

4.430 Daylighting



Christoph Reinhart
4.430 Course Introduction

Sky over MIT



Massachusetts Institute of Technology
Department of Architecture
Building Technology Program

"My research goal is to **change current** sustainable **design practice** by developing, validating and testing analysis workflows and metrics that lead to improved design solutions as far as occupant **comfort** and health as well as building **energy** use are concerned. The premise of my work is that an informed decision is a better decision."

"This is my favorite class."



Course Description

The primary focus of this 9 credit course is the study of natural and electric lighting in an architectural context. The course promotes the integration of occupant comfort, energy efficiency and daylight availability throughout the design process and places an emphasis upon the role light can play in shaping architecture.



At the end of the course you will be able to ...

- formulate your own definition of what constitutes 'good' lighting,
- conduct a series of daylighting design techniques from rules of thumb and simulation to high dynamic range photography and physical model building,
- develop a comprehensive lighting strategy for your projects.



What skills are you going to acquire?



Rules of Thumb for Massing and Façade Design



Diagram of daylighting in different architectural schemes removed due to copyright restrictions.

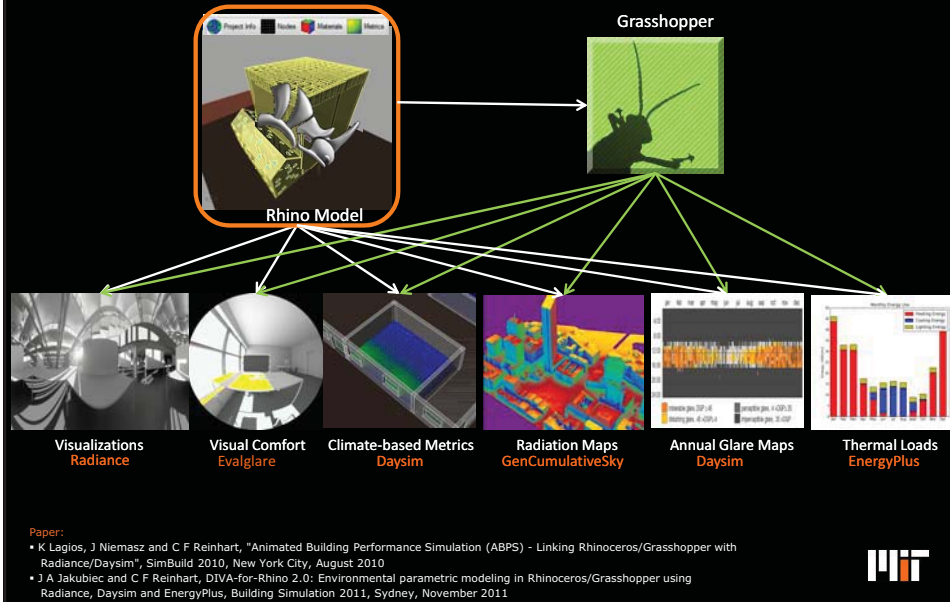


Daylit Area (2 times the window head height)
Non-Daylit Area

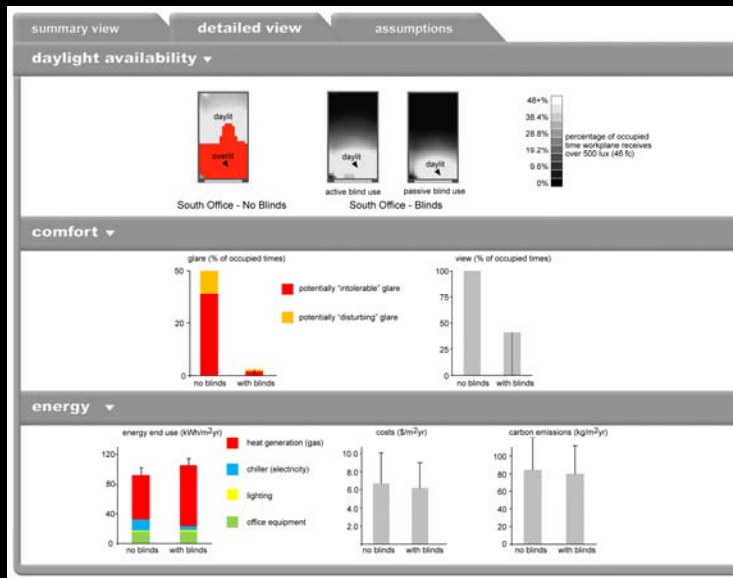


DIVA for Rhino

[www.diva-for-rhino.com]



