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Seriously Sustainable Lighting
The Short Road to Net Zero

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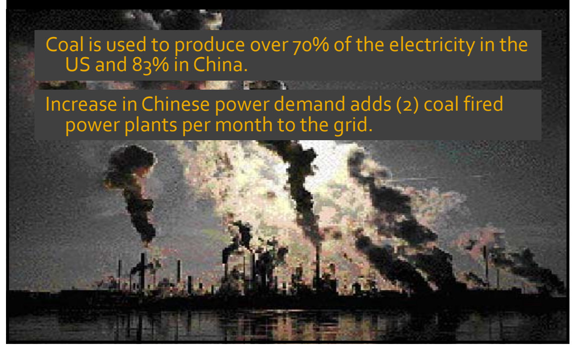
Thank you!

Learning Objectives

- How does lighting and related building science contribute to the challenges of global climate change, carbon neutrality and sustainability/
- How urgent are the issues?
- What are the most immediate opportunities?
- What long term changes must we make in current practices?

Present Day



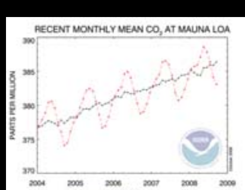
Coal is used to produce over 70% of the electricity in the US and 83% in China.

Increase in Chinese power demand adds (2) coal fired power plants per month to the grid.

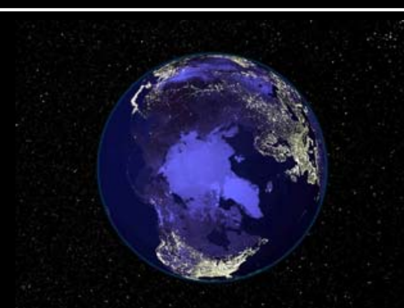
Present Day

Global climate change is accelerating as greenhouse gas concentration rises faster than expected.

CO_2 concentration will soon damage ecosystems.



An international challenge



Sustainability is the Word

"Green is the new Black" - *NY Times, 2007*

The Promise of Modern Lighting

- Beauty, discovery, wonder
- Necessary contributions to the functionality of the built environment
- Creative contributions to the enjoyment of life

The Reality of Modern Lighting

The Opportunity of Modern Lighting

Lighting is a prime opportunity to mitigate energy use and greenhouse gas production

- 70% of lighting energy use is by day
- 50% of lighting energy use is by older, inefficient technologies

The Opportunity of Modern Lighting

Lighting is 22-25% of electric energy use in the US

- 40% commercial
- 30% industrial
- 15% residential
- 10% outdoor and signs
- 5% other

The Opportunties of Efficient Lighting

- Reduce total lighting energy use
  - Free up capacity for other uses
- Reduce on-peak lighting energy use
  - Free up capacity for other uses
- Improve the human environment
  - Health benefits
  - Productivity
- Improve the built environment
  - Capital improvements without capital investment
- Reduce human impact and carbon footprint
  - Less energy use
  - Dark skies at night

We Use Too Much

Let's Fix That

Daylighting

The Next Great Frontier of Design
It is the Key to Net Zero

Daylighting's Challenges

- Four generations of architects and engineers lost to cheap energy
- Limited number of qualified architects, consultants and educators
- No established methodology or dominant theory
- Eighty years of bad habits

Overglazing

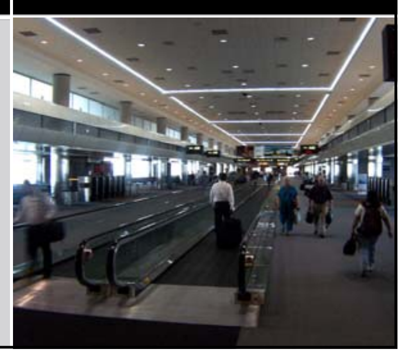
- Glass too transmittive
- Relies too much on low-e for solar gain control
- Passive shading only works on one of four facades
- Curtain wall poorly insulated

Orientation

- This photo faces north!
- 20-30X too much daylight
- Poor insulation
- Too much glare on sunny days
- Electric lights all on

Lighting Controls

"Value" engineering – spend $2Million in energy to save $1Million in first costs



Waste

More than ½ of the electric light energy goes straight up into the sky

Understanding Limitations

- Climate
- Latitude
- Average available daylight <3000 lumens per square foot in NE USA

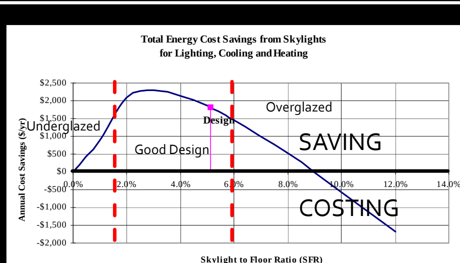
Steps to Better Daylighting

- Passive measures first
  - Climate tuned orientation and shading
  - Cooling season solar gain control
    - Passive exterior components (natural and man made)
    - High performance glazing
  - As much insulation as possible
    - Skylights
    - Curtain walls
  - Multiple skins

