Forget Sustainability! The New Phrase is Zero Net!!!!!!
Background

Portions of this material were developed for

- The IESANZ Conference, Queenstown, NZ October 2008
- The PLDA Conference, Berlin, October 2009
- Joint PG&E/SCE/SMUD Class on Zero Net design
Coal is used to produce over 55% 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.
Global climate change is accelerating as greenhouse gas concentration rises faster than expected.

CO₂ concentration will soon damage ecosystems.
An international challenge
Sustainability is the Word

“Green is the new Black” - NYTimes, 2007
Although not always popular
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
Lighting is 25% of electric energy use in the US and 5% of ALL energy use.
The Zero Net Movement

Architecture + Engineering
Zero Net Reduces Building Energy Use

U.S. BUILDING SECTOR ENERGY CONSUMPTION PROJECTIONS 2005-2050

Source: ©2009 2030, Inc. / Architecture 2030
Assumptions: The Building Sector will consume 78.6% of total U.S. electricity production in 2050 (EIA).
Zero Net Reduces Building Generated Carbon Emissions

U.S. BUILDING SECTOR CO₂ EMISSIONS PROJECTIONS 2005-2050

**Source:** ©2009 2030, Inc. / Architecture 2030


**Assumptions:** The Building Sector will consume 78.6% of total U.S. electricity production in 2050 (EIA).
What is Zero Net?

- Combination of grid and renewable energy sources
- Net grid use is zero
Zero Net Math

Electric Use
Gas Use
Total Energy Use
Generated

Drawn from Electric Grid
Drawn from gas system
PV Output

+ ≤
Overarching Considerations
## Design Criteria

<table>
<thead>
<tr>
<th>Old</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IES Recommended light levels</td>
</tr>
<tr>
<td></td>
<td>Code Required Controls</td>
</tr>
<tr>
<td></td>
<td>Outdoor lighting for safety and security</td>
</tr>
<tr>
<td></td>
<td>IES Recommended light levels</td>
</tr>
<tr>
<td></td>
<td>Where</td>
</tr>
<tr>
<td></td>
<td>For how long</td>
</tr>
<tr>
<td></td>
<td>Code required controls</td>
</tr>
<tr>
<td></td>
<td>Plus significant energy saving controls</td>
</tr>
<tr>
<td></td>
<td>Add dimming ballasts</td>
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<tr>
<td></td>
<td>Outdoor lighting only when and where needed</td>
</tr>
</tbody>
</table>
The Big Ideas

1. All buildings not just offices and schools
2. The building *must* be daylighted
3. Super efficient lighting systems
4. Super effective lighting controls
5. Super efficient luminous environments
6. No wasted lumens
Basic Principles

- Reduce consumption wherever possible
- Use a combination of renewable energy sources
  - Daylighting
  - Photovoltaics (PV)
  - Wind and Other
Zero Net lighting design

Less is more
Daylighting

- Become a daylighting designer
- Aid the architectural team in the selection of windows and skylights
- Help select shading elements
- Help design BIPV
Energy Savings by Daylighting

Lighting Power Profile at Equinox - Clear

- Title 24 Allowed
- Connected Lighting Power
- Actual Power Use

Redding School for the Arts, Redding CA
Design for dynamic light levels

- **SUNLIGHT OUTDOORS**
- **MAXIMUM WINTER LEVEL**
- **MAXIMUM SUMMER LEVEL**
- **DESIGN LIGHT LEVEL**
- **MINIMUM USEABLE LIGHT**
- **EGRESS LIGHTING ONLY**

**DESIGN PROBLEM:**
- GYMNASIUM
- 500 LUX
Gymnasium Daylighting

Performance
Sacramento, CA USA
Semi-arid 37° North
Skylight/floor ratio 4.2%
Skylight SHGC 0.32
Skylight VLT 0.64
Light/heat ratio 2.0
Equiv. LPW 232
Day/Elec ratio 3
Max summer lux ~1500

Annual clear hours 3100
Cooling day autonomy is almost 100%
Heating day autonomy is >75%
Modular skylights with splay

Linear toplight
Toplighting

Modular skylights with clerestory

Linear toplight
Tubular Daylight Device

Performance
Portland, OR USA
Pacific NW 46° North
Skylight/floor ratio 3.0%
Windows on west
Skylight SHGC 0.32
Skylight VLT 0.64
Light/heat ratio 2.0
Equiv. LPW 232
Day/Elec ratio 3
Max summer lux ~1500

Annual clear hours 2200
Cooling day autonomy is almost 100%
Heating day autonomy is <25%
South facing shading
South facing high performance glazing
Sidelighting

West facing shading
Sidelighting

- Diffuse shaded glazing
- 25% window wall ratio
- .1 U value
- 25% VLT
Layered Daylighting

Toplight, sidelight, clerestory
Energy use by day:  < 0.15 w/sf
Typical for 12 hours
1.8 w/hour per sf per day

Maximum evening lighting:  < 1 w/sf
Typical for 4 hours
4 w/hr per sf per day
Can be applied to glazing systems

- Shading
- Lowers VLT
- Lowers SHGC
BIPV Daylighting

Performance

Eugene, OR USA
Pacific NW 44° North
Skylight/floor ratio 12%
South window w/PV
Skylight SHGC .22
Skylight VLT .28
Light/heat ratio 1.27
Equiv. LPW 150
Day/Elec ratio 2.0
Max summer lux ~2000

Annual clear hours 2400
Cooling day autonomy is almost 100%
Heating day autonomy is <25%
Super efficient lighting systems

- Highest efficacy sources
- Highest efficiency luminaires
- Highest coefficient of utilization
Efficacy of Lamp & Ballast

