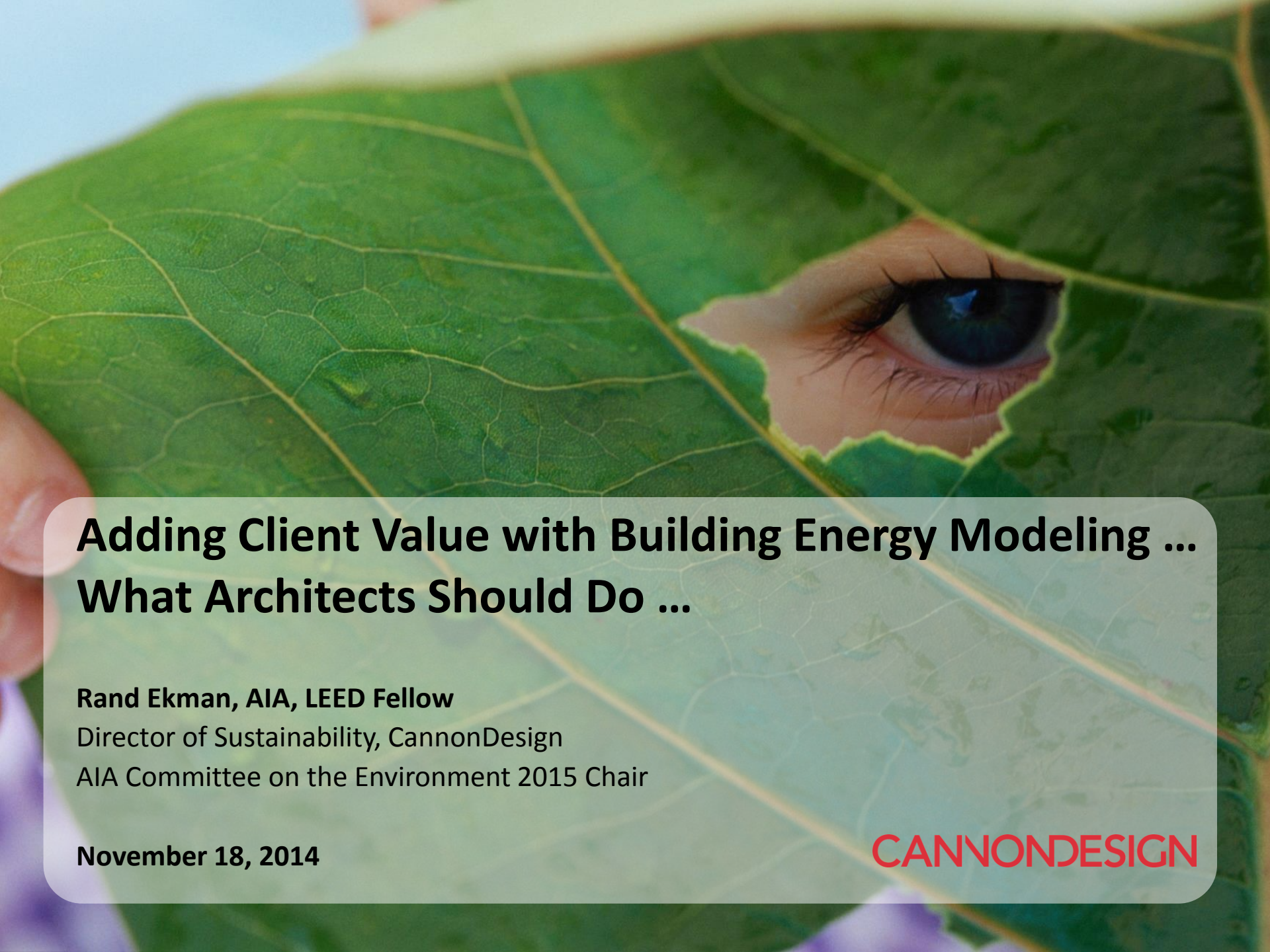


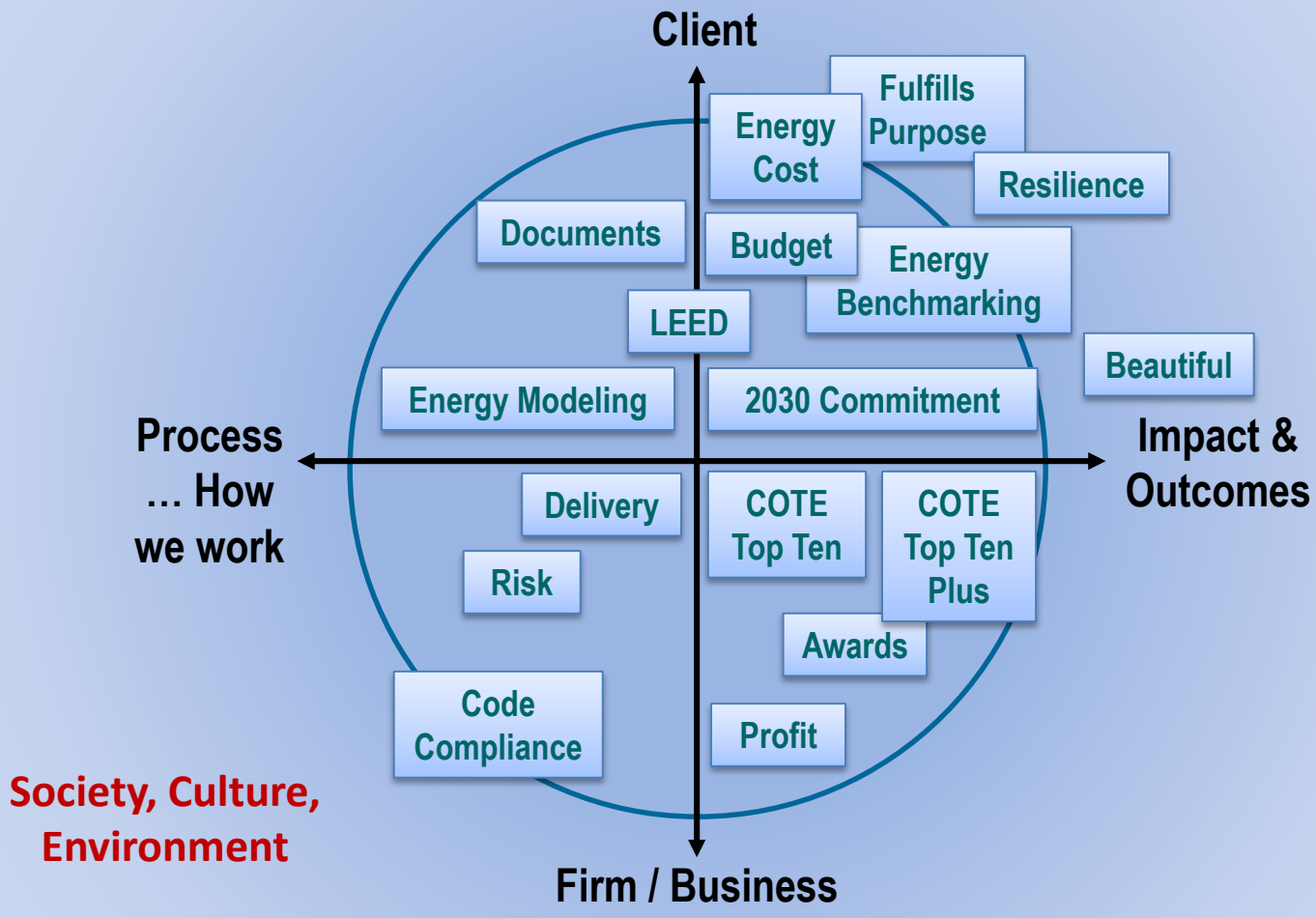
# Adding Client Value with Building Energy Modeling … What Architects Should Do …

**Rand Ekman, AIA, LEED Fellow**
Director of Sustainability, CannonDesign
AIA Committee on the Environment 2015 Chair

**November 18, 2014**

CANNONDESIGN

# Performance Matters

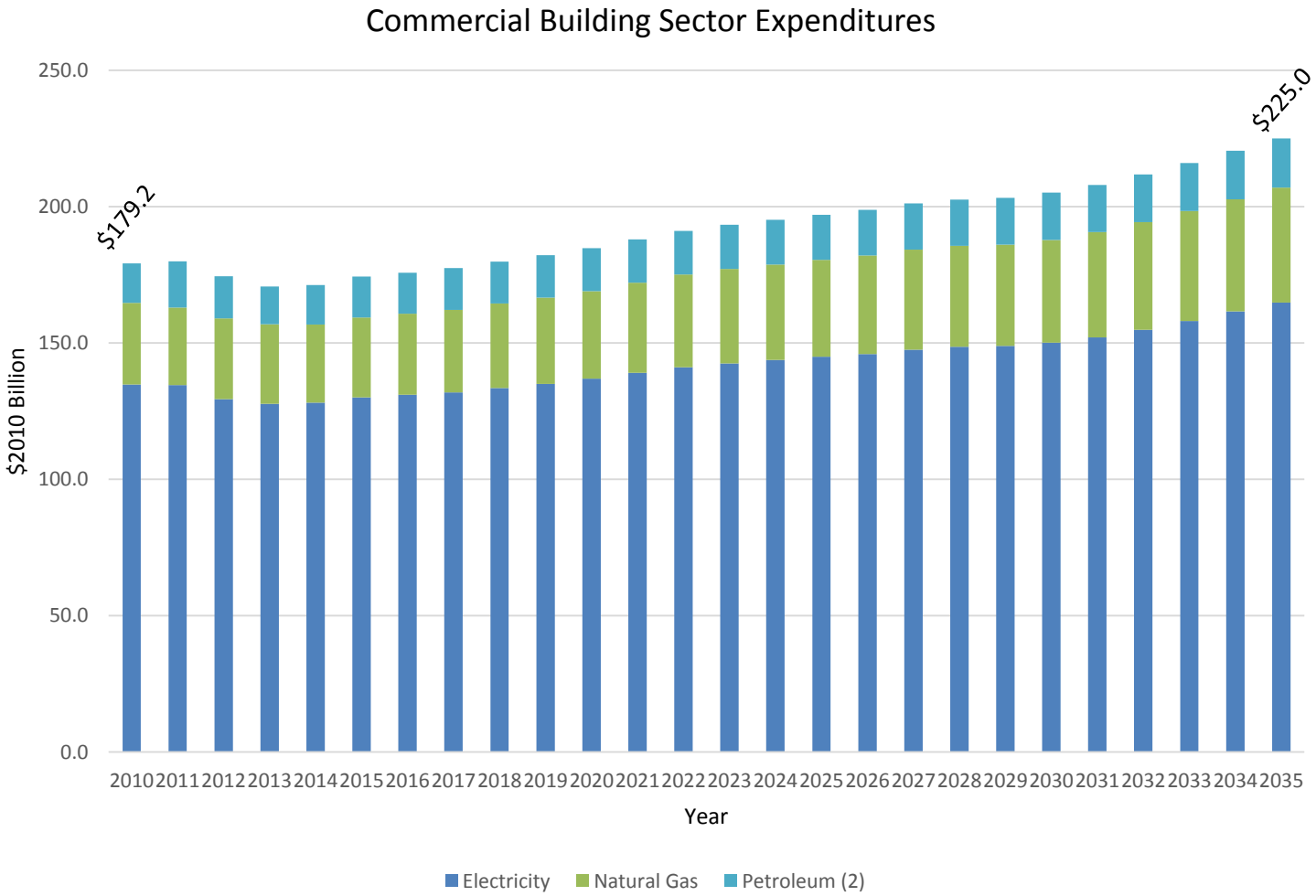


# Performance Matters

- Energy Use
- Lifecycle Operating Cost
- Carbon and Greenhouse Gas
- Environmental impacts
- Professional Recognition
- Quality Design
- Codes and Regulations

# Performance Matters to Your Clients

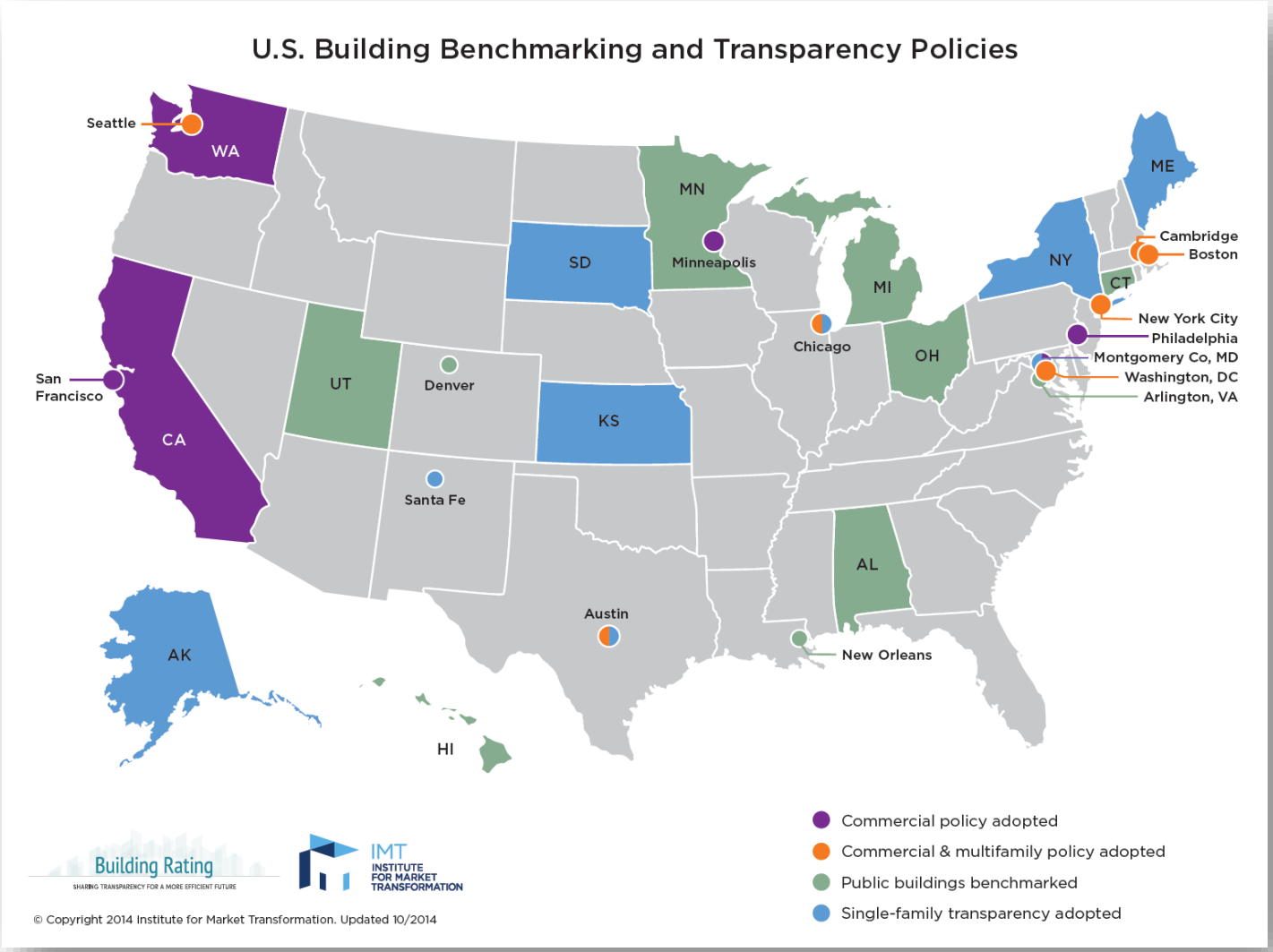
## … Energy Cost




U.S. Department of Energy Building Energy Data Book

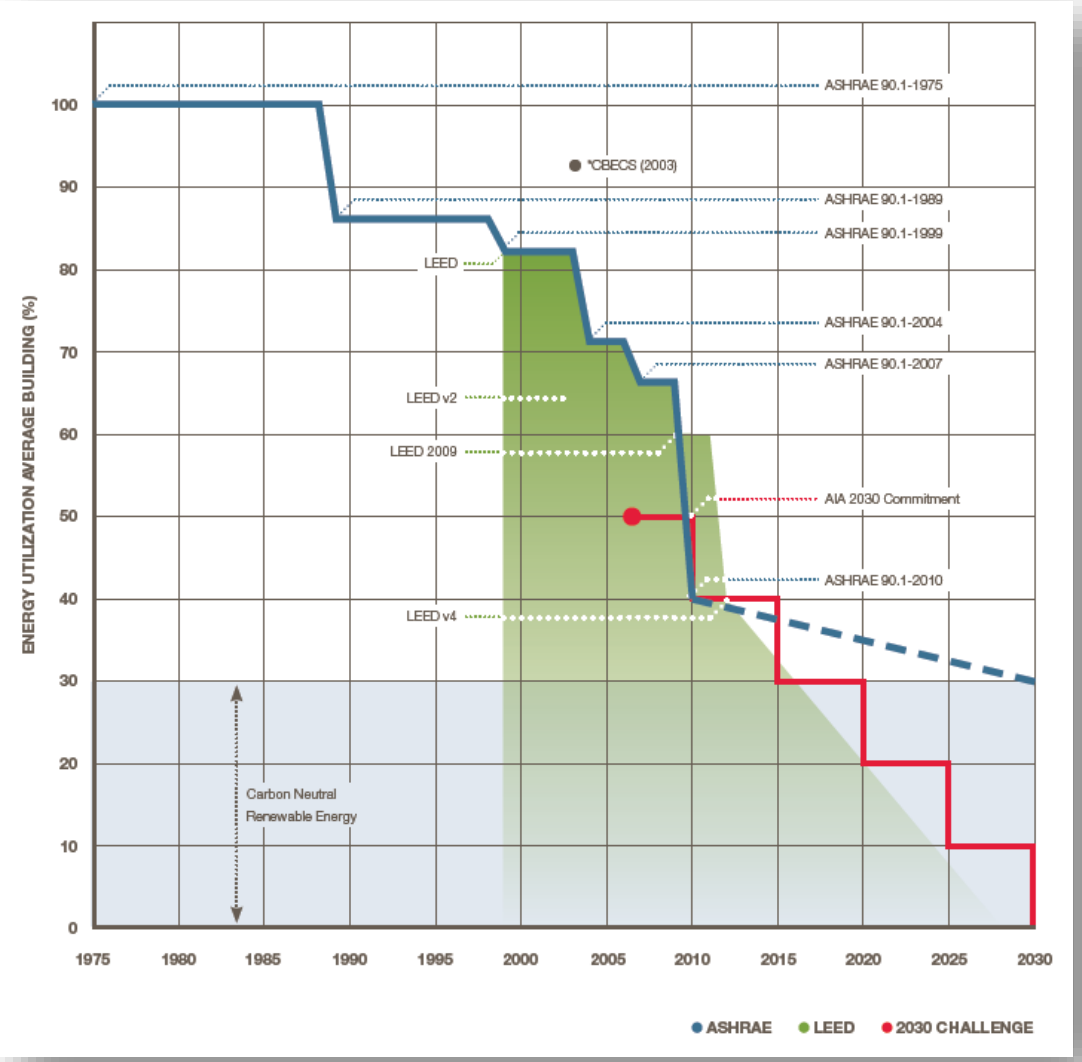
# Performance Matters to Your Clients

## … Energy Benchmarking



# Performance Matters to Your Business

## … Energy Codes

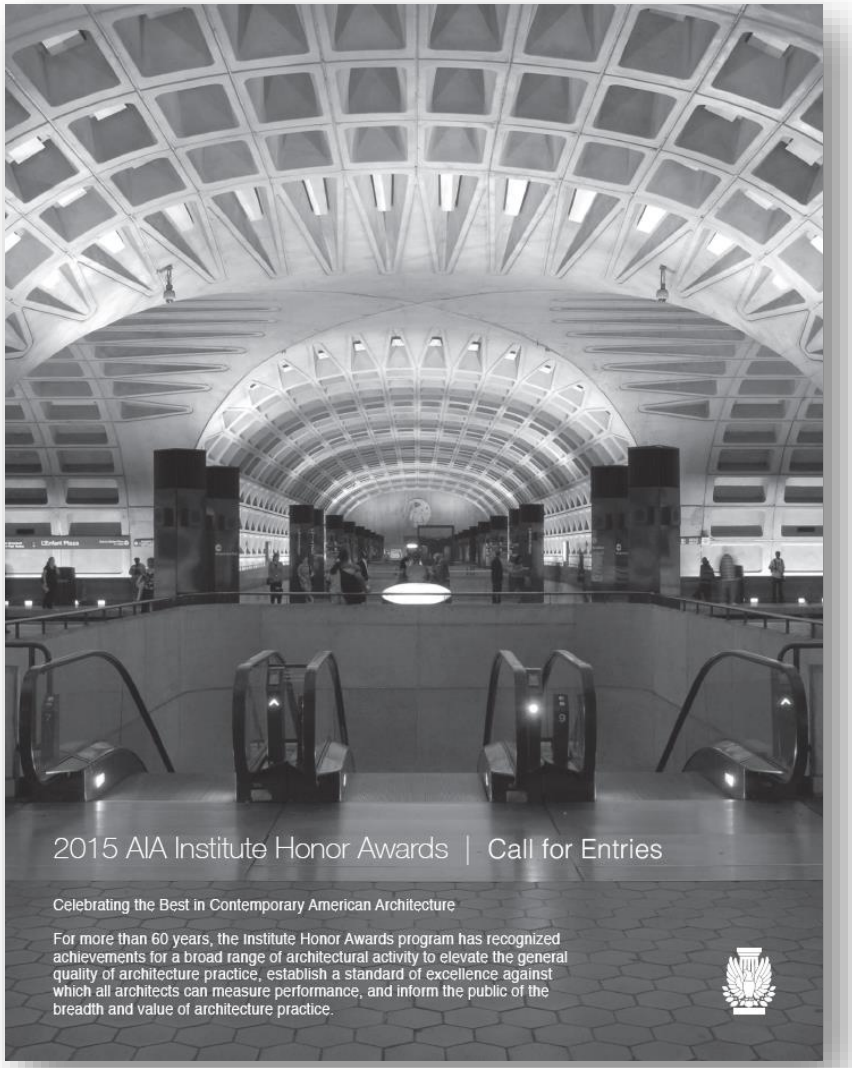


# Performance Matters to Your Business

## … AIA Honor Awards

**Energy**: A brief summary of energy and carbon reduction strategies, plus metrics per Energy Star Target Finder. If the submitted building type is not listed on the Target Finder Web site, use the Architecture 2030 Challenge Targets.

