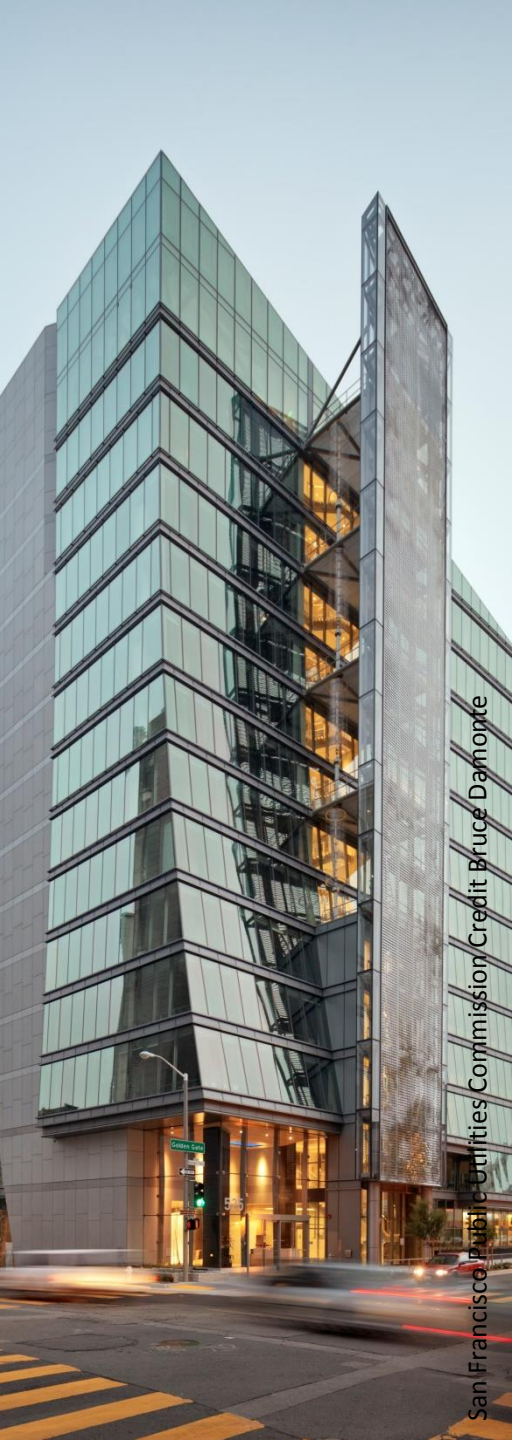
San Francisco Public Utilities Commission/Credit Bruce Damonte

Transition to Net Zero: Design Paradigms for Creating Ultra-Efficient Buildings

May 28, 2014

Mark Frankel
Technical Director
New Buildings Institute

David Kaneda
Principal
Integral Group

Clark Brockman
Principal
SERA Architects

nbi new buildings institute

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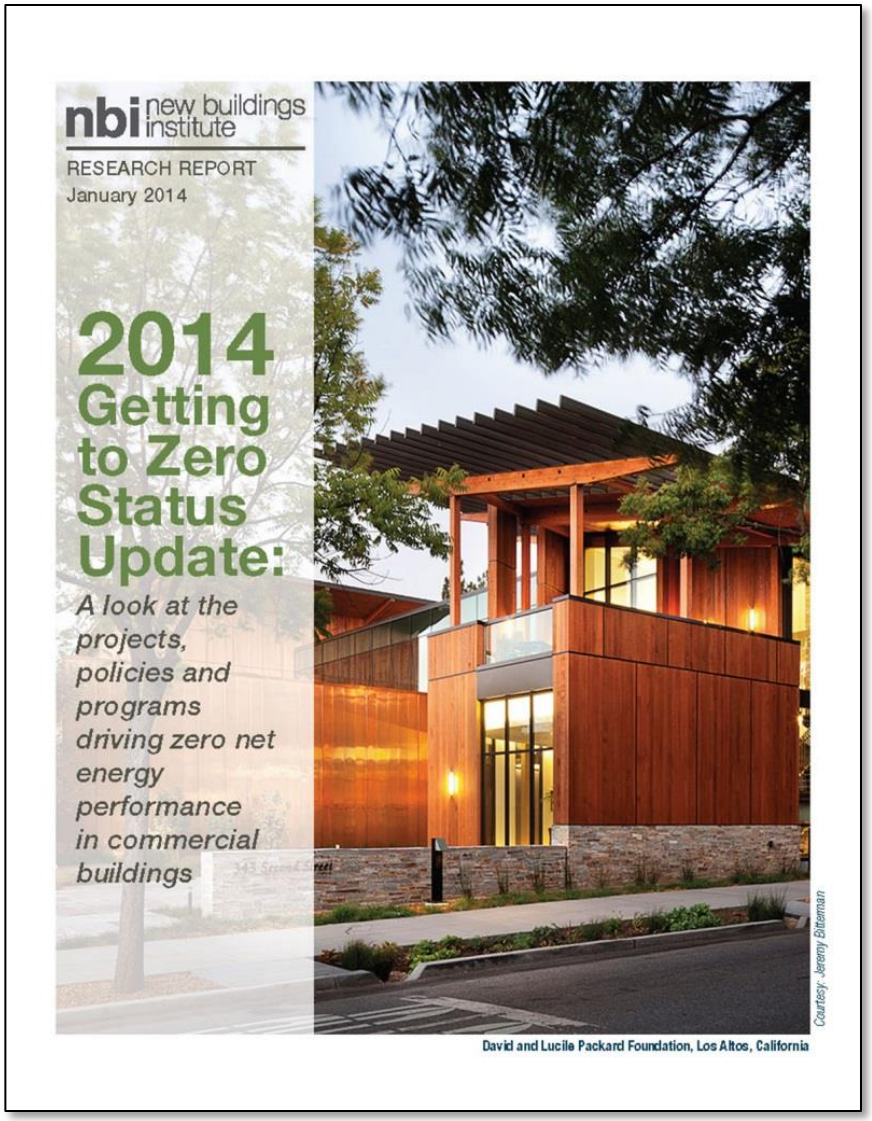
nyserda
Energy. Innovation. Solutions.

nationalgrid

Efficiency Vermont

2014 Getting to Zero Status Update



Transformation to Net Zero

Buildings

Policy and Code

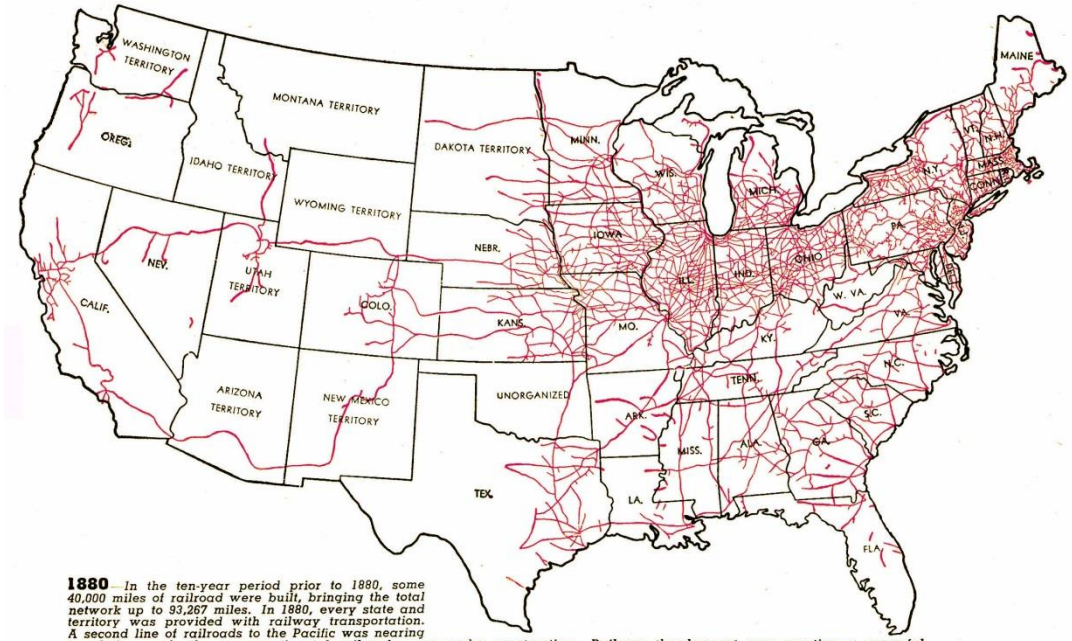
Design Process

Technologies and Market

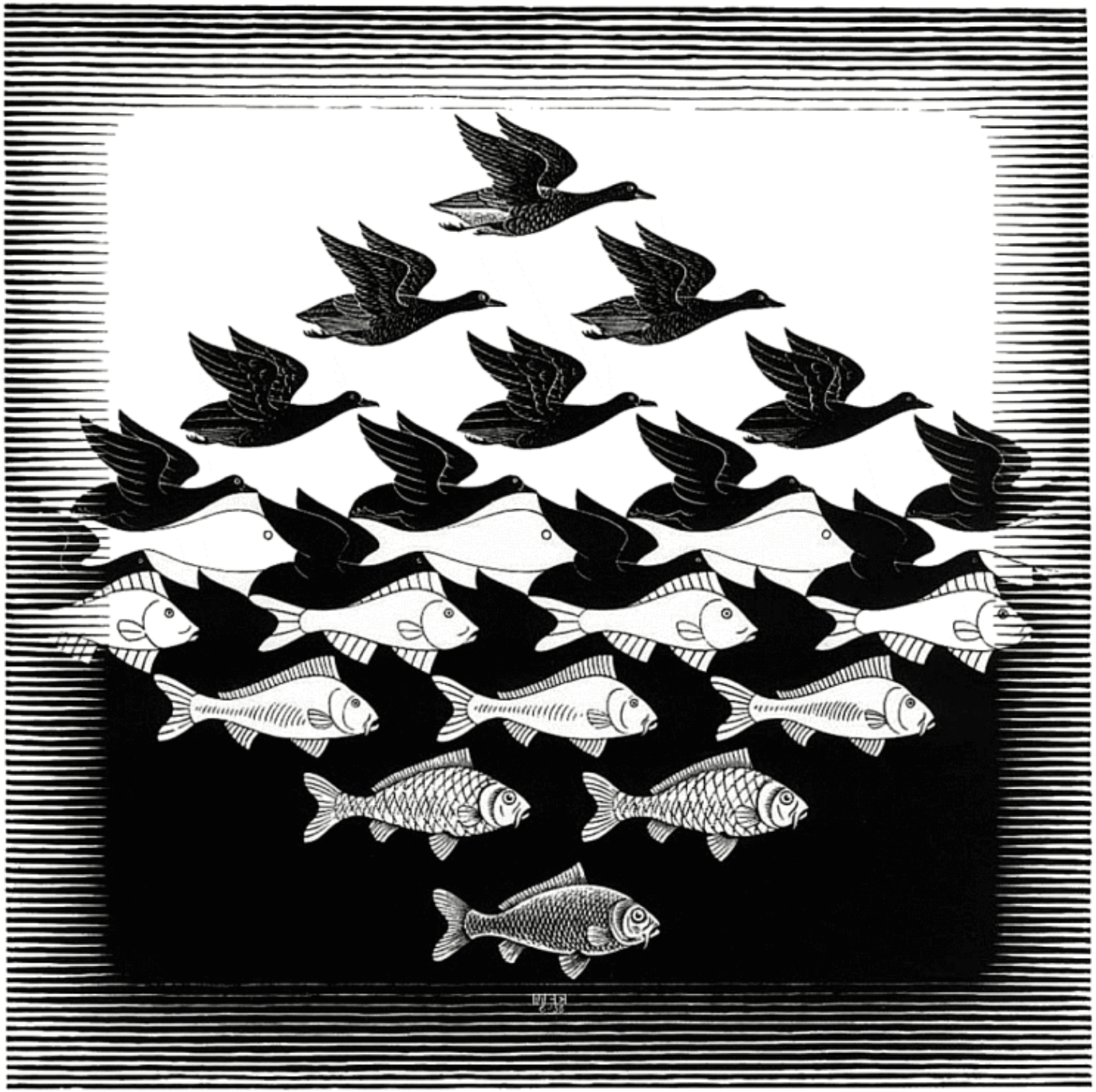
Canals ~1840

www.lib.utexas.edu

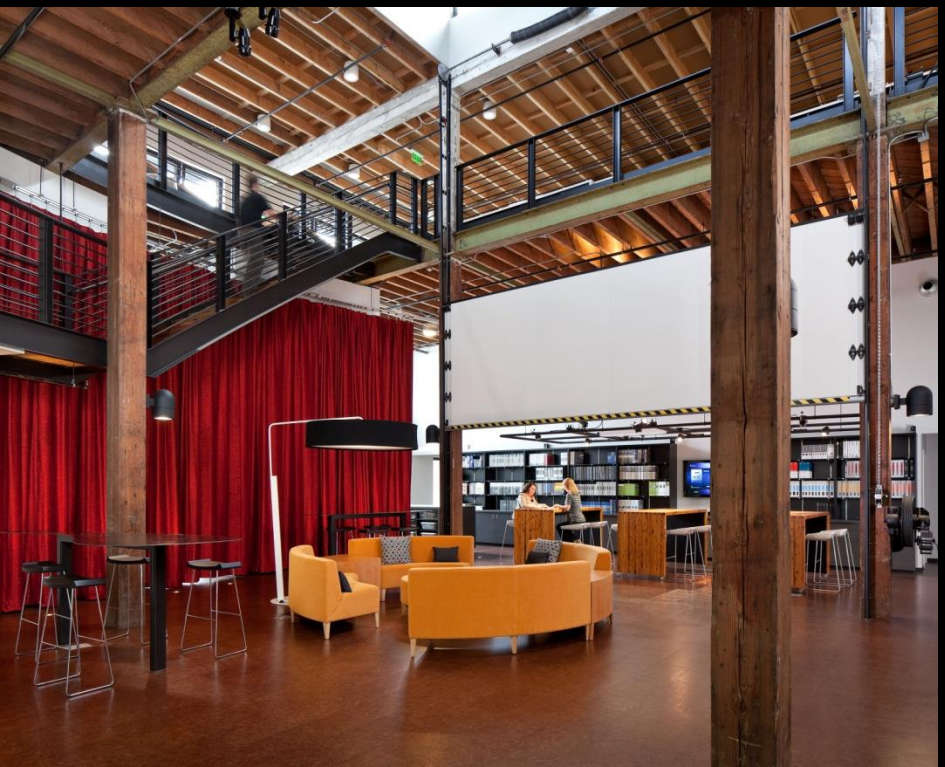
Railroads ~1880



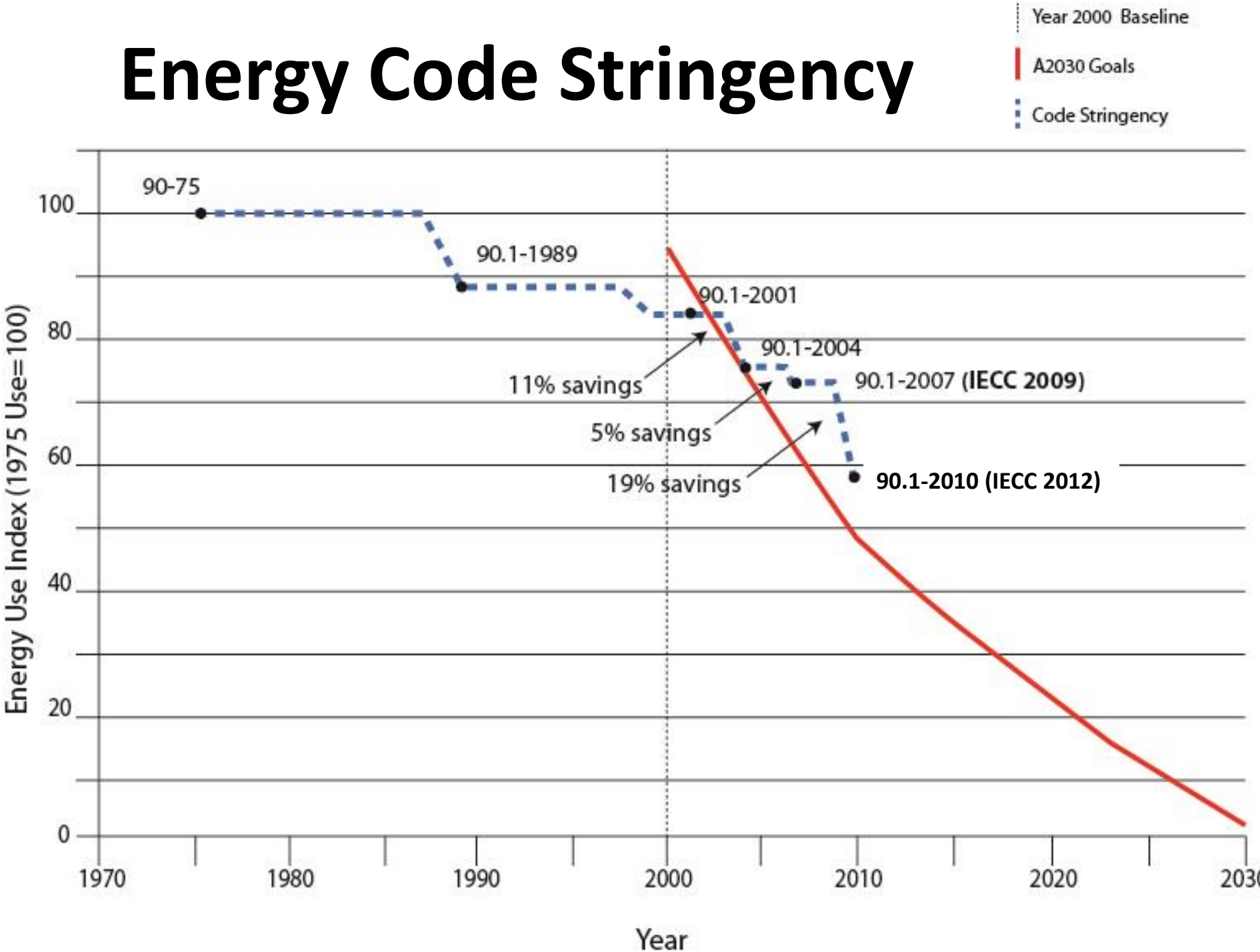
1880—*In the ten-year period prior to 1880, some 40,000 miles of railroad were built, bringing the total network up to 93,267 miles. In 1880, every state and territory was provided with railway transportation. A second line of railroads to the Pacific was nearing completion, and other transcontinental railroads were under construction. Railway development was exerting a powerful influence upon immigration and agricultural and industrial growth throughout the country.*