Dashboards

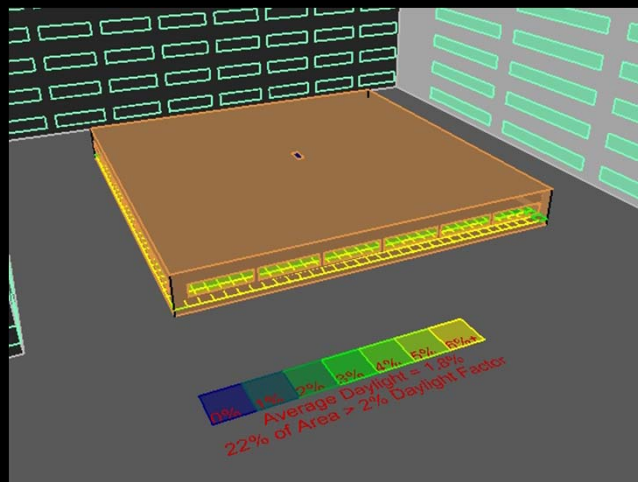


Courtesy of Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

Paper
 • Reinhart C F, J Wienold, "The Daylighting Dashboard - A Simulation-Based Design Analysis for Daylit Spaces". Building and Environment, 2011 46:2 386-396



Animated Building Performance Simulation



Simulation: J Niemasz, K Lagios, and J Sargent

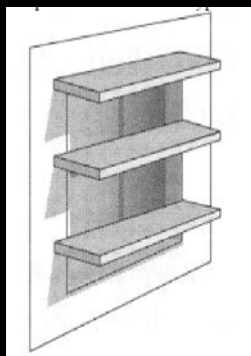


Simulation Approach for This Class

- ❑ Physically based versus 'pretty pictures'.
- ❑ Visualizations versus metric based analysis
- ❑ Both types of analysis are slowly converging.
- ❑ You may use other software (please discuss your choice with me).



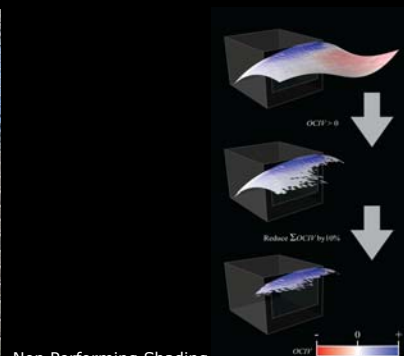
Shading Device Design



Conventional Shading



Photo by [Paperclips0701](#) on Wikipedia Commons.



Non Performing Shading

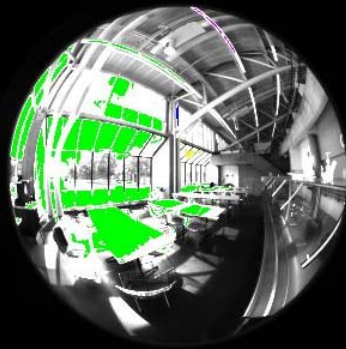
SHADERADE
(J Sargent, J niemas, C Reinhart)

Courtesy of Jon Sargent, Jeff Niemasz, and Christoph Reinhart. Used with permission.



Back and forth between Reality and Simulation

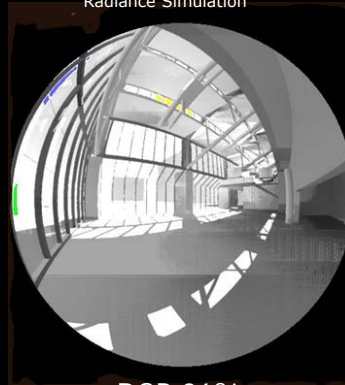
HDR Photography (R Mogri)



DGP 35%

Courtesy of Rashida Mogri. Used with permission.