- Predicted EUI in kBtu/sf/yr excluding on-site renewable energy contribution
- Predicted EUI in kBtu/sf/yr including on-site renewable energy contribution (carbon offsets will not be counted)
- Predicted percent (%) regional energy reduction per Energy Star Target Finder
- (Optional) Actual EUI in kBtu/sf/yr including on-site renewable energy contribution (based on 1-yr utility records)



# Performance Matters to Your Business

## … AIA 2030 Commitment

| | |
|---|---|
| 101 | number of firms submitting reports – 11% decrease |
| 1.6 billion | total amount of gross square feet (GSF) – 9% increase |
| 2441 | number of projects reported – 150% increase |
| 34% | average Predicted Energy Use Intensity (PEUI) reduction – 3% decrease |
| 7% | percent of total GSF meeting the current 60% reduction target – 5% decrease |
| 66% | percent of total GSF using energy modeling – 14% increase |
| 401 | number of projects meeting the 60% reduction target – 200% increase |
| 73 | number of net zero energy projects – 500% increase |
| 3,866 | number of interiors only projects |
| **19%** | average Lighting Power Density reduction for interiors projects – 2% increase |

# Performance Matters to Your Business

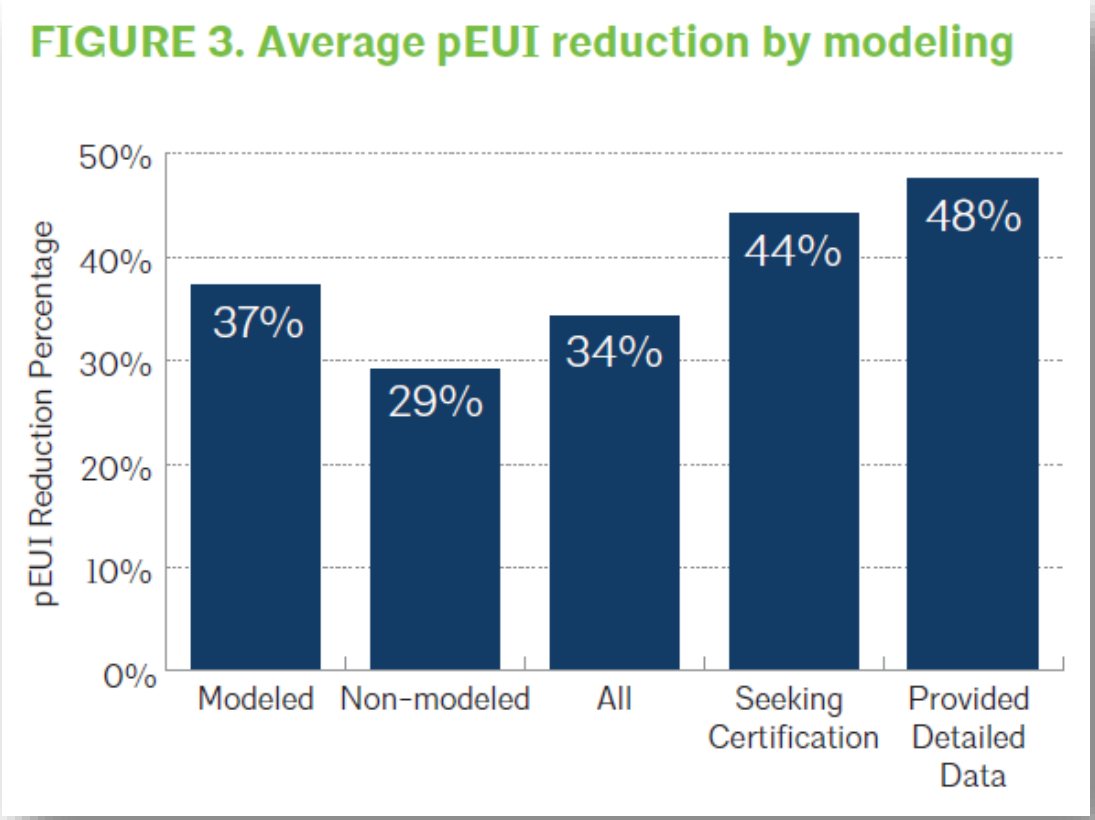
## … AIA 2030 Commitment

### Predicted Project Performance

Modeled projects were predicted to perform on average **8% better** than non-modeled projects

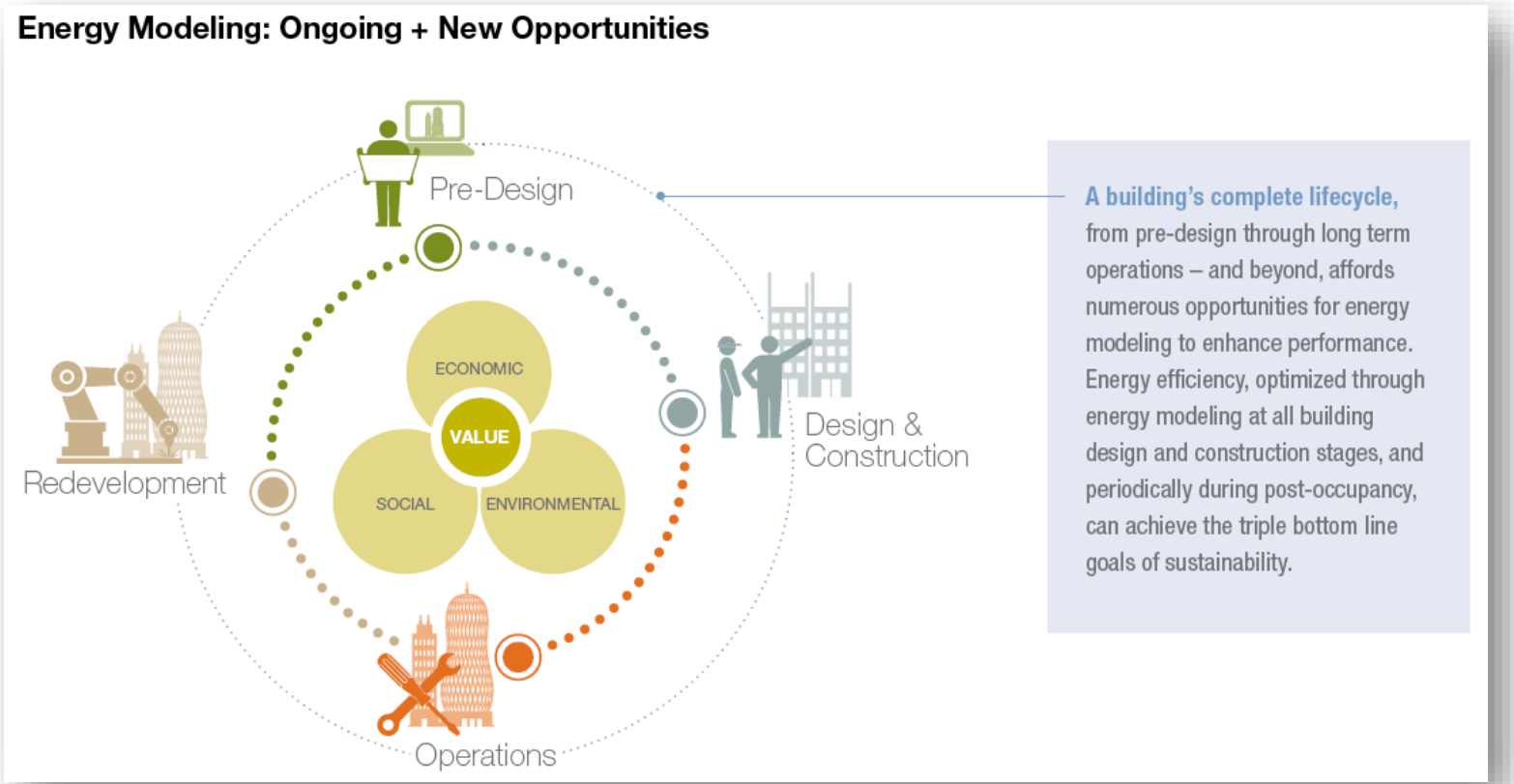
Projects seeking 3rd party certification performed **10% better** than average

Projects reporting detailed data performed **14% better** than the average



# Performance Matters to Your Business

## … New Business Oportunities



# Performance Matters to The AIA

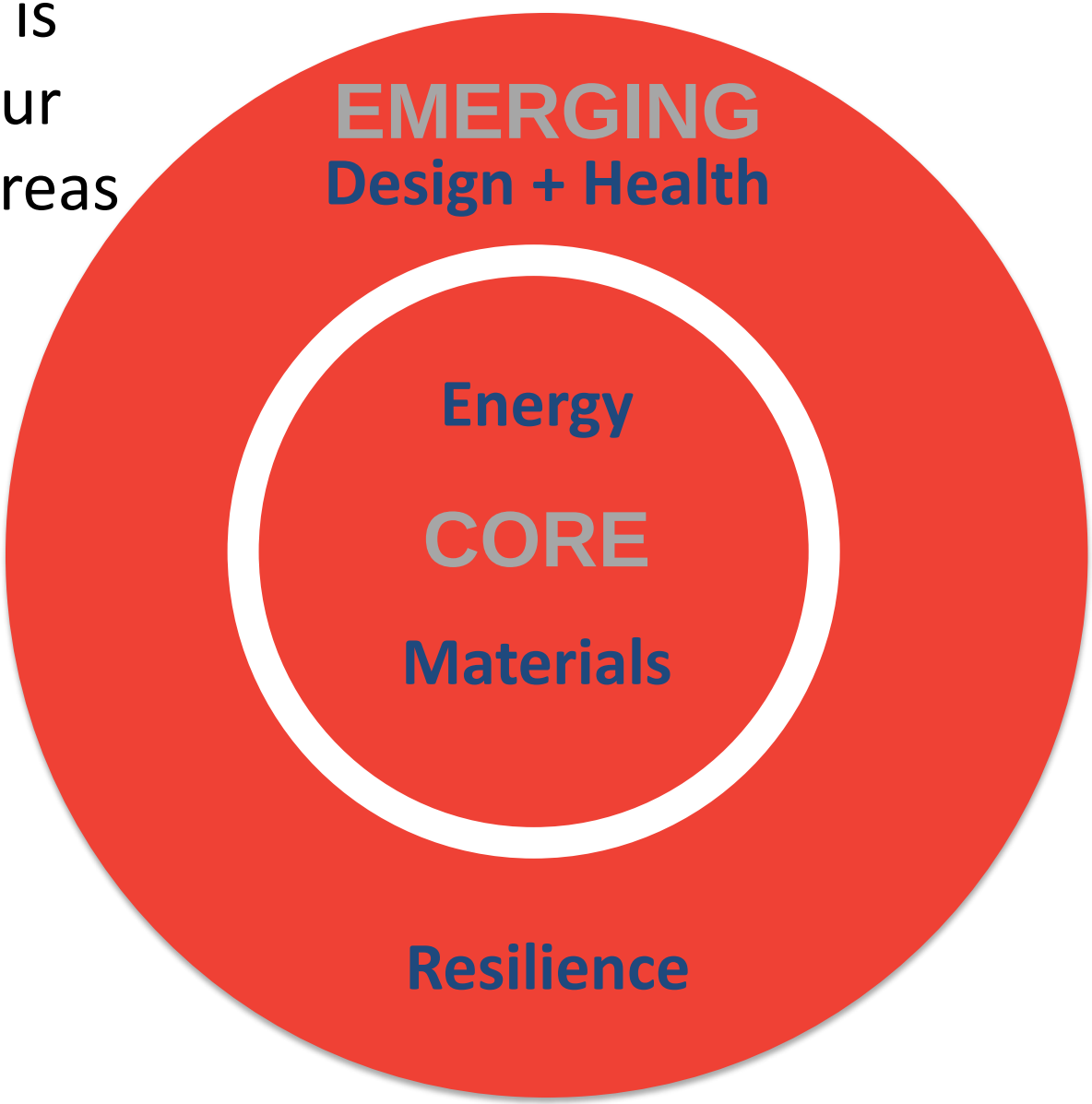
## … AIA Position Statement

| | |
|---|---|
| ***C. Public Policy: Architects are Environmentally Responsible*** | *The creation and operation of the built environment require an investment of the earth's resources. Architects must be environmentally responsible and advocate for the sustainable use of those resources.* |
| **Supporting Position Statements** | |
| **1. Energy and the Built Environment** | The AIA supports governmental policies, programs, and incentives to encourage energy conservation as it relates to the built environment as well as aggressive development and harvesting of energy from renewable sources. Architects are encouraged to promote energy efficiency and waste reduction in the built environment, encourage energy-conscious design and technology, plus support a national program for more efficient use and recycling of non-renewable resources and carbon-neutral design strategies.<br>*(approved December 2009; through December 2014)* |

| | |
|---|---|
| **3. Sustainable Architectural Practice** | The AIA recognizes a growing body of evidence that demonstrates current planning, design, construction, and real estate practices contribute to patterns of resource consumption that will inhibit the sustainable future of the Earth. Architects, as the leaders in design of the built environment, are responsible to act as stewards of the Earth. Consequently, we encourage communities to join with us to take the leadership to change the course of the planet's future and support legislative and regulatory strategies that implement sustainable design practices to advance the goal of achieving carbon-neutral buildings by the year 2030.<br>*(approval extended May 2012, to December 2014)* |