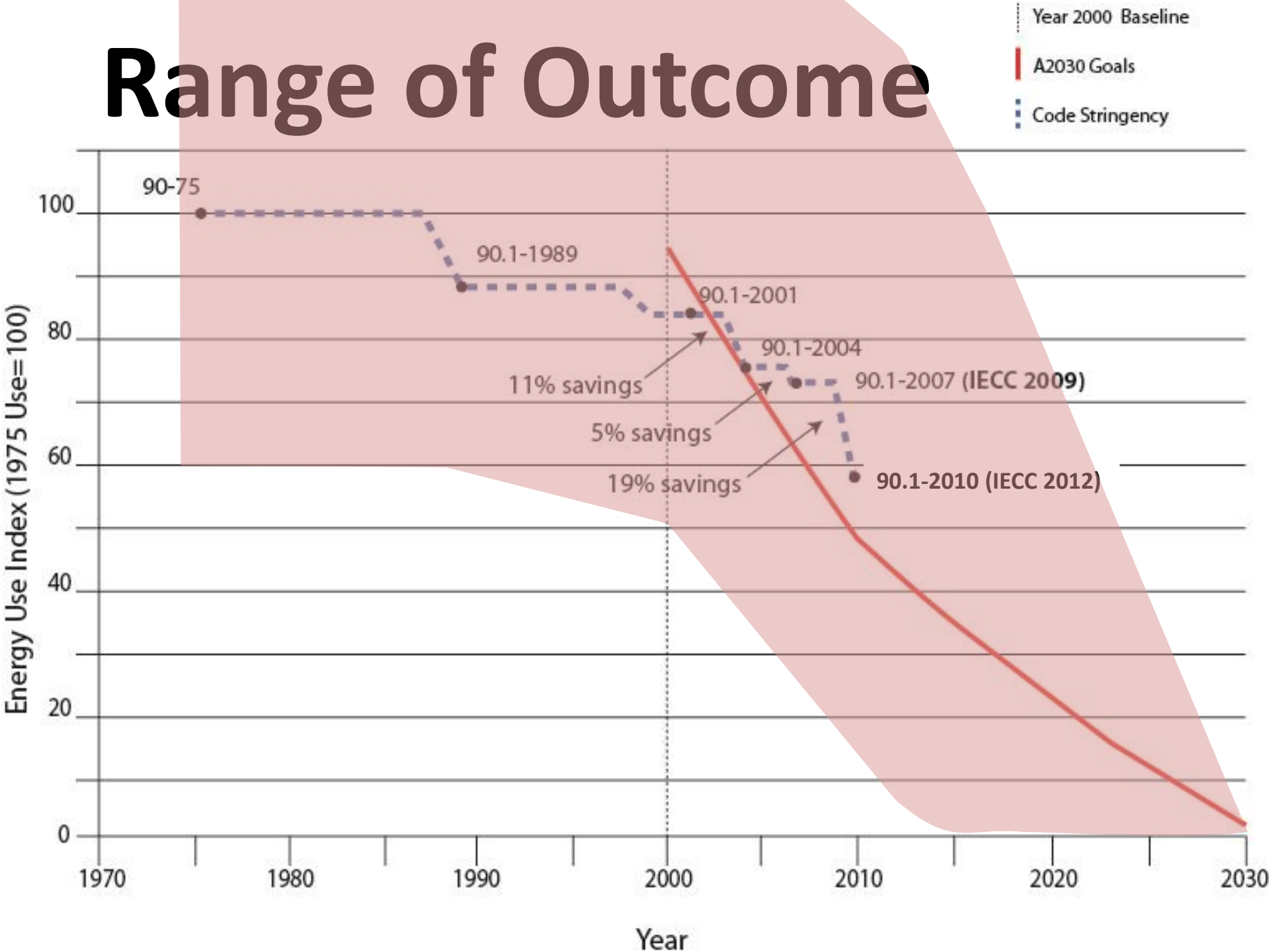

261



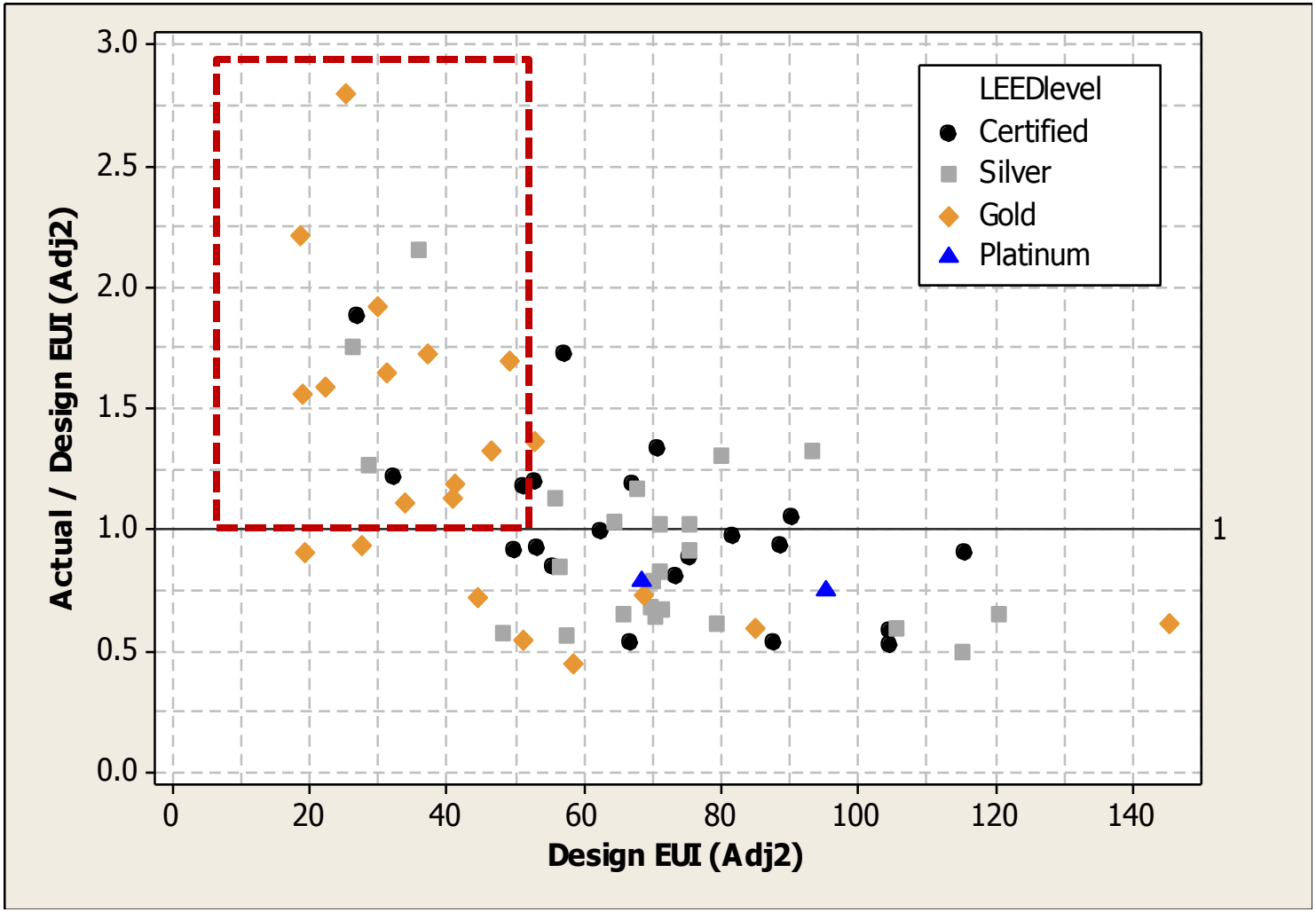
Energy Code Stringency



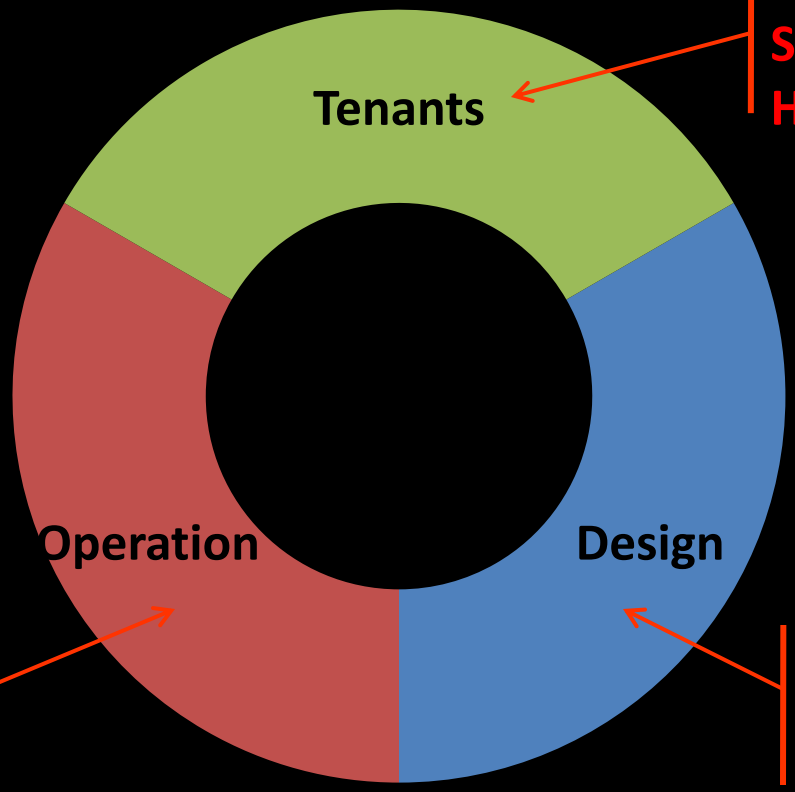
Range of Outcome



Performance Expectations vs. Outcome



Different Players Affect Building Performance

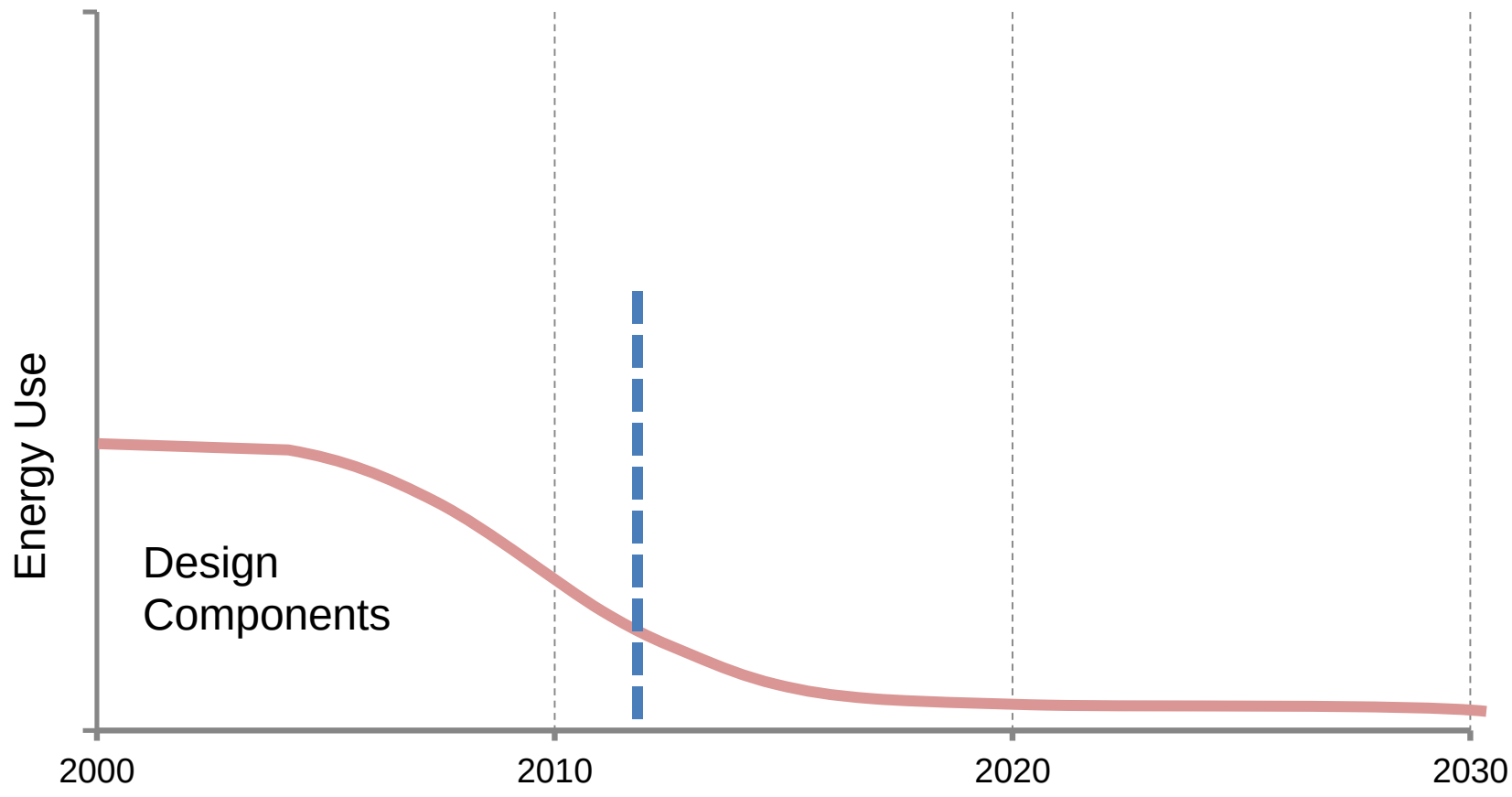


Computers and Equipr
Schedule
Habits

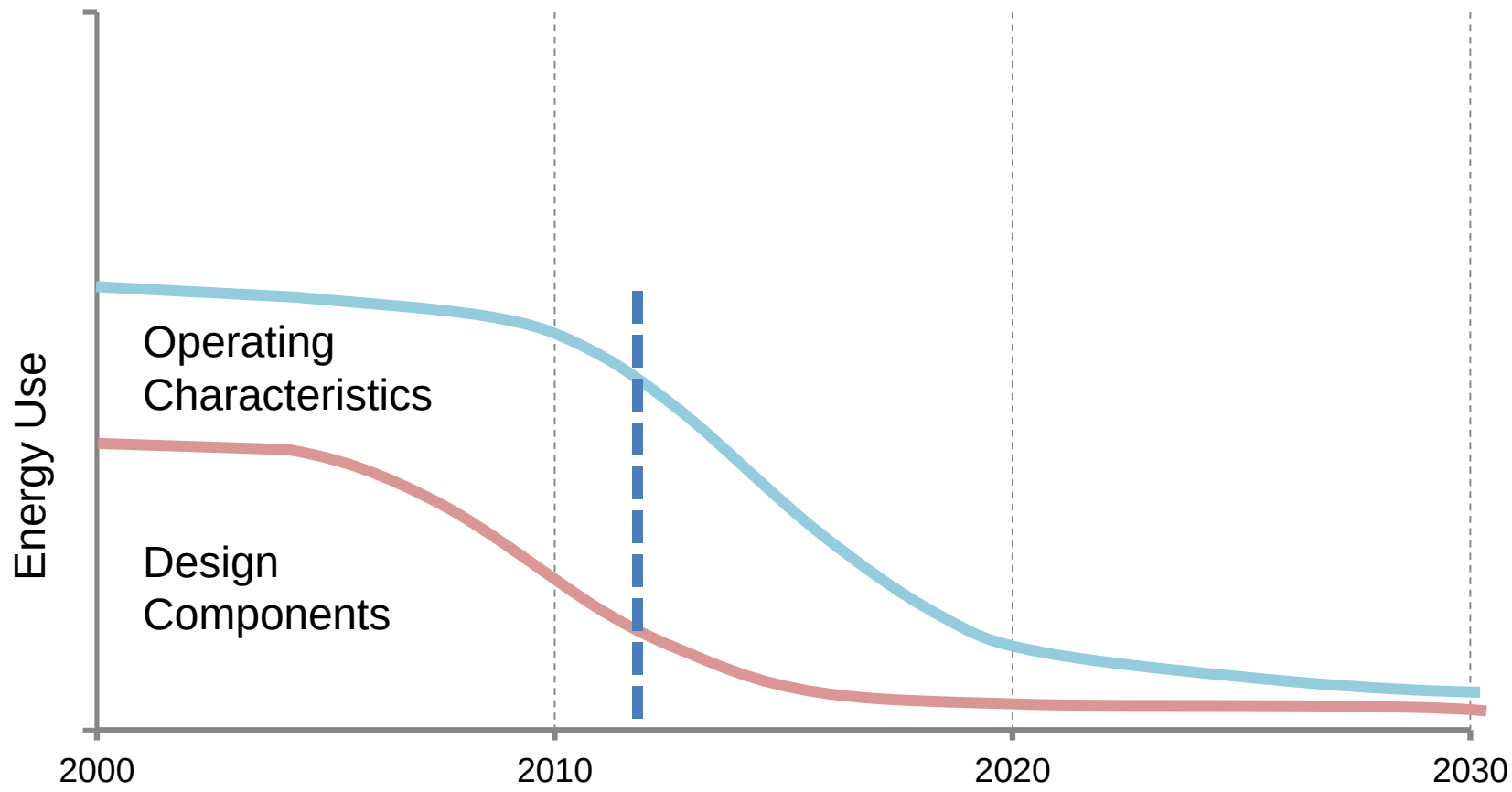
Staffing
Controls
Maintenance
Commissioning

Layout
Integration
Installation
Components and Fe

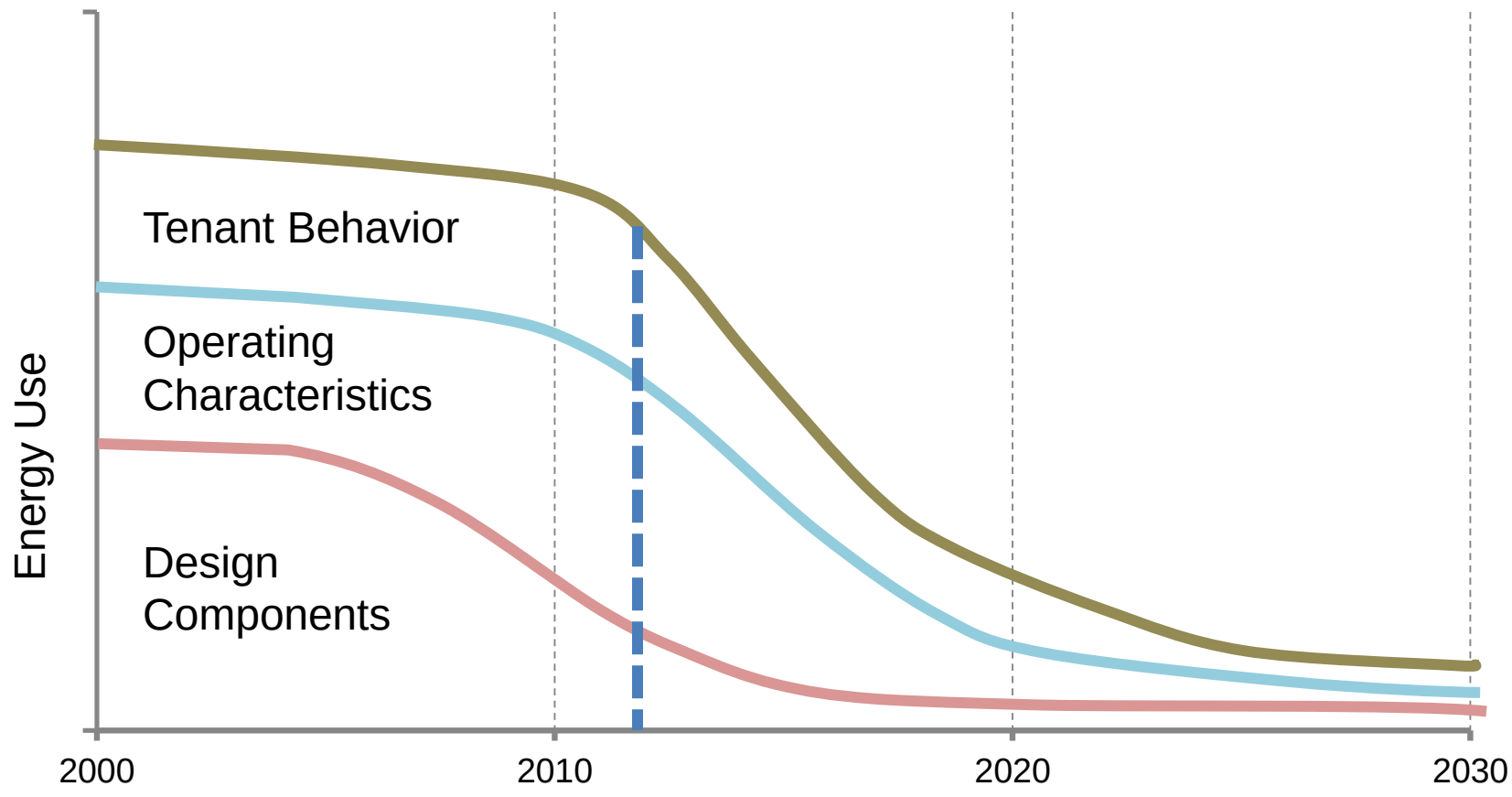
Components of energy outcomes



Components of energy outcomes



Components of energy outcomes



Plug Load Power Density
Measured Performance (W/SF)

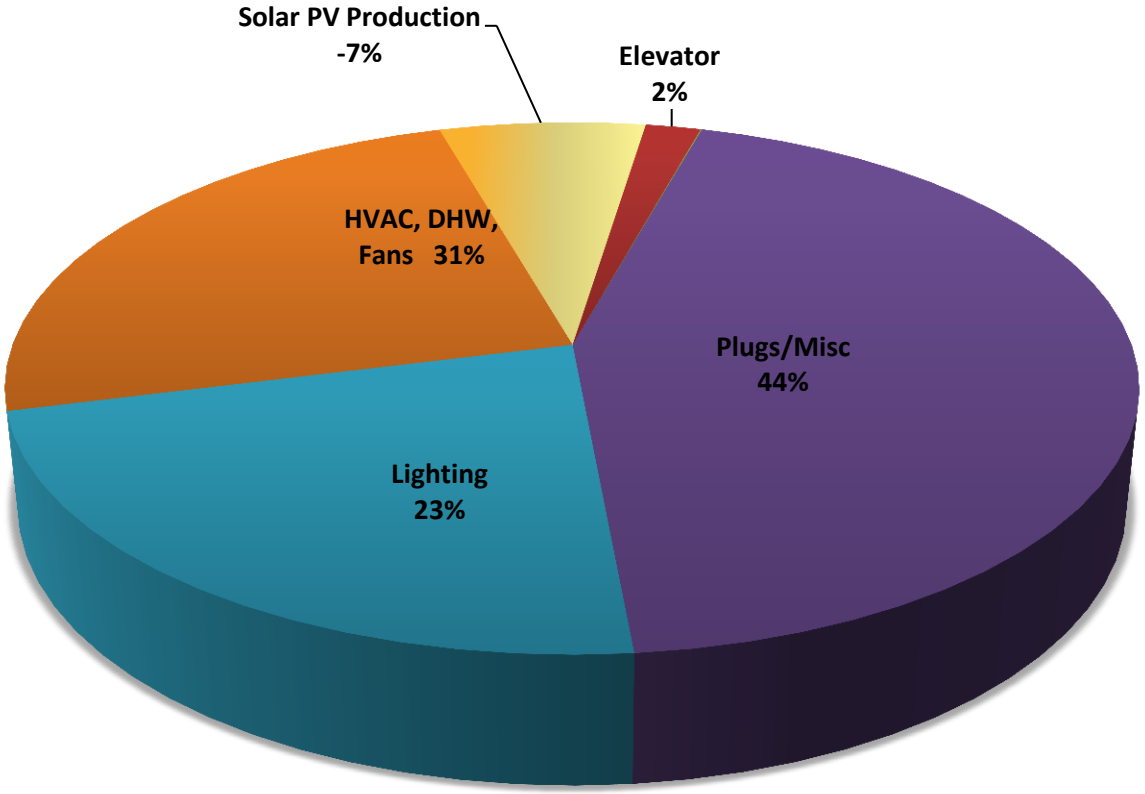
Office Location:	Size (SF)	Average Weekday Daytime	Average Weekday Night	Measured Peak	% of total at night	Ratio of Plug Load to Lighting Load
Irvine, CA 1	8,328	0.8	0.4	1.6	**47%**	**4x**
Irvine, CA 2	1,500	0.8	0.6	1.8	**70%**	**2x**
Rosemead, CA	16,500	0.5	0.3	0.7	**63%**	**equal**
Los Angeles, CA	8,024	1.5	1.46	2.1	**97%**	**5x**
Vancouver, BC	9,000	0.6	0.3	0.8	**49%**	**1.2x**

Source: nbi Office of the Future Pilot Project Monitoring

End Use in HP Buildings

RFM: Energy End Use based on 16 months

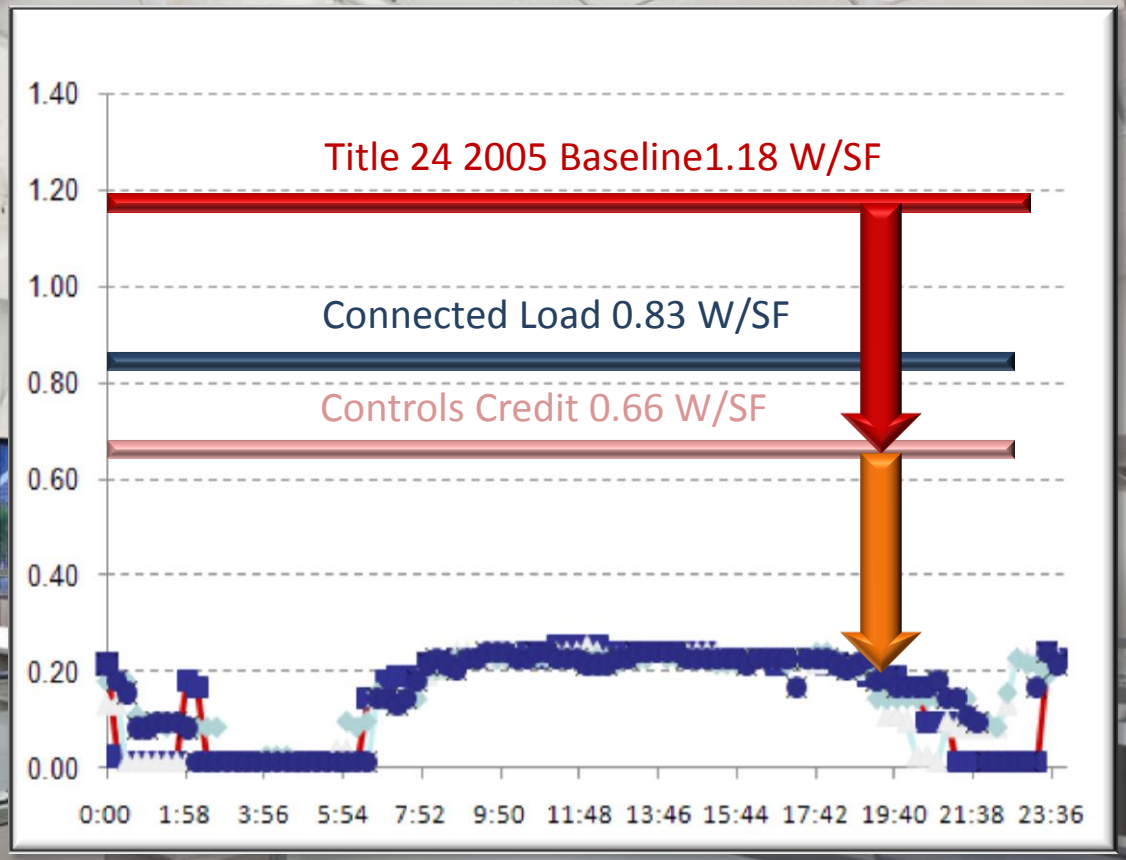
EUI = 20 kBtu/sf/yr



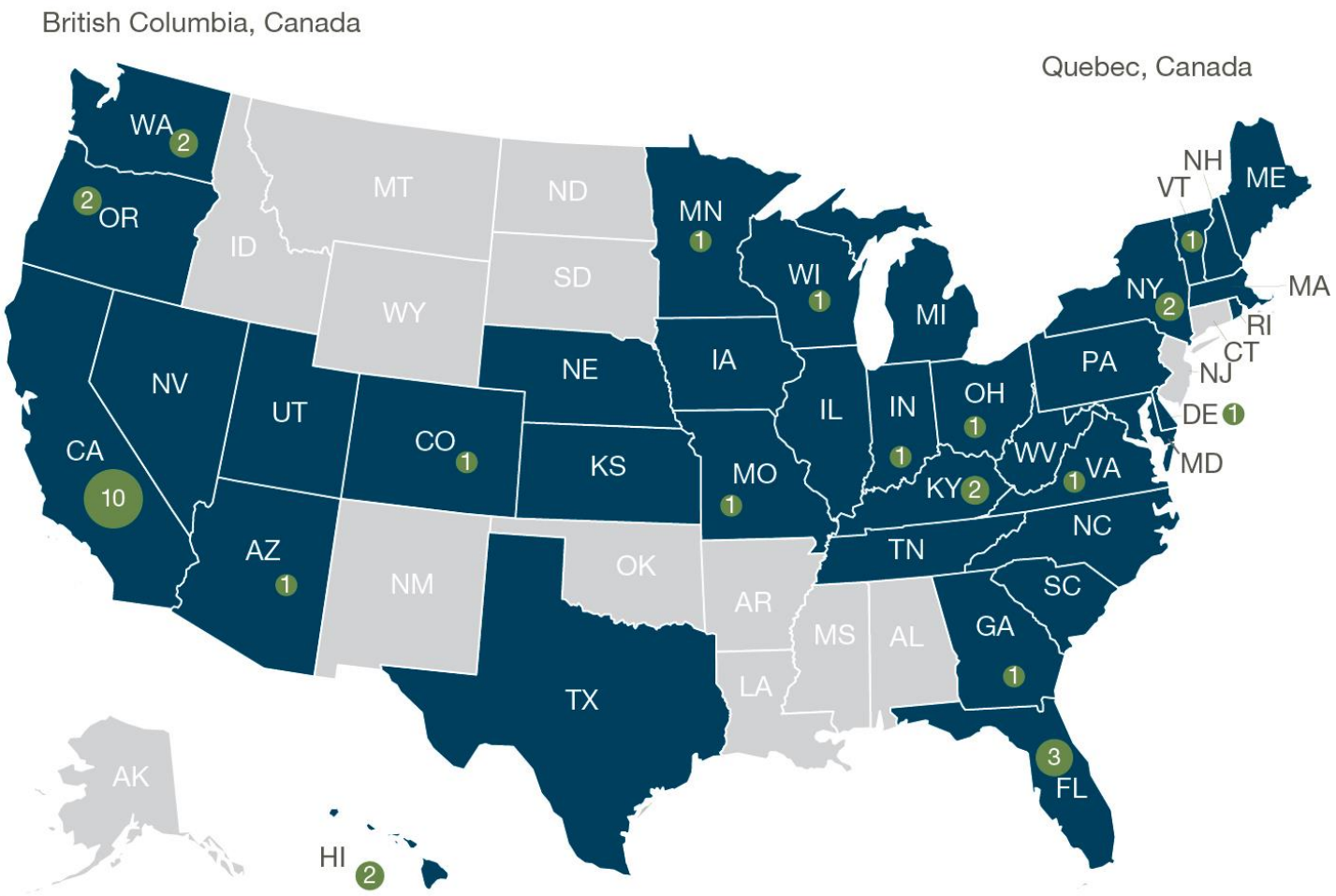
- Solar Produced
- Elevator
- Plugs/Misc
- Lighting
- HVAC,DHW,Fans

Office of the Future Program

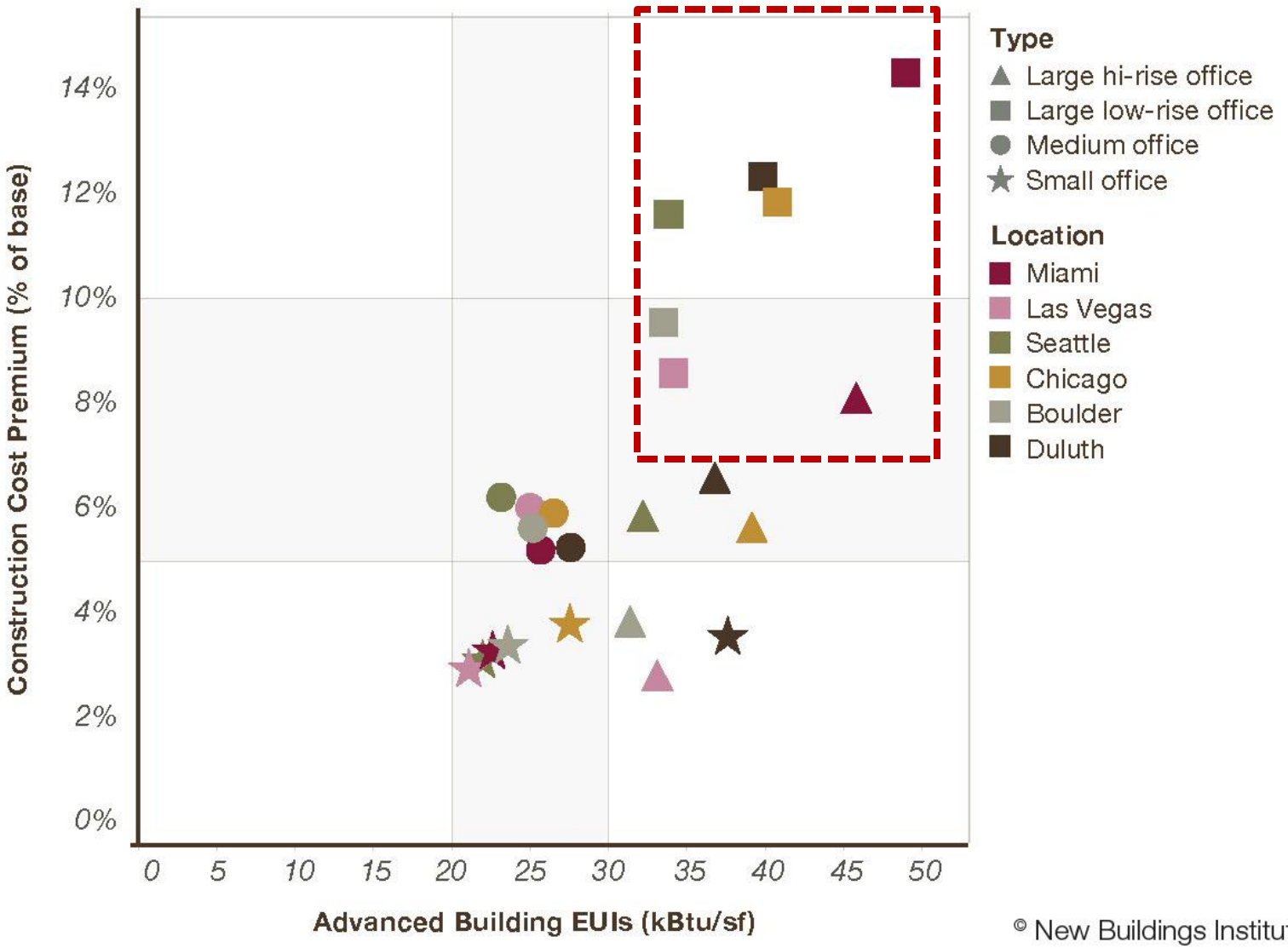
- Single-Fixture Task-ambient (task light provides ambient)
- All building lighting on occupancy sensors
- Private offices 50% auto-on with occupancy sensors, all lights auto-off