Steps to Better Daylighting

- Active measures second
  - Active shading
    - Exterior shades
    - Blinds and perforated shades
    - Optical blinds and shades
  - BIPV
  - Solar Collecting (rarely a good idea)
    - Heliostats
    - Fiberoptics and light pipes

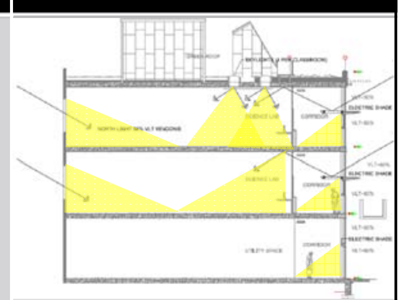
Best Practices – a balance



Layered daylighting

Let the architecture drive fenestration choices

- Windows
- Clerestories
- Light shelves
- Skylights



Natural Ambient Sales Lighting

JEWELRY STORE
Tubular daylighting devices with CMH track

Ambient lighting
- Sunny day, 100+ fc
- Cloudy day, 10-50 fc
- Night 5 fc

- Merchandise lighting
- Sunny day, 300-400 fc
- Cloudy day, 200-300 fc
- Night, 150-200 fc

CONNECTED LIGHTING POWER 3.1 w/sf

BIPV

Building Integrated Photo Voltaics

- Generate electricity (10-11% conversion efficiency)
- Provide shading (up to 90% reduction in visible light transmission)

Changes to Policies and Priorities

Less is more

Low Power Lighting

- Low watt sources
  - LED
  - Halogen
  - Fluorescent
- High Efficacy Sources
  - Linear fluorescent
  - High wattage HID
- High Efficiency Sources and Luminaires
  - LED
  - Plasma HID

Dynamic Standards

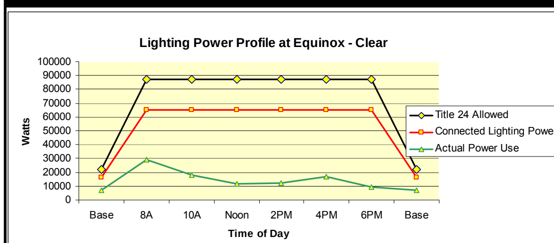
CURRENT

- Illuminance
  - Fixed
- Energy
  - Power. Fixed

PROPOSED

- Illuminance
  - Ranges
  - Adaptation based
- Energy
  - kWh
  - Demand based

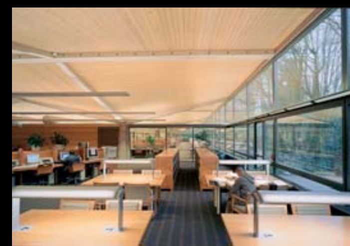
Energy Codes, not Power Codes



Real Time Energy Measurement

- Measure actual lighting power
- Disaggregate building energy use
  - Lighting
  - Computers
  - Transportation
  - Process
  - Food preparation
  - HVAC
  - Etc.
- Prominently Display data

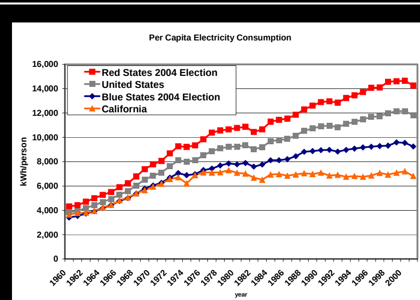
Competitions Reward Sustainable Design



Require Modern Controls

- Digital infrastructure
- Smart, dimming ballasts and drivers
- Useful software
- Design principles and theory
- Proper strategy for each application

Codes and Retrofitting work



Reduce or Eliminate Excessive Exterior Lighting

Incentivize Better Buildings

For the Planet

- Reduce total use
- Free up peak power
- Make renewable non-carbon sources go further

For the Industry

- Good counter-cycle business
- Exciting integration of new light sources
- New opportunity to do quality lighting

Towards Net Zero

The Secret is Conservation First
There is no better way than daylighting

Defining "Net Zero"

Responsible Options

- Net Zero Electricity
- Net Zero Conventional Energy Use
- Net Zero Total Energy Use
- Net Zero Carbon Footprint
- Net Zero Electric TOU

Net Zero Options

	Measured Grid Energy Use	Measured Gas/fossil fuels Use	Net Energy of Building Materials and Construction	CO^2 generated by operations
Electricity	✓			
Energy Use	✓	✓		
Total Energy	✓	✓	✓	
Carbon Footprint	✓	✓	✓	✓
Electric TOU	✓*			

Concept Behind NZ Electric TOU

- Building energy demand profile does not match non-depletable source profile
- Excess thermal energy can be stored but excess electric energy is better off returned to the grid as a "bank"
- Bank "account" is depleted periodically
- Peak users pay a premium
- Peak generators are rewarded