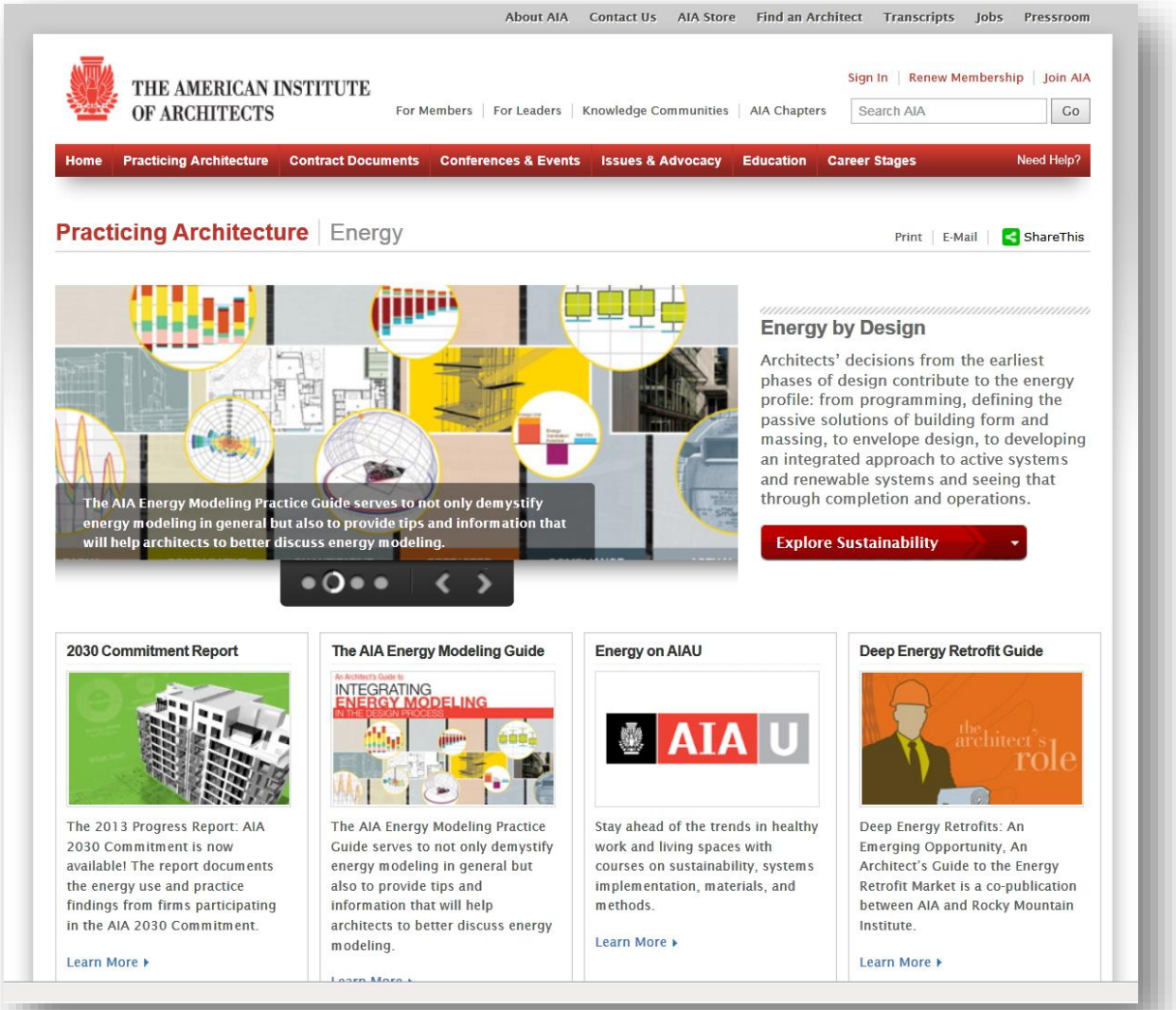
# Performance Matters to The AIA

… Energy is one of Four Priority Areas



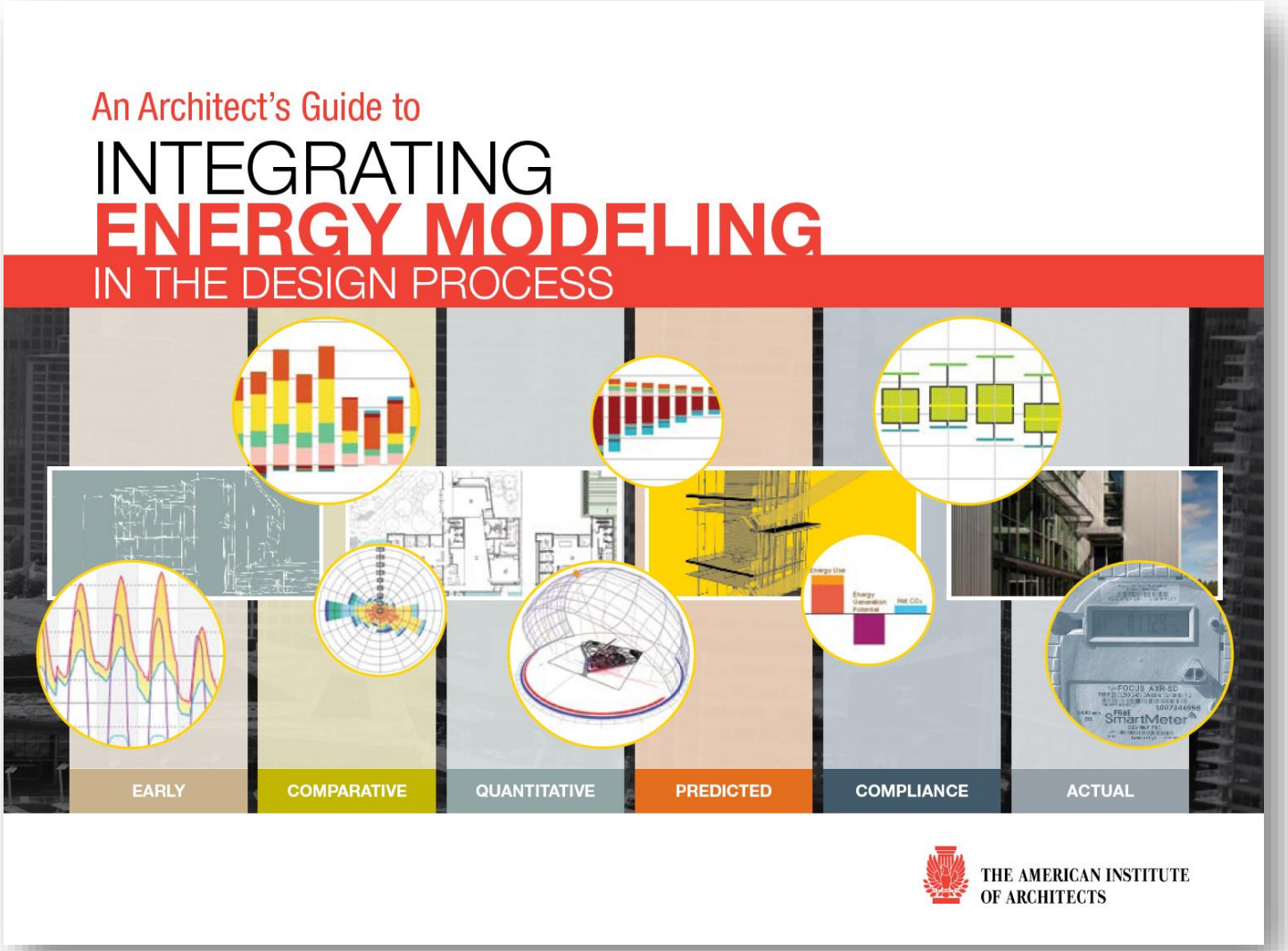
# Performance Matters to The AIA

## … Resources



# Performance Matters to The AIA

… Resources



# Performance Matters to The AIA

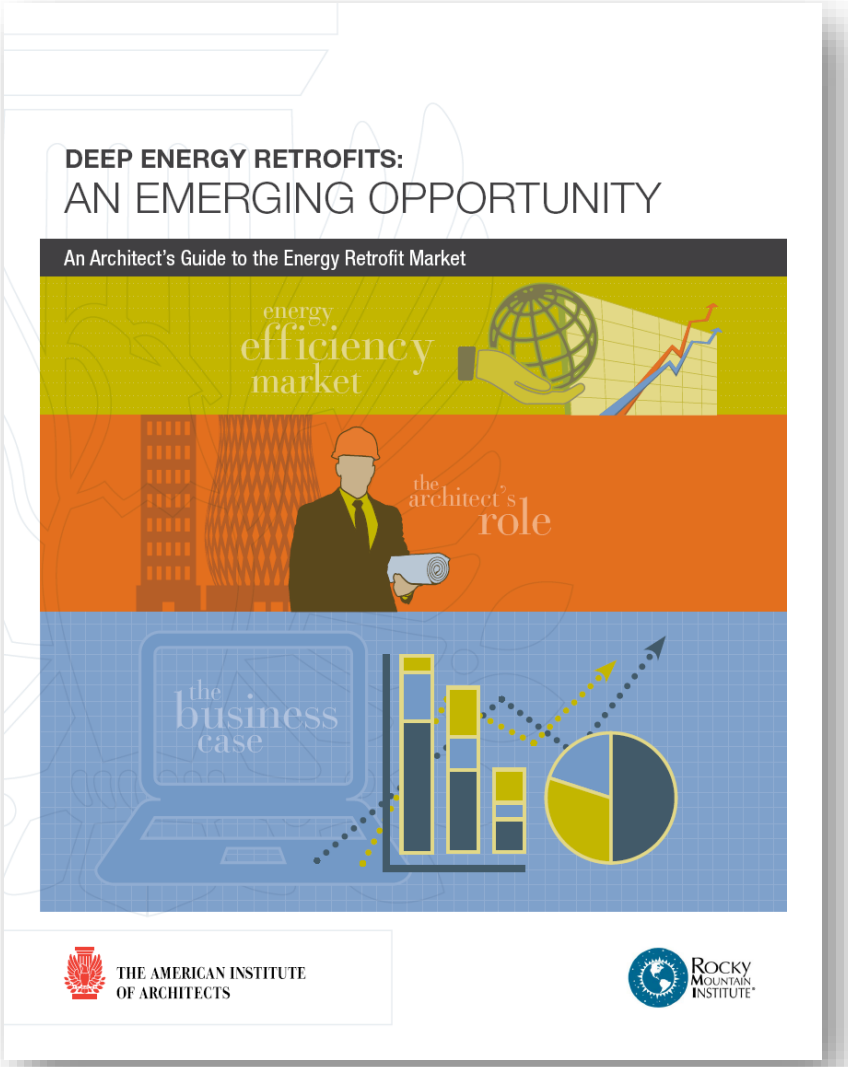
... aiau.aia.org

- Small Firm Sustainability Strategies
- Four Stages of Energy Modeling in the Building Design Life Cycle
- Deep Energy Retrofits
- Living the Low-Energy Life

- Online continuing education.
- high-quality, curated, educational content for and, in many cases, by architects.
- Available 24/7

# Performance Matters to The AIA

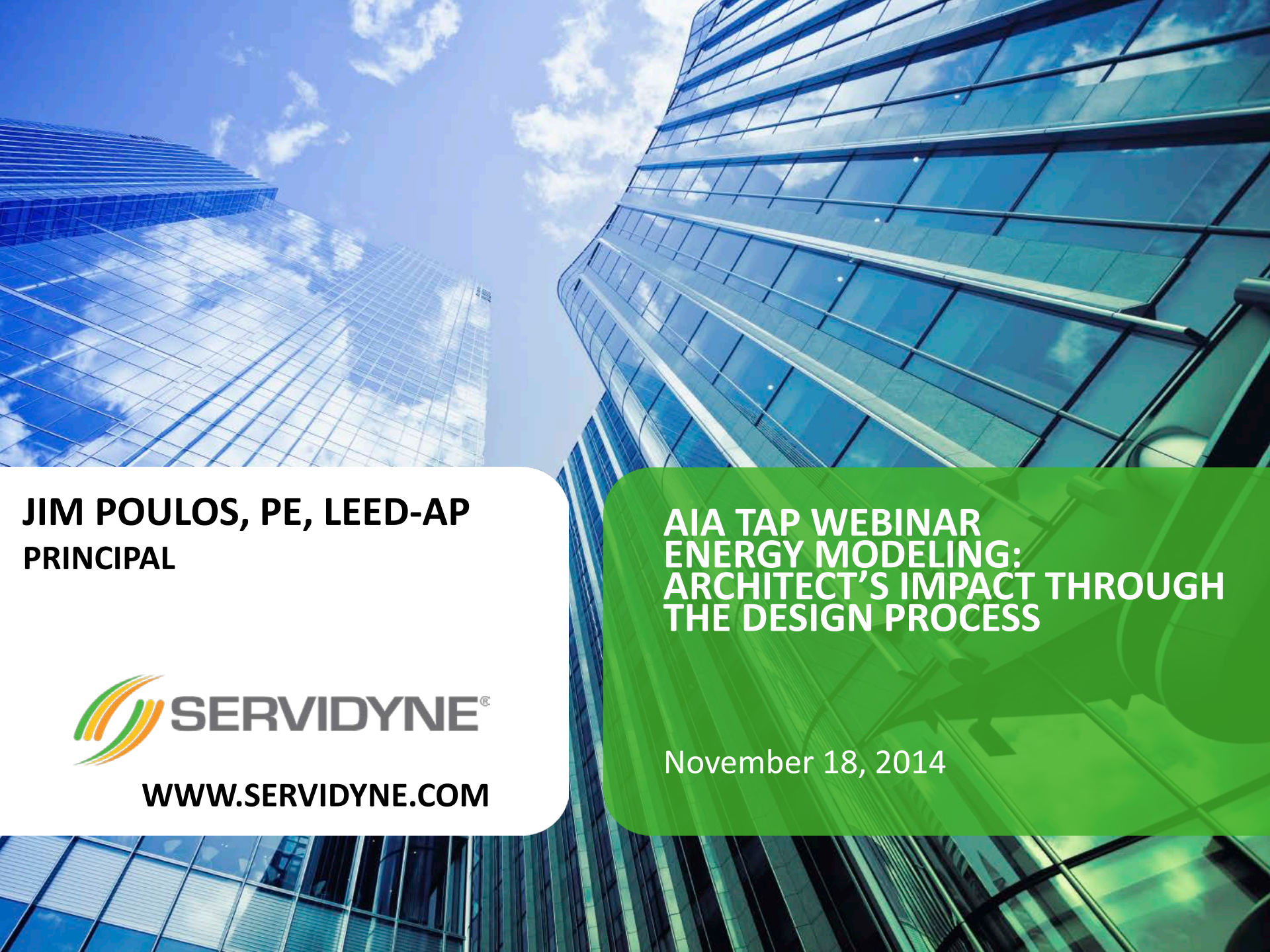
## … Resources



# What Architects should do

… Energy is a Design Problem

Performance Matters AIA

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**PRINCIPAL**

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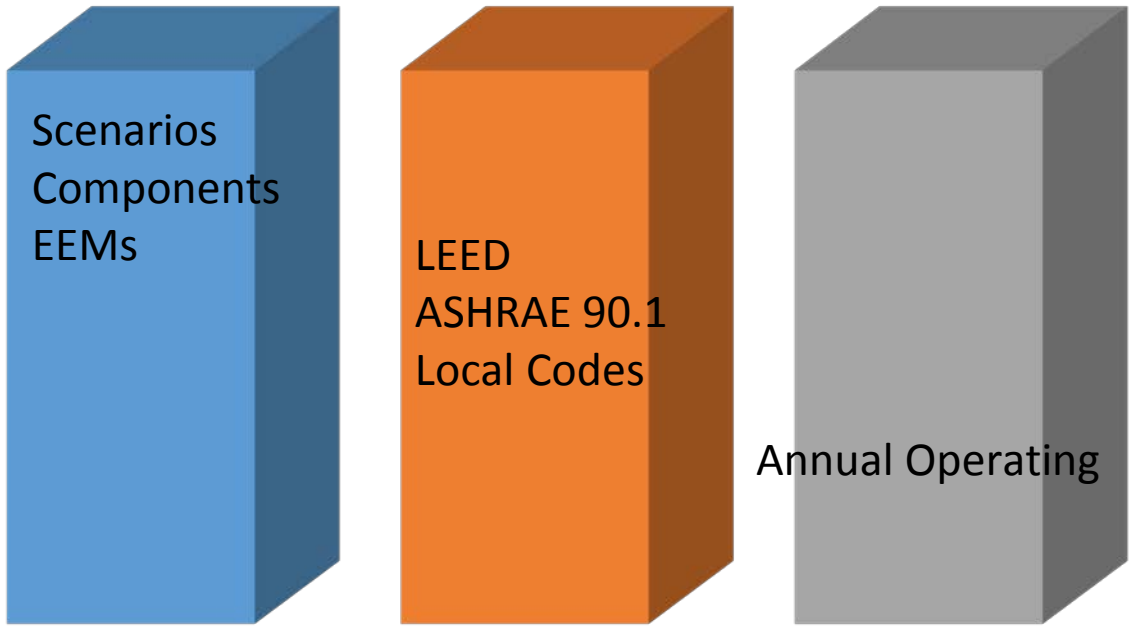
# AIA TAP WEBINAR ENERGY MODELING: ARCHITECT'S IMPACT THROUGH THE DESIGN PROCESS

November 18, 2014

# VALUE TO CLIENTS FOR ENERGY MODELING




**Comparative** **Compliance** **Predictive**

# HOURLY MODELS

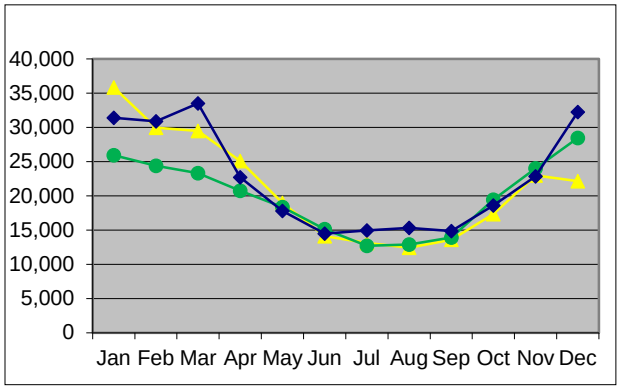
## WWW.BUILDINGTOOLS.ENERGY.GOV

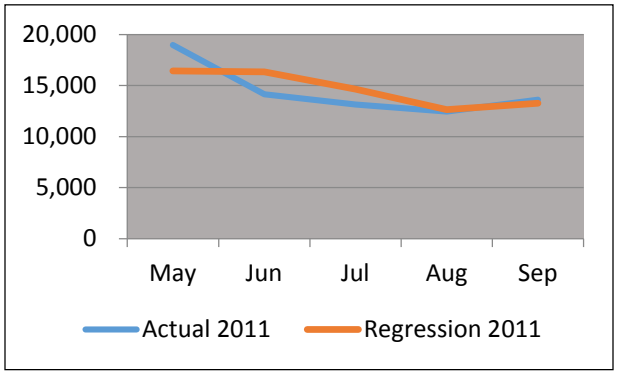


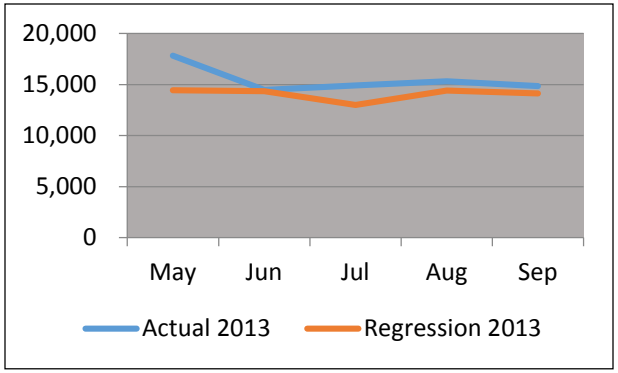

# BIN DATA MODELS

| Annual Fan Energy Savings Calculations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Existing Condition | | | | | | | | | |
| Temp | Percent | Percent | Fan | CHWP | HWP | On-peak | Mid-peak | Off-peak | Occ Total | Unocc Total |
| Bin | Air Flow | Fan BHP | kW | kW | kW | kWh | kWh | kWh | kWh | kWh |
| 102 | 0% | 0% | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 |
| 97 | 100% | 110% | 14.27 | 0.00 | 0.00 | 250 | 0 | 0 | 250 | 0 |
| 92 | 98% | 90% | 11.70 | 0.00 | 0.00 | 1,085 | 0 | 0 | 1,085 | 0 |
| 87 | 90% | 90% | 11.70 | 0.00 | 0.00 | 2,842 | 0 | 0 | 2,842 | 0 |
| 82 | 82% | 73% | 9.42 | 0.00 | 0.00 | 3,590 | 0 | 0 | 3,590 | 0 |
| 77 | 75% | 56% | 7.28 | 0.00 | 0.00 | 3,371 | 0 | 0 | 3,371 | 0 |
| 72 | 67% | 42% | 5.42 | 0.00 | 0.00 | 3,187 | 0 | 0 | 3,187 | 0 |
| 67 | 59% | 30% | 3.85 | 0.00 | 0.00 | 2,160 | 0 | 0 | 2,160 | 0 |
| 62 | 51% | 30% | 3.85 | 0.00 | 0.00 | 1,896 | 0 | 0 | 1,896 | 0 |
| 57 | 43% | 19% | 2.43 | 0.00 | 0.00 | 1,100 | 0 | 0 | 1,100 | 0 |
| 52 | 40% | 19% | 2.43 | 0.00 | 0.00 | 1,129 | 0 | 0 | 1,129 | 0 |
| 47 | 40% | 19% | 2.43 | 0.00 | 0.00 | 1,097 | 0 | 0 | 1,097 | 0 |
| 42 | 40% | 19% | 2.43 | 0.00 | 0.00 | 1,153 | 0 | 0 | 1,153 | 0 |
| 37 | 40% | 19% | 2.43 | 0.00 | 0.00 | 1,099 | 0 | 0 | 1,099 | 0 |
| 32 | 40% | 19% | 2.43 | 0.00 | 0.00 | 914 | 0 | 0 | 914 | 0 |
| 27 | 40% | 19% | 2.43 | 0.00 | 0.00 | 600 | 0 | 0 | 600 | 0 |
| 22 | 40% | 19% | 2.43 | 0.00 | 0.00 | 337 | 0 | 0 | 337 | 0 |
| 17 | 40% | 19% | 2.43 | 0.00 | 0.00 | 157 | 0 | 0 | 157 | 0 |
| 12 | 40% | 19% | 2.43 | 0.00 | 0.00 | 61 | 0 | 0 | 61 | 0 |
| 7 | 40% | 19% | 2.43 | 0.00 | 0.00 | 29 | 0 | 0 | 29 | 0 |
| 2 | 40% | 19% | 2.43 | 0.00 | 0.00 | 13 | 0 | 0 | 13 | 0 |
| -3 | 40% | 19% | 2.43 | 0.00 | 0.00 | 3 | 0 | 0 | 3 | 0 |
| Total/Peak | | | 14.27 | 0.00 | 0.00 | 26,073 | 0 | 0 | 26,073 | 0 |

# CORRELATION MODELS




## Estimated Laundry Energy Usage & Costs

| | | | |
|---|---|---|---|
| Number Rooms | 400 | Utility water deg F | 60 |
| Laundry? (Y/N) | Y | Laundry lbs/occ room per day | 20.0 |
| % Wastewater Recycled | 0.0% | Average Occupancy | 61.0% |
| Water Gal/Lb | 3.0 | % Laundry Reduction | 0% |

## Hotel Annual Laundry Usage

| | |
|---|---|
| Current laundry lbs/yr processed | 1,781,200 |
| Outsourced lbs/yr | 0 |
| Remaining in-house lbs/yr | 1,781,200 |
| **Annual Natural Gas Usage** | |
| Laundry Dryer Therms | 41,212 |
| Laundry Flatwork Ironer Therms | 0 |
| Laundry Presses Therms | 6,987 |
| Laundry HW Therms | 30,058 |
| ***Total Natural Gas Therms*** | ***78,257*** |
| **Annual Water Usage** | |
| Laundry Water Mgals | 5,344 |
| **Annual Electricity Usage** | |
| Dryer kWh | 54,484 |
| Washer kWh | 78,233 |
| Flatwork Ironer kWh | 0 |
| Misc Equipment kWh | 23,601 |
| ***Total Electricity kWh*** | ***156,318*** |
| Gas Use (BTU per Lb) | 4,393 |
| Electricity Use (kWH per 100 Lbs) | 8.8 |