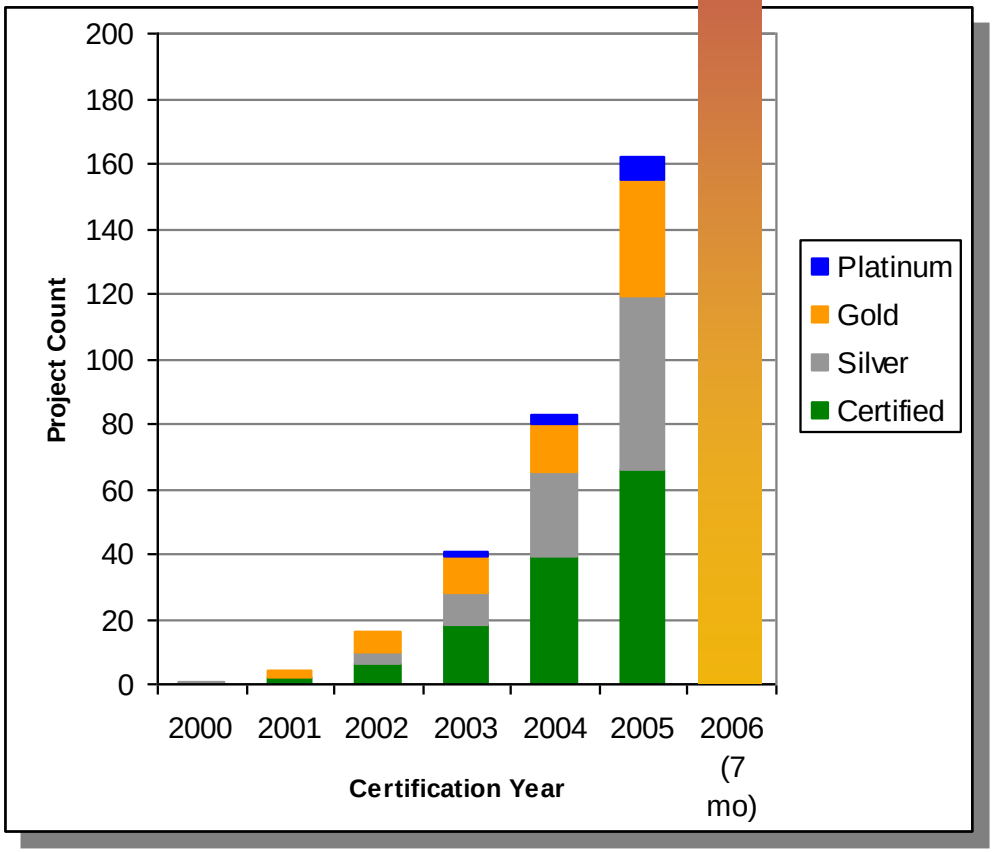
Courtesy of Glumac


British Columbia, Canada
Quebec, Canada
WA 2
OR 2
CA 10
NV
ID
MT
WY
UT
AZ 1
CO 1
NM
ND
SD
NE
KS
OK
TX
MN 1
IA
MO 1
AR
LA
WI 1
IL
MS
MI
IN 1
KY 2
TN
AL
OH 1
WV
GA 1
FL 3
SC
NC
VA 1
PA
NY 2
VT
NH
ME
1
MA
RI
CT
NJ
DE 1
MD
AK
HI 2

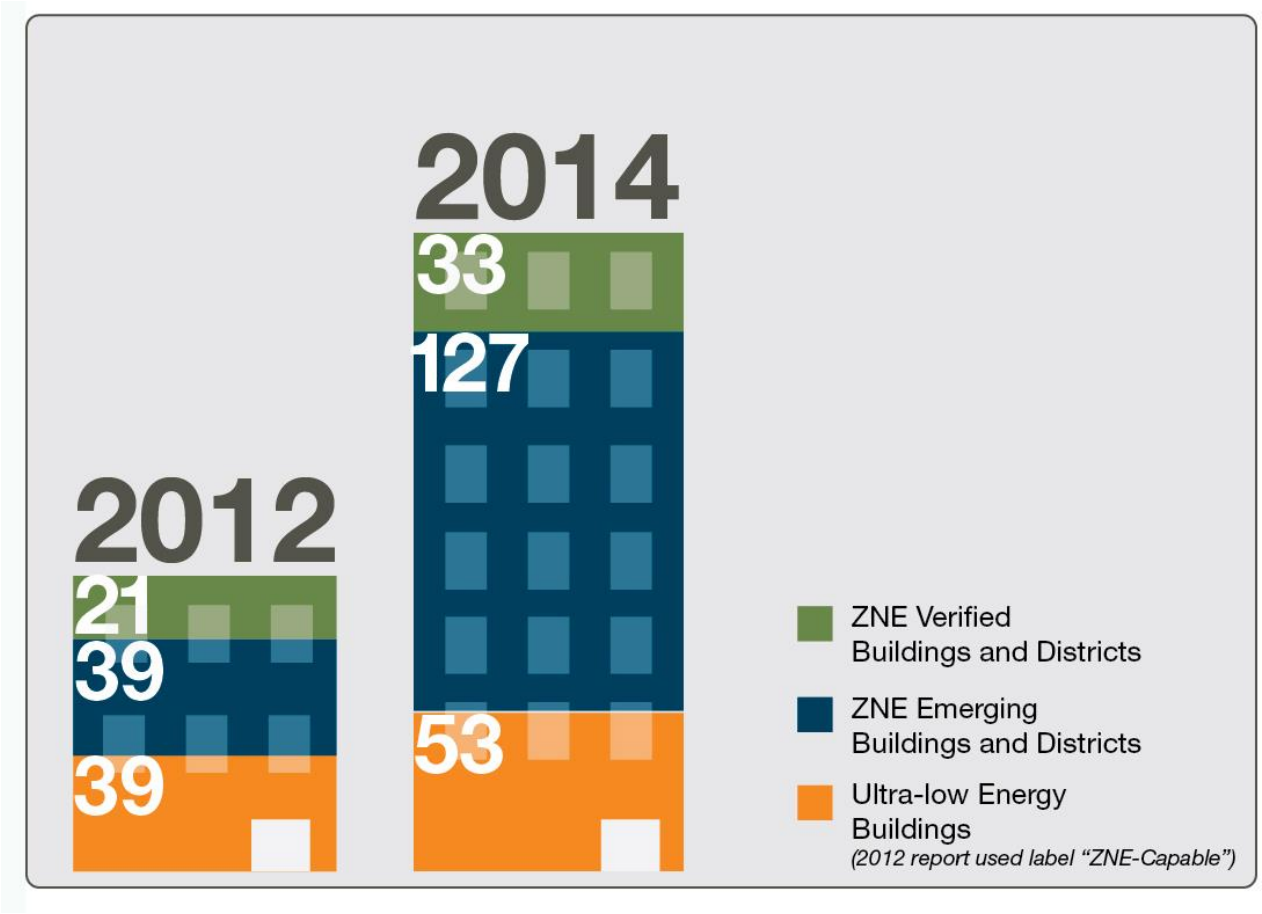
Efficiency First



Total LEED Projects



Number of Projects from 2012 to 2014



"That Which Exists Must Be Possible"

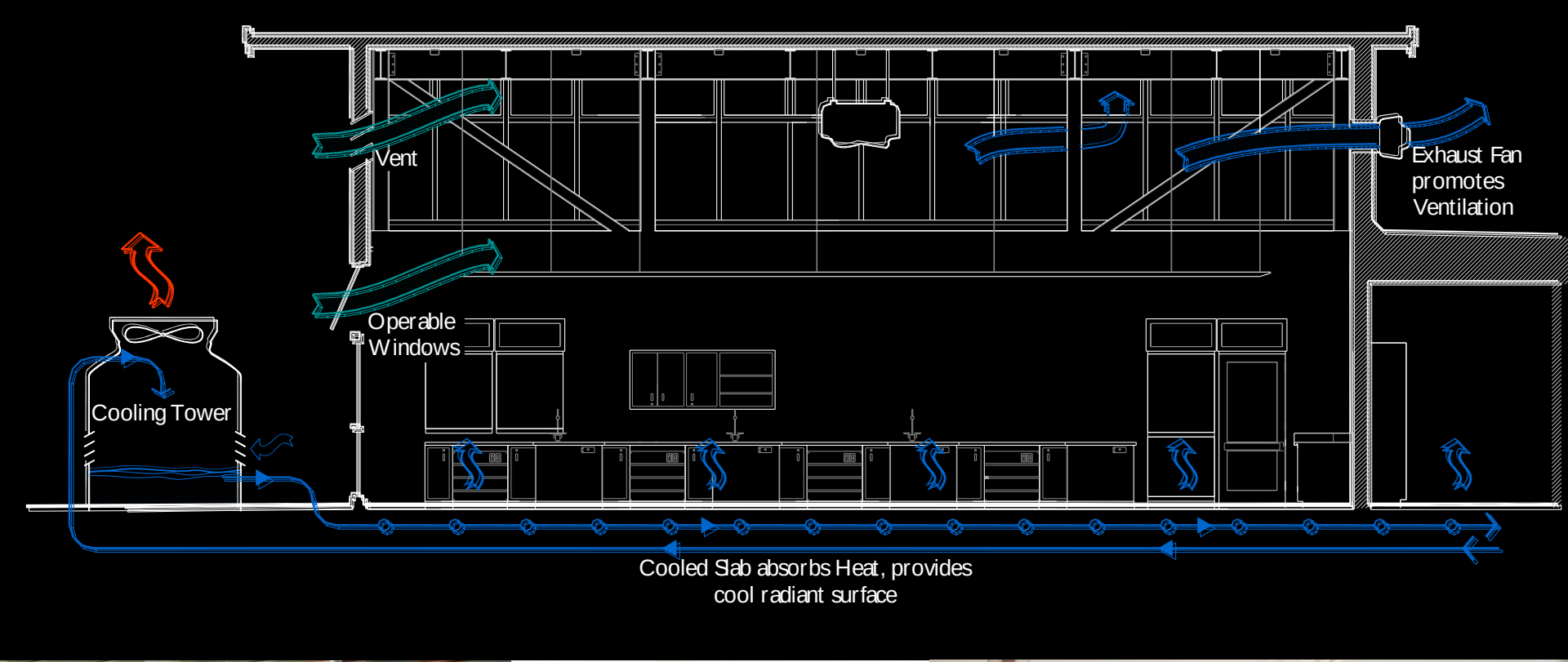
INTEGRAL GROUP

Net Zero Energy (r)Evolution

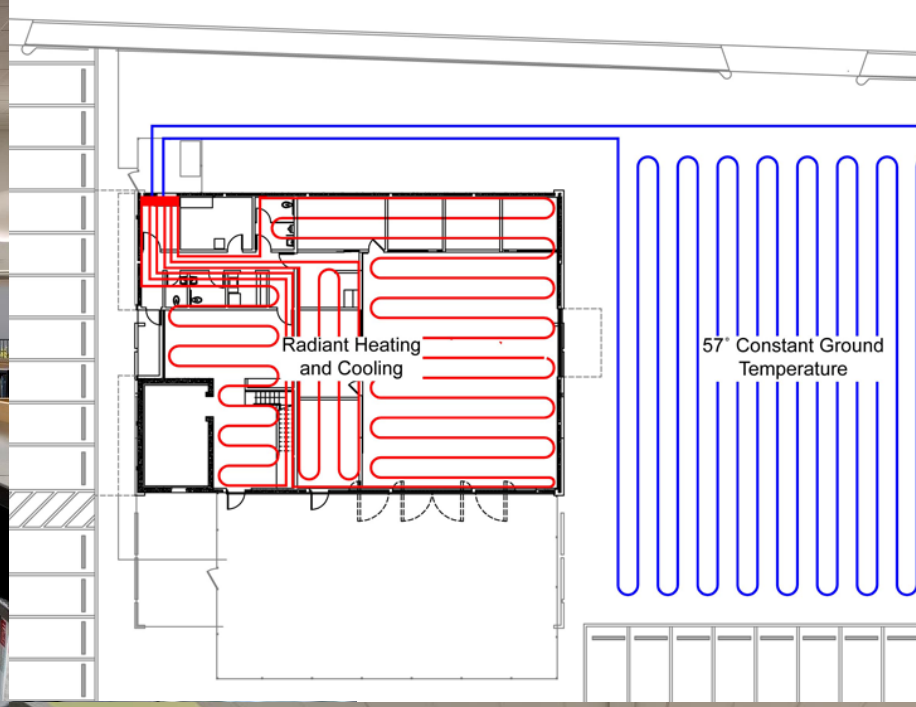
DEEP GREEN ENGINEERING

David Kaneda, PE, FAIA, LEED AP
Managing Principal :: Electrical Design Leader
Integral Group

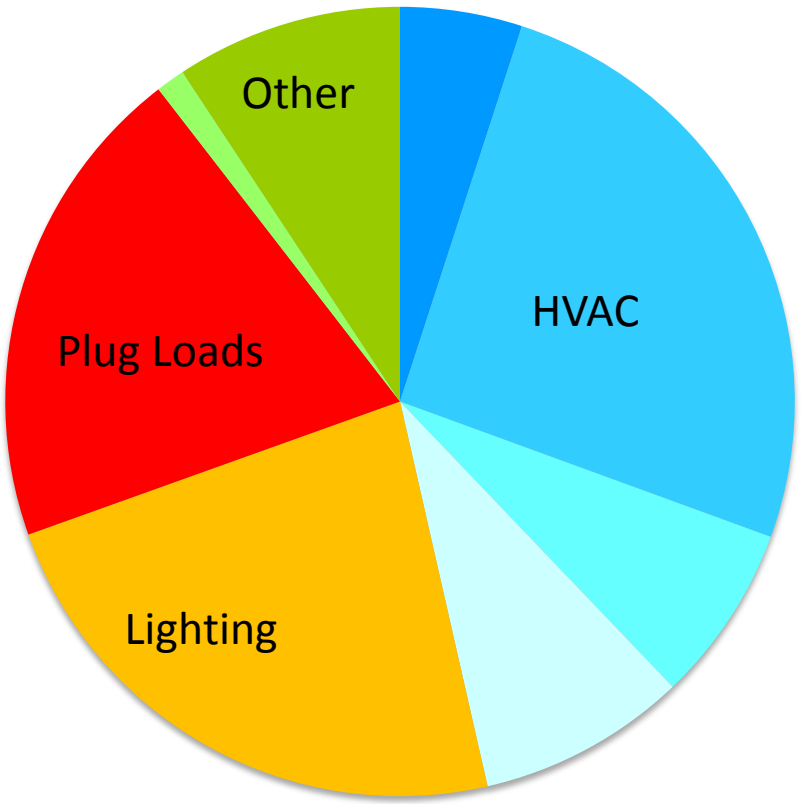
Westmont High School Science Education Building
Dreiling Terrones Architects
Grid Neutral


Vent
Exhaust Fan promotes Ventilation
Operable Windows
Cooling Tower
Cooled Slab absorbs Heat, provides cool radiant surface

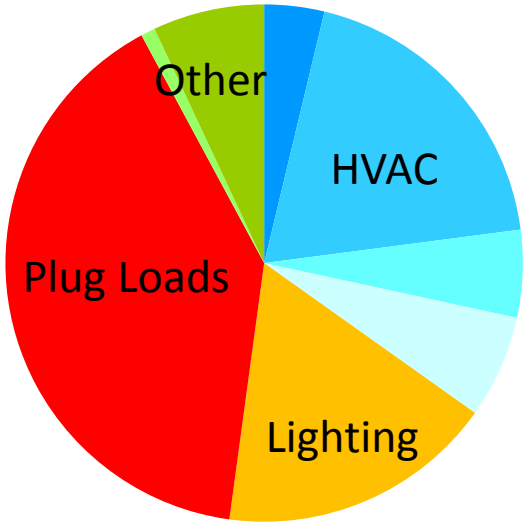
IDeAs Z^2 Design Facility
EHDD Architecture
First – ILFI certified Net Zero Energy


Radiant Heating
and Cooling
57˚ Constant Ground
Temperature

Reduce Plug Loads

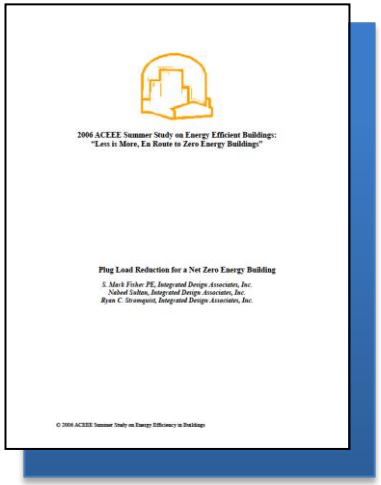


Standard Commercial Building

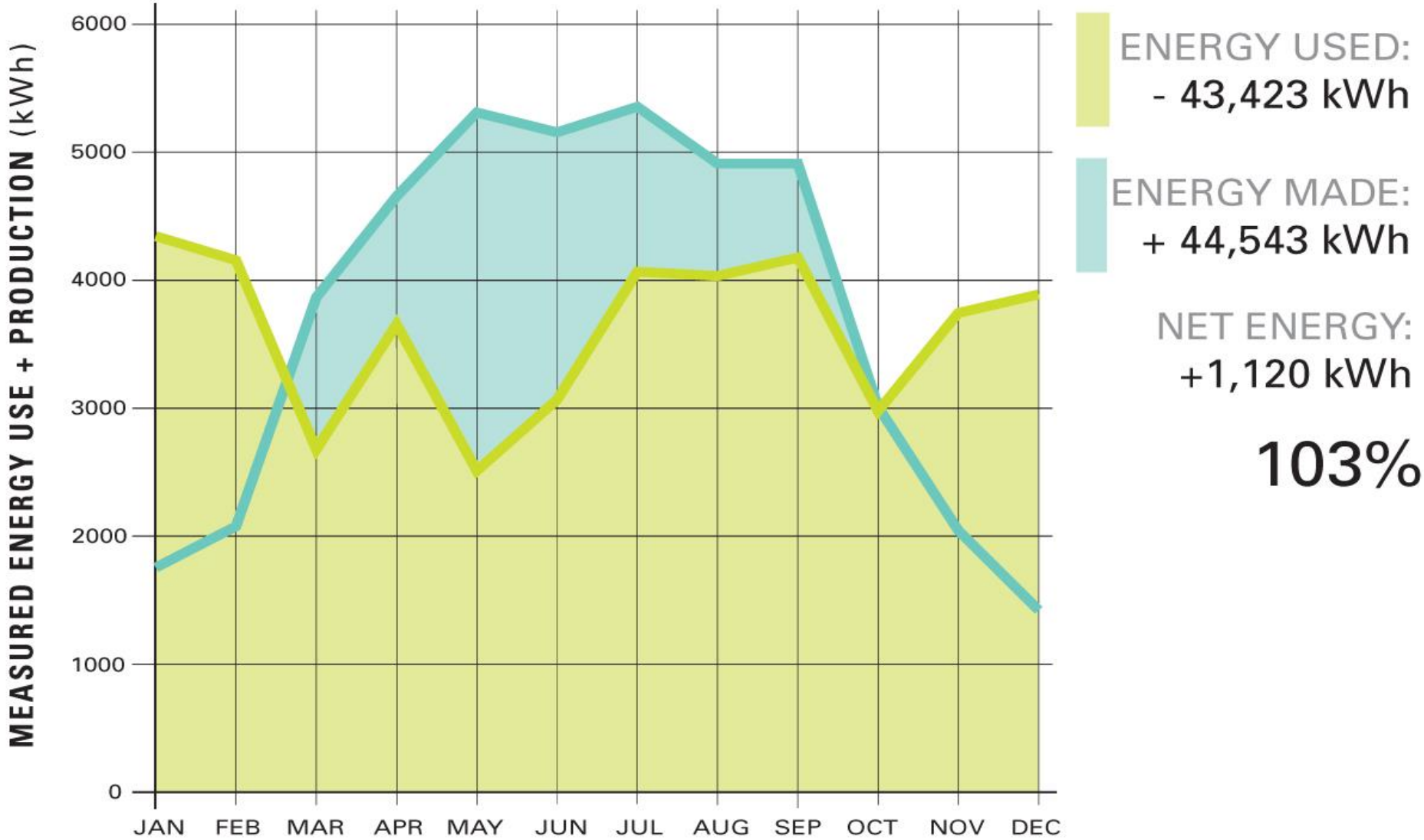


High Efficiency Design

~50% below standard



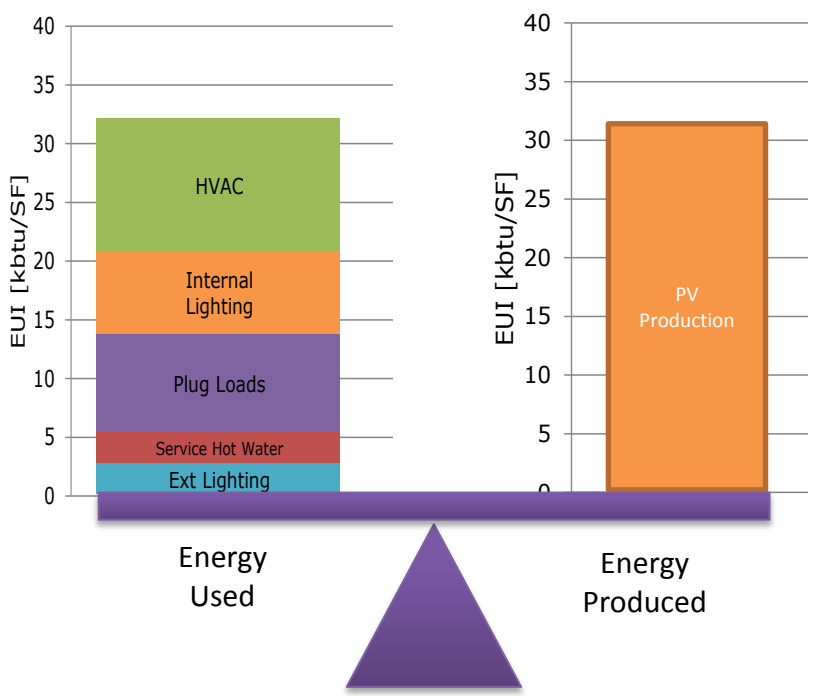
Production > Consumption

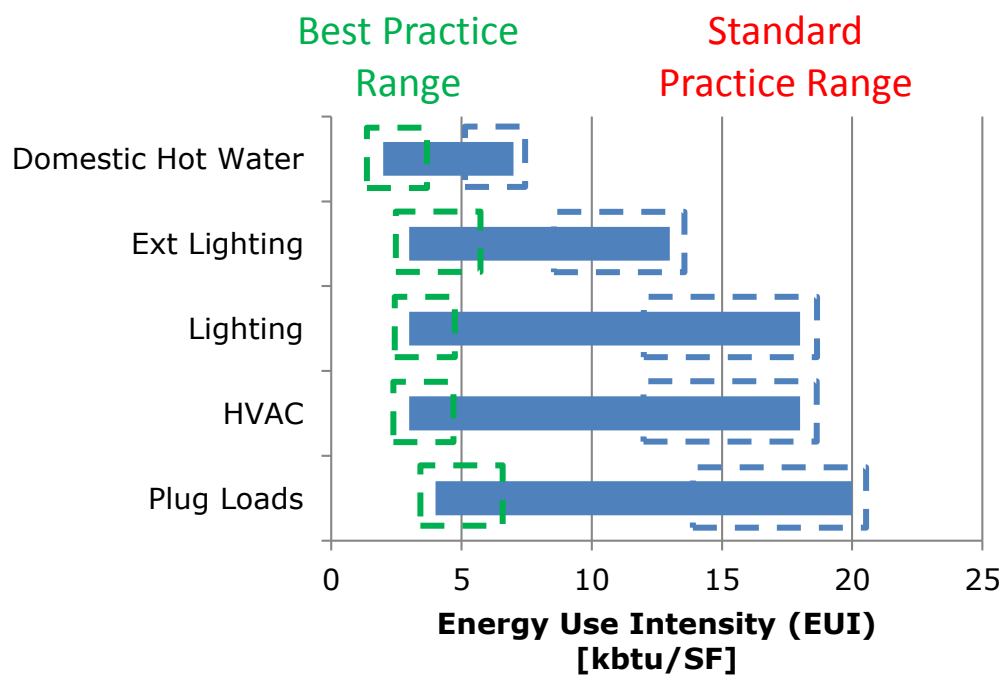



NREL RSF
RNL Architects
Largest verified Net Zero Energy

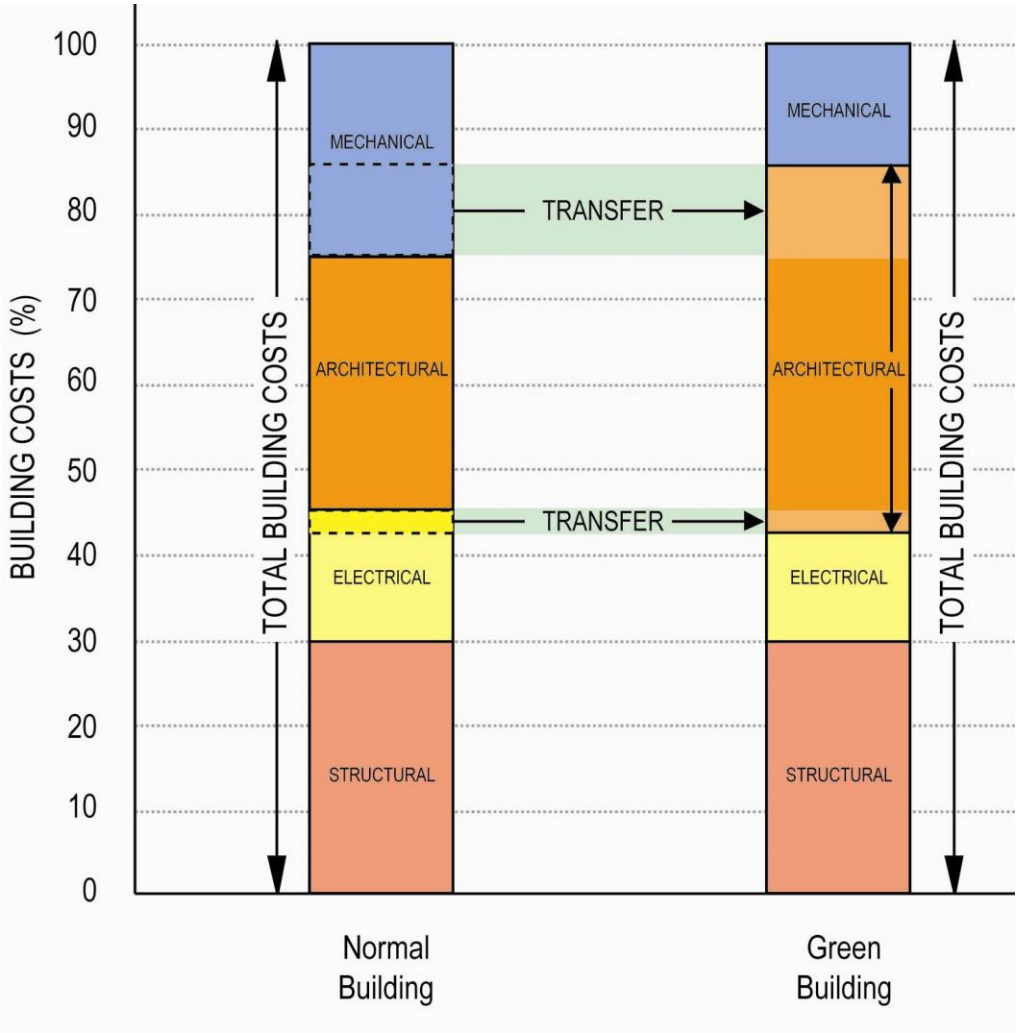
Set an Energy Budget

- Set a maximum energy budget to help make design decisions
- Understanding "Best Practices" in the context of the Energy Budget