- Electronic Ballast
- A few unusual products
- Green Zone
- Latest Improvements

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Mean Lumens Per Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>White LED 2860K</td>
<td>80</td>
</tr>
<tr>
<td>White LED 5500K</td>
<td>70</td>
</tr>
<tr>
<td>Halogen IR (60 w att)</td>
<td>40</td>
</tr>
<tr>
<td>Halogen IR (500 w att)</td>
<td>30</td>
</tr>
<tr>
<td>175 w att standard metal halide (mag)</td>
<td>20</td>
</tr>
<tr>
<td>100 w att standard metal halide (mag)</td>
<td>15</td>
</tr>
<tr>
<td>350 w att pulse start metal halide (mag)</td>
<td>10</td>
</tr>
<tr>
<td>150 w att ceramic metal halide T6</td>
<td>80</td>
</tr>
<tr>
<td>150 w att ceramic metal halide T7DE</td>
<td>70</td>
</tr>
<tr>
<td>13 w att compact fluorescent</td>
<td>60</td>
</tr>
<tr>
<td>32 w att compact fluorescent</td>
<td>50</td>
</tr>
<tr>
<td>57 w att compact fluorescent</td>
<td>40</td>
</tr>
<tr>
<td>Standard T-12 (mag)</td>
<td>30</td>
</tr>
<tr>
<td>Standard T-8</td>
<td>20</td>
</tr>
<tr>
<td>Standard T-5HO</td>
<td>15</td>
</tr>
<tr>
<td>Standard T-5</td>
<td>10</td>
</tr>
<tr>
<td>High Performance T-5</td>
<td>80</td>
</tr>
<tr>
<td>High Performance T-8</td>
<td>70</td>
</tr>
</tbody>
</table>
Luminaires

Efficiency (percent)

- Wraparound T8
- Parabolic 3-lamp T8
- T5 Uplight office T5HO
- T5 High Bay Open T5HO
- RT5 troffer 2x4 T5
- Suspended direct/indirect T8
- Basket troffer 2x4 T8
- CF Downlight CF32
- 4" linear recessed lens T5

Green Zone
Coefficient of Utilization

CU (percent)

- Wraparound T8
- Parabolic 3-lamp T8
- T5 Uplight office T5HO
- T5 High Bay Open T5HO
- RT5 troffer 2x4 T5
- Suspended direct/indirect T8
- Basket troffer 2x4 T8
- CF Downlight CF32
- 4" linear recessed lens T5

Dark line RCR=2.5
Light line RCR = 5

Green Zone
<table>
<thead>
<tr>
<th>Lighting System</th>
<th>Footcandles (fc)</th>
<th>Watts per Square Foot (w/sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General lighting systems</td>
<td>50</td>
<td>0.6</td>
</tr>
<tr>
<td>Ambient lighting systems</td>
<td>30</td>
<td>0.45</td>
</tr>
<tr>
<td>High bay/big box lighting</td>
<td>50</td>
<td>0.7</td>
</tr>
<tr>
<td>Classroom lighting</td>
<td>40+</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Direct-indirect  40+fc @ o.
Indirect 30fc @ 0.5 w/sf
High Bay         50 fc @ <1 w/sf
High efficiency recessed  50 fc @ 0.6 w/sf
Two mode classroom  30 fc min @ 0.8 w/sf
Current MR16 size

- **HIR (3000K)**
  - Spot 20w 10° 6000 cd
  - Flood 20w 25° 2500 cd

- **CMH (3000K)**
  - Spot 20w 12° 9000 cd
  - Flood 20w 25° 2900 cd

- **LED (3200K)**
  - Spot 7w 24° 1440 cd
  - Flood 4w 34° 375 cd
Super Effective Controls

- Dimming all sources
- All controls strategies
  - Multiple response daylighting integration
  - Adaptation compensation
  - Tuning
  - Manual dimming
  - Layered motion/occupancy/vacancy
  - Programmable predictive scheduling
  - Demand response
Design Strategies
Supporting Strategies

- Layered (task and ambient)
- Standard low energy solutions
- Natural ambient lighting designs for common and public spaces that dramatically reduce night time light levels and eliminate daytime operation of lighting
- Practical efficiency: situations in which electric lighting is more efficient than daylighting
Layered Design

Designs employing task lighting systems that allow minimum ambient and general lighting

Techniques include:
- Overhead low ambient
- Overhead natural ambient
- LED and fluorescent task lighting
Undershelf lighting 4.5 to 6 w/ft
Task light 9 watts
Natural ambient lighting

Designs for common and public spaces that dramatically reduce night time light levels and eliminate daytime operation of lighting.

Basic principle: lights off by day, minimal at night
Basic low energy solutions

Low energy solutions for areas where lights are always needed.

- Restrooms
- Stairs
- Corridors
Practical Efficiency

Situations in which electric lighting is more efficient than daylighting

- Restrooms
- Closets
- Mechanical and electrical spaces
- Areas of concentrated computer work
Targeted Results
Methods used: daylight harvesting, motion sensing, tuning, user-controlled switching and dimming
Examples:
New York Times 1.28 w/sf connected 0.38 w/sf average
Sidwell Friends School 0.9 w/sf connected 0.09 w/sf average
Redding School for the Arts (above) 0.7 w/sf connected 0.1 w/sf avg
Outdoor Lighting

- Minimum lighting power
- Reduced light levels – more uniformity
- Motion controlled lighting
- Dark building when unoccupied
Summary

- Connected indoor lighting power ~ 0.4 to 1 w/sf for most building types
  - Retail higher
- Lighting controls play a pivotal role in energy use
  - Use every practical controls combination
  - Dimming is worth 50% of the savings opportunity
www.benyalighting.com

Thank You