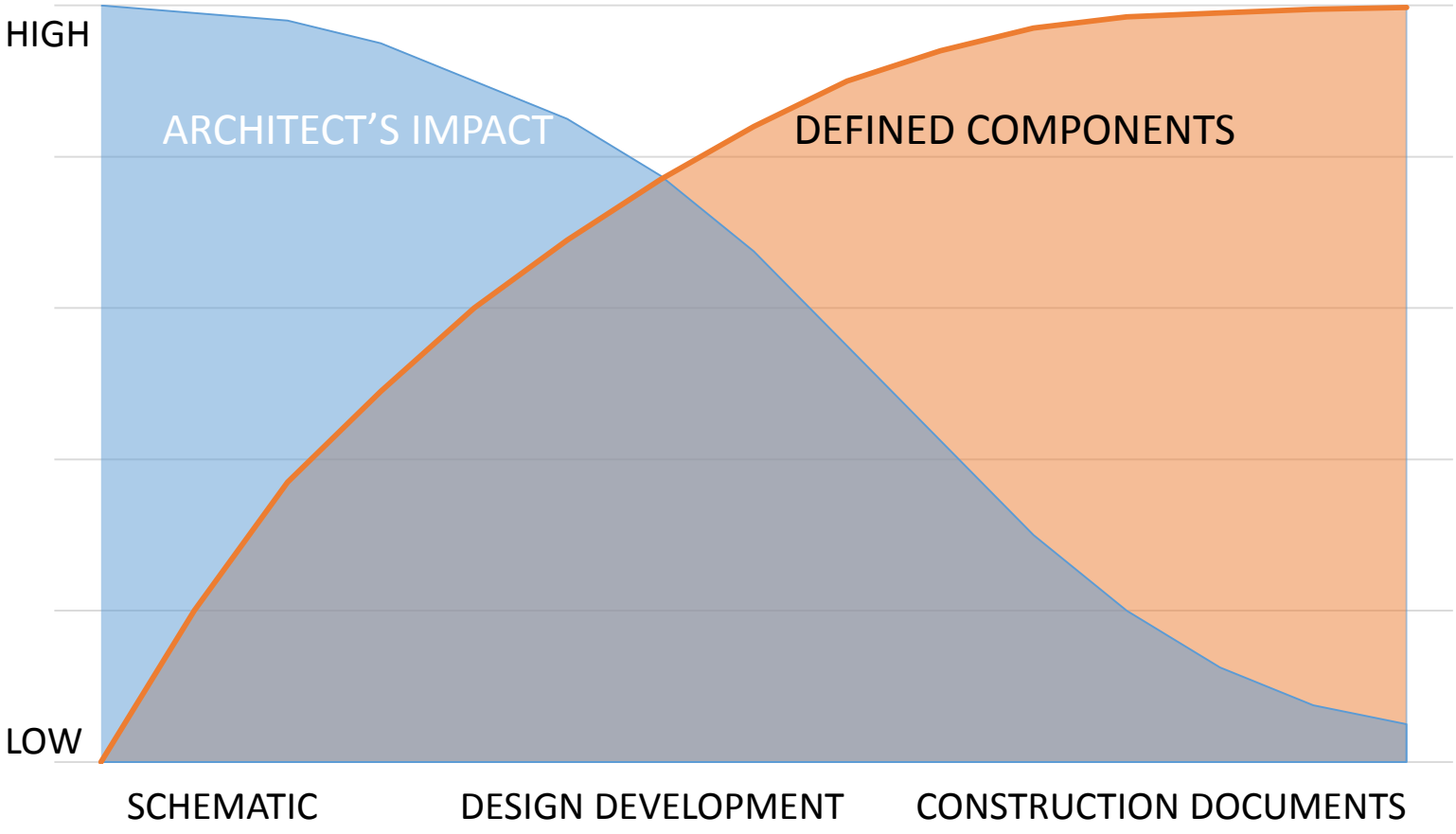
**Utility Rates**

| | |
|---|---|
| Natural Gas $/Therm | $1.67 |
| Water $/Mgal | $8.00 |
| Electricity $/kWh | $0.135 |

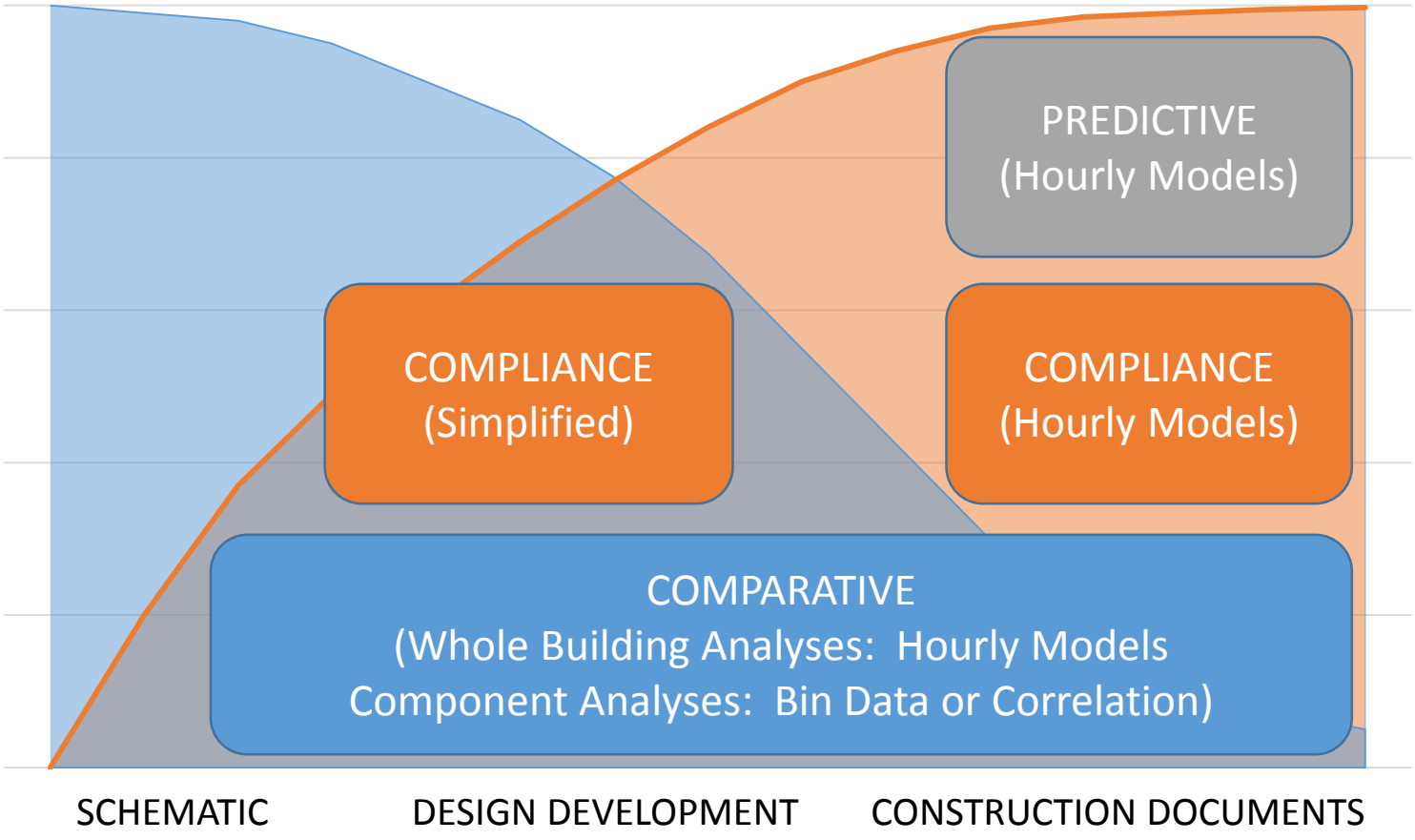
| | Annual Laundry Use | Annual Laundry Cost |
|---|---|---|
| Natural Gas (Therms) | 78,257 | $130,688 |
| Water (Mgal) | 5,344 | $42,749 |
| Electricity (kWh) | 156,318 | $21,103 |
| **Total** | --- | **$194,540** |

| | Total Hotel Energy Use | Laundry % of Total Energy |
|---|---|---|
| Natural Gas (Therms) | 306,557 | 25.5% |
| Water (Mgal) | 32,952 | 16.2% |
| Electricity (kWh) | 11,210,118 | 1.4% |

# DESIGN PROCESS



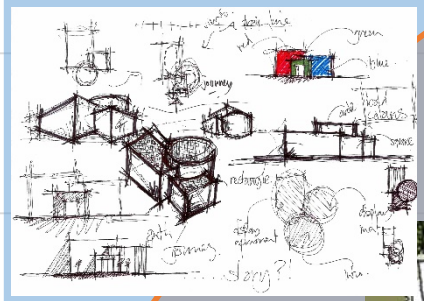
# ENERGY MODELING DURING DESIGN PROCESS



# GREATEST IMPACT / EARLY DESIGN

HIGH

**MASSING**
**ORIENTATION**



**IMPACTS:**
- **DAYLIGHTING**
- **COOLING**

LOW

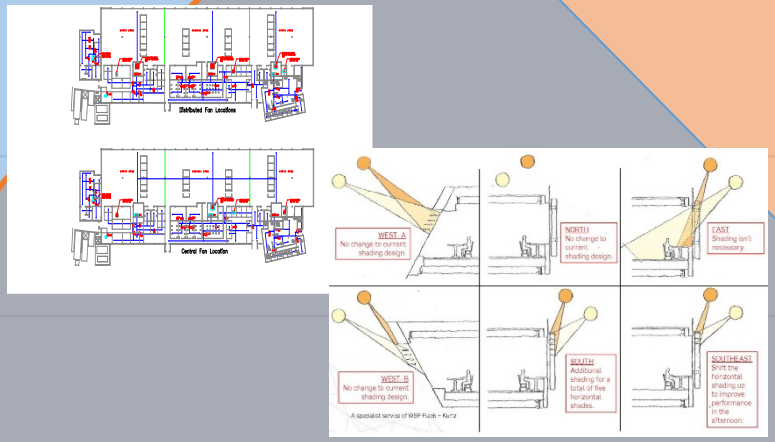
SCHEMATIC

# BIG IMPACT / MID-DESIGN

HIGH

LOW

**DISTRIBUTION SHADING**




**IMPACTS:**

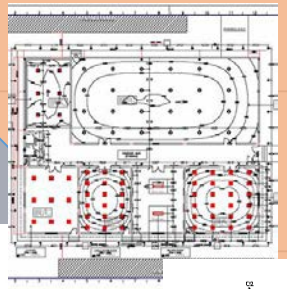
- **FANS**
- **SOLAR LOADS**

DESIGN DEVELOPMENT

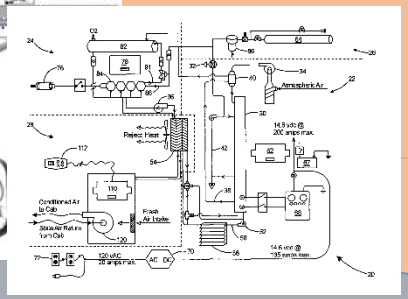
# LESS IMPACT / LATE DESIGN

HIGH

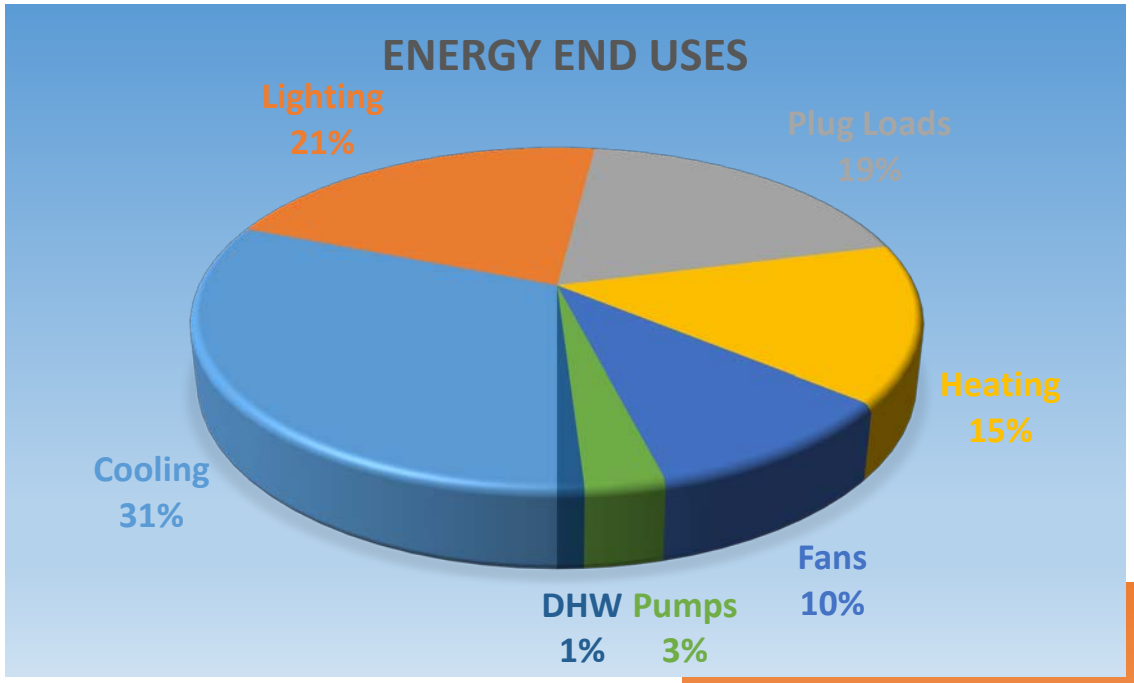
LOW

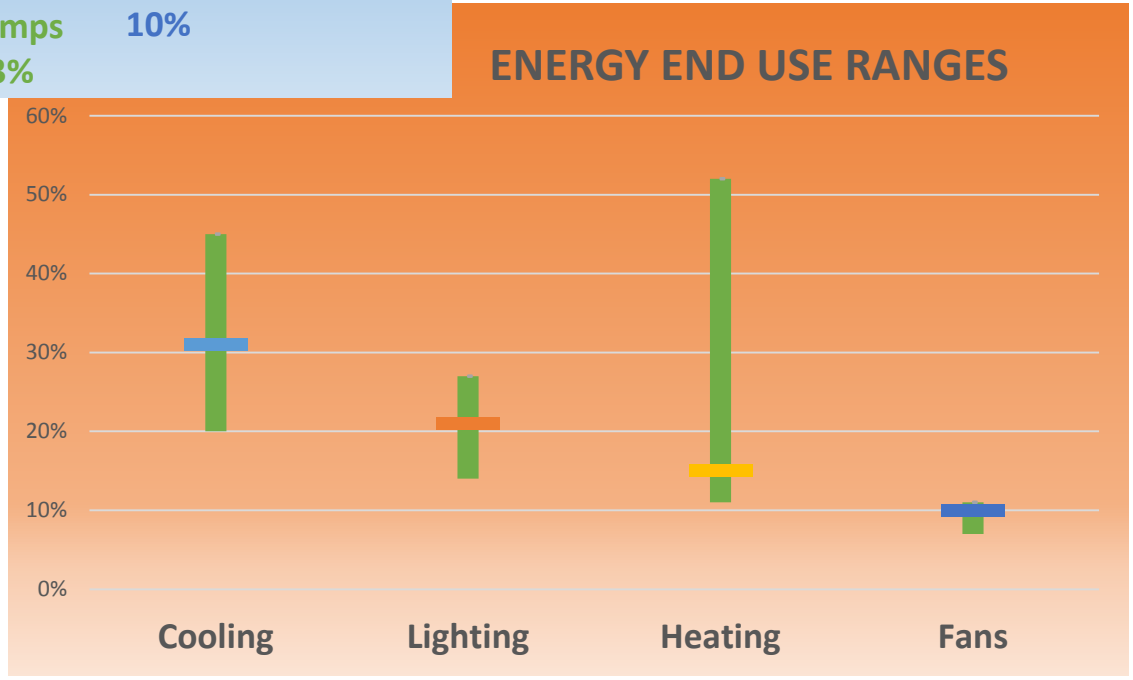


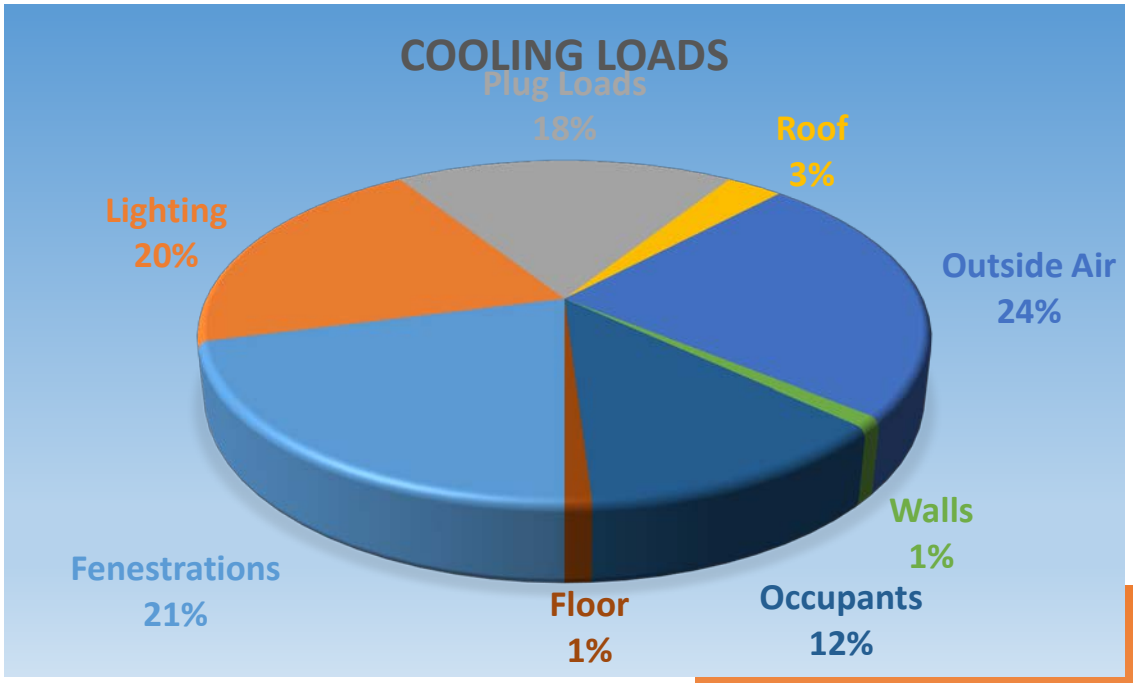
**LIGHTING**
**HVAC**
**EFFICIENCIES**
**CONTROLS**