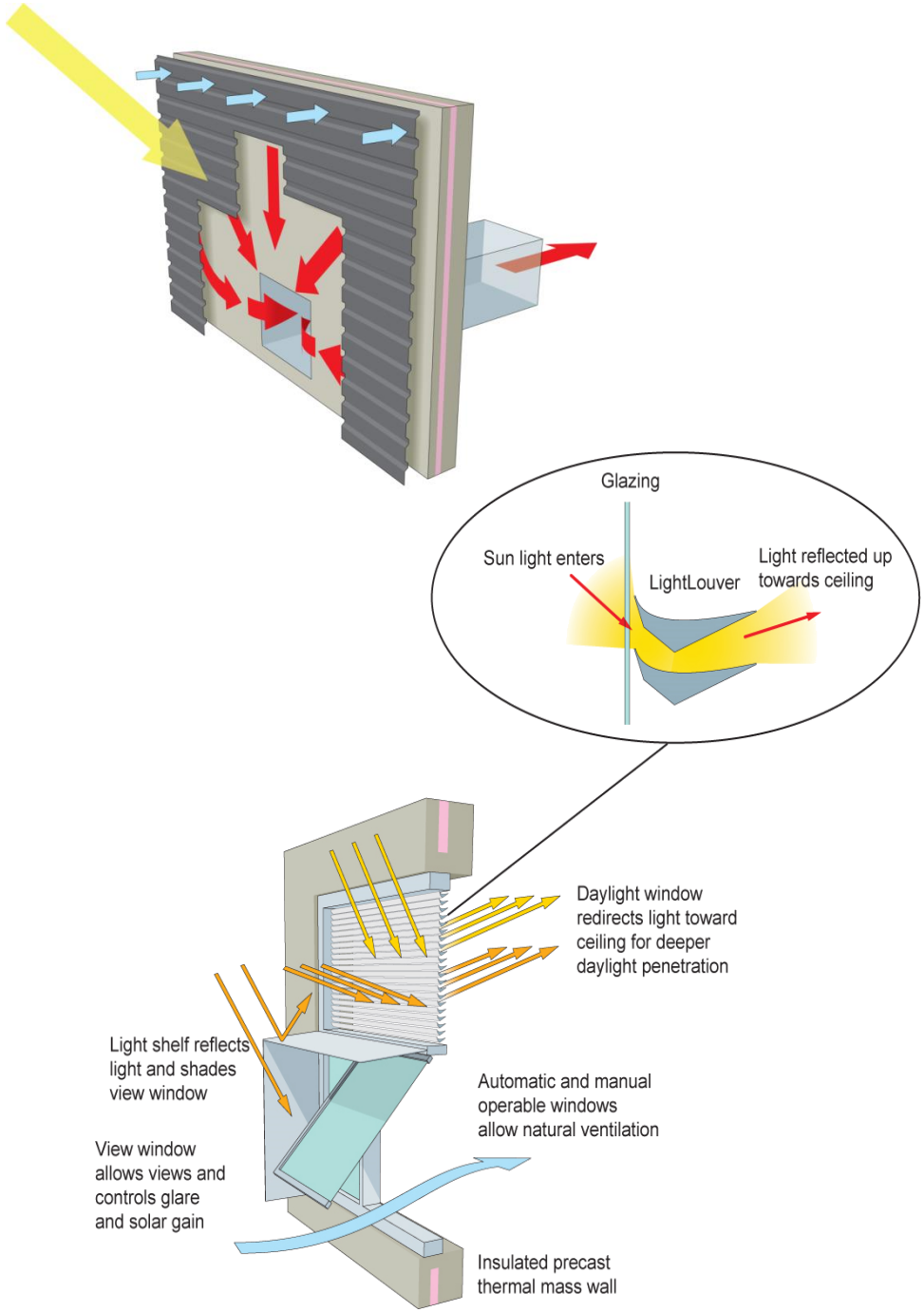


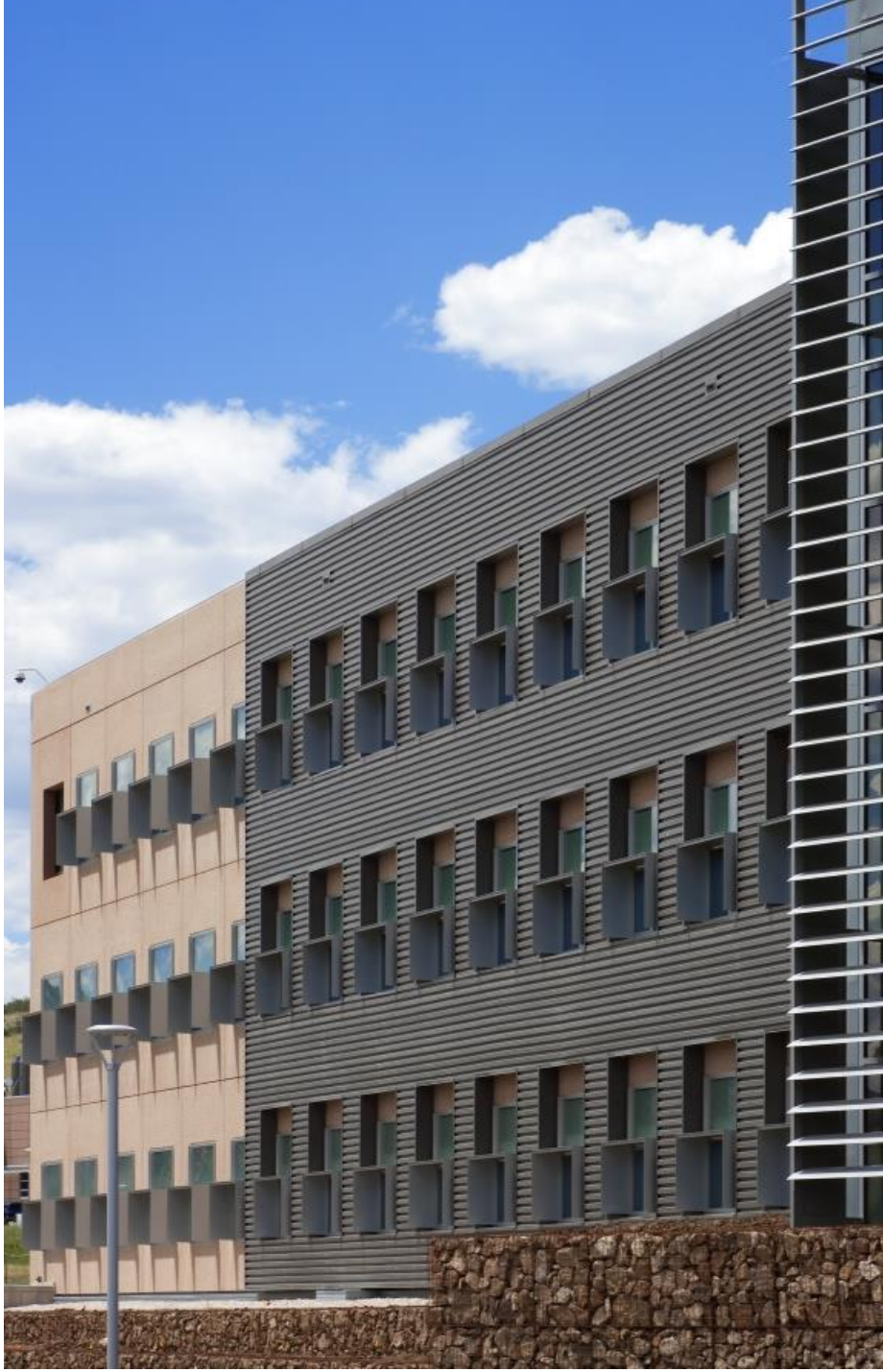


Cost Transfer

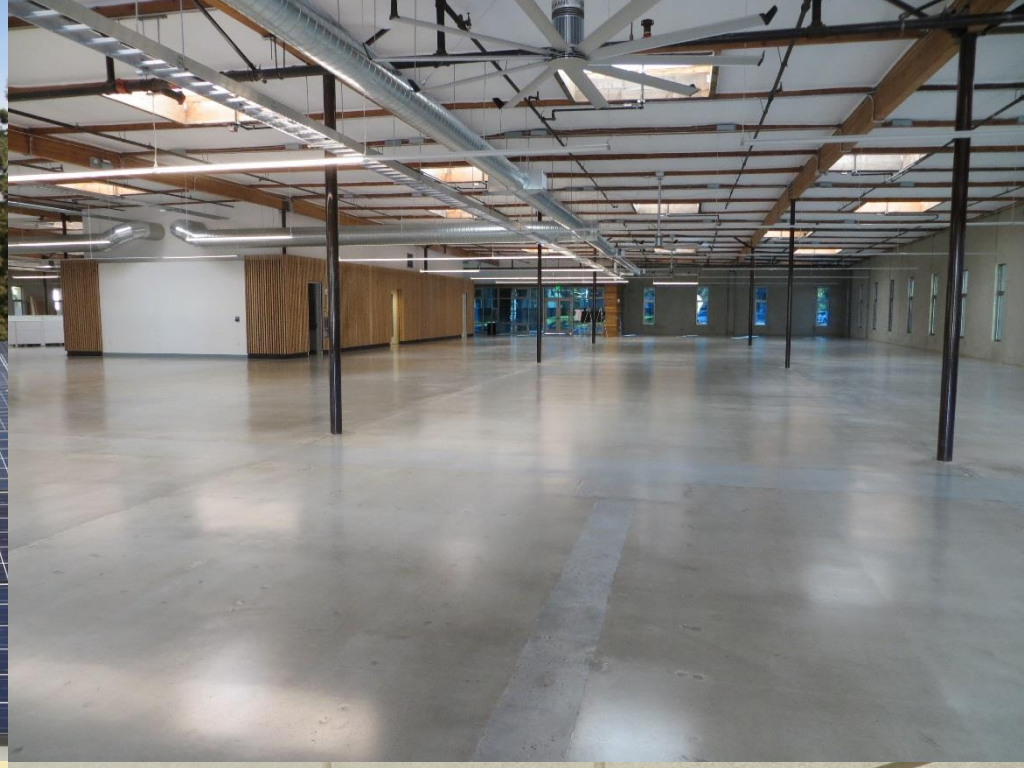


- ✓ Total cost same
- ✓ Mechanical cost less
- ✓ Invest in Architecture
- ✓ Active to passive
- ✓ Fragile to robust
- ✓ Longer life
- ✓ Less cost over life
- ✓ Simpler


Glazing
Sun light enters
LightLouver
Light reflected up towards ceiling
Daylight window redirects light toward ceiling for deeper daylight penetration
Light shelf reflects light and shades view window
Automatic and manual operable windows allow natural ventilation
View window allows views and controls glare and solar gain
Insulated precast thermal mass wall




435 Indio
RMW Architects
Net Zero Energy Spec Office



Net Zero Energy for Profit

- Performance based lease (carrot and stick for good occupant behaviour)
- Reduced reserve requirements (HVAC, lamp replacement)
- Reduced operating expenses (utilities, maintenance, etc)
- Reduced churn expenses (faster leasing)
- Reduced miscellaneous costs (unanticipated savings – no roof mechanical screen)

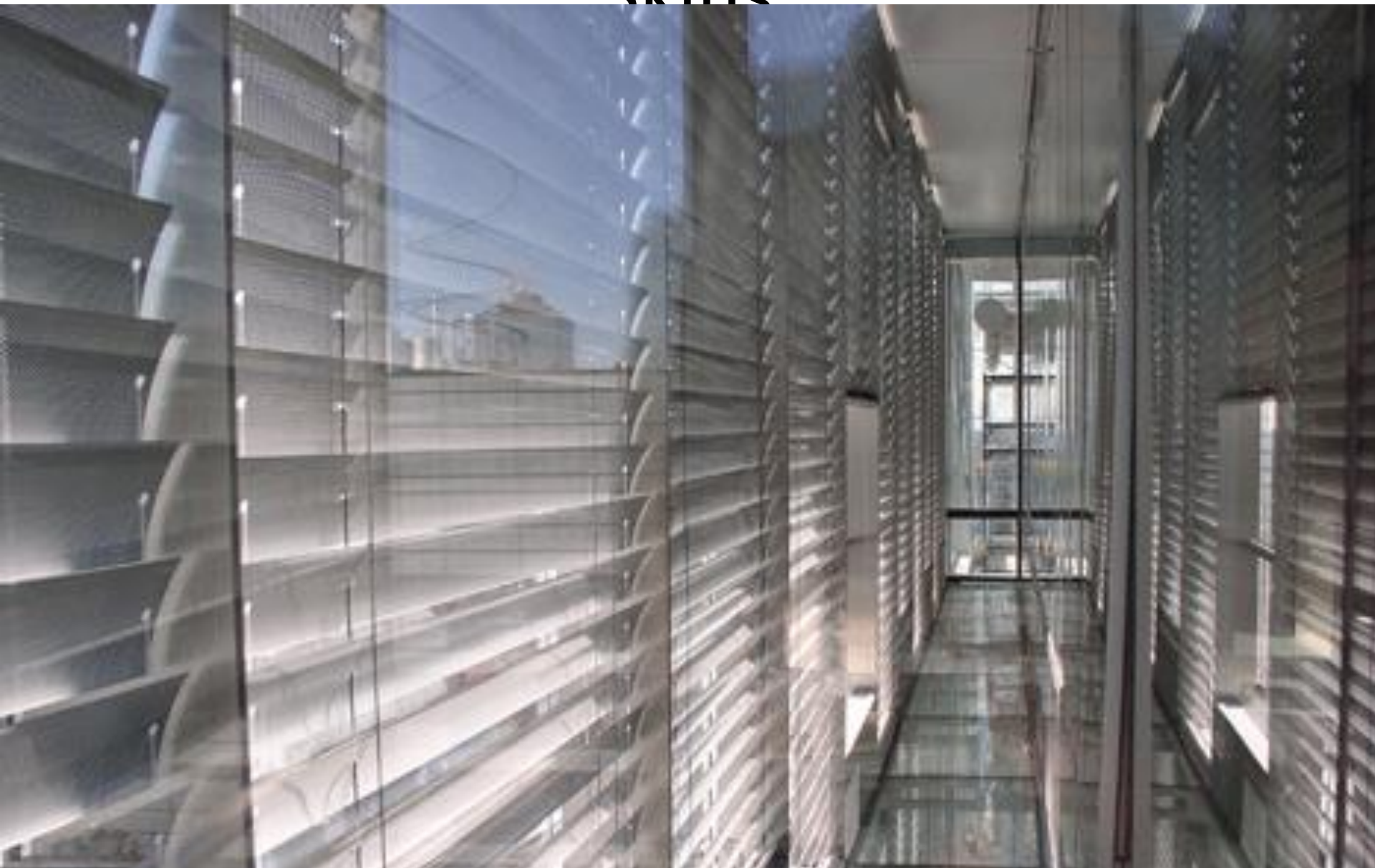
- $54/sf added construction cost (including PV array) offset by reduced expenses
- Annual operation savings: $163 K
- Fast lease: LOI in 3 months vs. anticipated 18 mo = $1.5 M
- 16 month payback

Looking Forward

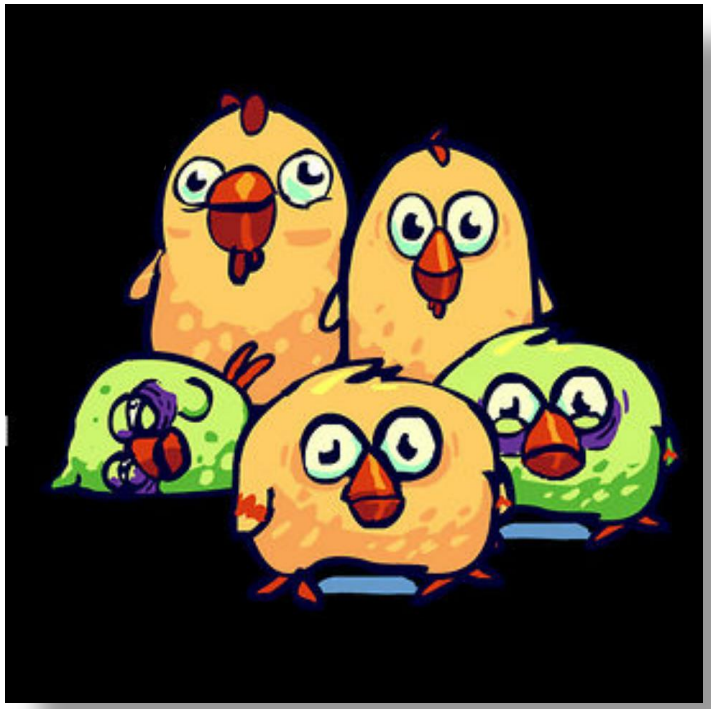
Integrated Design

Complex yet Simple

New Technologies for Building Skins



User Involvement



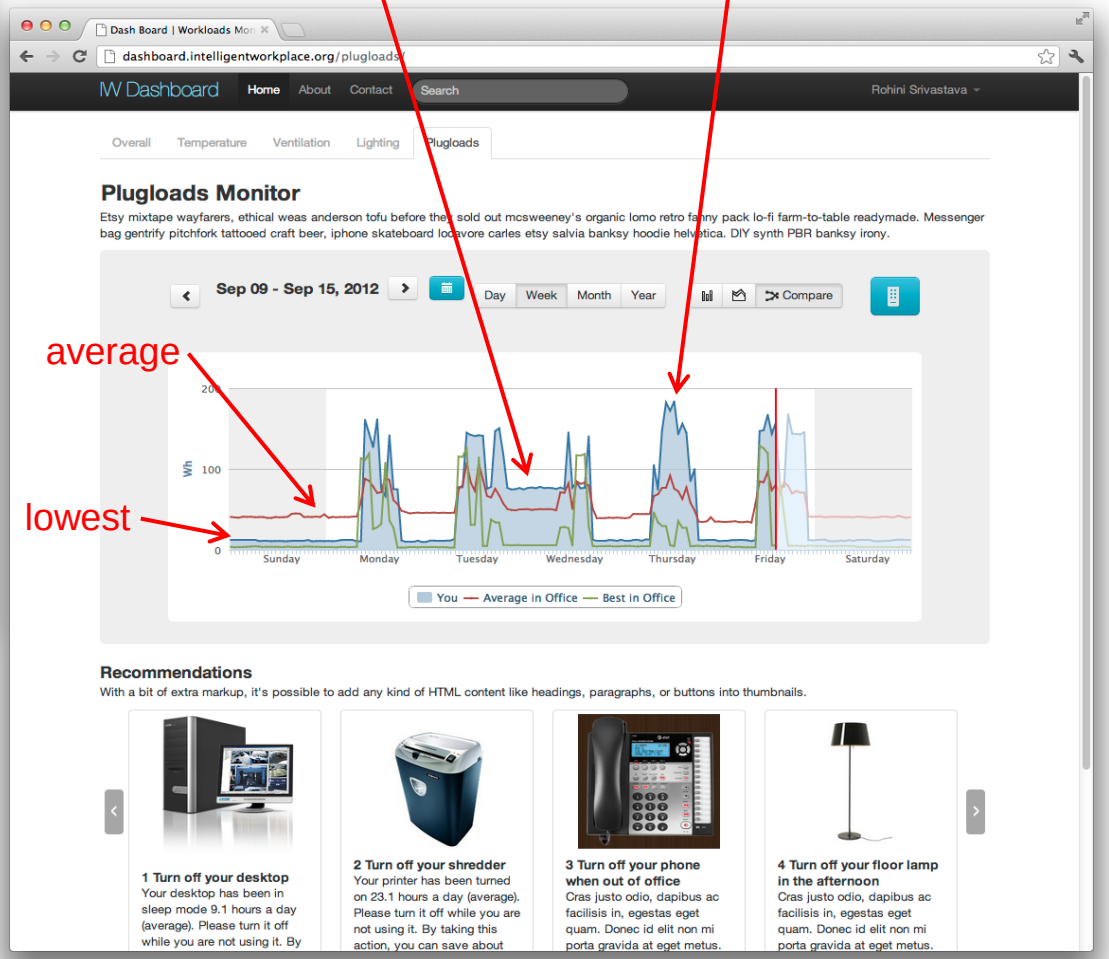
Courtesy: Brian Orland
Penn State University

Whoops, desktop on overnight!

YIKES! I use double the average!

average

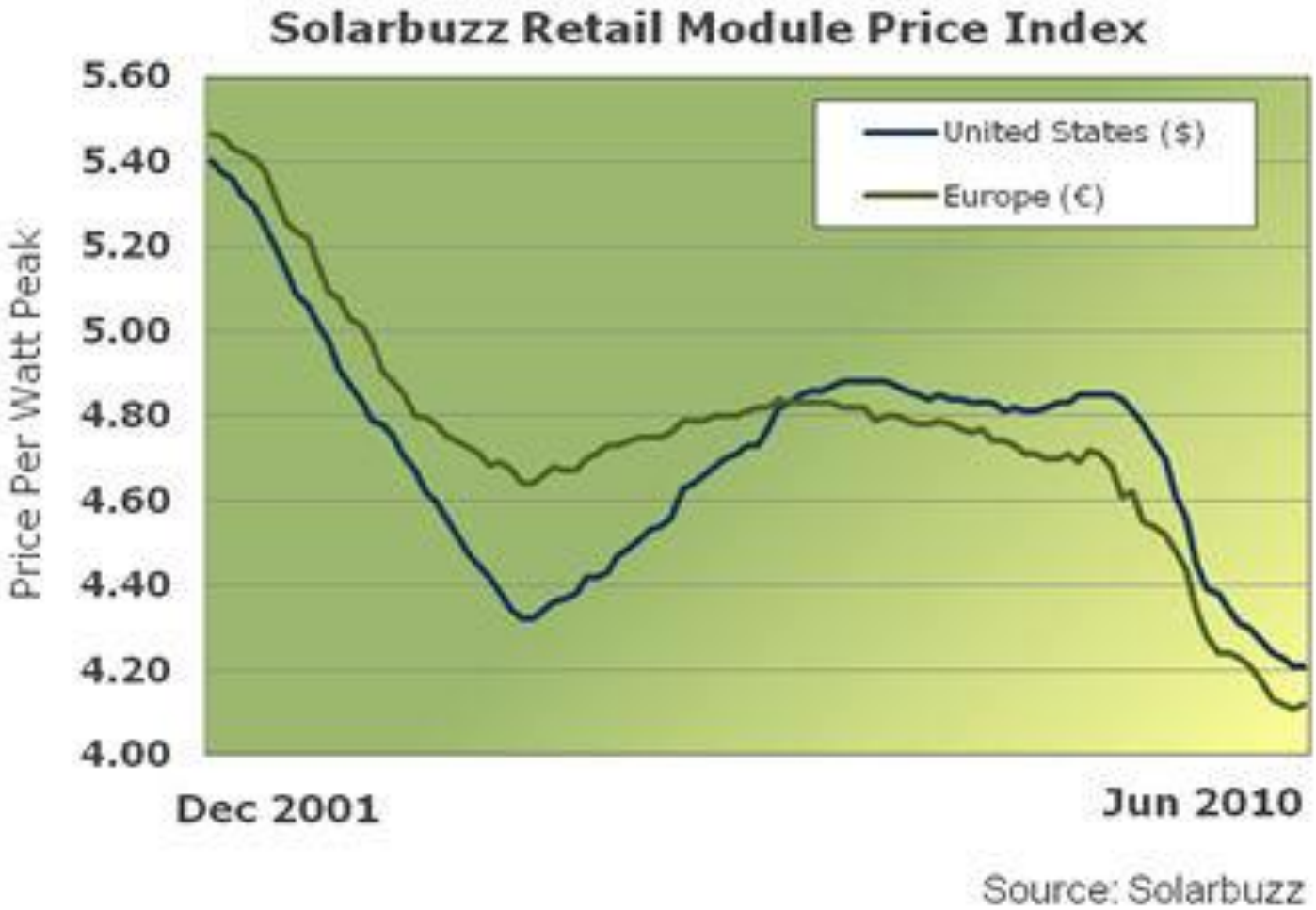
lowest



Courtesy: Vivian Loftness
Carnegie Mellon University

The Cost of PV is Dropping

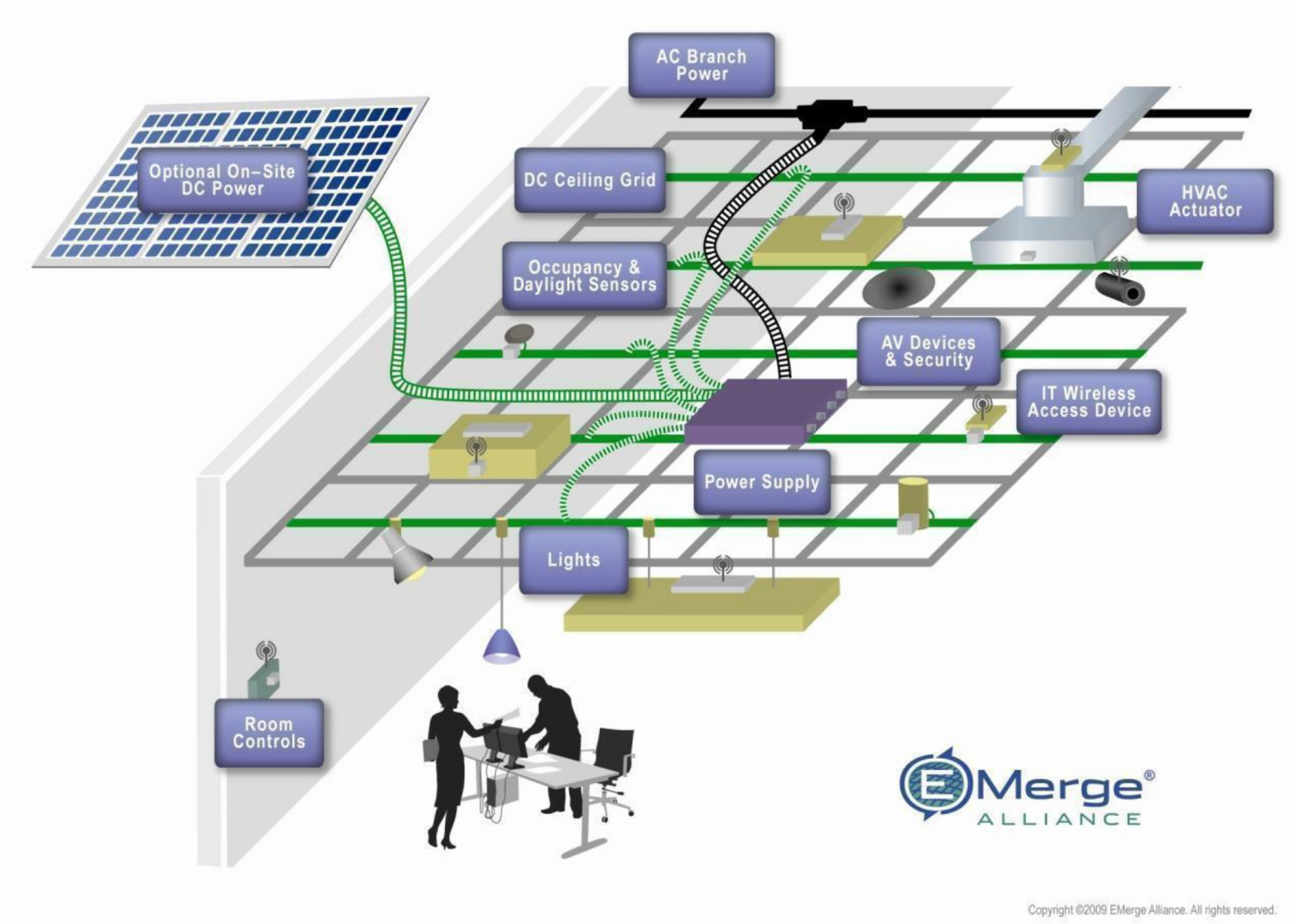
- 2008 - $9.50 a watt installed*
- 2013 - $3.10 a watt installed*



*(Bay Area)