Radiance Simulation

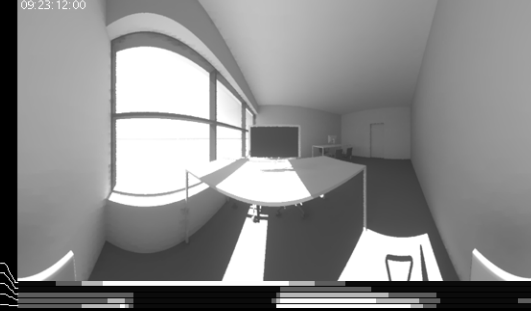


DGP 36%



Glare and Visual Comfort Analysis

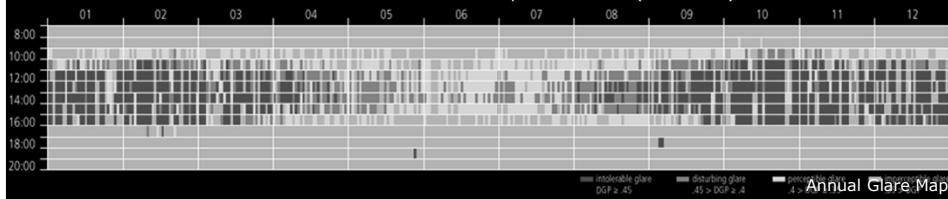
180 195 210 225 240 255 270 285 300 315 330 345 0 15 30 45 60 75 90 105 120 135 150 165 180



DGP
DGI
UGI
CGI
VCP

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Multidirectional Time Lapse Simulation (A Jakubiec)



Physical Model Building & Analysis

Image of students outside with heliodon removed due to copyright restrictions.



Courtesy of Shelby Doyle. Used with permission.

Heliodon Measurement

Model of the Carpenter Center



Mechanics

- Weekly lectures on Tuesdays and Thursday from 9.30 to 11.00. Guest lectures from the Medical School and Practitioners.
- Infrequent voluntary workshops on Thursdays.
- My availability: After class and during weekly office hours.
- All MIT students are very welcome.
- Prerequisites:
 - introductory class on building technologies
 - access to a newer laptop with **Rhino V4.0-SR8** or higher
 - a decent digital camera



Course Requirements

- ❑ Attendance of all lectures and workshops is mandatory.
- ❑ All assignments have to be submitted on time, usually on Thursdays before class. The assignments will help you to work on your course projects throughout the term.
- ❑ You are expected to give a midterm presentation on your group project in class on March 20th or 22nd.



Methods of Assessment

- ❑ Grades will be determined based on the quality and quantity of completed assignments, participation in class discussions, and the quality of the two course presentations.
- ❑ Class participation (15%)
- ❑ Timely submission of assignments (45%)
- ❑ Midterm presentation (10%)
- ❑ Final presentation (30%)
- ❑ Midterm and final presentations will be graded based on the
 - clarity of the project's (day)lighting objectives,
 - originality and inner logic of the design techniques used,
 - comprehensiveness of the final design solution,
 - overall quality of the presentation.



Assignment 1 – Essay on Daylighting

Task 1.1: Essay on Daylighting (Individual Assignment)

We all experience light and daylight every day of our lives and our attitude towards light, shadows and colors is a direct consequence of how we have seen the world. As a result, we carry our personal, preconceived notions within us of what constitutes 'good lighting' or a 'well daylit space'. These intuitions can inform our designs in unique ways. In order to preserve these raw attitudes towards lighting before they become 'diluted' by the concepts presented in this course, please write a two-part essay of 200-300 words on (1) what you think are the characteristics of a well daylit space and (2) what your motives are for implementing daylight in your projects? You may provide photos of daylit space(s) to support your remarks. Treat this essay as your personal 'touchstone' throughout the course and occasionally return to it.

Strong projects will have a **distinct attitude** towards lighting.



Daylighting & Sustainable Design



Generic Definition of Daylighting

Daylighting is the act of lighting the interior and/or exterior of a building with natural daylight.



Brief History of Daylighting



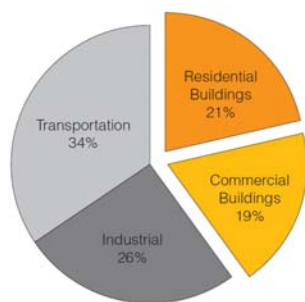
Photo by [Daderot](#) on Wikipedia Commons.
MIT Chapel by E Saarinen, 1955.

- ❑ Default solution until the 1940s.
- ❑ 1st renaissance during the 1970s primarily to save energy.
- ❑ 2nd renaissance since 2000, light as a provider of more healthy and productive work spaces.