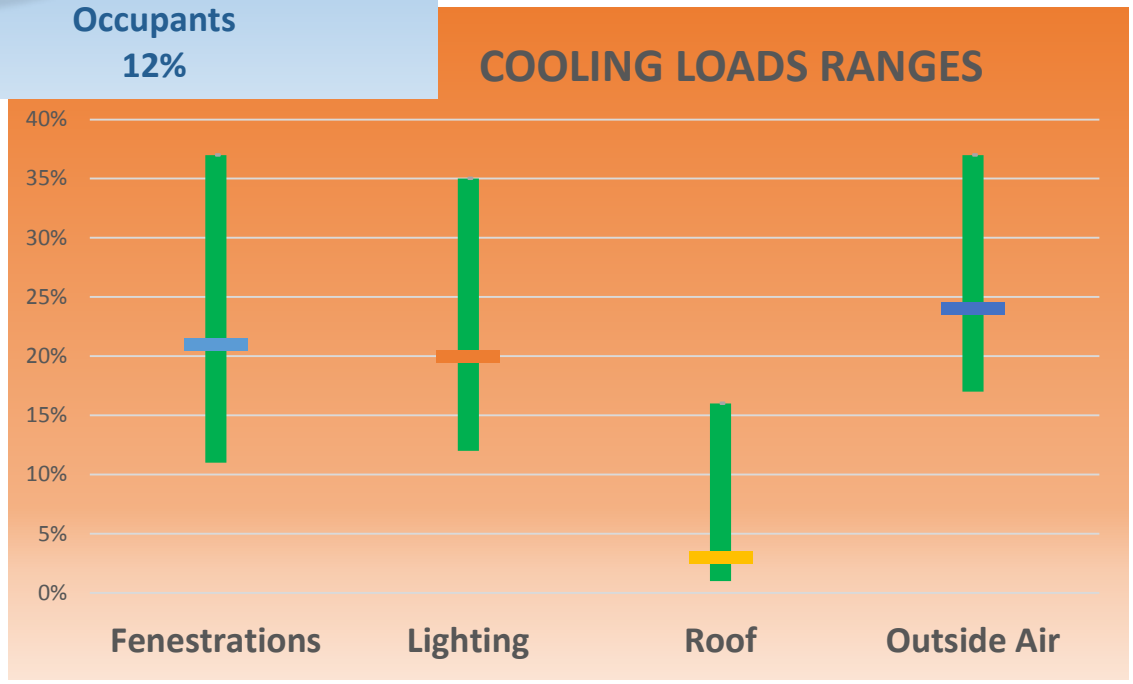



CONSTRUCTION DOCUMENTS

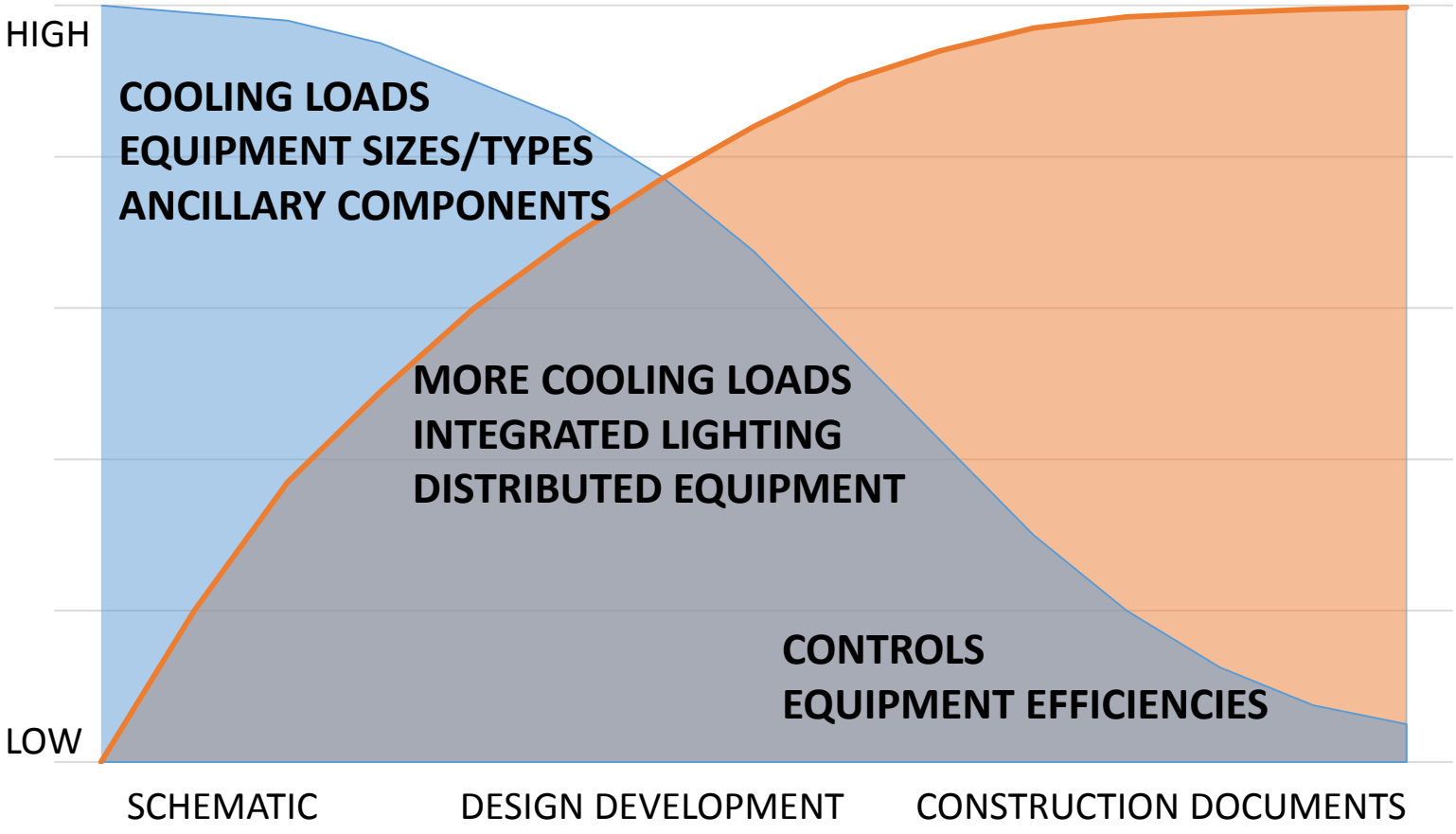

ENERGY END USES
Lighting
21%
Plug Loads
19%
Heating
15%
Cooling
31%
Fans
10%
DHW
1%
Pumps
3%

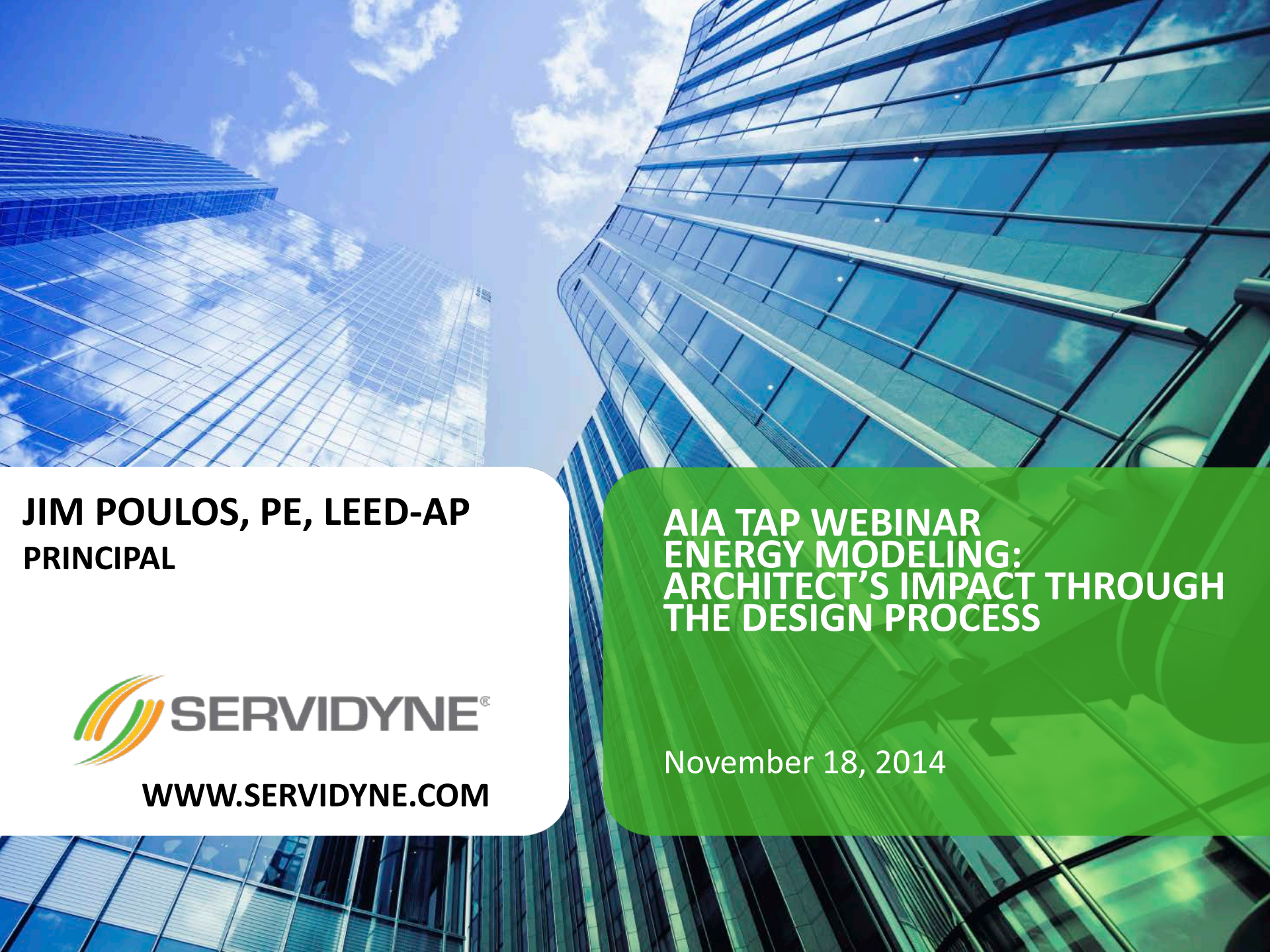

ENERGY END USE RANGES
60%
50%
40%
30%
20%
10%
0%
Cooling
Lighting
Heating
Fans


COOLING LOADS
Plug Loads
18%
Roof
3%
Lighting
20%
Outside Air
24%
Walls
1%
Fenestrations
21%
Floor
1%
Occupants
12%


COOLING LOADS RANGES
40%
35%
30%
25%
20%
15%
10%
5%
0%
Fenestrations
Lighting
Roof
Outside Air

# ARCHITECT'S IMPACT THRU DESIGN PROCESS






**JIM POULOS, PE, LEED-AP**
**PRINCIPAL**

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# AIA TAP WEBINAR ENERGY MODELING: ARCHITECT'S IMPACT THROUGH THE DESIGN PROCESS

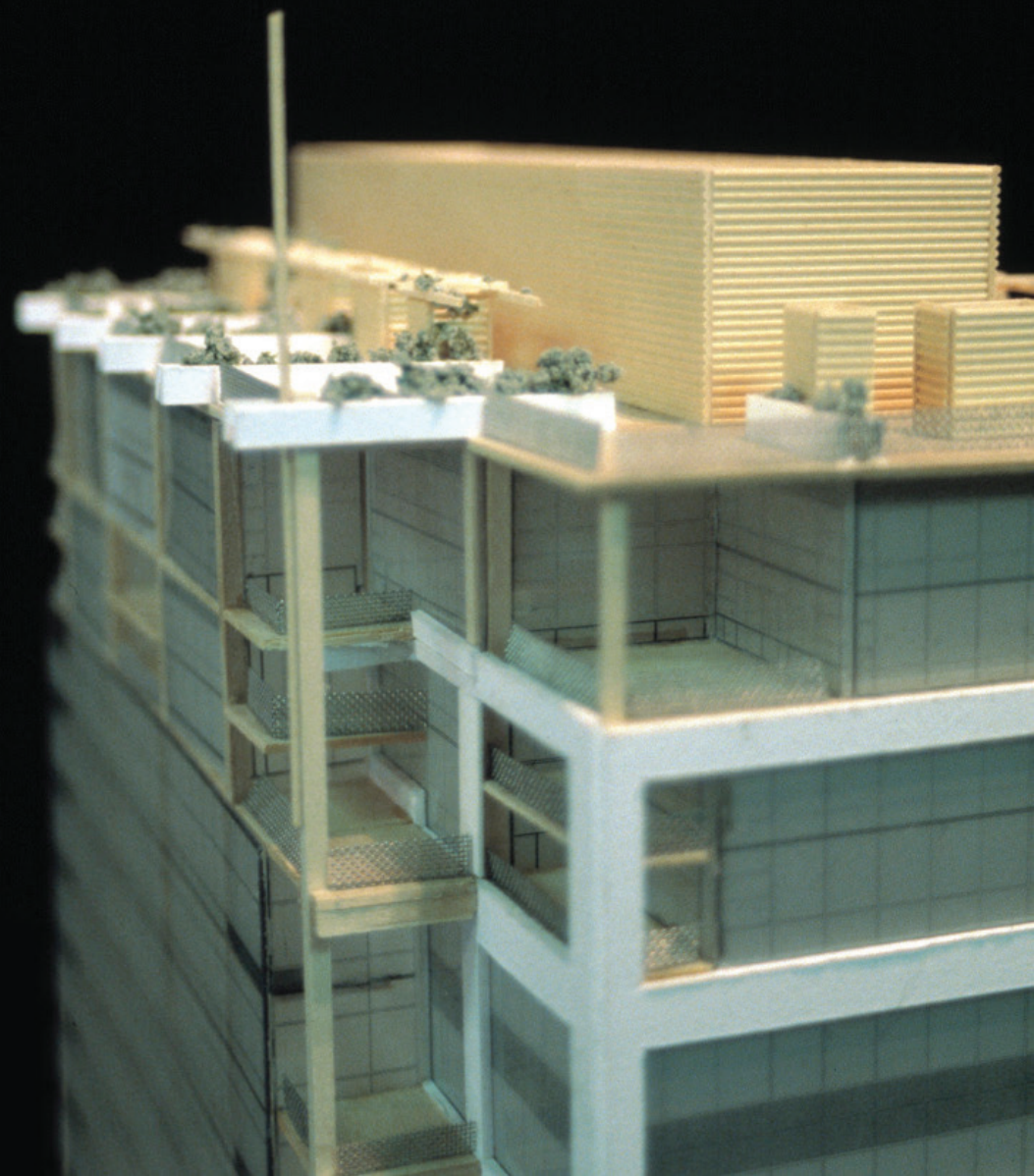
November 18, 2014

# AIA TAP WEBCAST

11-18-2014

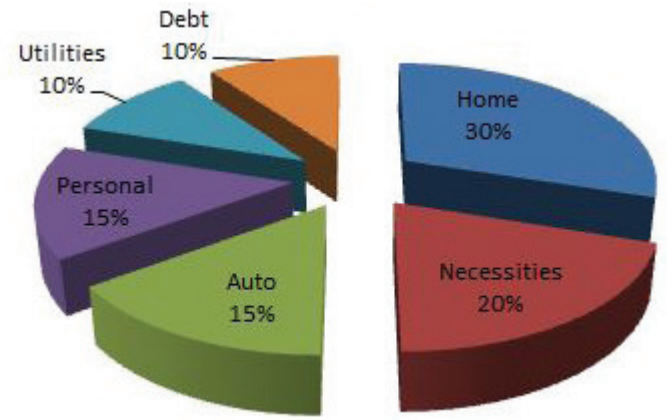
Kjell Anderson, AIA, cSBA, LEED AP BD+C
LMN Architects

"All models are wrong
but some are useful."
- GEORGE E.P. BOX



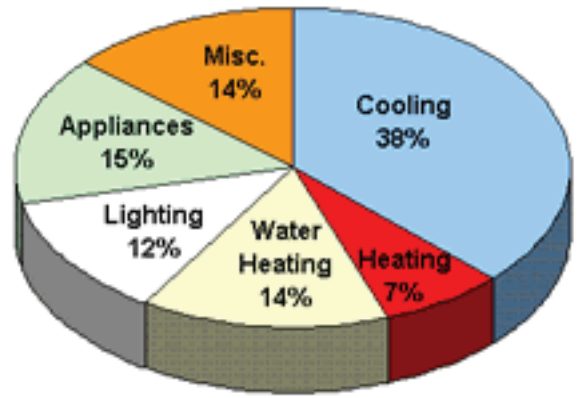
“All models are wrong
but some are useful.”
- GEORGE E.P. BOX

HOUSEHOLD BUDGET

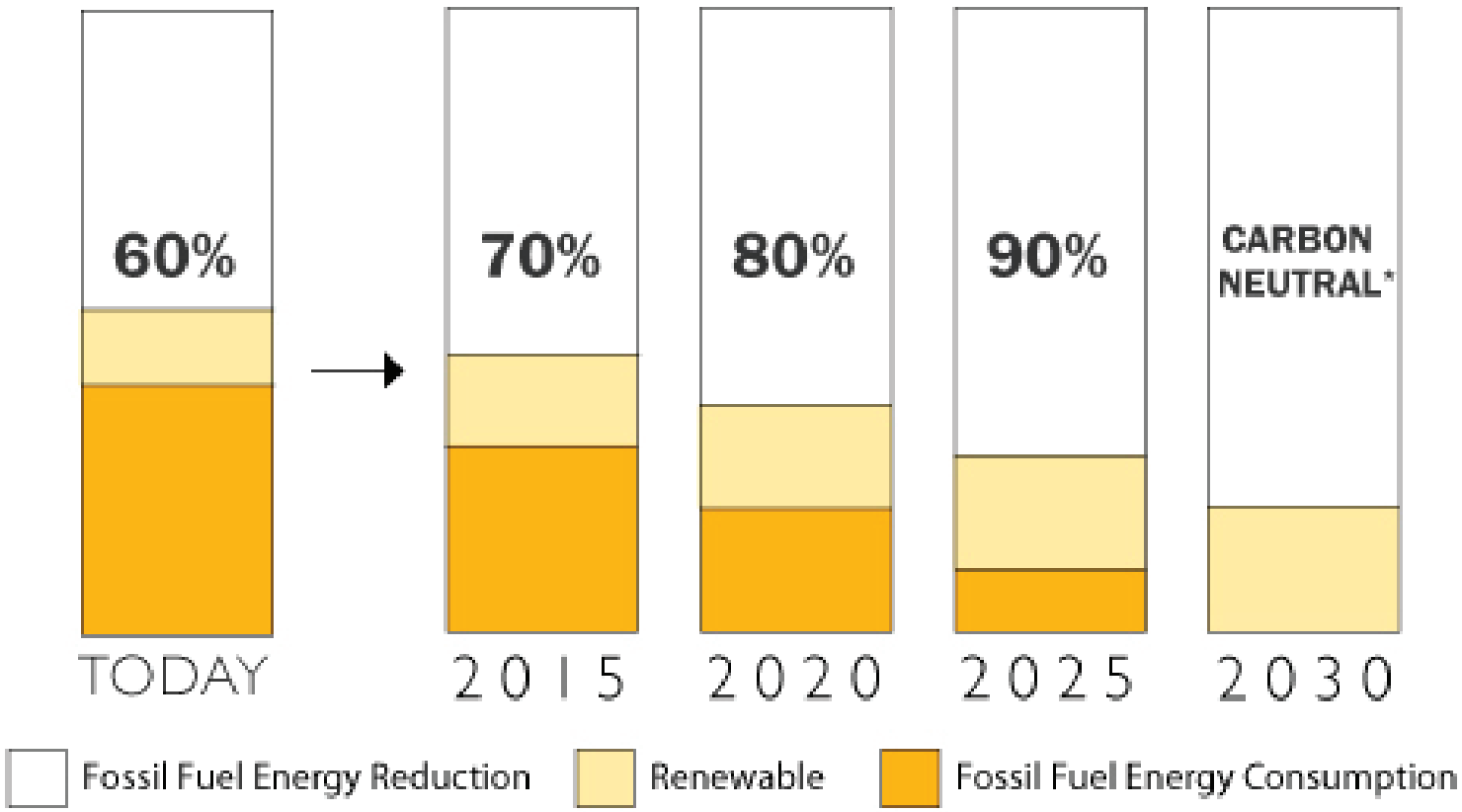



$50,000/year

ENERGY BUDGET

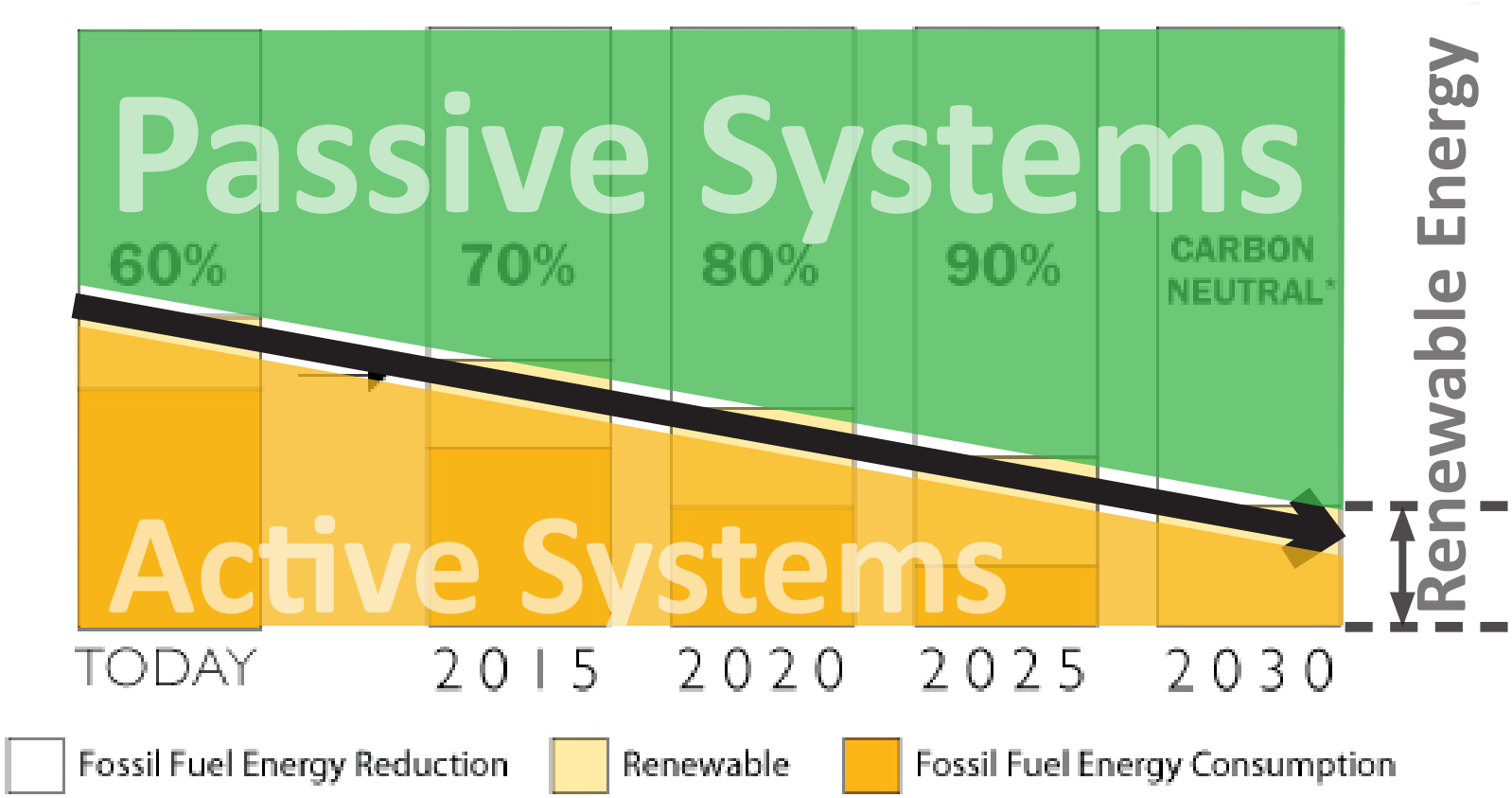



50 kBtu/ft²/year




**The 2030 Challenge**


**Using no fossil fuel GHG-emitting energy to operate.*




**The 2030 Challenge**



**Using no fossil fuel GHG-emitting energy to operate.*

# a brief history of energy modeling...

Mechanical System
Sizing (Peak Loads)

---

How big are loads?
Do I need 4 tons or 8
tons of cooling?