SPEED
LIMIT
25

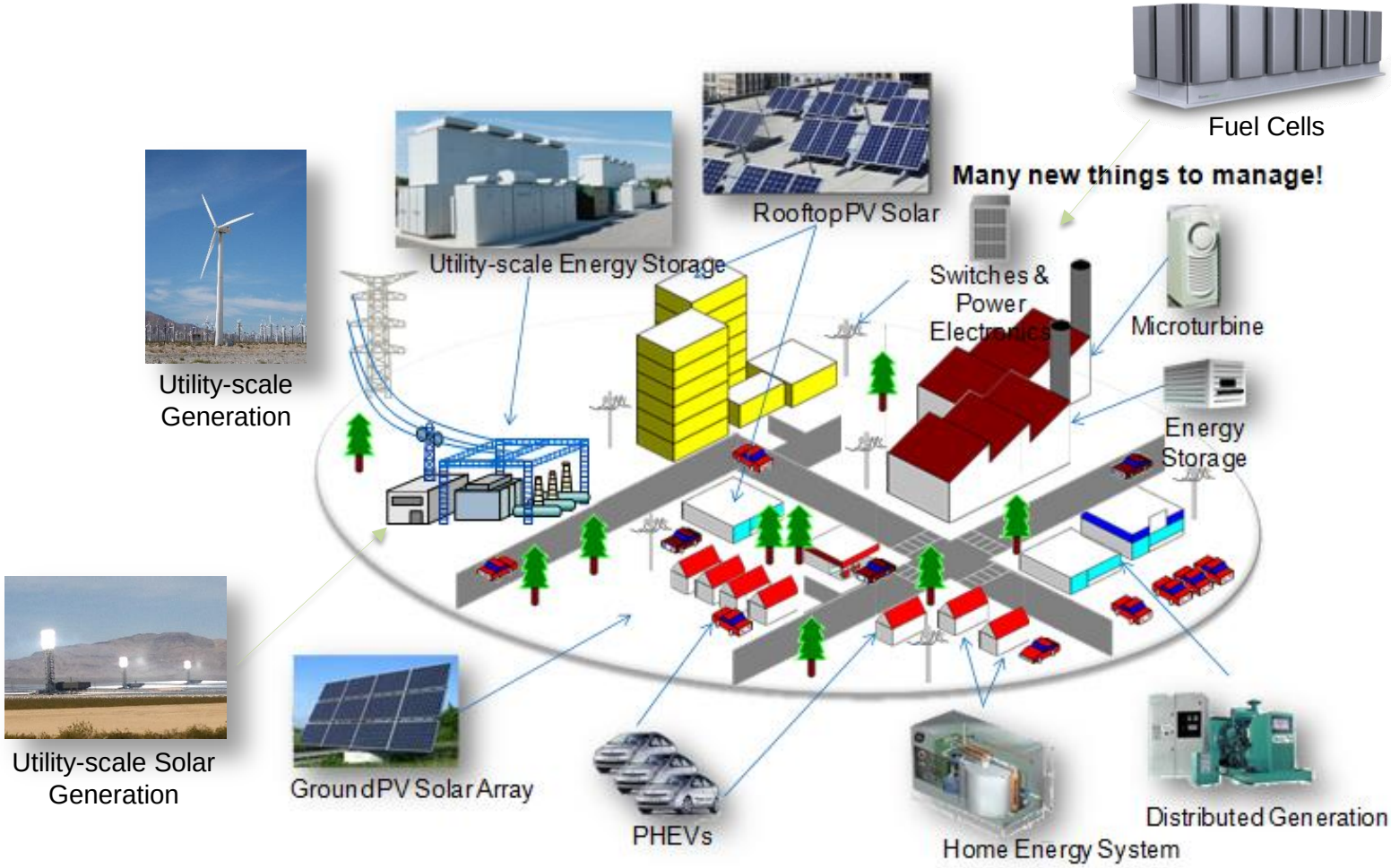
DC Power Distribution



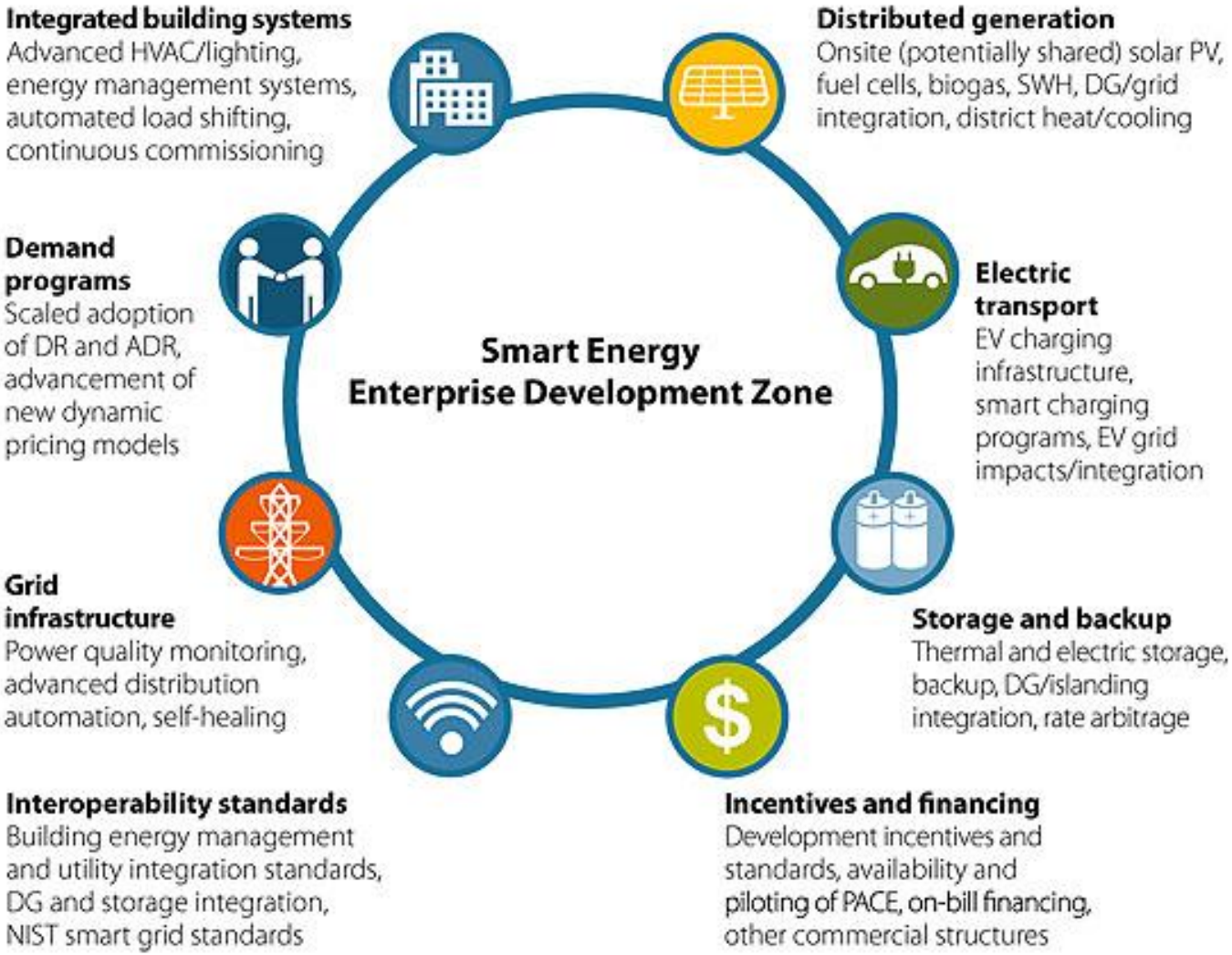
Battery Storage

TESLA

Microgrids

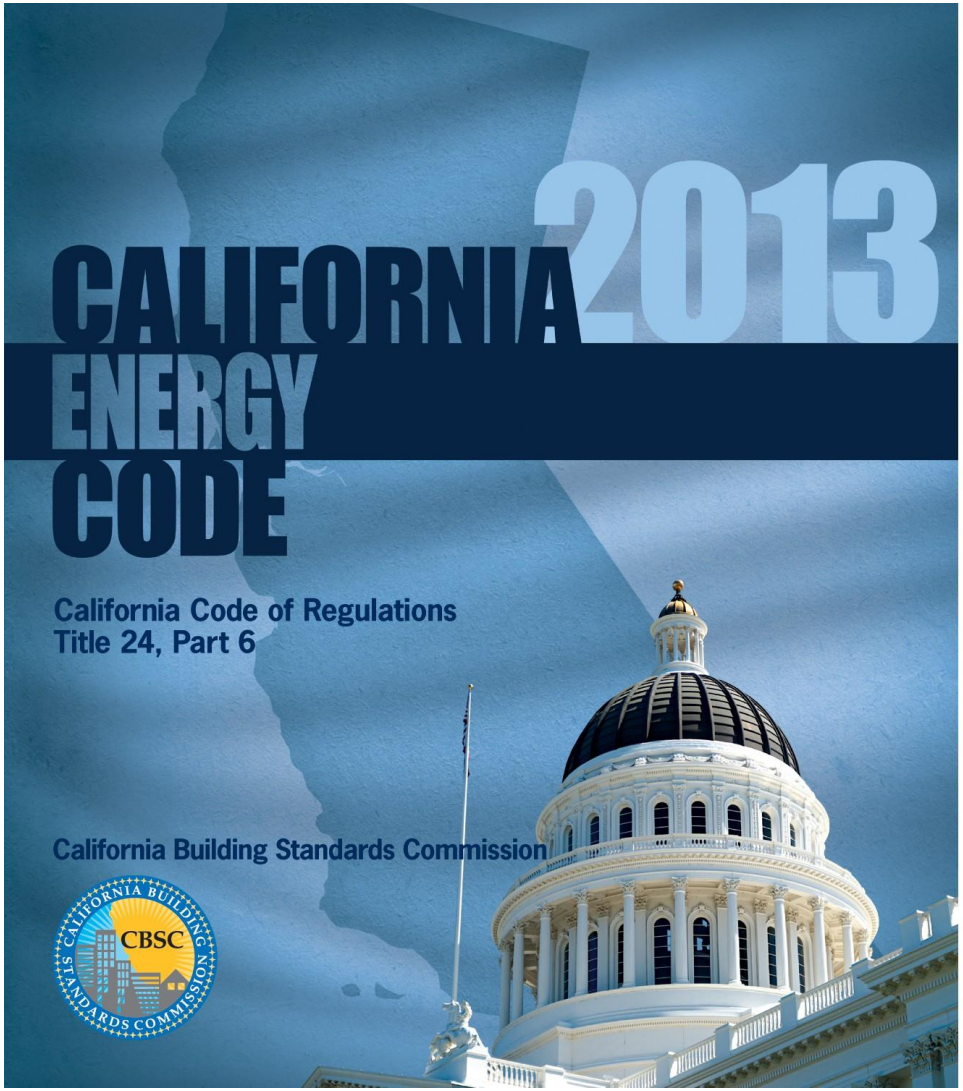

Fuel Cells
Many new things to manage!
Rooftop PV Solar
Utility-scale Energy Storage
Utility-scale Generation
Switches & Power Electronics
Microturbine
Energy Storage
Utility-scale Solar Generation
Ground PV Solar Array
PHEVs
Home Energy System
Distributed Generation

Community Scale

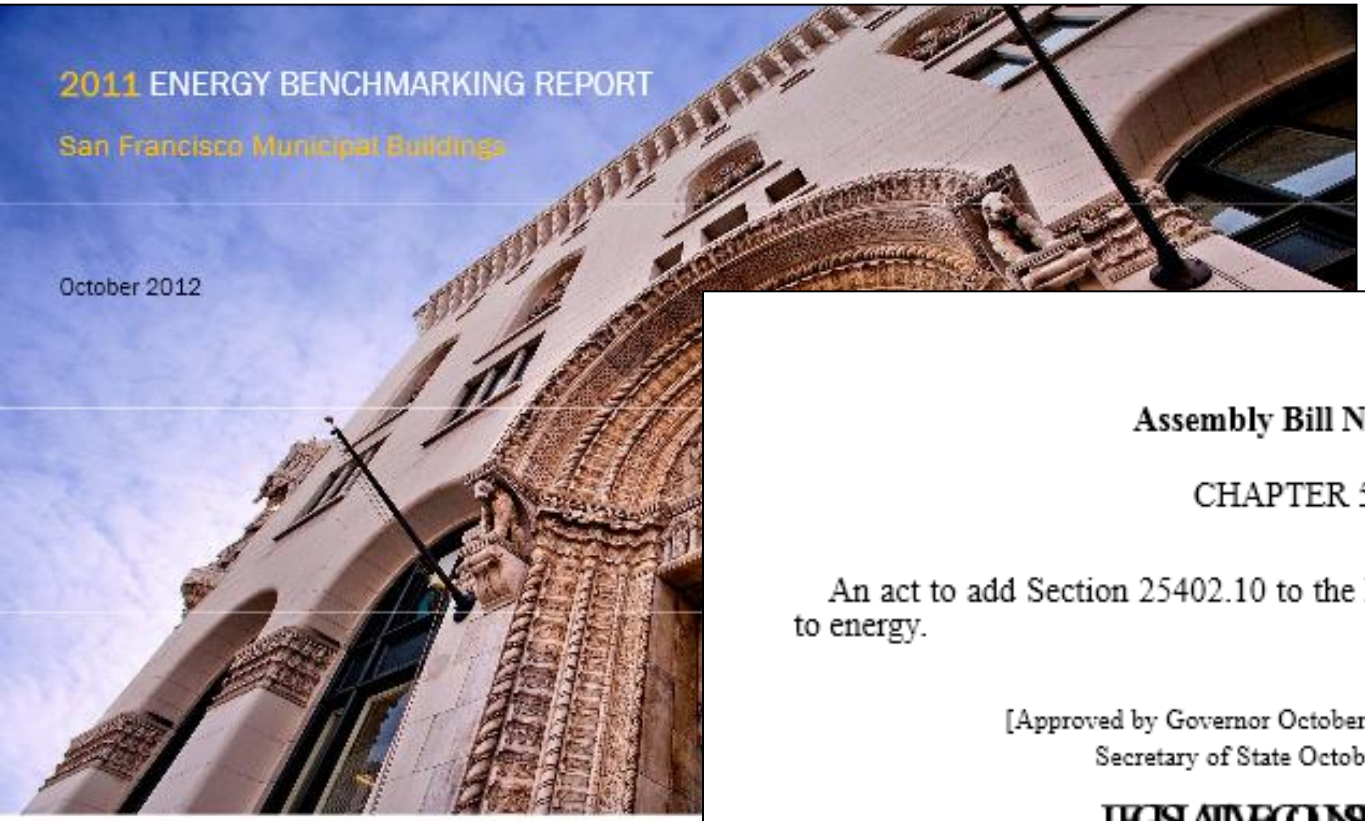


More Aggressive Building Codes

- Performance Based Energy Codes
- More aggressive energy efficiency requirements
- Zero energy targets



New Laws



San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

Assembly Bill No. 1103

CHAPTER 533

An act to add Section 25402.10 to the Public Resources Code, relating to energy.

[Approved by Governor October 12, 2007. Filed with Secretary of State October 12, 2007.]

LEGISLATIVE COUNSEL'S DIGEST

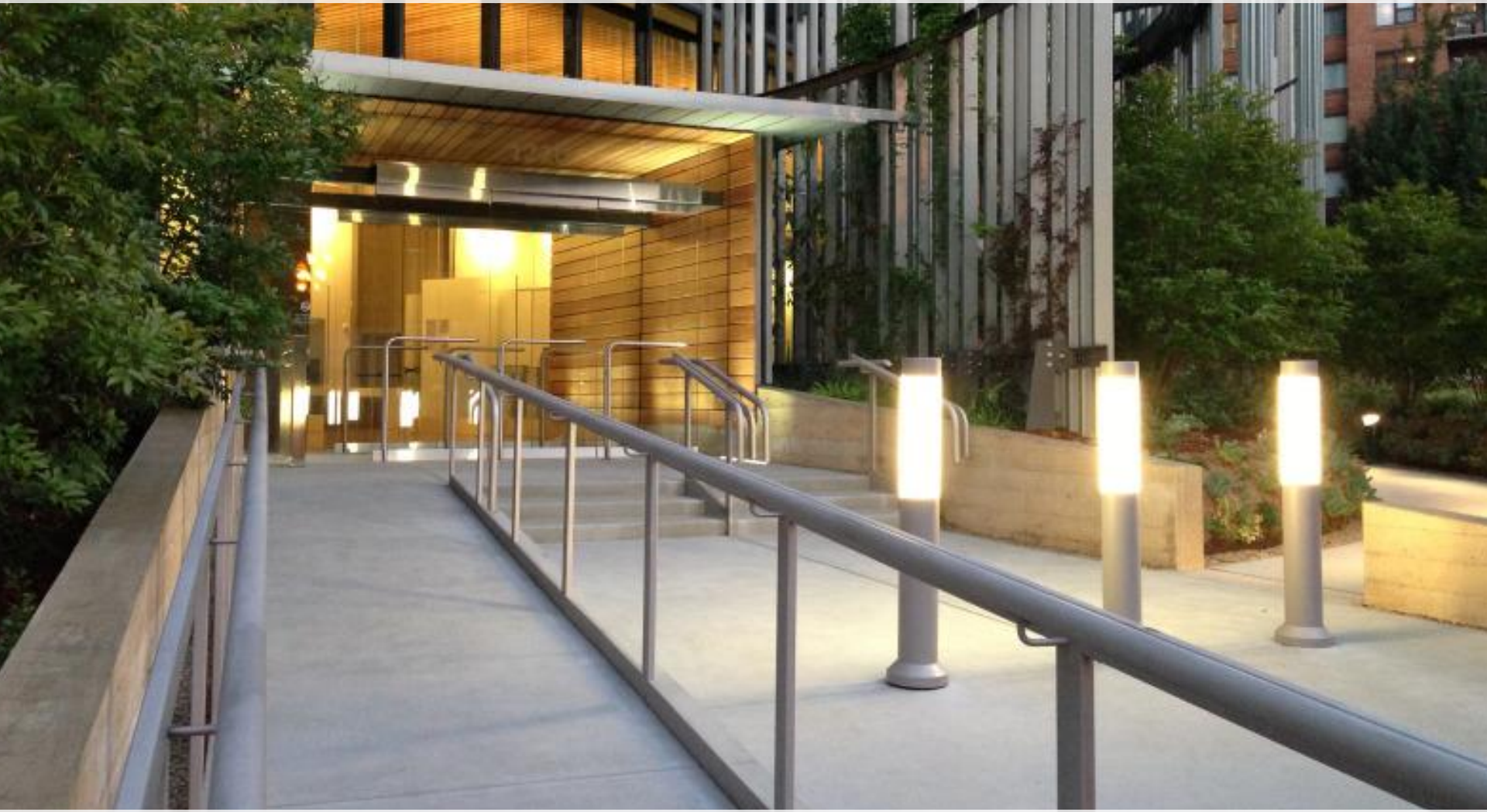
AB 1103, Saldana. Energy: commercial buildings: consumption.

Existing law declares that electrical energy is essential to the health, safety, and welfare of the people and the economy of this state, and it is the state's policy to promote all feasible means of energy conservation.

This bill would require electric and gas utilities, as defined, on and after January 1, 2009, to maintain records of the energy consumption data of all nonresidential buildings to which they provide service, in a format compatible for uploading to the United States Environmental Protection Agency's Energy Star Portfolio Manager (Energy Star Portfolio Manager), for at least the most recent 12 months. Upon written or secured electronic

New Standards

DESIGN PARADIGMS FOR CREATING ULTRA-EFFICIENT BUILDINGS



NBI Webinar: A Presentation by Clark Brockman, SERA Architects

May 28, 2014

PORTLAND

OREGON

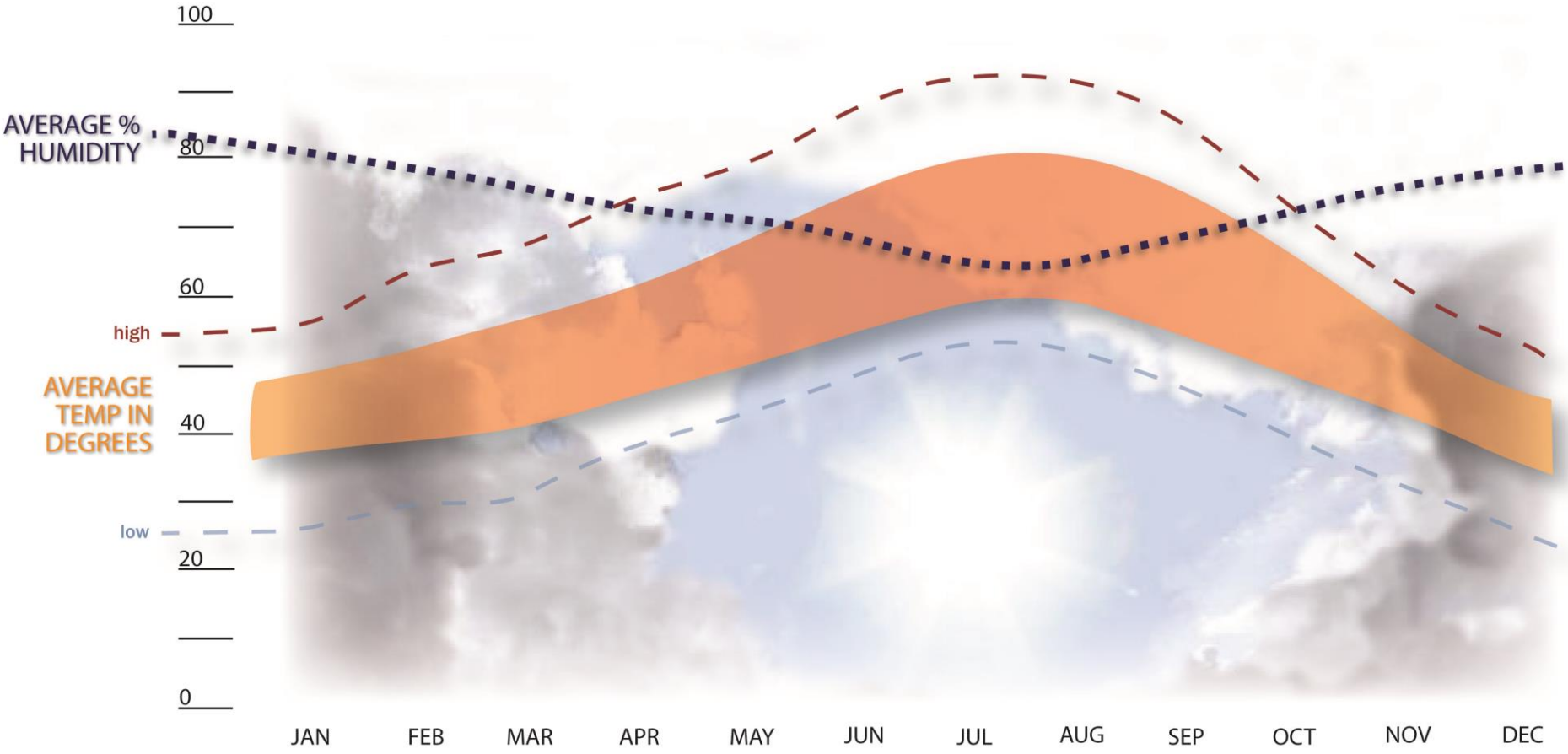
POPULATION: 603,106 (METRO: 2,226,009)

LATITUDE: 45.5236° N

METRO LAND AREA: ~770 Square Miles

CLIMATE

PORTLAND - TEMPERATURE / HUMIDITY

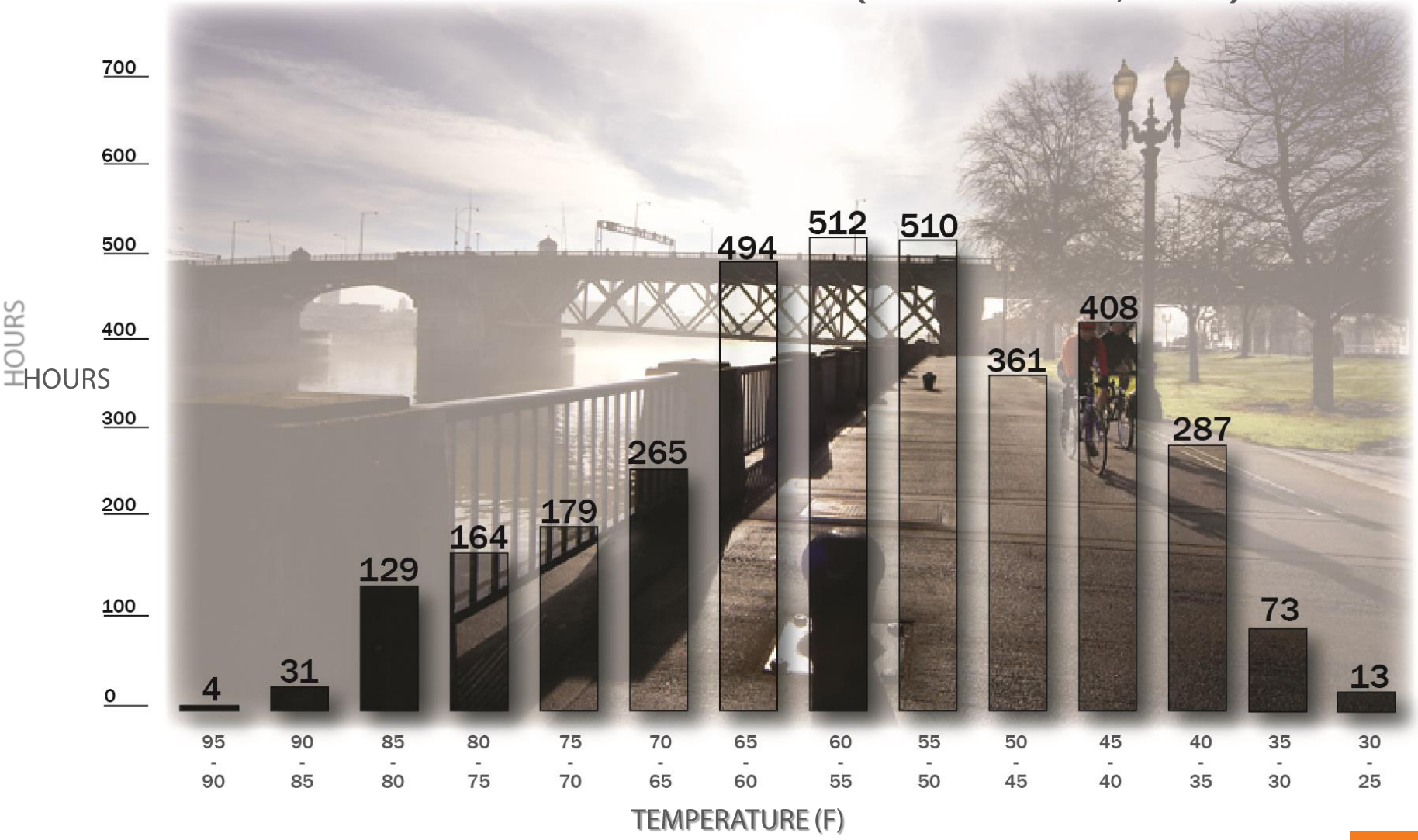


Data Source: TMY3 726980 WMO Station Number
Location: Portland Intl. Airport

SERA

CLIMATE

PORTLAND TEMPERATURE BINS (6AM-7PM, M-F)



SERA

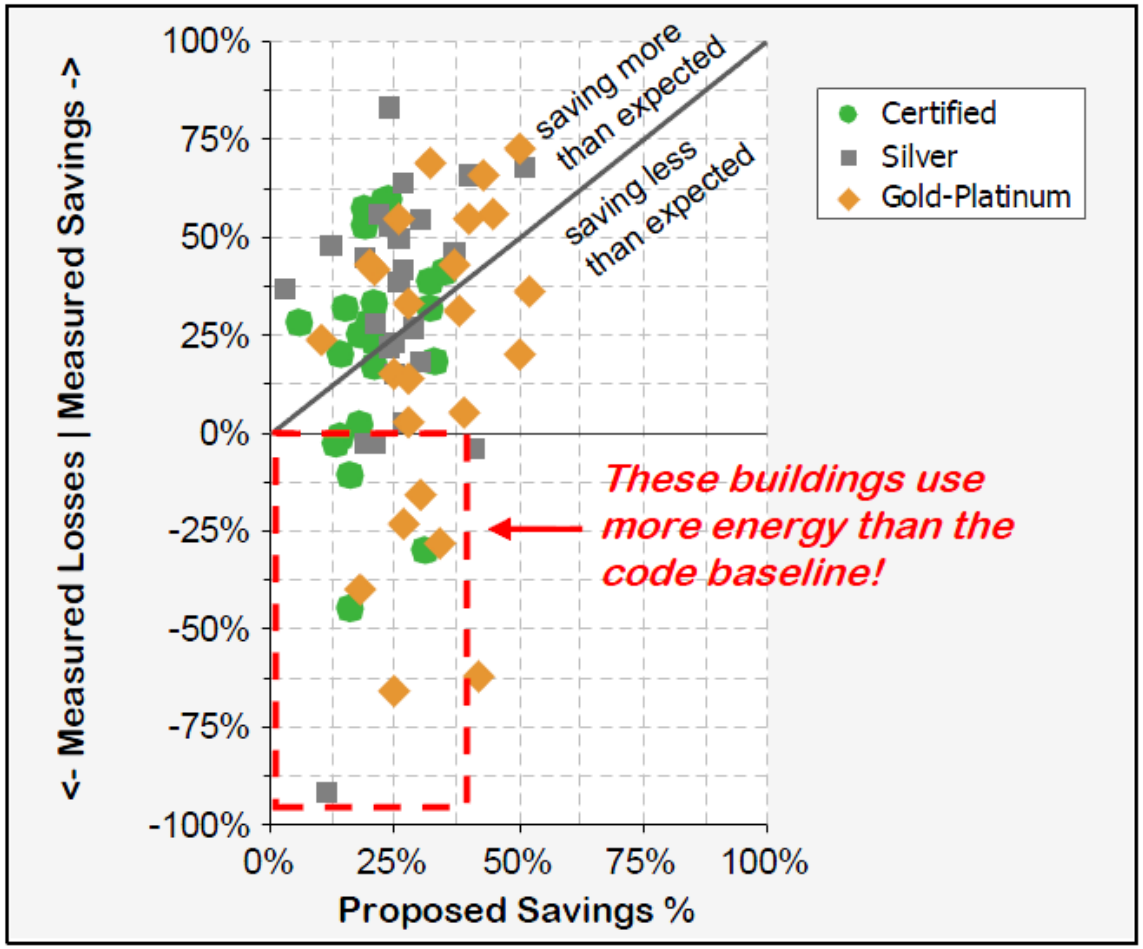
ENERGY USE

PREDICTED vs. ACTUAL (121 LEED BUILDINGS)

"ESSENTIALLY, ALL MODELS ARE WRONG, BUT SOME ARE USEFUL"

- George E.P. Box

Gravesend, Kent, U.K.



