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Net-Zero Office Building
(Bullitt Center- Proposed Net-Zero Office Building in Seattle, WA - Used as Platform for Simulation)

Image: The Miller Hull partnership
Bullitt Center Energy Use: Path to Net-Zero
(Targeting Living Building Challenge)

Lighting Measures:
- Daylight responsive photo-controls
- Reduced LPD (0.4 W/sf)
- No “off-hour” lighting (Sweep Control)
Lighting Consumes 20% of US Site Energy and 38% of Site Electricity (EIA, 2009)

**Lighting Energy in NW Buildings**

Office Building: Seattle Energy Code 2009

EUI $\sim 42 \text{ kBtu/ft}^2\text{-yr}$

Lighting alone $= \sim 11.25 \text{ kBtu/ft}^2\text{-yr}$
Lighting Consumes 20% of US Site Energy and 38% of Site Electricity (EIA, 2009)

Lighting Energy in NW Buildings

Office Building: Seattle Energy Code 2009

EUI ~42 kBtu/ft²-yr
Lighting alone = ~11.25 kBtu/ft²-yr

Bullitt Center

EUI ~16 kBtu/ft²-yr
Lighting alone = ~3.7 kBtu/ft²-yr - with P-Cell Control

If daylight performance is not persistent over time the project will not meet net-zero operation, nor meet qualitative experiential goals.
10% Clear Sky....still often drives manual blinds configuration.
Expected Cycling for Glare Control
Passive User System vs. Weather Responsive Automation
(Southeast Façade SEATTLE per TMY)
Optimized per Sky Condition and Weather
Pre-programmed for Solar Orientation and Overshadowing

Image: Warema
Automated Blinds Systems
Existing and Emerging Glass Technology offers potential for:

- Improved Building Energy Performance
- Building Integrated Power Generation
- Improved Visual Comfort

Switchable Glazing Technology
Conceptual Design
Daylighting Simulation
Daylighting Simulation:
Effect of Atrium – CIE overcast
Primarily Side-lit Building
No "Height Departure"

11′-6” floor to floor

77% of the floor area has daylight levels below 2%
Proposed Plan with “Height Departure”

14’-2” floor to floor

38% of the floor area has daylight levels below 2%
Top Floor Plan with Diffuse Skylights

Floor to ceiling varies

~5% Skylight to Floor Area
Simulation Process
Daylight Illuminance by Zone
Luminance at key Workstation Locations
Shadow Studies and Scene Geometry/Materials
Deployment Schedule*: Switchable Glazing

21 September, Clear Skies

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Transparent State: Tvis = 70%   SHGC = ~0.4
Darkened State: Tvis = 3%   SHGC = ~0.1

*Switching on presence/absence of direct beam sunlight in critical visual task areas
**South glazing shaded by exterior PV array
### Deployment Schedule*:

Automated Exterior Venetian Blinds**

21 September, Clear Skies

- Slat dimension: 4” (100mm)
- Slat reflectance = 50%
- Glass: Tvis = 70%  SHGC = ~0.4

*Switching on presence/absence of direct beam sunlight in critical visual task areas.

** Slat deployed at minimum angle from horizontal to just block direct sunlight.
Batch Simulation in Radiance and Image Processing

1. Render All Timesteps/Scenes in Radiance
2. Under All Sky Conditions (Clear and Overcast)
3. Batch Process HDR Images in False Color
4. Convert to JPEG LDR Luminance Maps

*Anyhere Software, G. Ward
Create Dynamic Luminance Maps
Dynamic Luminance Maps:
Primary Visual Field Luminance
(SE Workstation)

Baseline
No Sun Control

Automates Electrochromic Windows

Automated Exterior Venetian Blinds

21 December 12:00
Clear Skies

21 December 12:00

21 December 12:00
Dynamic Illuminance Map

Analysis Grid
RAD Illuminance
Contour Range: 300 - 2000 Lux
In Steps of: 200 Lux

December 21, Sunny Sky
Exterior Venetian Blinds by Zone (Façade)
ECWs by Zone (Façade)
Median Illuminance (Entire Floor Plate) by System

![Graph showing median comparison of illuminance by system. The x-axis represents Time of Day (September 21) with values ranging from 5:30 to 18:30. The y-axis represents illuminance in lux, ranging from 0 to 1000. The graph includes lines for BLINDS, VARIABLE TRANSMITTANCE GLAZING, NONE, and OVERCAST conditions.]
Integration with Light Redirection Systems

Optimum Transparency State Vs. ECW Shading State Via Controls

Weather Responsive Switching and Solar Shading

BLINDS
- Optimized on:
  - Glare Control
  - Heating and Cooling
  - Occupancy

ECW
- Manual Control by user Preference
- With Manual Fabric Shades for Privacy

Optimum Transparency State Vs.
ECW Shading State Via Controls
Integration with Light Diffusion Systems

Spectrally-Selective Switching and Intensity Control

Energy Harvesting (Optimized Insolation Control)

Tvis Control/Darkening

Diffusion Layer (PVB)
Thanks!

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UW College of Built Environments
Dynamic Luminance Map: *Baseline- No Blinds or Shades*
Dynamic Luminance Map: Dynamic Blinds Deployment
Dynamic Luminance Map: *Baseline - No Blinds or Shades*
Dynamic Luminance Maps: Primary Visual Field Luminance

EH ECW Transparent State Window
Visual Transmittance 70%

EH ECW Visible Transmittance at 1%

EH-ECW Visible Transmittance at 15%

21 December 12:00