Late in Design Phase

# a brief history of energy modeling...

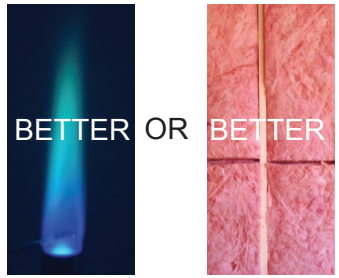
Mechanical System Sizing (Peak Loads)

Comparing strategies. (Energy Conservation Measures, EEM/ECMs)

---

How big are loads? Do I need 4 tons or 8 tons of cooling?

Is it better to insulate more or upgrade the boiler efficiency?

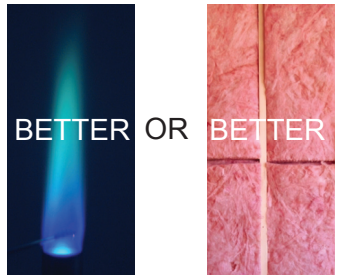



Late in Design Phase

Middle of Design Phase

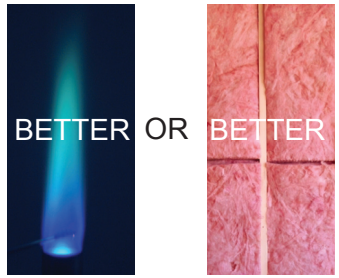
# a brief history of energy modeling...

YOU ARE HERE

| Mechanical System Sizing (Peak Loads) | Comparing strategies. (Energy Conservation Measures, EEM/ECMs) | Compliance |
|---|---|---|
| How big are loads? Do I need 4 tons or 8 tons of cooling? | Is it better to insulate more or upgrade the boiler efficiency? | Is my building at least as good as a prescriptive code building?? |
|  |   |   |
| Late in Design Phase | Middle of Design Phase | ASHRAE 90.1<br>LEED<br>Energy Code<br>Usually late in Design Phase |

# a brief history of energy modeling...

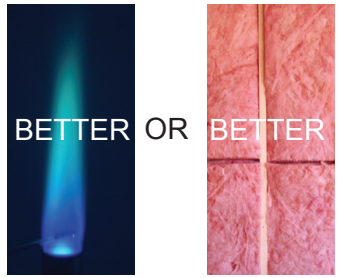
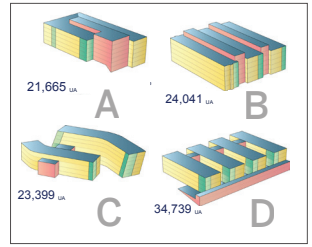
YOU ARE HERE

| Mechanical System Sizing (Peak Loads) | Comparing strategies. (Energy Conservation Measures, EEM/ECMs) | Compliance | Prediction |
|---|---|---|---|
| How big are loads? Do I need 4 tons or 8 tons of cooling? | Is it better to insulate more or upgrade the boiler efficiency? | Is my building at least as good as a prescriptive code building?? | Will the design and operations be able to meet 40 kBtu/sf/year? |
|  |   |   ASHRAE 90.1 LEED Energy Code |  |
| Late in Design Phase | Middle of Design Phase | Usually late in Design Phase | Throughout Design Phases |

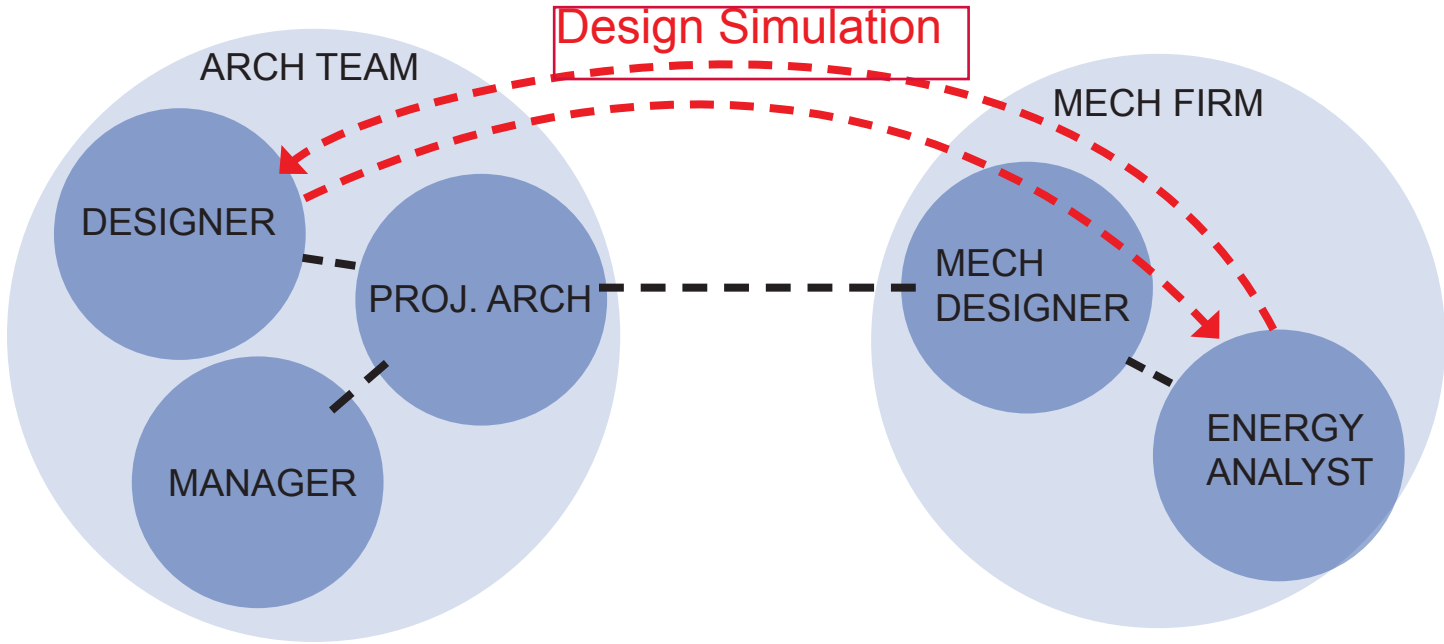
# a brief history of energy modeling...

YOU ARE HERE

This is the only one that typically addresses/compares geometry and passive systems

| Mechanical System Sizing (Peak Loads) | Comparing strategies. (Energy Conservation Measures, EEM/ECMs) | Compliance | Prediction | Design |
|---|---|---|---|---|
| How big are loads? Do I need 4 tons or 8 tons of cooling? | Is it better to insulate more or upgrade the boiler efficiency? | Is my building at least as good as a prescriptive code building?? | Will the design and operations be able to meet 40 kBtu/sf/year? | What quality/quantity of daylight does each space have? Do I need more shading? |
|  |   |   ASHRAE 90.1 LEED Energy Code |  |   |
| Late in Design Phase | Middle of Design Phase | Usually late in Design Phase | Throughout Design Phases | Early Design Phase, Testing Geometry |

# Who Does Energy Modeling?

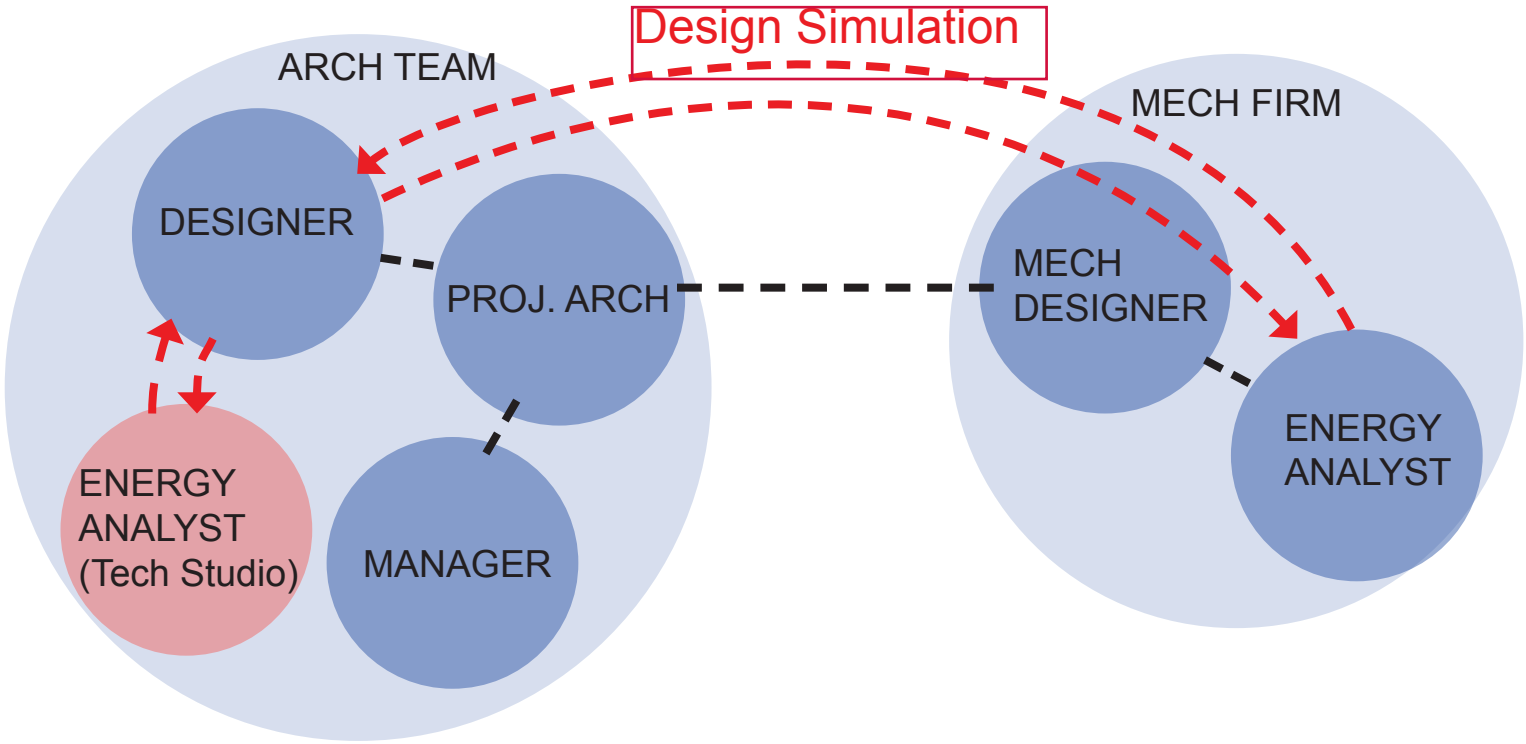



- Usually an Energy Analyst, often housed within a Mechanical Design Firm.
- For some types of Analysis, the best physical location is within an Architecture firm.

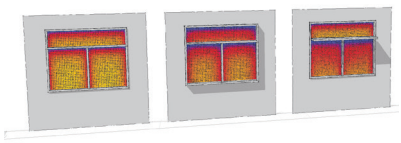
Common Issues with Energy Analysis:

- Design team is not asking a design question, just asking for 'analysis.'
- Design team is not willing to incorporate answers to analysis questions.
- Geometry is difficult to translate from design team to energy modeling software. Design Changes may require extensive time (fee) to redraw model. This means either they are not picked up by Analyst or fee increases for early analysis.
- Energy Analyst makes a great deal of assumptions that are correct, on average. For a particular building, however, they may not be appropriate.

# Who Does Energy Modeling?

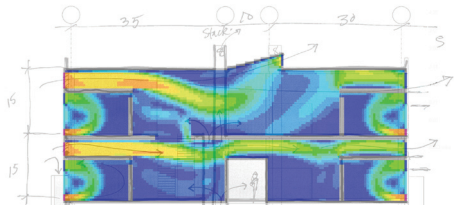



Some Types of Design Energy Simulation

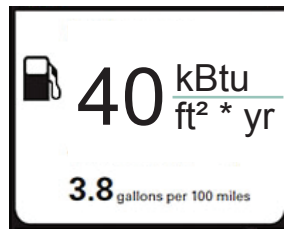


Solar/Shading

Daylighting

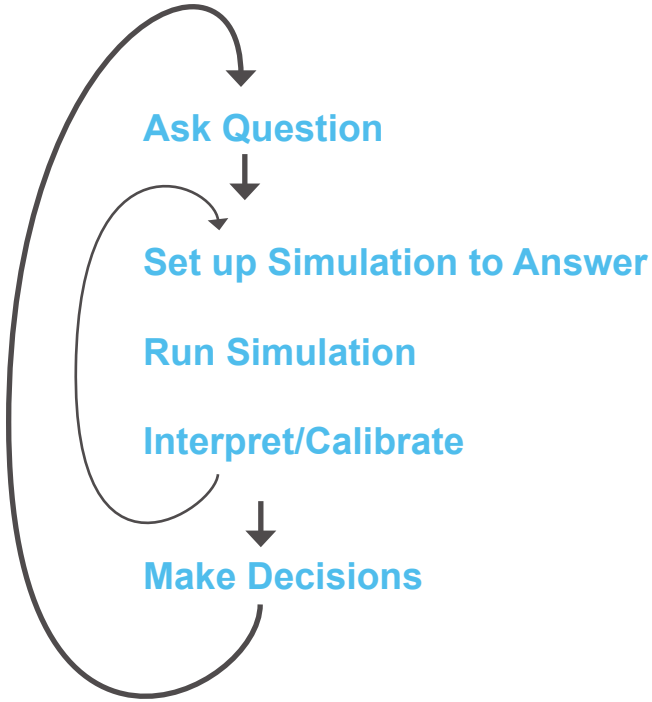


Airflow

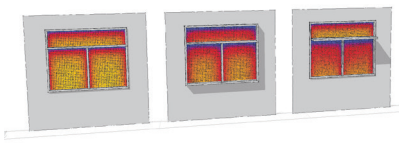



Energy Modeling/ Comfort

## Simulation Process

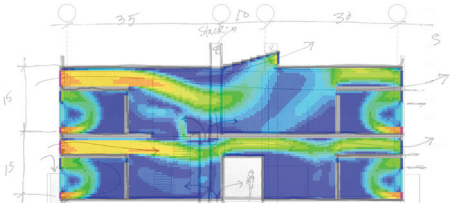



### Some Types of Design Energy Simulation

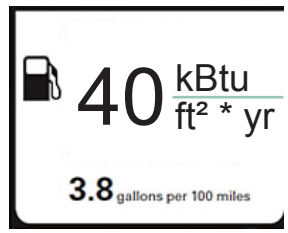


Solar/Shading

Daylighting

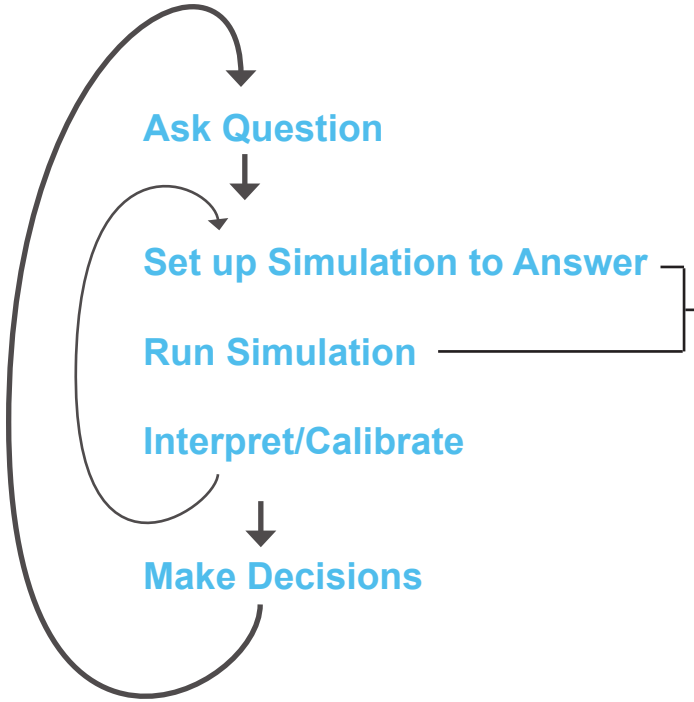


Airflow




Energy Modeling/
Comfort

## Simulation Process




Software

## Software Types, with examples

**3d Modeler** — Allows geometry to be created

- Revit
- Rhino
- 3d SketchUp
- ...

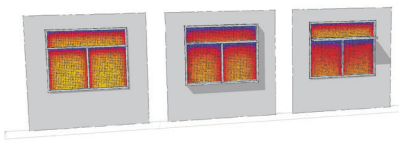
**Graphic User Interface** — Buttons are clicked to set properties, run simulations, and see results

- Sefaira
- Diva
- IES-VE
- Vasari/Green Building Studio
- ...

**Engine** — The underlying algorithms that simulate the physical world

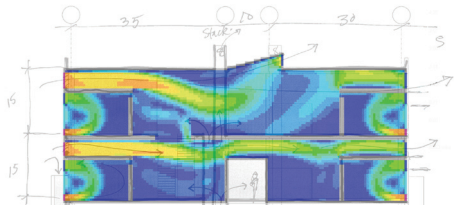
- Radiance
- EnergyPlus
- DOE2
- ...

## Some Types of Design Energy Simulation

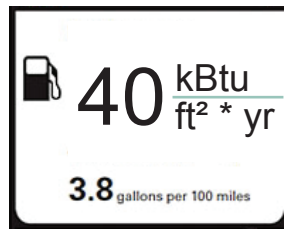


Solar/Shading

Daylighting



Airflow

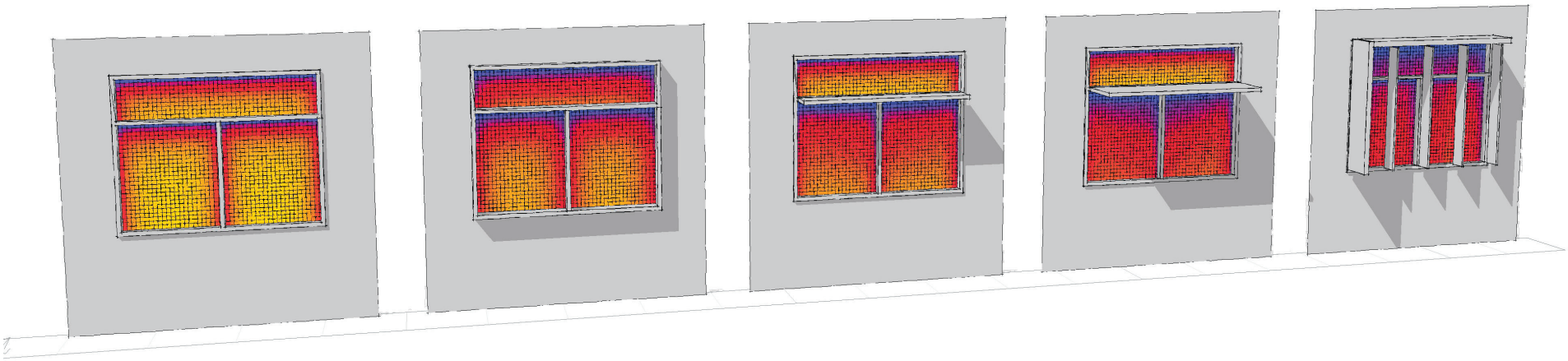



Energy Modeling/ Comfort

## Solar Energy Investigations

### Question

- What is the relative performance of various shading strategies?