'Green' Building Design

United States CO₂ Emissions by Sector



Source: US Energy Information Agency

Source Daylighting Handbook (Reinhart)

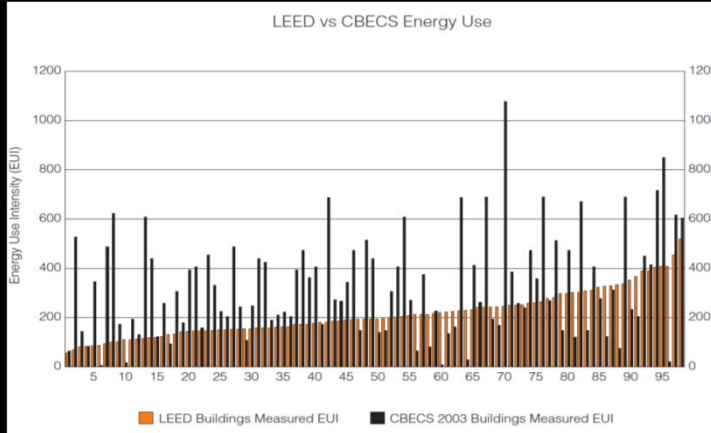


Greenbuild 2011, Source Daylighting Handbook (Reinhart)

- ❑ The 'green' building market has become a mass movement (Greenbuild ~30,000 visitor, Light+Building 180,000 visitors).
- ❑ External pressures such as climate change.



Performance of LEED Buildings

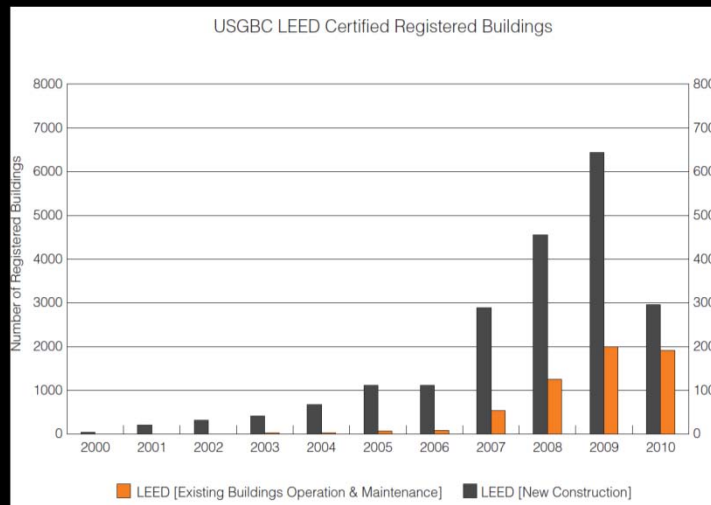


LEED-NBI data, CBECS matching by Newsham et al, 2009 Figure from Daylighting Handbook (Reinhart)

- ❑ LEED buildings have on average a 30% lower EUI (Energy Use Intensity).
- ❑ A third of LEED buildings had a higher EUI than their matched CBECS counterpart.



Trend for LEED-NC and LEED-EBOM

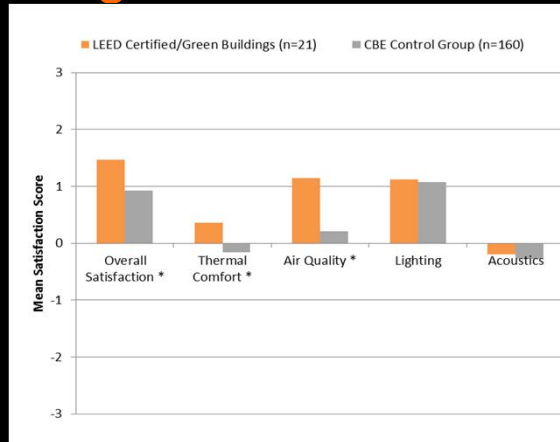


Data USGBC, Figure from Daylighting Handbook (Reinhart)

- ❑ Owners are learning that commissioning is key.



Environmental Satisfaction in LEED Buildings



S Abbaszadeh et al., 2006, Figure from Daylighting Handbook (Reinhart)

- ❑ Environmental satisfaction with lighting and acoustics in LEED buildings the same as in conventional buildings. Main complaint: “not enough daylight”
- ❑ In 2009, out of over 1200 buildings that were certified under LEED, 43% and 66% were awarded the daylighting and view credits, respectively.

To-Do for Thursday

- ❑ Install EnergyPlus 7.0 from <http://apps1.eere.energy.gov/buildings/energyplus/>
- ❑ Install DIVA 1.9 beta from www.diva-for-rhino.com



Questions?



Courtesy of Sustainable Design Lab at MIT & MoDe Studio. Used with permission.

Solar Radiation Map for Cambridge

<http://architecture.mit.edu/faculty/christoph-reinhart> \ Projects



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