass Types
PPG Solarban 72 + Solarban 72

Visualizing Glass Types

September 21, 4:00pm / Clear Sunny Skies

September 21, 10:00am / Clear Sunny Skies

September 21, 4:00pm / Clear Sunny Skies + Interior Shades Deployed

December 21, 12:00pm / Overcast Skies

VLT - 0.55
SHGC - 0.26
U-Value - 0.15
Front Face VR - 0.16
PPG Solarban 72 + Solarban 60

Visualizing Glass Types

September 21, 4:00pm / Clear Sunny Skies

September 21, 10:00am / Clear Sunny Skies

September 21, 4:00pm / Clear Sunny Skies + Interior Shades Deployed

December 21, 12:00pm / Overcast Skies

VLT - 0.56
SHGC - 0.27
U-value - 0.15
Front Face U/R - 0.15
PPG Solarban 72 + Sungate 400

Visualizing Glass Types
Single Pane Starphire Low Iron Glass, For Reference

Visualizing Glass Types
Bonus - Yet *Another* Convergence!
East Facing Façade in Menlo Park, California
East Facing Façade in Menlo Park, California
Thank You!

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