Guiding Principles

1. Negawatts cost less than megawatts
2. Passive beats active any time
3. Start with the low hanging fruit on all trees

Daylighting

Daylighting can save:
- Up to 100% of lighting demand
- The cooling associated with lighting demand
- Excessive cooling due to sub-optimal daylighting
- Cooling energy coincident with other peaks

Step 2: Efficient Electric Lighting

- High efficiency lighting equipment
- Smart Lights – ability to control through digital lighting infrastructure
- Natural ambient design technique – in daylighted spaces, avoid trying to produce daytime light levels with electric light
- Low ambient design
- Integrated control that assures daylight harvesting

Top Technologies

Lighting Gear
- Super T8
- T5
- Compact fluorescent
- LED
- HID
- Efficient luminaires

Lighting Designs
- Minimize light levels
- Task/ambient
- Low ambient
- Natural ambient

Step 3: Controls Integration

- Takes advantage of the day-night cycle
- Variable natural light levels by day (but not too high)
- Low light levels by night (but not too low)
- Electric lights OFF by day – let the levels follow nature

Step 4: Check Computer Power

2007 oPod Survey of California Offices

Lighting	1.1 w/sf
Computers	0.7 w/sf
Monitors	0.4 w/sf
Printers and misc	> 0.2 w/sf
TOTAL computers	1.3+ w/sf

I. T. Power can be as high as 3-4 w/sf in regular spaces

Simple I.T. Changes

- Use laptops or thin clients
  - Standard office computer 60-120 watts
  - Laptop 15-50 watts
  - Thin client 10-20 watts
- Use LCD screens
- Minimize wall-warts
- Employ IT energy management software

Step 5: Control Other Plug Loads

oPod Survey Plug Loads Discovered

Portable space heaters (10%)	1500w
Hot/cold water dispenser	500 w
Personal refrigerator (2%)	120 w
Personal fan (5%)	25 w

Step 6: Mechanical and Envelope Solutions

Passive Systems such as
- Passive solar techniques
- White roof
- Better insulation
- Natural ventilation

Active Systems such as
- Hot water collectors
- Heat pumps (ground or water source)
- Dark sky systems
- Storage systems

Step 7: Load Shedding Controls

A system to shed loads to force a better demand profile or simply prevent use at bad times

A system to shed load in response to grid demand and/or time of use costs

Step 8: Easy on the "green" source

Lights	1.1 w/sf	Lights	0.2 w/sf
Computers	1.1 w/sf	Computers	0.5 w/sf
HVAC (cooling)	1.0 w/sf	HVAC (cooling)	.5 w/sf
Plug load other	.5 w/sf	Plug load other	.25 w/sf
Non-process	.5 w/sf	Non-process	.25 w/sf
DEMAND	4.2 w/sf	DEMAND	1.7 w/sf

A Net Zero Building will have..

- North facing triple glazed façade
- Central north facing clerestory skylight
- South facing windows with light shelf
- Skylights throughout
- Water source or ground source heat pump
- Natural ventilation
- Green roof with PV array
- Good insulation

A Net Zero Building will have..

- General lighting 0.3 w/sf
- Task lighting 0.45 w/sf
- Digital dimming and controls for all systems
- Daylighting designed for >90% effectiveness
- Demand response and management controls
- Workstation sensors
- >95% conversion to laptops without desktop monitor
- All LCD monitors on other computers

Net Zero Electricity

The Chartwell School, Seaside CA

EHDD Architects, San Francisco

- LEED Platinum
- Practical Costs

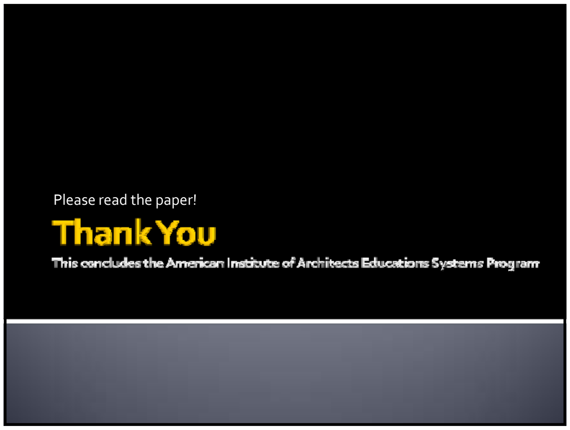
Net Zero Electricity

Other Keys to Success

- Totally integrated design team
- Daylighting is part of schematic design
- Owner, architect, engineers and consultants are all part of schematic design
- Early definition of goals
- Early identification of incentives and rules
- Use LEED later not now

For posting of this program check www.benyalighting.com

Net Zero Buildings - Why Wait for the Future?


Please read the paper!
Thank You
This concludes the American Institute of Architects Educations Systems Program