PREDICTED vs. ACTUAL ENERGY USE OF LEED BUILDINGS

Source: New Buildings Institute: Energy Performance of LEED NC Buildings, 2008

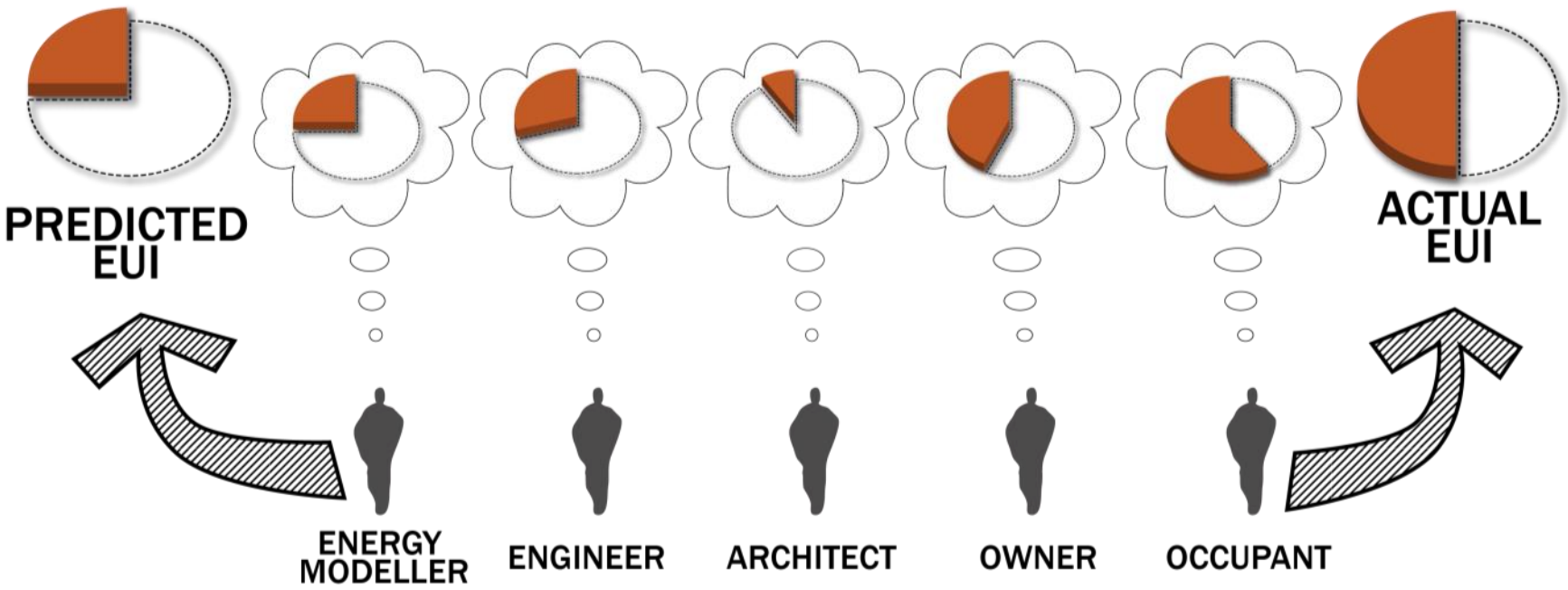
ENERGY USE

REALITY

REMEMBER,
BUILDINGS DON'T
USE ENERGY,
PEOPLE DO.

ENERGY USE

PREDICTED vs. ACTUAL



ENERGY MODEL

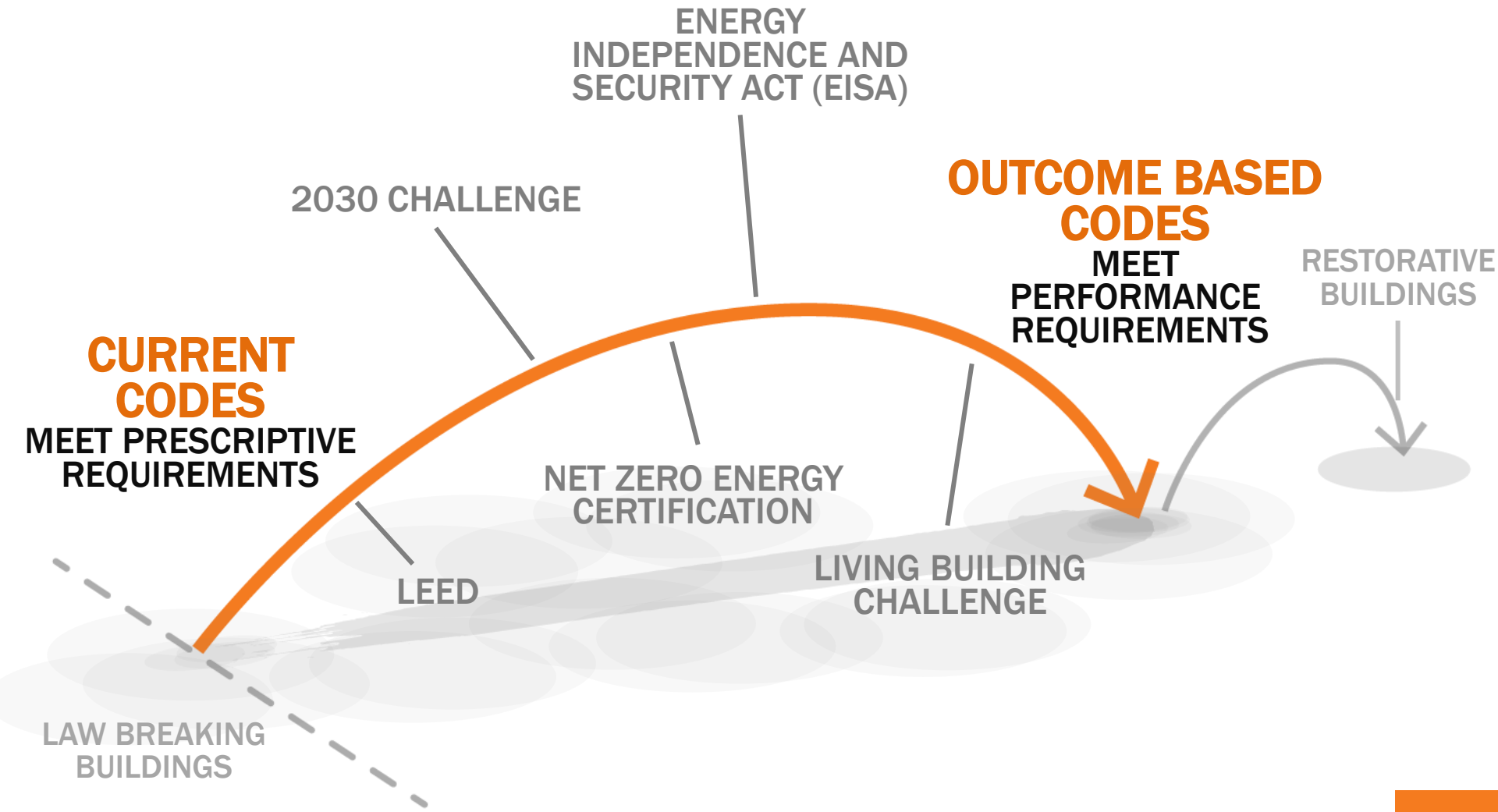
TRACKING LOG

MECHANICAL ENGINEER
ARCHITECT
OWNER (FACILITY)
LIGHTING DESIGNER
OWNER (IT)
ALL TEAM
ELEVATOR CONSULTANT

INTERNAL LOADS	OWNER AND DESIGN TEAM PROVIDED DATA	ENERGY MODEL INPUT
Occupant Density (SF/Person unless otherwise indicated)	OWNER	
BUILDING AVERAGE		
Total Building FTE (# people)		
Short-term visitors <1 hour (average #people/day)		
Long-term visitors >1 hour (average #people/day)		
occupied office sf		
Occupied office sf/ program occupants		
by Space type		
Sample space type - Office		
Lighting Power Density (Watts/SF)	LIGHTING DESIGNER	
BUILDING AVERAGE		
by Space type		
Sample space type - Office		
Plug Load Power Density (Watts/SF)	OWNER	
BUILDING AVERAGE		
by Space type		
Sample space type - Office		
Misc Load Assumptions	ALL TEAM	
BUILDING AVERAGE		
by Space type		
Elevator energy and usage assumptions (kWh)	ELEVATOR CONSULTANT	
Power Demand (kW or hp)		
Energy Use (kWh/yr)		
Quantity		

OUTCOME BASED CODES

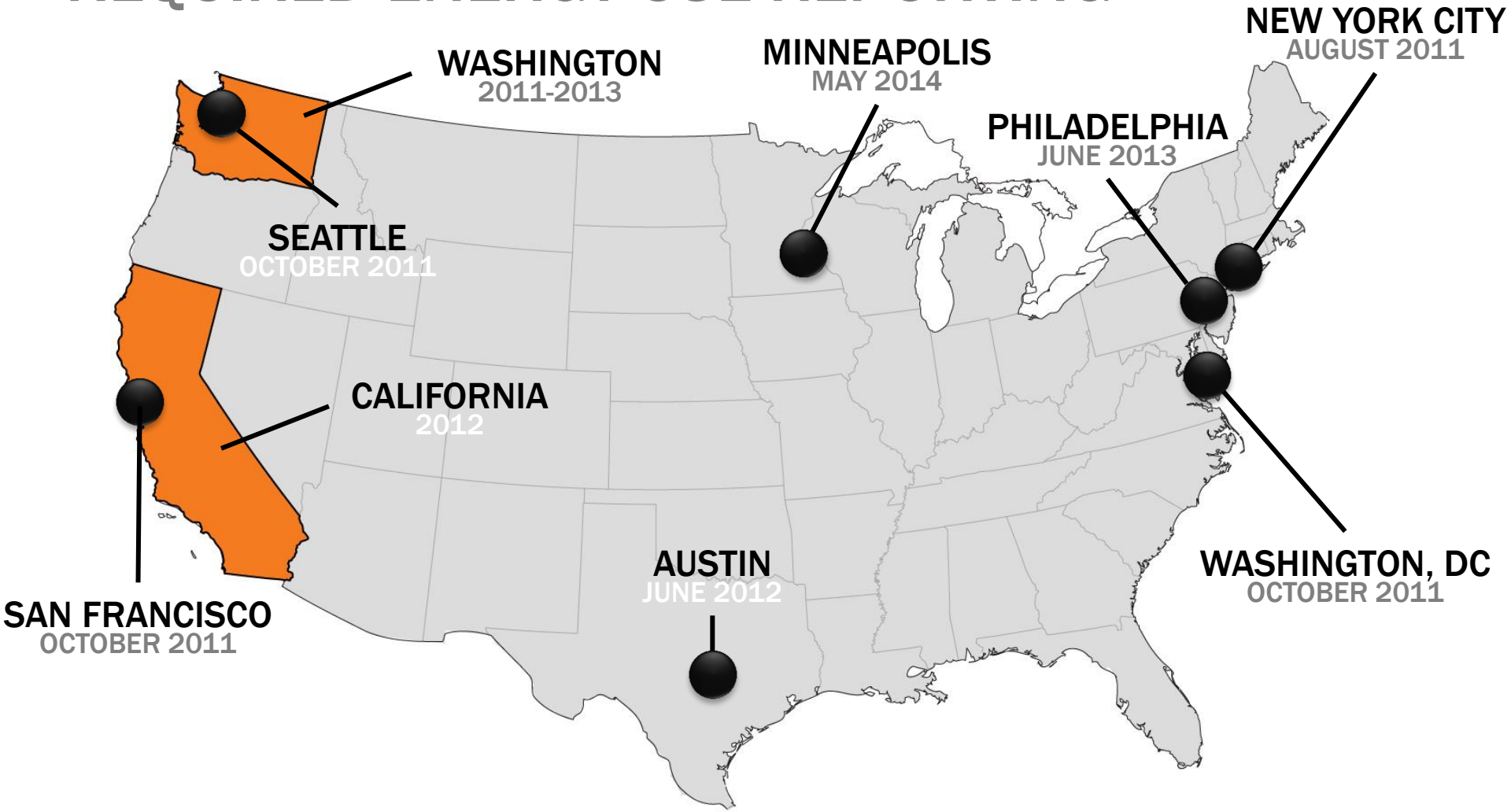
FOCUSED ON ACTUAL PERFORMANCE



SERA

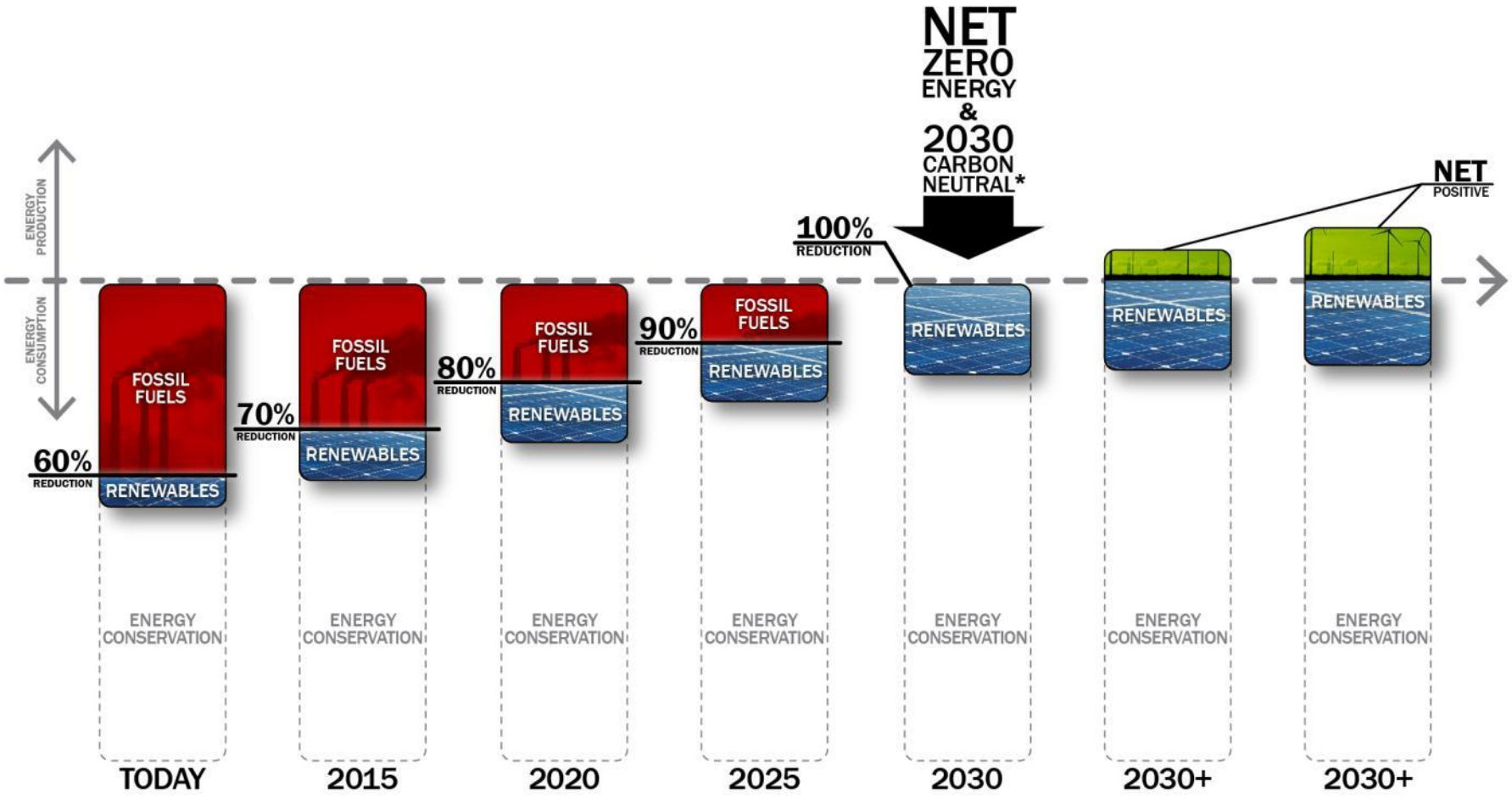
REPORTING

REQUIRED ENERGY USE REPORTING



ARCHITECTURE 2030

REDUCTIONS IN BUILDING FOSSIL FUEL USE



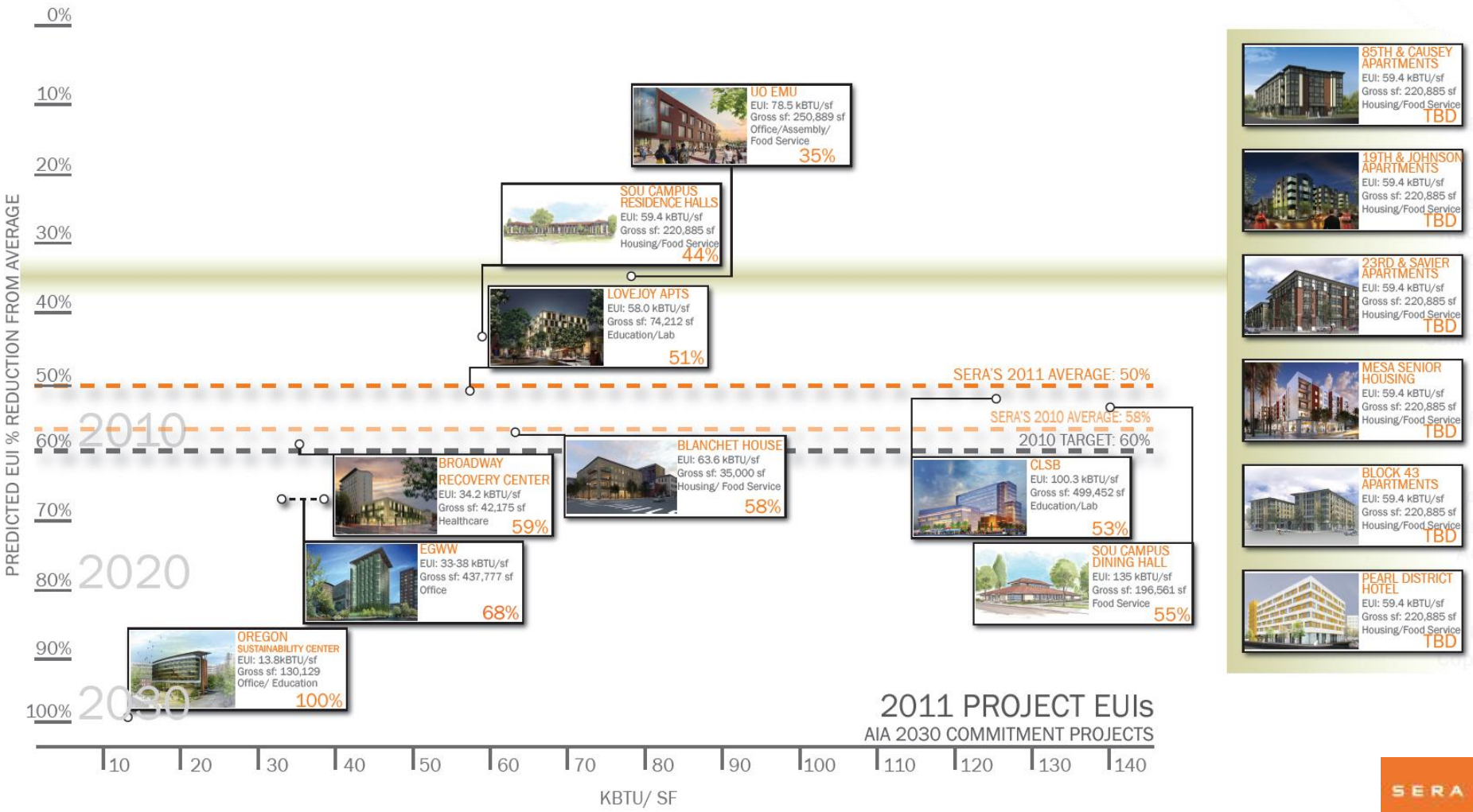
Source: Architecture 2030, based on statistics from Energy Information Administration

* USING NO FOSSIL FUEL GHG-EMITTING ENERGY TO OPERATE

http://architecture2030.org/the_solution/solution_energy

SERA

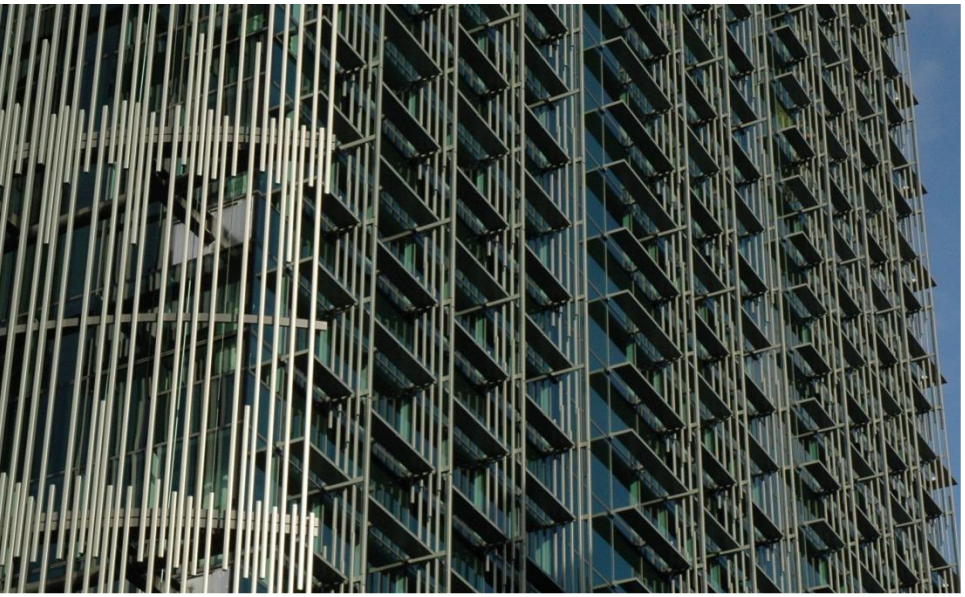
2011 EUI REPORTING



SERA

FEDERAL BUILDING

EDITH GREEN WENDELL WYATT



EDITH GREEN-WENDELL WYATT
FEDERAL BUILDING MODERNIZATION

PROJECT TEAM

EDITH GREEN-WENDELL WYATT
FEDERAL BUILDING MODERNIZATION

Owner:

GSA

A/E Team:

SERA ARCHITECTS

Cutler Anderson Architects
135 Parfiff Way, SW
Bainbridge Island, WA 98110

CUTLER ANDERSON ASSOCIATES

STANTEC

INTERFACE

PAE

KPFF

ATELIER DREISEITL

CMc Team:

HOWARD S WRIGHT

Howard S. Wright COMPANIES

BENSON

McKINSTRY

DYNALECTRIC

OTIS

NUPRECON

ARRA and EISA

MINIMUM PERFORMANCE CRITERIA

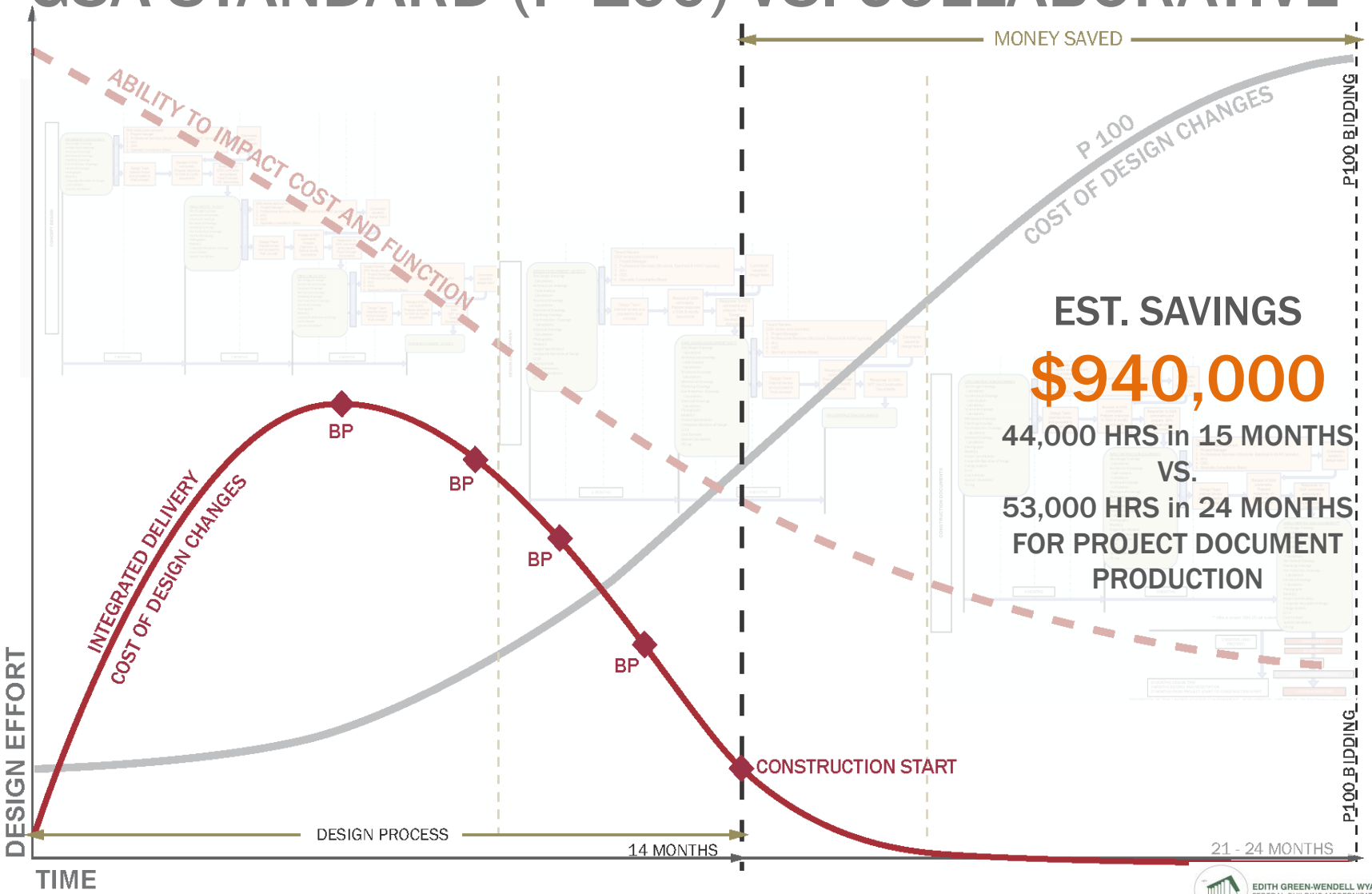
Energy Star Requirements	Water Conservation Requirements	Energy Conservation Requirements	LEED Requirements
Score goal: 97	20% Indoor potable water reduction 50% Outdoor potable water reduction	55% Fossil fuel reduction 30% Energy usage reduction 30% Solar thermal	Gold Required Platinum Goal

ENERGY GOAL


DESIGNED ENERGY UTILIZATION INTENSITY kBTU/SF/yr
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
94
77 – 83 Existing EGWW building (437,777 sf)
34 – 36 +/- 15% Renovated EGWW target range
40
35
32
24
NATIONAL AVERAGE FACILITY
CHESAPEAKE BAY FOUNDATION
MARYLAND
30,600 SF
NREL (WITH DATA CENTER)
COLORADO
218,000 SF
SCHLITZ AUDUBON NATURE CENTER
WISCONSIN
39,000 SF
ALDO LEOPOLD LEGACY CENTER
WISCONSIN
11,900 SF

PROJECT DELIVERY

GSA STANDARD (P-100) VS. COLLABORATIVE

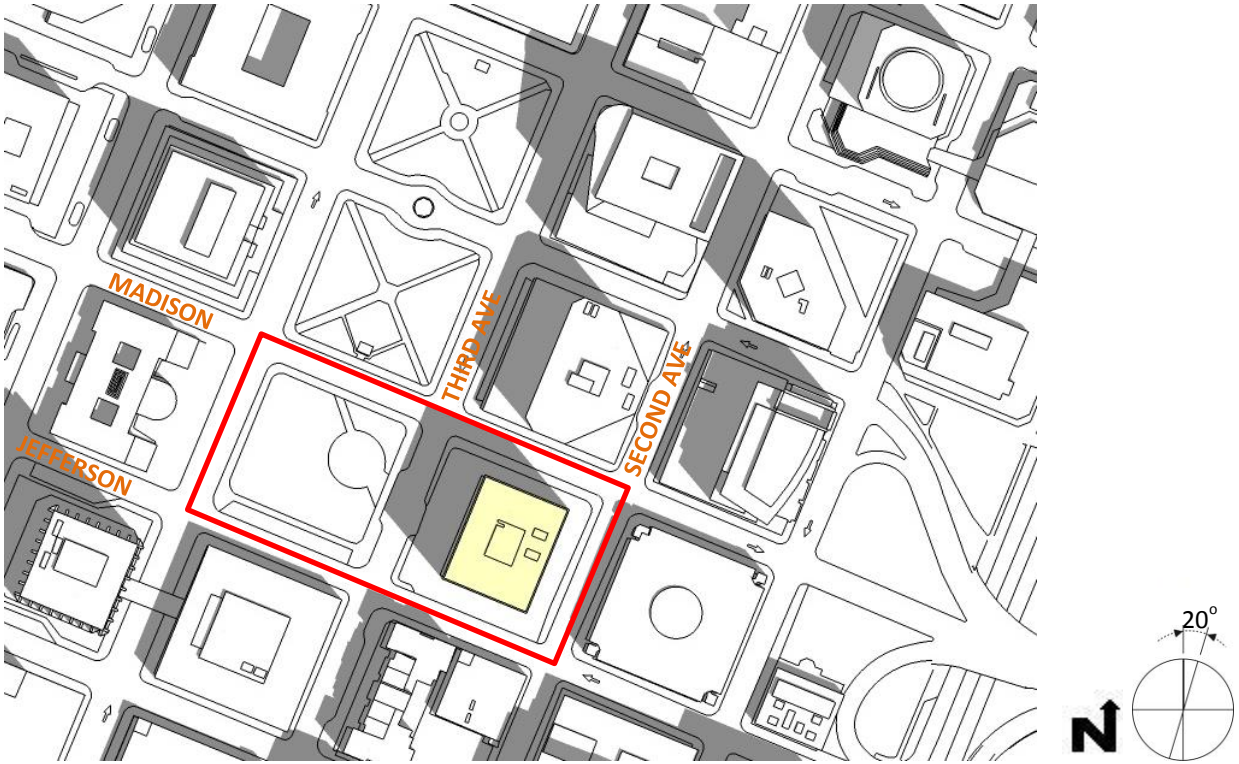


EDITH GREEN-WENDELL WYATT FEDERAL BUILDING MODERNIZATION

SERA

ANALYSIS

BUIDLING ORIENTATION



Transform a 512,400 square foot, 18-story, 1974 office building into a LEED Platinum cornerstone of GSA's green building portfolio.

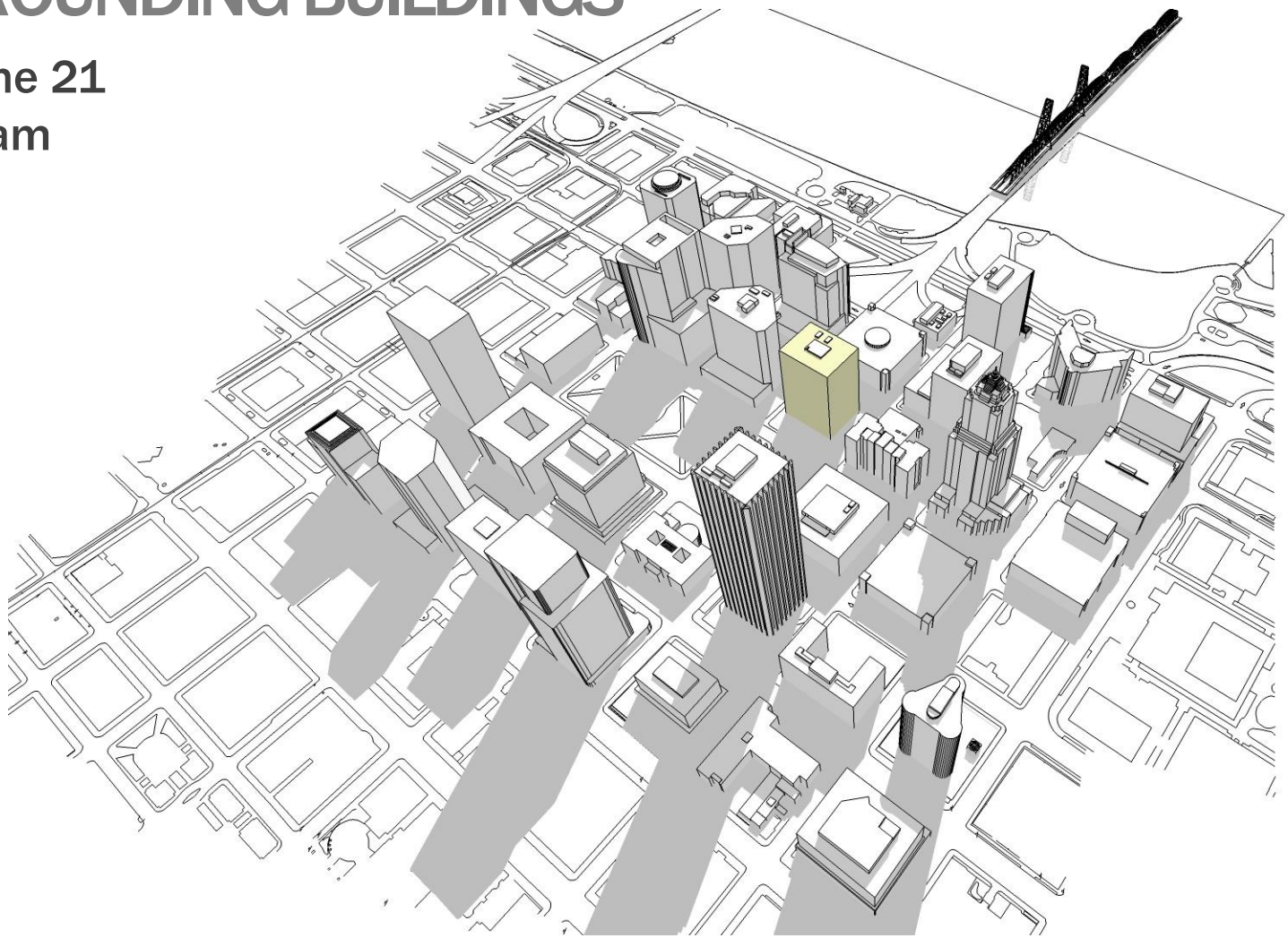
BUDGET: $ 141,000,000

EDITH GREEN-WENDELL WYATT
FEDERAL BUILDING MODERNIZATION

ENVELOPE STUDY

SURROUNDING BUILDINGS

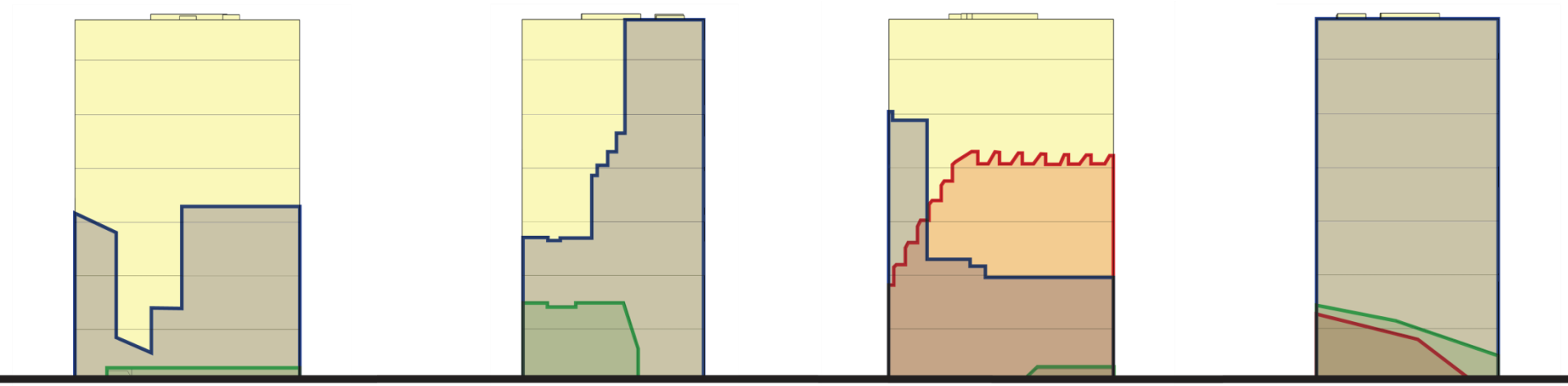
June 21
8 am



EDITH GREEN-WENDELL WYATT
FEDERAL BUILDING MODERNIZATION

ENVELOPE STUDY

SHADING FROM ADJACENT BUILDINGS



East Elevation
10 am

South Elevation
2 pm

West Elevation
4 pm

North Elevation
8 am

Shaded Area

March / September

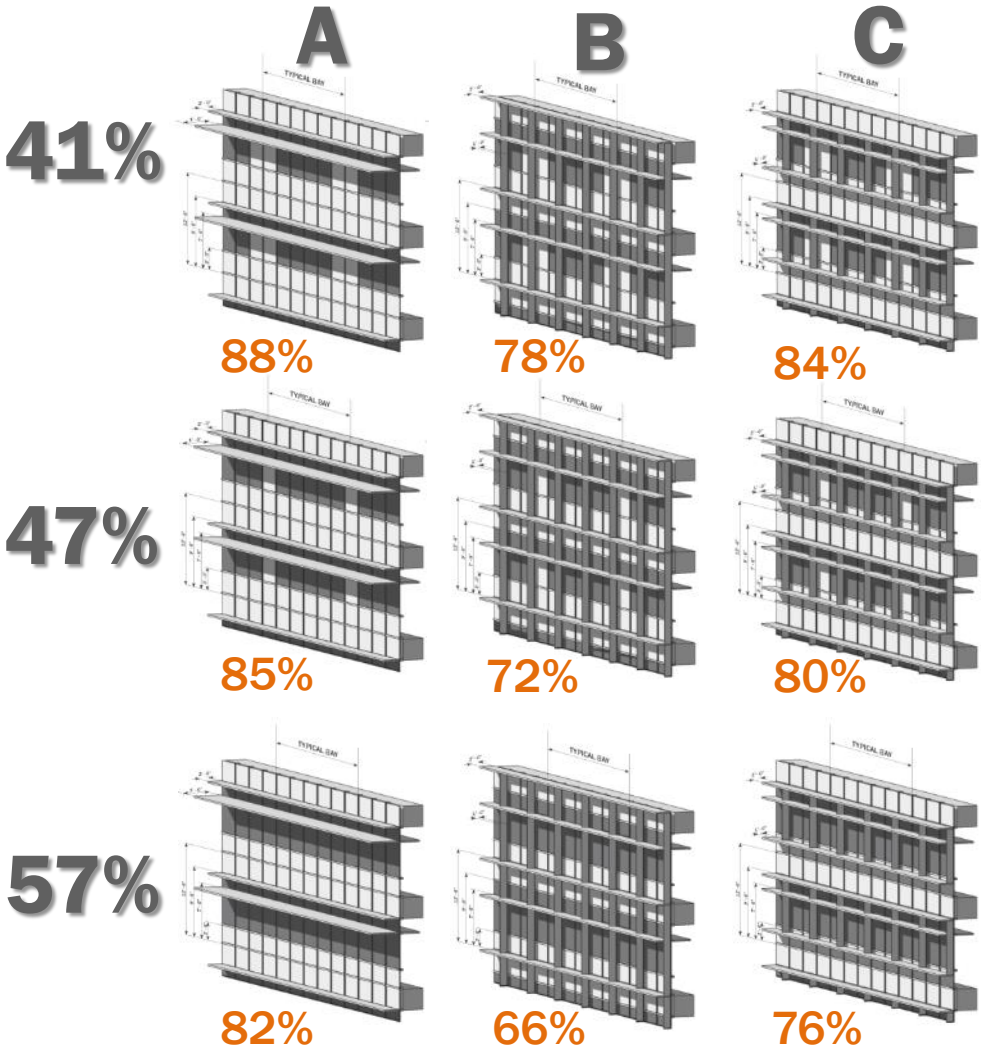
June

December

EDITH GREEN-WENDELL WYATT
FEDERAL BUILDING MODERNIZATION

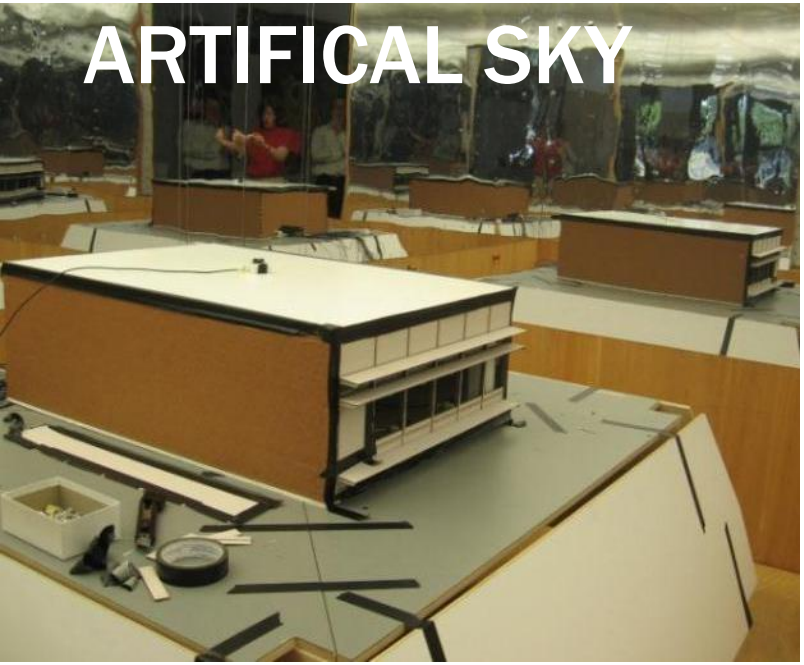
SHADING STUDY

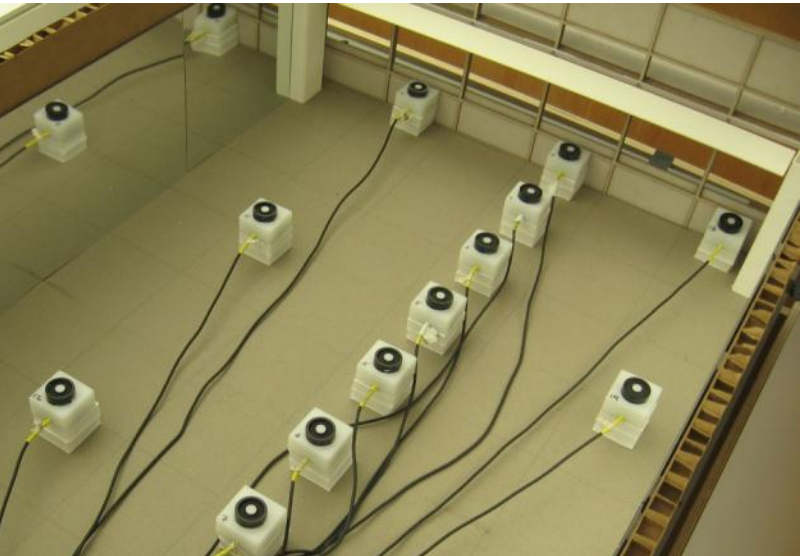
HELIDON TESTING

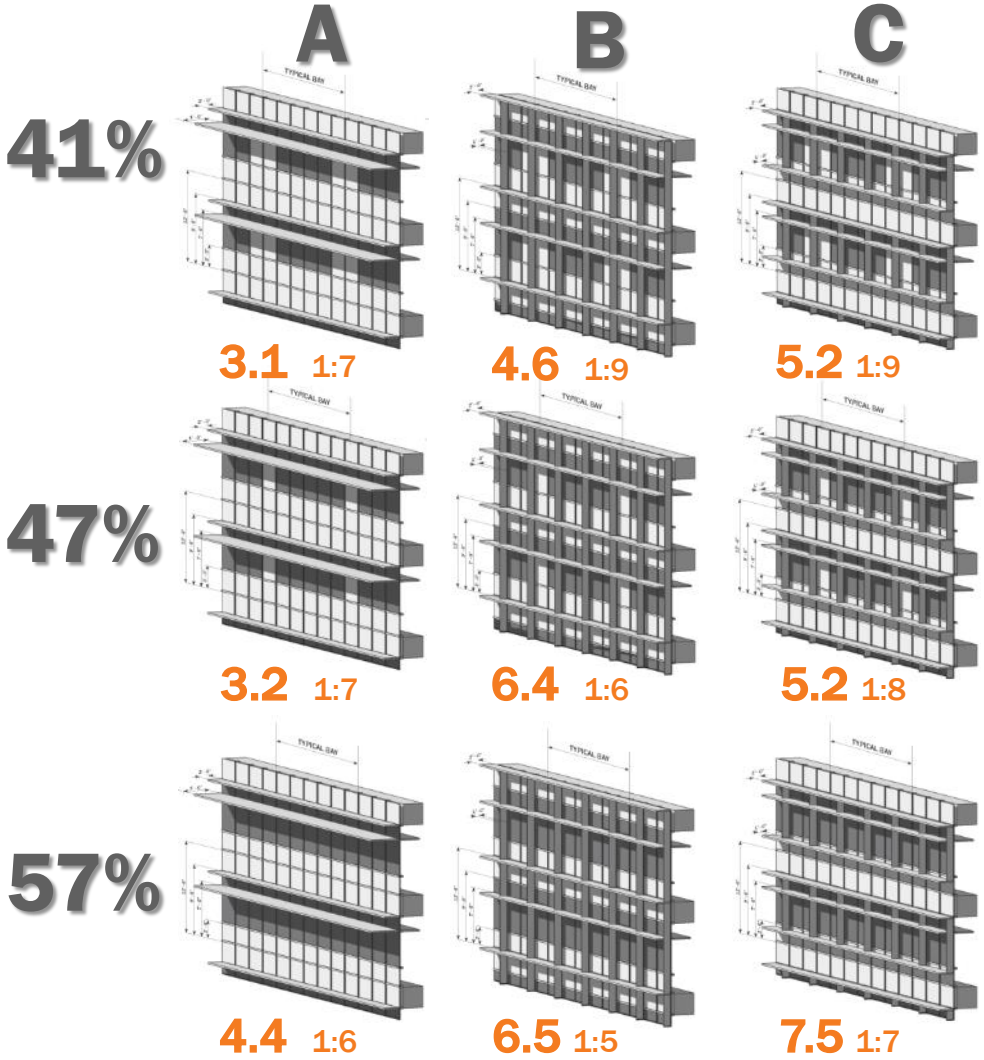


% annual shading, south facade

DAYLIGHT STUDY







Daylight Factor min/max ratio 16 ft perimeter zone

STUDY RESULTS

A HYBRID SOLUTION

Thermal analysis

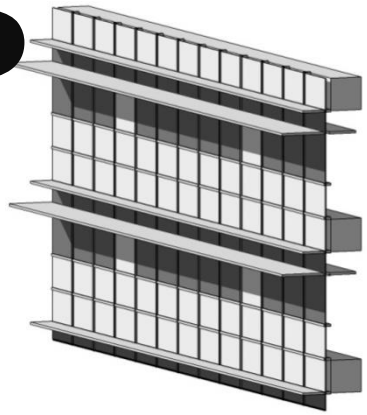
- Percentage glazing
- Shading

Daylight analysis

- Surrounding buildings shading
- Building integrated shading
- Interior light quality
- Energy savings

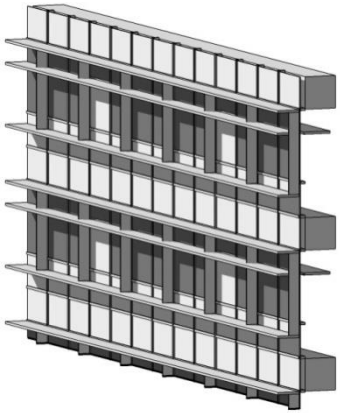
Ongoing Studies

- Energy Sensitivity Analysis



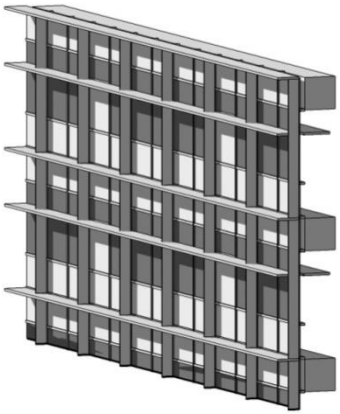
A

East 80%
South 85%
3.2 ave. daylight factor



B

East 72%
South 72%
6.4 ave. daylight factor

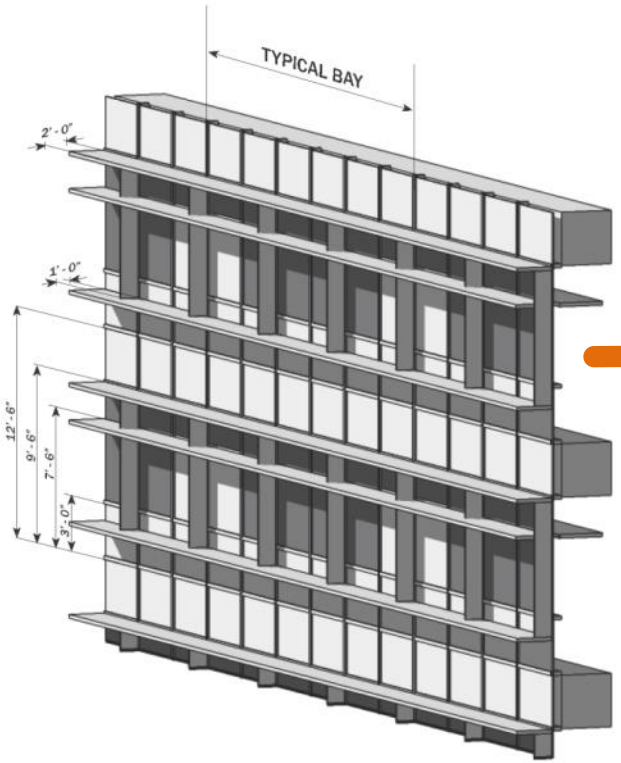


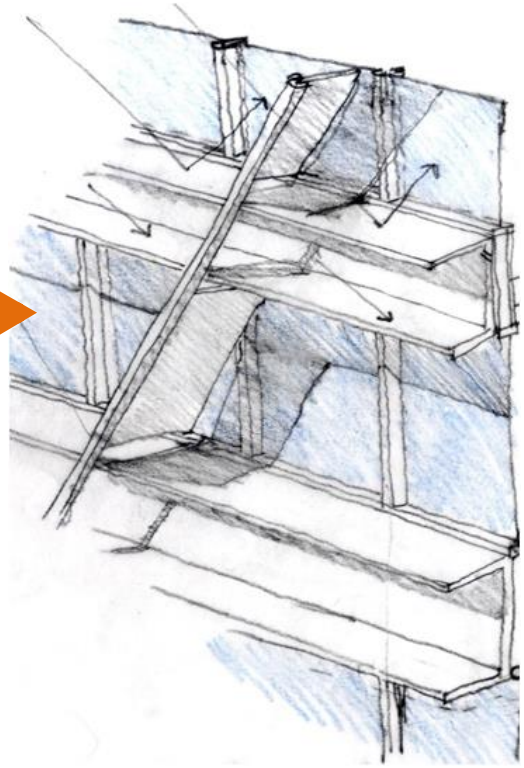
C

East 82%
South 80%
5.2 ave. daylight factor

DATA DRIVEN DESIGN

FROM STUDY TO DESIGN TO CONSTRUCTION





REEDS ON EAST FAÇADE

DESIGN/ANALYSIS

EAST & SOUTH ELEVATION STRATEGIES

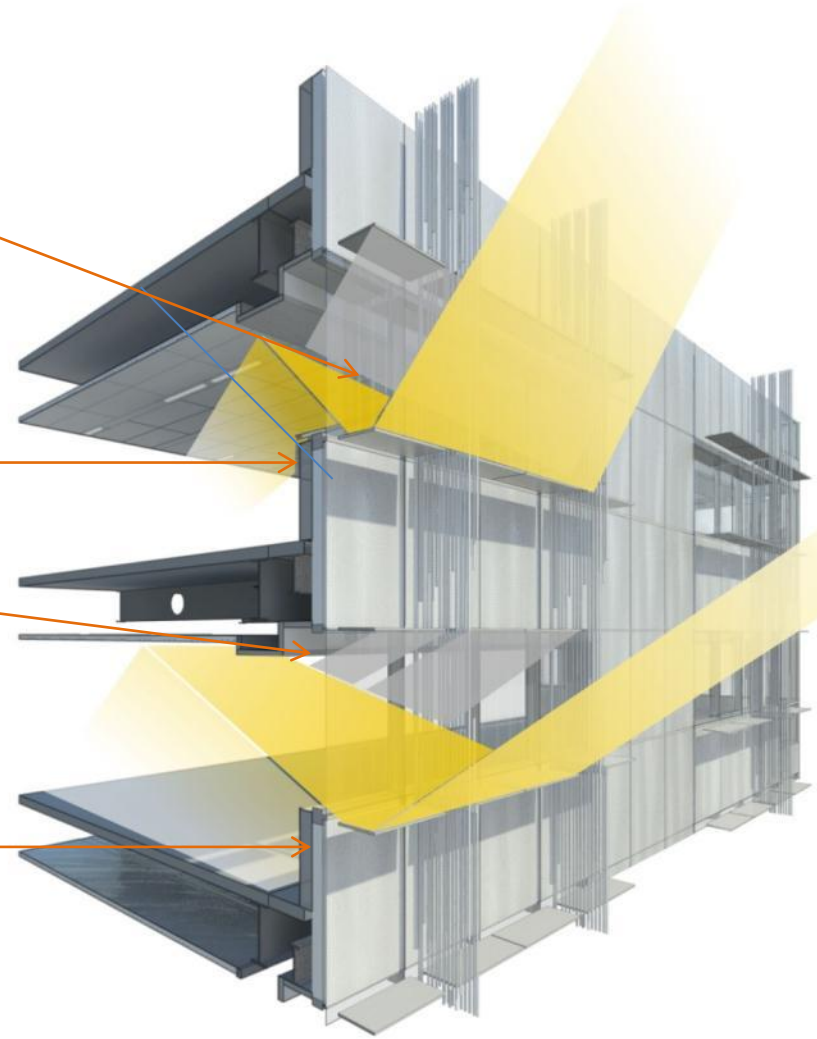
Summer mid-day sun (high angle)