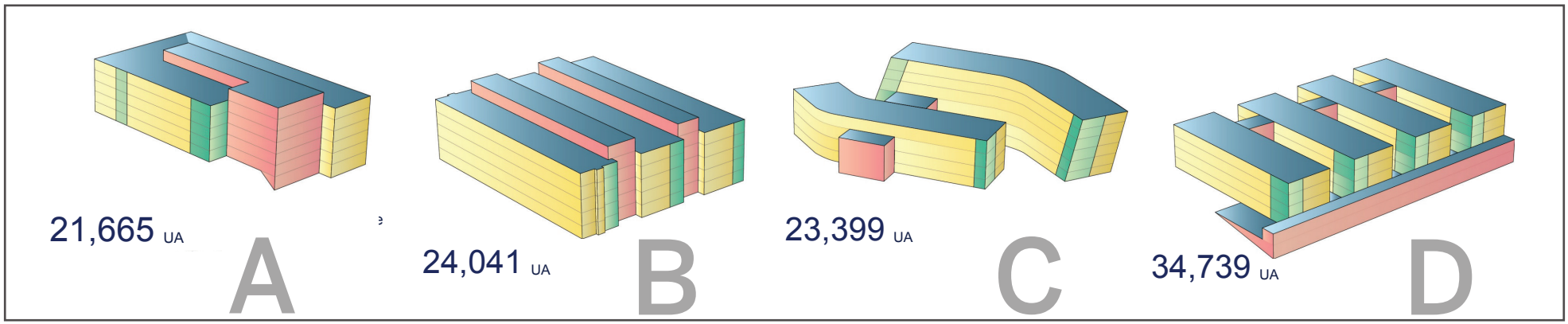


## Massing Comparison

### Question

- How often can electric lights be dimmed or off?
- What is optimal geometry to balance daylight with envelope performance?

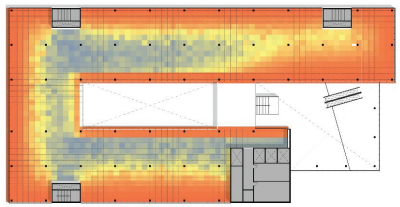
40% Glazing
60% Glazing
90% Glazing



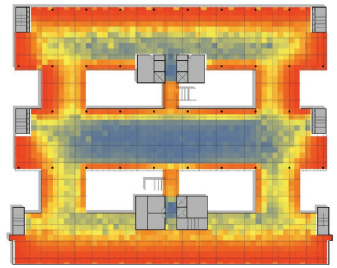
# Massing Comparison

## Result: A and C perform best

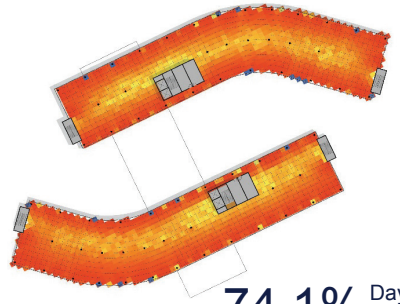
Daylight Autonomy
100% 0%



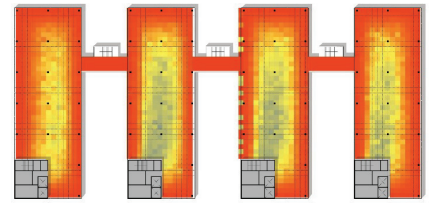
62.9% Daylight Autonomy



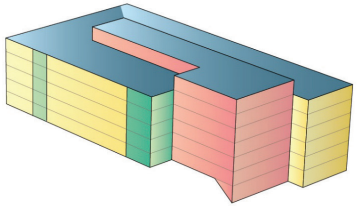
53.4% Daylight Autonomy



74.1% Daylight Autonomy

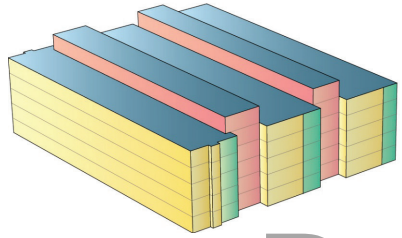


70.4% Daylight Autonomy



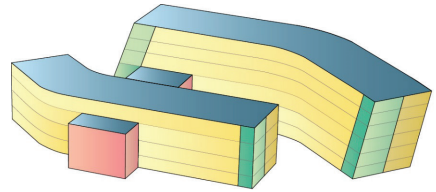
21,665 UA

A



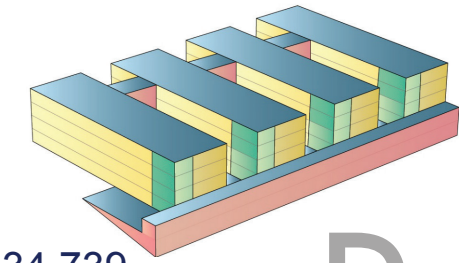
24,041 UA

B



23,399 UA

C



34,739 UA

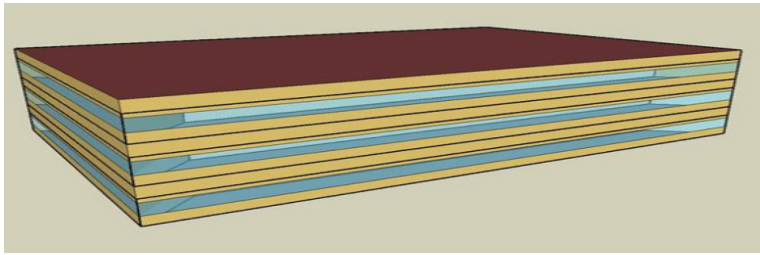
D

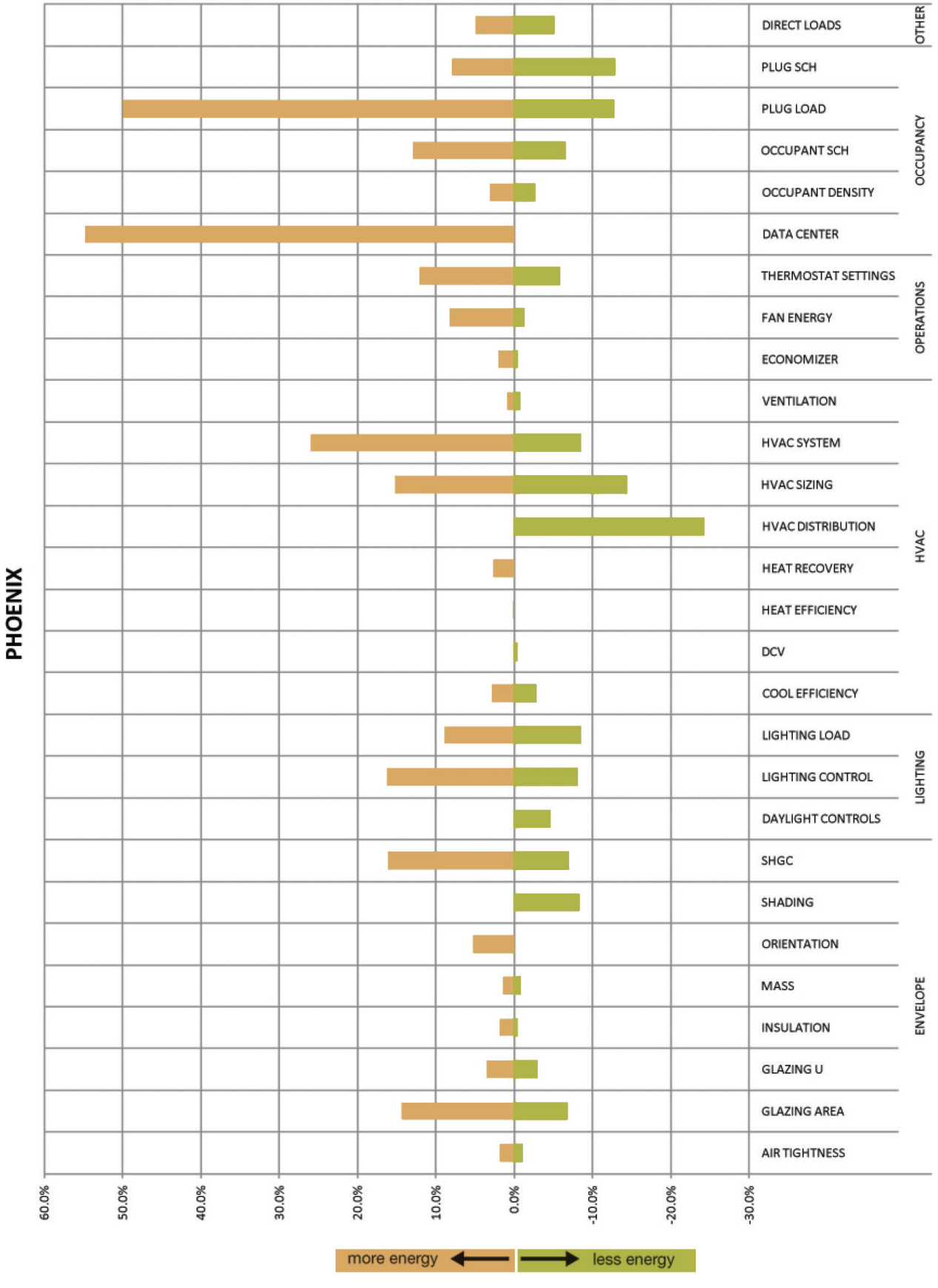
# Sensitivity Analysis

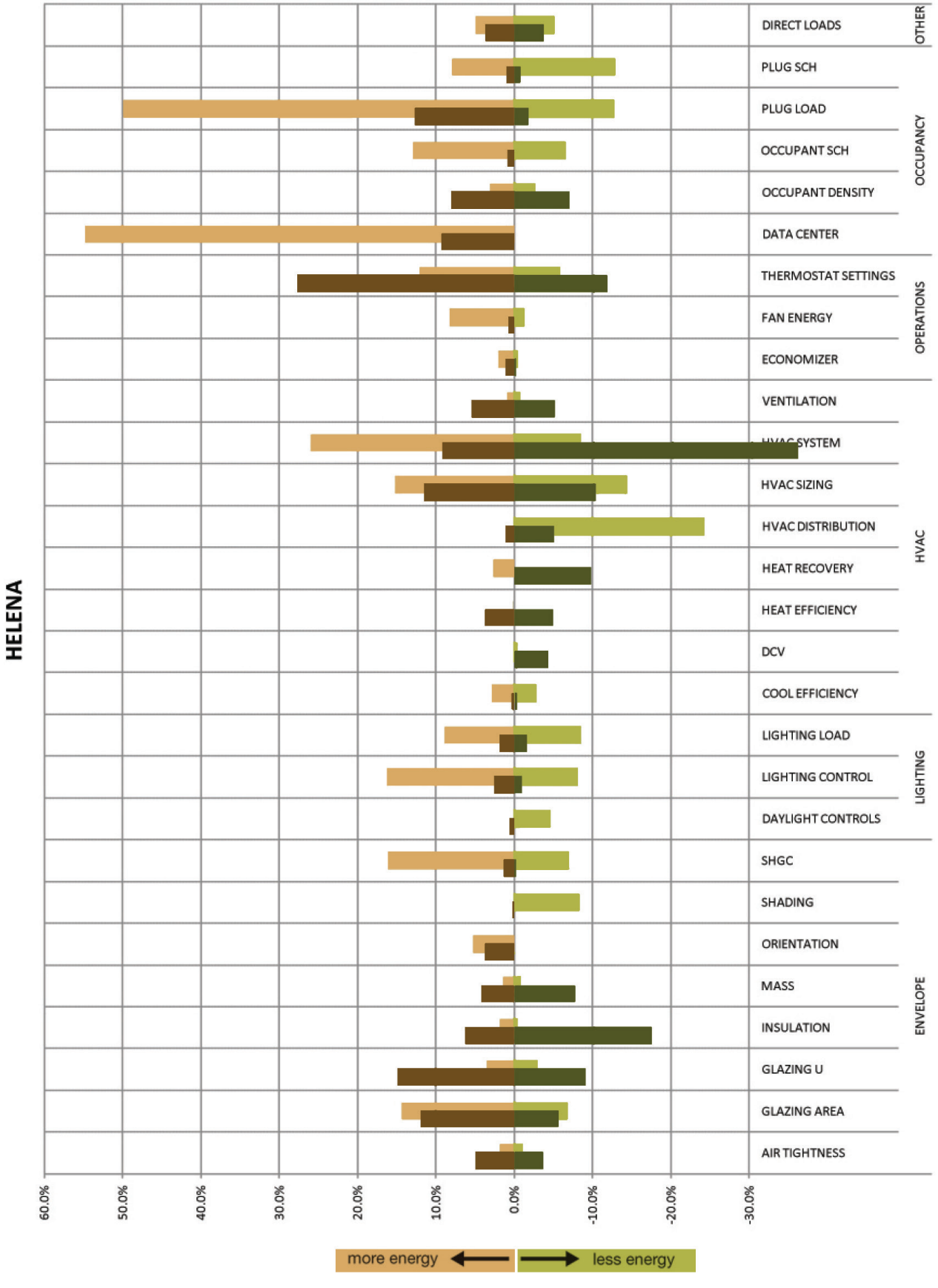
Table 1. Variable List and Range

| Category | Variable | Low Performance | Base Case | High Performance |
|---|---|---|---|---|
| Envelope | Building Area (SF) | 52,630 | 52,630 | 52,630 |
| | Number of Floors | 3 | 3 | 3 |
| | Thermal Zoning | Core zone w/4 perimeter zones on each floor | Core zone w/4 perim-eter zones on each floor | Core zone w/4 perimeter zones on each floor |
| | Perimeter Zone Depth | 15' | 15' | 15' |
| | Floor to Floor (ft) | 13' | 13' | 13' |
| | Floor to Ceiling (ft) | 9' | 9' | 9' |
| | Aspect Ratio & Orientation | N/S 2.5-1 | E/W 1.5-1 S | E/W 2.5-1 |
| | Mass | Wood frame (no slab) | 4" slab | 12" slab |
| | Insulation | R-11 metal frame | ASHRAE 90.1-2007 Seattle | ASHRAE 189 |
| | Glazing Area | 60% | 33% | 20% |
| | Shading | NONE | NONE | FIXED 3' horizontal |
| | SHGC | 0.76 | 0.38 | 0.15 |
| | Glazing U | 0.93 | 0.48 | 0.28 |
| | Air Tightness | 0.013 | 0.29 | 0.62 |
| Occupancy | Occupant Density | 130 SF/Person | 200 SF/Per-son | 400 SF/Person |
| | Occupant Schedule | 16 Hour WD + 12Hour SAT | 12 Hour WD + 6 Hour SAT | 8 Hour WD + 4 Hour SAT |
| | Plug Loads | 2.0 w/SF | 0.75 w/SF | 0.4 w/SF |
| | Plug Schedule | 80% on at Night | 40% on at Night | 5% on at Night |
| | Data Center | 1.5 % of floor area, 100 w/SF | NONE | 1.5% of floor area, 35 w/ SF |

| BUILDING GEOMETRY | | |
|---|---|---|
| Total Area | 53625 | ft^2 |
| Number of Floors | 3 | |
| Aspect Ratio | 2:1 | |
| Floor to Floor Height | 13 | ft |
| Floor to Ceiling Height | 9 | ft |
| Window to Wall Ratio | 0.33 | |



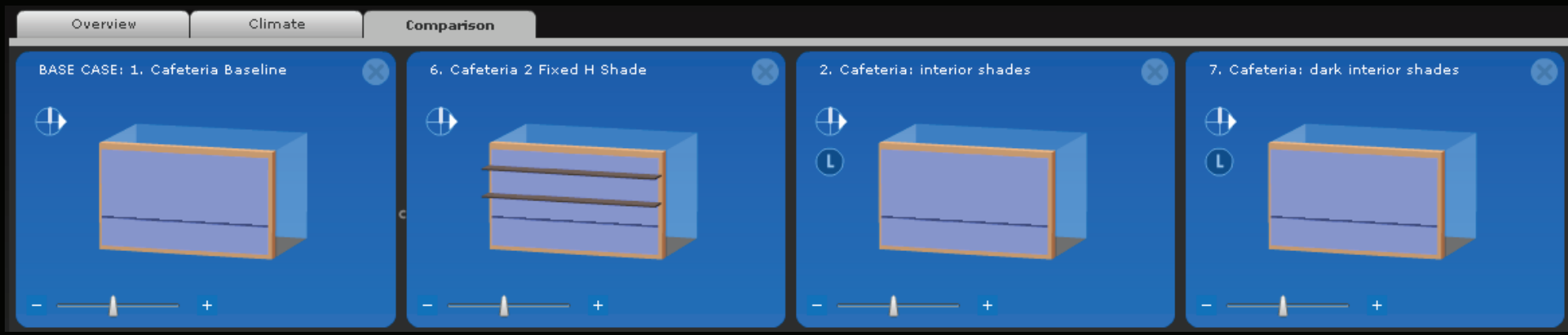

PHOENIX
DIRECT LOADS
PLUG SCH
PLUG LOAD
OCCUPANT SCH
OCCUPANT DENSITY
DATA CENTER
THERMOSTAT SETTINGS
FAN ENERGY
ECONOMIZER
VENTILATION
HVAC SYSTEM
HVAC SIZING
HVAC DISTRIBUTION
HEAT RECOVERY
HEAT EFFICIENCY
DCV
COOL EFFICIENCY
LIGHTING LOAD
LIGHTING CONTROL
DAYLIGHT CONTROLS
SHGC
SHADING
ORIENTATION
MASS
INSULATION
GLAZING U
GLAZING AREA
AIR TIGHTNESS
OTHER
OCCUPANCY
OPERATIONS
HVAC
LIGHTING
ENVELOPE
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
-10.0%
-20.0%
-30.0%
more energy
less energy

