Simulating for Nothing
Radiance's role in the design of a large net zero energy building

Eighth Annual Radiance Workshop, Harvard University

Rob Guglielmetti
October 22-23, 2009
Simulating for Nothing

National Renewable Energy Laboratory
Research Support Facility (RSF)
Net Zero Energy Office Building
Introduction

Acknowledgements

- Initial daylighting design developed by RNL Design (Architect), Stantec (Engineer), and Architectural Energy Corporation (Sustainable Design Consultant)
- Daylighting design refined by the speaker while employed by Architectural Energy Corporation
- Speaker is now employed by the National Renewable Energy Lab (NREL)
- Images and data were presented to NREL throughout the design process
Project Goals

- Capacity: 750 people
- Size: 220,000 ft^2
- EUI: 25 Kbtu/ft^2/yr
- 50% energy savings over ASHRAE 90.1
- $250/ft^2
- LEED Platinum
  - LEED iEQ 8.1 (daylighting) credit required
- Net Zero Energy building, via:
  - Base building energy efficiency
  - On-site wood chip heating facility
  - Roof- and site mounted PV (power purchase agreement)
Introduction

Program
- Open and private office space
- Data center
- Conference rooms
- Library
- Exercise room
- Café
Daylighting

- Radiance modeling determined maximum allowable section depth (N/S)
- Achieves 25fc across majority of main wing floor plate (noon, equinox, clear sky), satisfying LEED iEQ 8.1 requirement
Design Response – Competition Phase

Daylighting
- Punched windows with “daylight” and “view” panes
- Daylight redirecting devices (Lightlouver) on daylight glazing
- Simple fixed overhang/vertical fin devices on vision glazing (ties into natural ventilation requirement)
- Office furniture
Design Response – Competition Phase

- Overhang sized to work in conjunction with furniture partition heights to control direct sun on work surfaces
- Entire space programming responsive to and supporting daylighting
Design Development

- Confirmation of design
  - Overhangs blocking direct sun?
  - Adequate daylight throughout year?
  - Satisfy LEED iEQ8.1 requirement?
    - 25FC, 75% task area, Equinox/noon/clear sky
- Inform lighting control zones
- Estimate lighting control response for energy analysis
- Qualitative evaluation
  - Several space types
Design Development

- Overhang Performance
  - Minimal direct sun on desks

Winter
- 8:30 a.m.
- 3:30 p.m.

Equinox
- 8:30 a.m.
- 3:30 p.m.

Summer
- 8:30 a.m.
- 3:30 p.m.
- 6:30 p.m.
Design Development

Winter

Equinox

Summer

9:00 a.m.  12:00 p.m.  5:00 p.m.
Design Development

Main wings – interior analysis
  – Created detailed Radiance model
  – Used .ies photometric files to model Lightlouver performance
Design Development

LEED Analysis - Typical Floor
# Design Development

**LEED Analysis - Top Floor**

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**LEED-qualifying Area**

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210 153 136 852
210 153 136 852
```
Design Development

Top vs. Typical Floor Illuminance Distribution
Design Development

Top vs. Typical Floor Illuminance Distribution

Top Floor Vs. Typical Floor

Calculation Point

NORTH

SOUTH
Design Development

LEED Analysis vs. Actual Space Conditions

| 58 | 40 | 51 | 65 | 53 | 38 | 32 | 48 | 55 | 64 | 39 | 32 | 47 | 65 | 52 | 40 | 53 | 38 | 32 | 34 | 46 | 55 | 40 | 33 | 46 | 55 | 54 | 44 |
| 55 | 40 | 51 | 65 | 53 | 38 | 32 | 48 | 55 | 64 | 39 | 32 | 47 | 65 | 52 | 40 | 53 | 38 | 32 | 34 | 46 | 55 | 40 | 33 | 46 | 55 | 54 | 44 |
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Design Development

LEED Analysis (no furniture) vs. Actual Space Conditions

Daylight Illuminance Comparison

- open space
- with workstations

Calculation Point

Illuminance (FC)

120
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Design Development

Integrated Analysis – “What about the Energy Use?”

– LEED daylight credit “analysis” an inexact measurement of an incomplete performance metric
– “Point-in-time”, misses things (good and bad)
– Need to measure annual, whole-building energy-use impacts of daylight-responsive lighting controls
– Lightlouver devices not easily simulated on annual basis; ies files were generated with forward raytracing for specific times
– rtcontrib and climate-based daylight modeling (CBDM) workflows are the next frontier for this work
Design Development

Integrated Analysis – “What about the Energy Use?”

For the RSF calculations:
– Lightlouver geometry was explicitly modeled in Radiance
– Radiance’s light backwards raytracing was used (no mkillum, no photon map)
– Cranked up the rendering parameters, waited a long time, and STILL assumed there was a significant underestimation of the daylight contribution
– Used SPOT to perform annual simulation of daylight performance and dimming response, generated schedule “include file” for DOE2 energy analysis
– Energy modelers included SPOT schedule in DOE2 energy runs
Construction Documents

Detailed Renderings

Day

Night
Construction Documents

Lighting Control Zones

Annual Daylight Availability - Third Floor
Construction Documents

Lighting Control Zones

- Logical control zoning was determined through annual simulation
- Francesco Anselmo’s “radmap” used for annual sky simulations
- Prevailing daylight availability dictated control zoning
Construction Documents

Lighting Control Zones

Annual Daylight Availability – North Wing
Construction Documents

Lighting Control Zones – East-West

Annual Daylight Availability – North Wing
Construction Documents

Lighting Control Zones – North-South

- Zone 1
- Zone 2
- Zone 3

Applied to Floors 1 & 2 in energy model

First Floor

Applied to Floors 3 & 4 in energy model

Third Floor

Annual Daylight Availability – North Wing
Additional Visualizations

Desk Placement Glare Issue

- Repositioned Reception Desk

Original View; Equinox, 7:30 a.m.

Relocated Desk View; Equinox, 7:30 a.m.
Additional Visualizations

2nd Floor Conference Room, Summer, 3:00 p.m.
Additional Visualizations

Café in Afternoon
Additional Visualizations

Sunshade Ineffective due to open sides/top; recommend adding solid sides

View Without Recommended Sunshade Modification  View with Recommended Sunshade Modification
Thank You