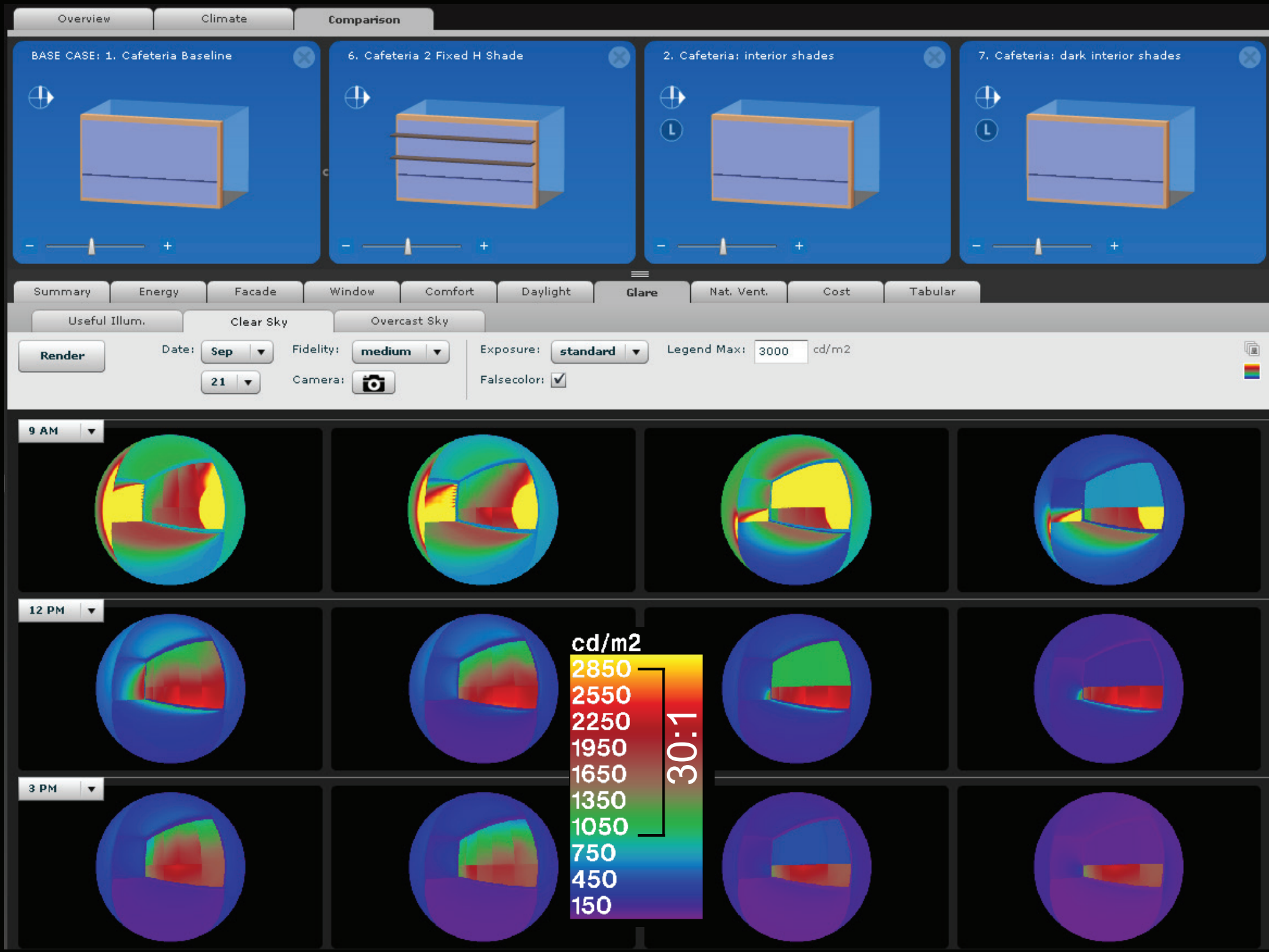

HELENA
DIRECT LOADS
PLUG SCH
PLUG LOAD
OCCUPANT SCH
OCCUPANT DENSITY
DATA CENTER
THERMOSTAT SETTINGS
FAN ENERGY
ECONOMIZER
VENTILATION
HVAC SYSTEM
HVAC SIZING
HVAC DISTRIBUTION
HEAT RECOVERY
HEAT EFFICIENCY
DCV
COOL EFFICIENCY
LIGHTING LOAD
LIGHTING CONTROL
DAYLIGHT CONTROLS
SHGC
SHADING
ORIENTATION
MASS
INSULATION
GLAZING U
GLAZING AREA
AIR TIGHTNESS
OTHER
OCCUPANCY
OPERATIONS
HVAC
LIGHTING
ENVELOPE
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
-10.0%
-20.0%
-30.0%
more energy
less energy

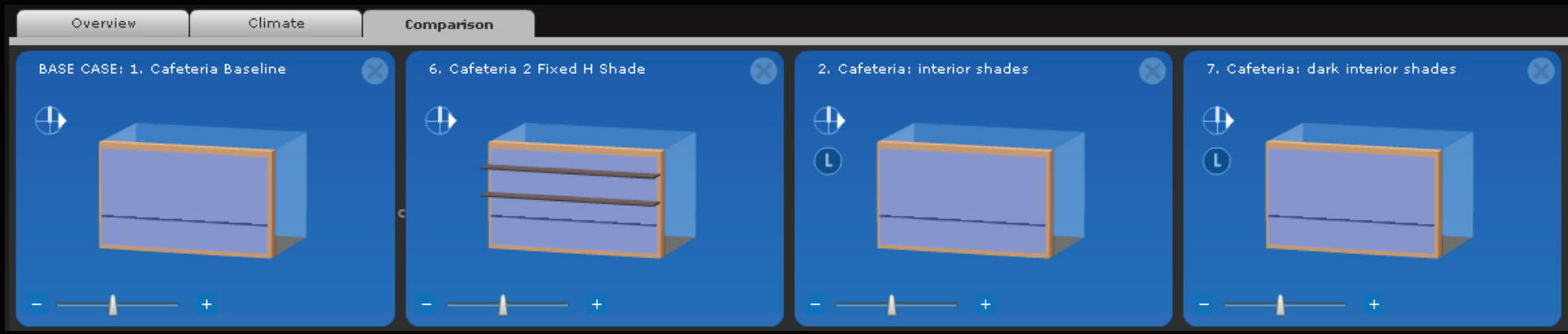
## Daylighting Investigations

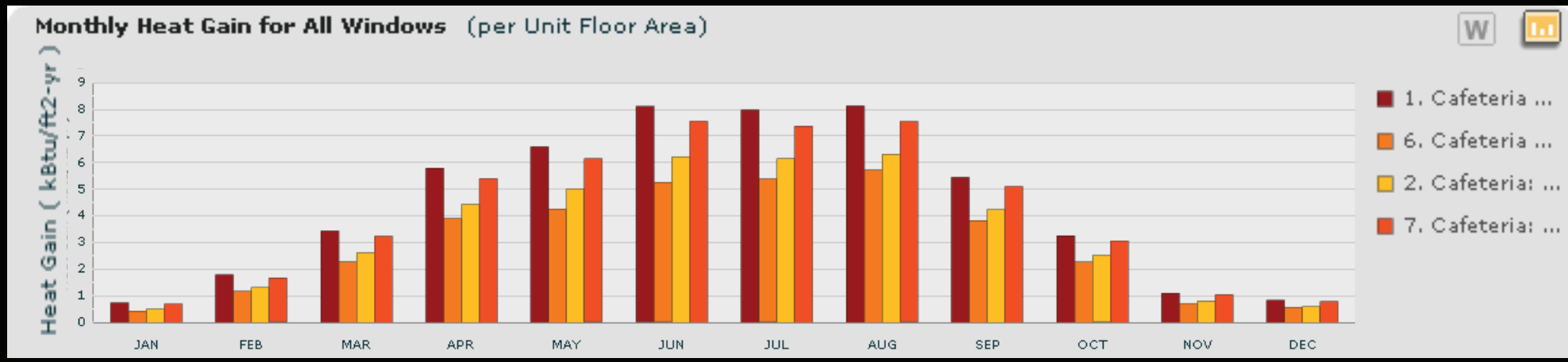
### Question

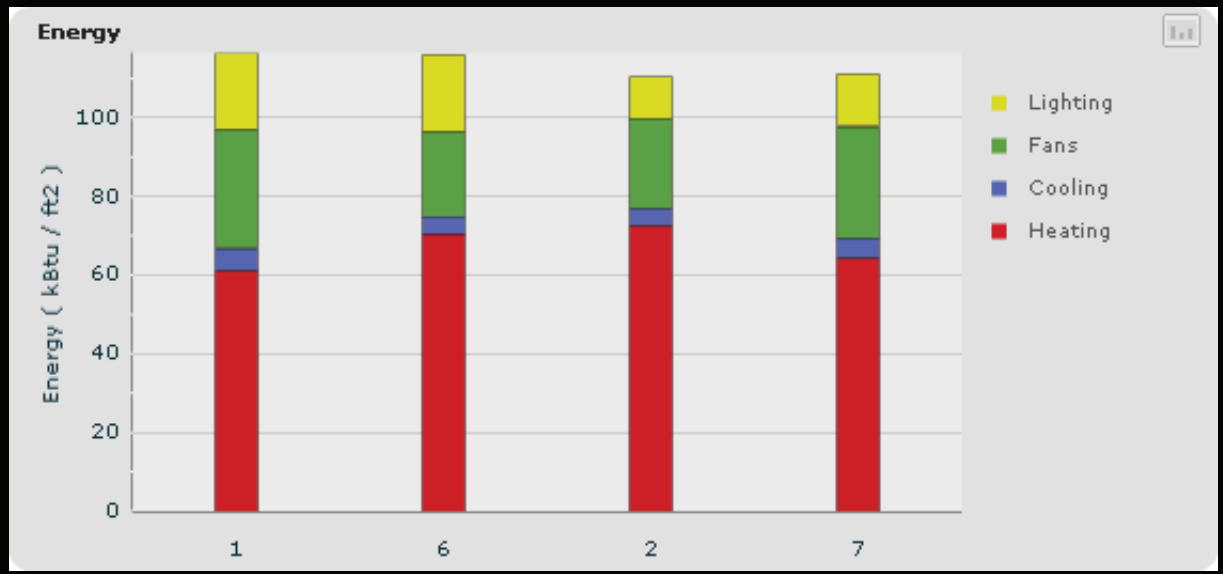
- For an existing, East-facing highly-glazed facades,is there a best strategy to reduce glare and cooling loads?

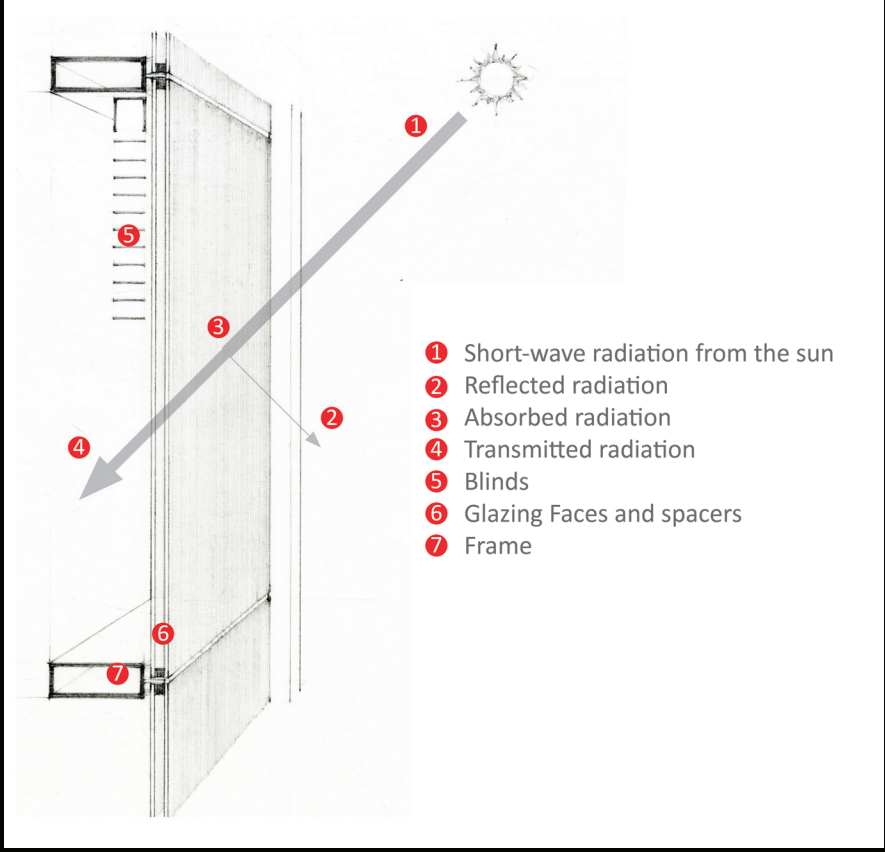



Overview
Climate
Comparison
BASE CASE: 1. Cafeteria Baseline
6. Cafeteria 2 Fixed H Shade
2. Cafeteria: interior shades
7. Cafeteria: dark interior shades
Summary
Energy
Facade
Window
Comfort
Daylight
Glare
Nat. Vent.
Cost
Tabular
Useful Illum.
Clear Sky
Overcast Sky
Render
Date:
Sep
21
Fidelity:
medium
Camera:
Exposure:
standard
Falsecolor:
Legend Max:
3000
cd/m2
9 AM
12 PM
3 PM
cd/m2
2850
2550
2250
1950
1650
1350
1050
750
450
150
30:1


Overview
Climate
Comparison
BASE CASE: 1. Cafeteria Baseline
6. Cafeteria 2 Fixed H Shade
2. Cafeteria: interior shades
7. Cafeteria: dark interior shades


Monthly Heat Gain for All Windows (per Unit Floor Area)
Heat Gain ( kBtu/ft2-yr )
0
1
2
3
4
5
6
7
8
9
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1. Cafeteria ...
6. Cafeteria ...
2. Cafeteria: ...
7. Cafeteria: ...


Energy
Energy ( kBtu / ft2 )
0
20
40
60
80
100
1
6
2
7
Lighting
Fans
Cooling
Heating




## SHADING SYSTEMS

Windows | Glazing Sys. | Shading Sys. | Frames

| ID | Name | Type |
|---|---|---|
| 1 | RS -- exterior -- light-colored | shade |
| 2 | RS -- exterior -- medium-colored | shade |
| 3 | RS -- exterior -- dark-colored | shade |
| 4 | RS -- interior -- light-colored | shade |
| 5 | RS -- interior -- medium-colored | shade |
| 6 | RS -- interior -- dark-colored | shade |
| 7 | RS -- between-glass -- light-colored | shade |
| 8 | RS -- between-glass -- medium-colored | shade |
| 9 | RS -- between-glass -- dark-colored | shade |
| 10 | VB -- exterior -- 3" slat (90 deg) | venetian blind |
| 11 | VB -- exterior -- 3" slat (45 deg) | venetian blind |
| 12 | VB -- exterior -- 3" slat (0 deg) | venetian blind |
| 13 | VB -- interior -- 1" slat (90 deg) | venetian blind |
| 14 | VB -- interior -- 1" slat (45 deg) | venetian blind |
| 15 | VB -- interior -- 1" slat (0 deg) | venetian blind |
| 16 | VB -- between-glass -- 0.45" slat (90 deg) | venetian blind |
| 17 | VB -- between-glass -- 0.45" slat (45 deg) | venetian blind |
| 18 | VB -- between-glass -- 0.45" slat (0 deg) | venetian blind |
| 19 | Screen -- exterior -- dark-colored w/ fine mesh (1 m | screen |
| 20 | Screen -- exterior -- dark-colored w/ medium mesh ( | screen |

## GLAZING TYPES

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas

| ID | Name | TVis | SHGC | U-factor |
|---|---|---|---|---|
| 1 | Single Clear 6 mm | 0.883647 | 0.817993 | 1.02464 |
| 2 | Double Clear (Air) | 0.786104 | 0.704054 | 0.47349 |
| 3 | Double Bronze (Air) | 0.476844 | 0.502193 | 0.47369 |
| 4 | Double Low-E Bronze (Air) | 0.443098 | 0.45254 | 0.33069 |
| 5 | Double Low Solar Low-E Tint (Air) | 0.521143 | 0.299475 | 0.29064 |
| 6 | Double Low Solar Low-E Clear (Air) | 0.700573 | 0.381879 | 0.29080 |
| 7 | Quad Low Solar Low-E Clear (Air) | 0.450973 | 0.292109 | 0.10817 |
| 8 | Double Glazed Triple Silver Low-E (Argon) | 0.638147 | 0.272156 | 0.23788 |
| 9 | Double Hi VT (LowIron) Low-E (Argon) | 0.723571 | 0.382557 | 0.24673 |
| 10 | Double High Performance Tint (Air) | 0.607054 | 0.393693 | 0.47356 |
| 11 | Double High Performance Tint (Argon) | 0.607054 | 0.389954 | 0.44853 |
| 12 | Double Low VT Low-E (Argon) | 0.371312 | 0.240973 | 0.25334 |
| 13 | Double Low-E Clear (Argon) | 0.69594 | 0.469166 | 0.24527 |
| 14 | Double Glazed Triple Silver Low-E Tint (Argon) | 0.543216 | 0.245632 | 0.23788 |
| 15 | Double Low-E Opaque (Air) | 0.027201 | 0.076764 | 0.29083 |
| 100 | Viracon -- VE-2M (2) clear/clear (air) | 0.702833 | 0.379199 | 0.29255 |
| 101 | Viracon -- VE-2M (2) clear/clear (argon) | 0.702833 | 0.374939 | 0.24671 |
| 102 | Viracon -- VE-2M (2) low-iron/low-iron (air) | 0.730261 | 0.389355 | 0.29258 |
| 103 | Viracon -- VNE-63 (2) clear/clear (air) | 0.621575 | 0.287753 | 0.28983 |
| 104 | Viracon -- VUE-50 (2) clear/clear (air) | 0.483656 | 0.255273 | 0.28904 |
| 105 | Viracon -- VE-85 (2) clear/clear (air) | 0.756618 | 0.5451 | 0.30896 |
| 106 | Viracon -- VE-85 (2) low-iron/low-iron (air) | 0.780671 | 0.599464 | 0.31092 |
| 107 | Viracon -- VRE-38 (2) clear/clear (air) | 0.36102 | 0.231406 | 0.29365 |
| 108 | Viracon -- VRE-59 (2) clear/clear (air) | 0.527115 | 0.33621 | 0.29745 |
| 200 | PPG -- SB 60 (2) clear/clear (air) | 0.701389 | 0.38205 | 0.29077 |
| 201 | PPG -- SB 60 (2) clear/clear (argon) | 0.701389 | 0.377556 | 0.24467 |
| 202 | PPG -- SB 60 (2) low-iron/low-iron (air) | 0.742233 | 0.400515 | 0.29094 |
| 203 | PPG -- SB 60 (2) light green/clear (air) | 0.629825 | 0.320573 | 0.29094 |
| 204 | PPG -- SB 60 (2) blue/clear (air) | 0.629825 | 0.320573 | 0.29094 |
| 205 | PPG -- SB 60 (2) bronze/clear (air) | 0.422279 | 0.271336 | 0.29094 |
| 206 | PPG -- SB 60 (2) gray/clear (air) | 0.352576 | 0.245984 | 0.29080 |
| 207 | PPG -- SB 70XL (2) 5 mm clear/clear (air) | 0.627799 | 0.277017 | 0.28548 |
| 208 | PPG -- SB 70XL (2) blue/clear (air) | 0.480918 | 0.235283 | 0.28490 |
| 209 | PPG -- SB 80 (2) clear/clear (air) | 0.47493 | 0.239661 | 0.28707 |
| 210 | PPG -- SB R100 (2) clear/clear (air) | 0.415423 | 0.232814 | 0.29129 |
| 300 | Pilkington -- Energy Advantage (2) clear/clear (air) | 0.729064 | 0.620352 | 0.33065 |
| 301 | Pilkington -- Eclipse Advantage (2) clear/clear (air) | 0.601037 | 0.551748 | 0.34542 |
| 302 | Pilkington -- Eclipse Gold/clear (air) | 0.361086 | 0.429957 | 0.47333 |
| 303 | Pilkington -- Solar-E (2) clear/clear (air) -- pyrolytic | 0.53272 | 0.447164 | 0.33292 |
| 400 | Guardian -- SN-68 (2) clear/clear (air) | 0.678005 | 0.376855 | 0.29232 |
| 401 | Guardian -- SN-62 (2) clear/clear (air) | 0.620965 | 0.312399 | 0.28869 |
| 402 | Guardian -- SN-54 (2) clear/clear (air) | 0.537535 | 0.281122 | 0.29053 |
| 403 | Guardian -- AG 50 (#2) clear/clear (air) | 0.501623 | 0.331478 | 0.29846 |
| 404 | Guardian -- Royal Blue 40 (#2) clear/clear (air) | 0.378816 | 0.311473 | 0.31436 |
| 405 | Guardian -- Silver 32 (#2) clear/clear (air) | 0.285322 | 0.303346 | 0.41899 |
| 500 | AFG -- Ti-AC 23 (2) clear/clear (air) | 0.381933 | 0.235021 | 0.29295 |
| 501 | AFG -- Ti-AC 36 (2) clear/clear (air) | 0.650264 | 0.359361 | 0.29057 |
| 502 | AFG -- Ti-AC 40 (2) clear/clear (air) | 0.679321 | 0.391198 | 0.29366 |
| 503 | AFG -- Ti-PS (2) clear/clear (air) | 0.74414 | 0.531519 | 0.30054 |
| 504 | AFG -- E2 (2) clear/clear (air) -- pyrolytic | 0.730005 | 0.626497 | 0.34361 |
| 505 | AFG -- Ti-PS (2) clear/clear/clear (argon) -- triple | 0.662828 | 0.484723 | 0.18982 |
| 506 | AFG -- Ti-AC 36 (2) clear/clear/clear (argon) -- triple | 0.579456 | 0.3255 | 0.18135 |
| 507 | AFG -- Ti-PS (2) + E2 (5) clear/clear/clear (argon) -- | 0.617423 | 0.462254 | 0.14968 |

# AIA TAP WEBCAST

11-18-2014

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Questions?