Low Glazing to Wall Ratio
40% glazing

Low Infiltration Rate
0.06 CFM

Well-Insulated Wall

Daylighting
Light shelves bounce light 16ft. into interior



Equinox morning sun (lower angle)

DESIGN/ANALYSIS

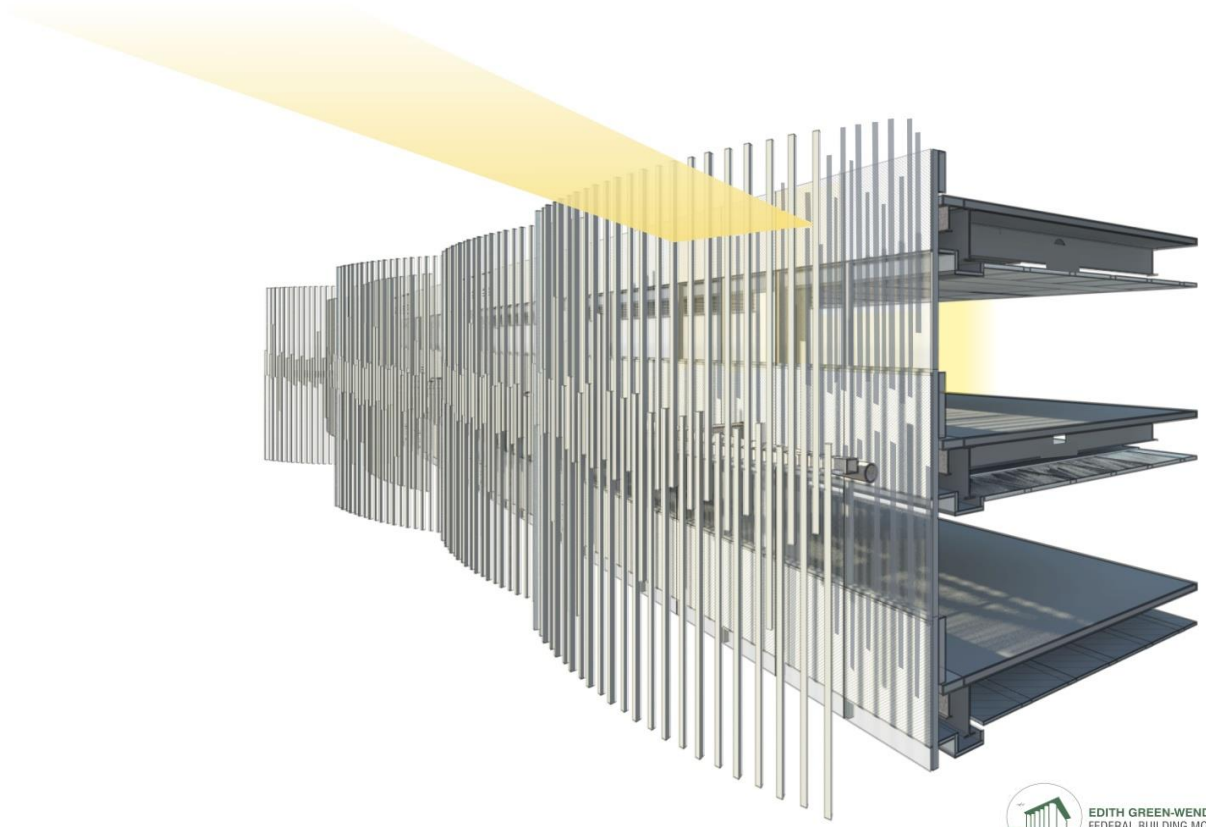
WEST ELEVATION SHADING STRATEGY

Shading reduces the heat gain on the building minimizing the energy needed for cooling.

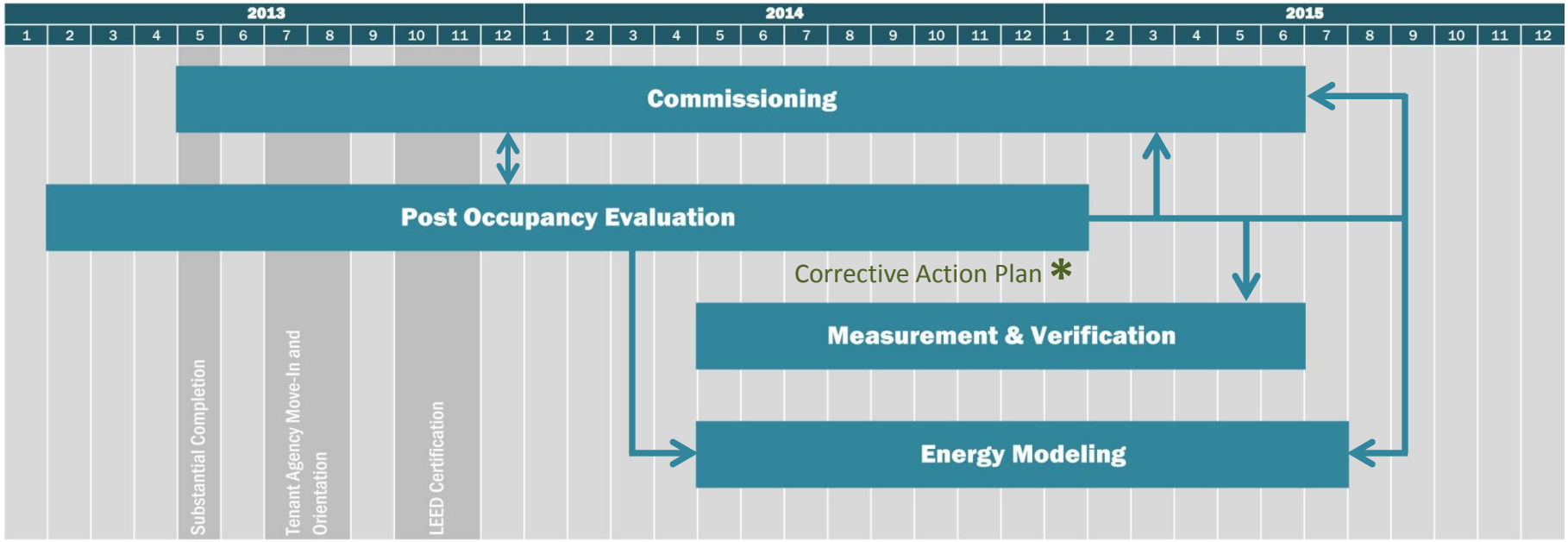
West Facade
Reeds provide avg. 50% shading

South & East Facades
Combination vertical + horizontal shades

North Facade
No shading



AFTERCARE
TUNING PERFORMANCE



TENANT ORIENTATION
TRAINING AND MILESTONES

TENANT DESIGN PROCESS

PROGRAMMING | CONFIG PLANS | DESIGN INTENT | DOCUMENTATION | CONSTRUCTION | MOVE-IN

PROJECT KICK-OFF:
INTRODUCTION
PROJECT GOALS
DESIGN PROCESS

PROJECT GUIDELINES:
SHARED AMENITIES
MODEL UNIT
51 STANDARDS

CHECK-IN:
COMMITTEES
OCCUPANT BEHAVIOR

WALK-THROUGH:
CONFIRM
ELEC/DATA

ORIENTATION SYMPOSIUM:
GEOGRAPHY
SYSTEMS
GOALS
INVOLVEMENT

TENANT ORIENTATION
TRAINING SYMPOSIUM

KNOW YOUR BUILDING

- Design History
- Systems and Strategies
- Sustainability Goals

KNOW YOUR IMPACT

- Occupant Behavior
- Shared Resources

KNOW YOUR NEIGHBORS

- Property Manager
- Green Team / Tenant Agencies

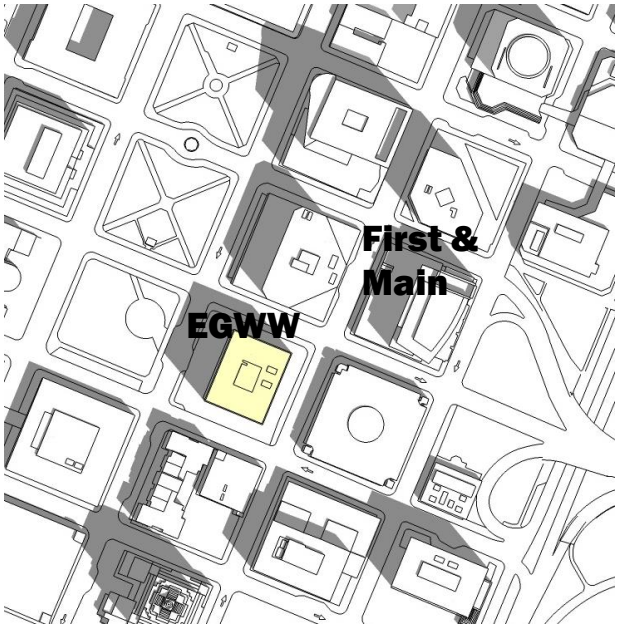
POST OCC EVALS
OCCUPANT SATISFACTION SURVEYS

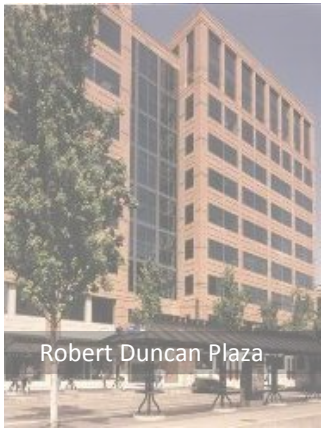
BEFORE & AFTER MOVE

Survey 3 largest agencies in their Existing Office spaces:

- First & Main Building
  2010 Class-A office building
  LEED-C&S Platinum
  One block away from EGWW

- Robert Duncan Plaza
  1991 office building
  Downtown Portland





POST OCC EVALS

CBE OCCUPANT SATISFACTION SURVEYS

INDOOR ENVIRONMENTAL QUALITY (IEQ)

- Thermal Comfort
- Lighting / Daylighting
- Indoor Air Quality
- Acoustics

+ Office Layout, Furnishings & General Satisfaction

Thermal Comfort

How satisfied are you with the temperature in your workspace?

Very Satisfied ○ ○ ○ ○ ○ ○ ○ Very Dissatisfied

Overall, does your thermal comfort in your workspace enhance or interfere with your ability to get your job done?

Enhances ○ ○ ○ ○ ○ ○ ○ Interferes

Air Quality

How satisfied are you with the air quality in your workspace (i.e. stuffy/stale air, cleanliness, odors)?

Very Satisfied ○ ○ ○ ○ ○ ○ ○ Very Dissatisfied

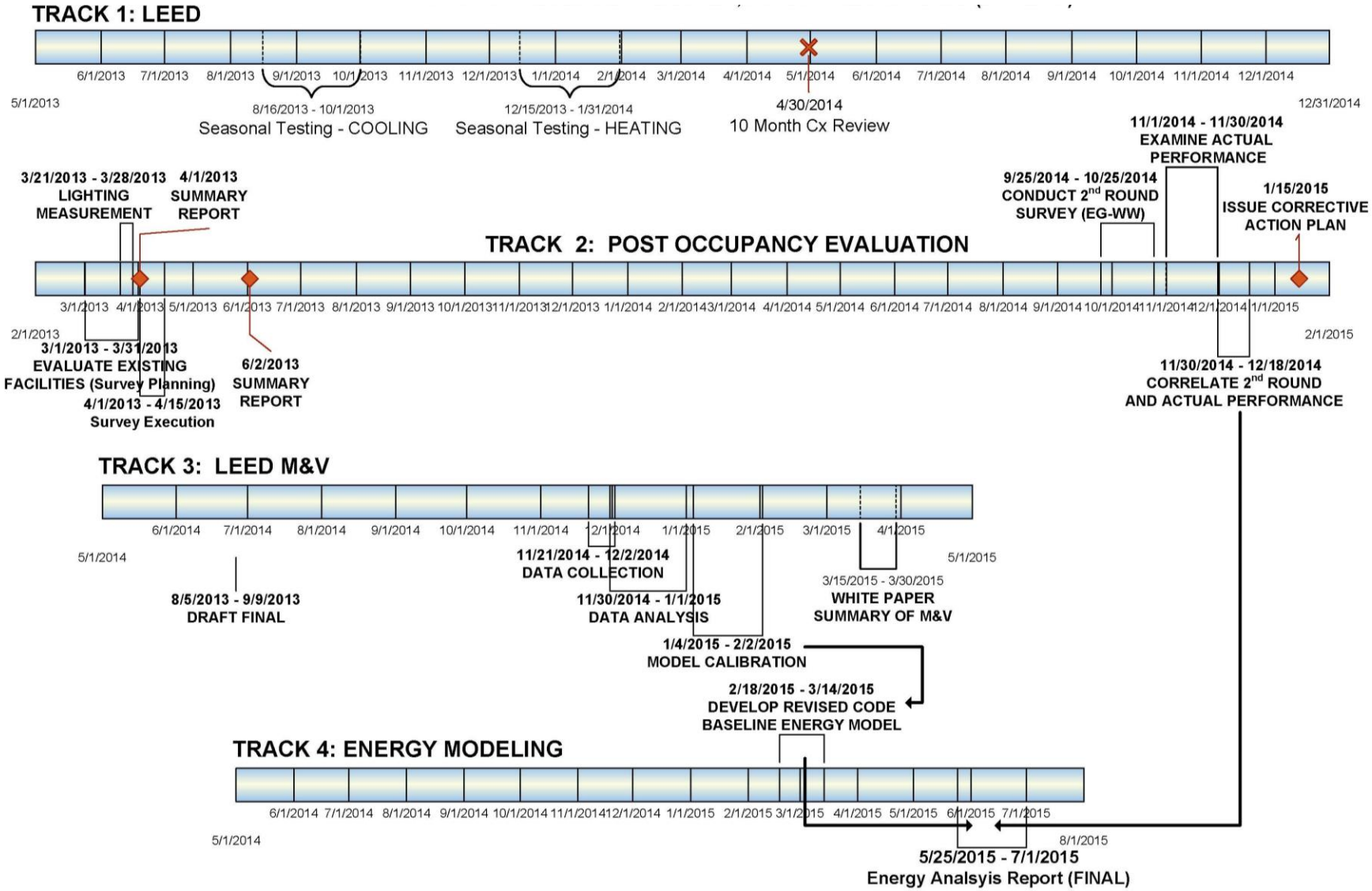
Overall, does the air quality in your workspace enhance or interfere with your ability to get your job done?

Enhances ○ ○ ○ ○ ○ ○ ○ Interferes

University of California, Berkeley – Center for the Built Environment (CBE)

POST OCC STUDIES

CBE, LBNL, M+V, MODELS and more…



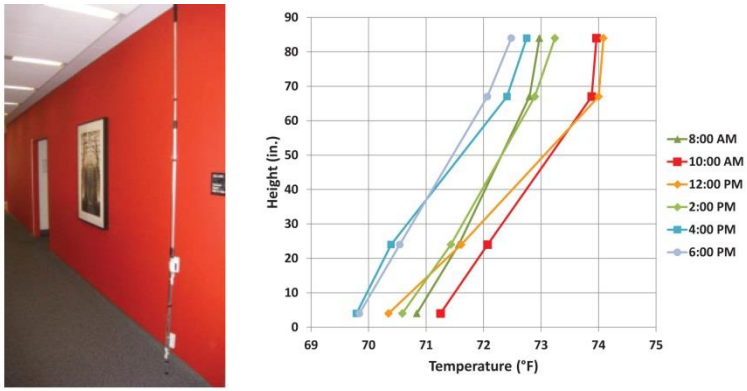
POST OCC EVALS
PHYSICAL MEASUREMENTS

INDOOR ENVIRONMENTAL QUALITY (IEQ)

- Thermal Comfort
- Electric Lighting
- Daylighting
- Indoor Air Quality
- Acoustics

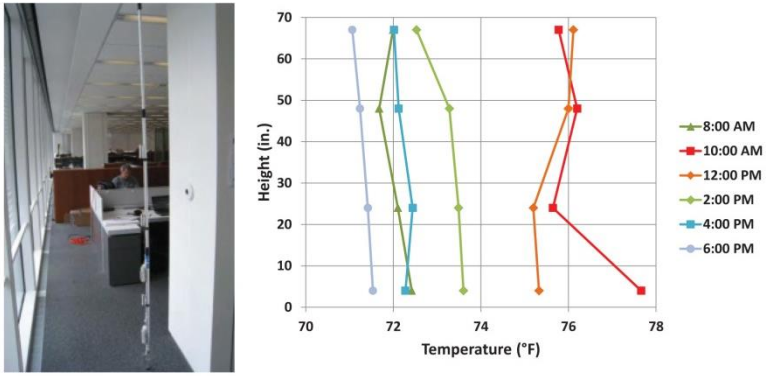
CORRELATE TO DESIGN

- IEQ parameters
  Lighting & Daylighting Studies
  Acoustics expectations
  Thermal Comfort Study
- Energy model assumptions



a) Photo of pole b) Temperature vs. height

Figure 20. East interior zone stratification pole and example hourly temperature profiles, 9/14/2011.



a) Photo of pole b) Temperature vs. height

Figure 21. East perimeter zone stratification pole and example hourly temperature profiles, 9/14/2011.

University of California, Berkeley – Center for the Built Environment (CBE)

COMMISIONING
ONGOING TUNING & OPTIMIZATION

SEASONAL TUNING

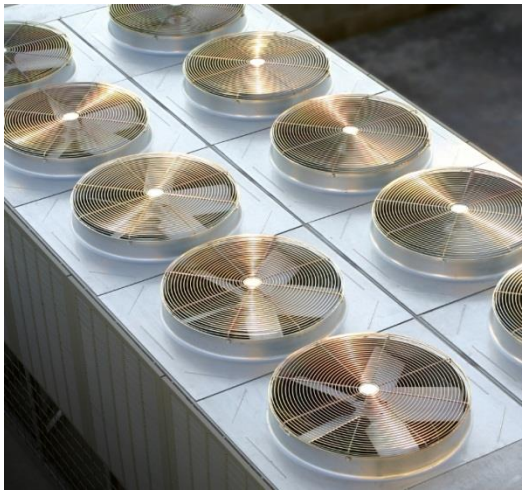
CALIBRATE ENERGY MODEL

CONNECT TO MEASUREMENT & VERIFICATION

- Tie into M&V and energy modeling cross-walk

TIE-IN WITH POST OCCUPANCY EVALUATIONS

- Involvement in corrective Action plan from occupant satisfaction



ONGOING M&V

ENERGY & WATER PERFORMANCE

ENERGY END USE METERS

- Major systems submetered

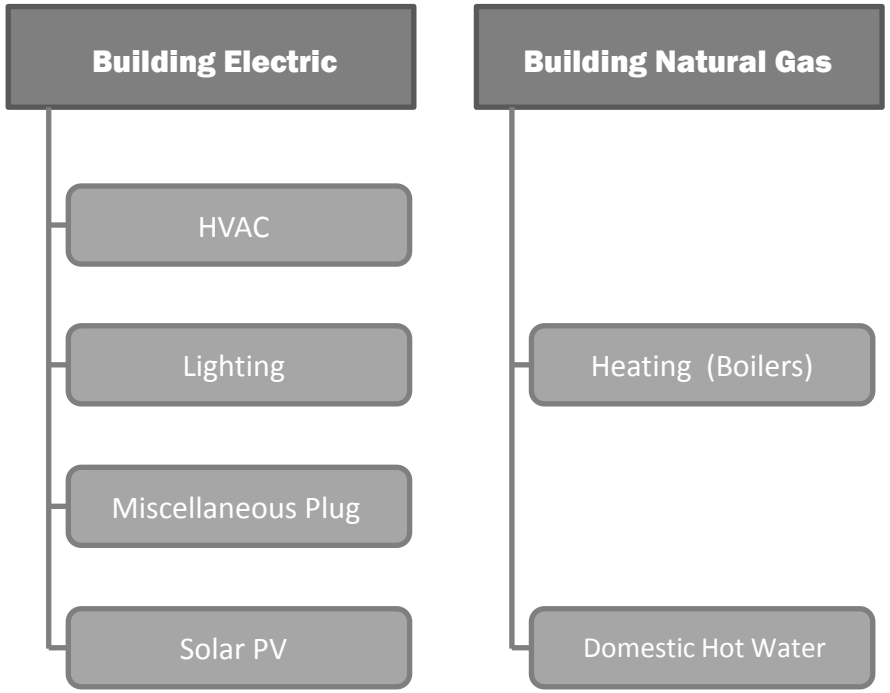
CORRELATE ACTUAL PERFORMANCE TO DESIGN

- Cross walk to early design energy model

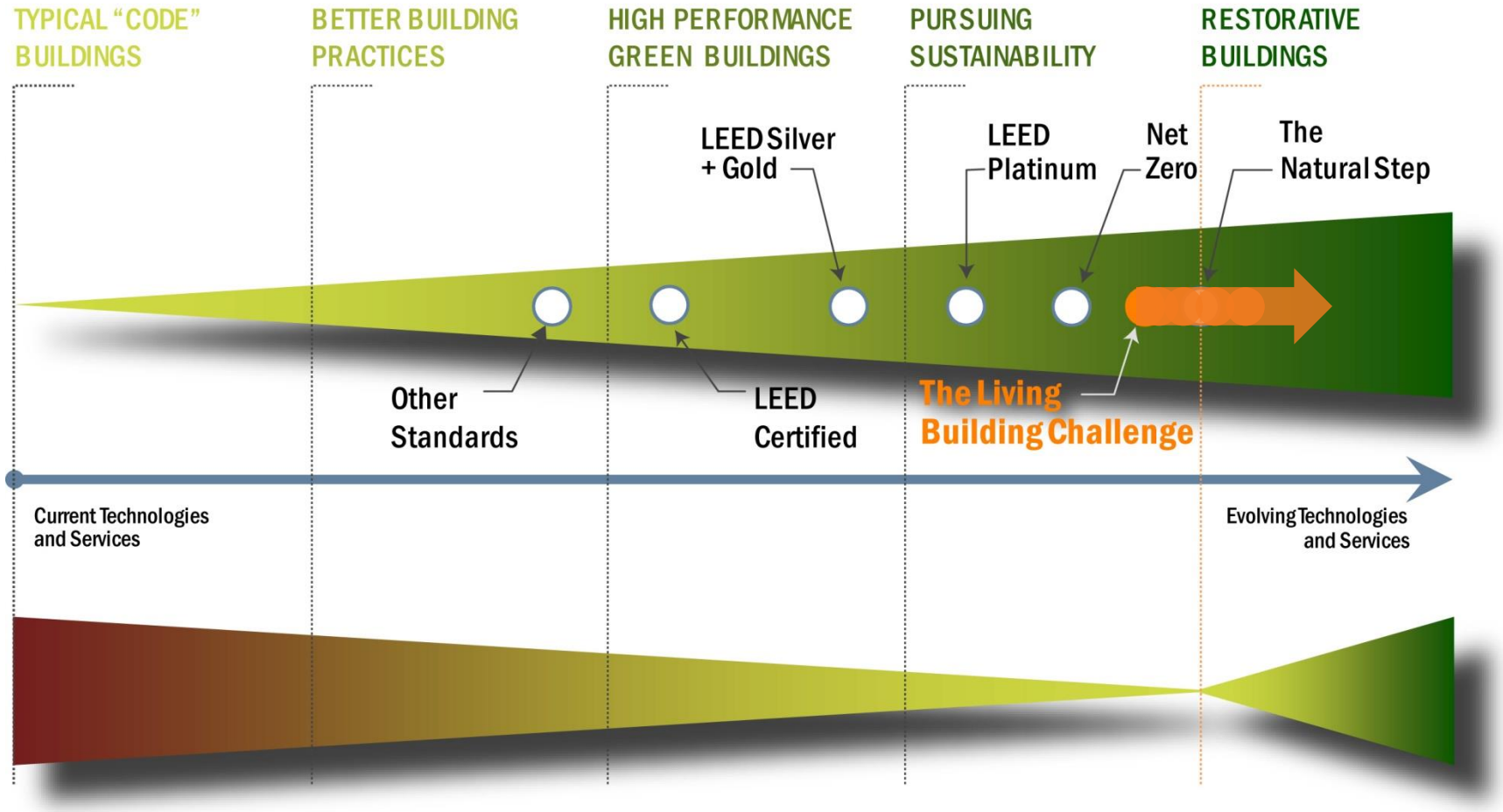
CALIBRATED MODEL FOR ONGOING OPTIMIZATION

WATER CALCULATOR

- Potable Water Use
- Rainwater catchment & Reuse



SHADES
OF GREEN



LIVING BUILDING CHALLENGE℠ 3.0

A Visionary Path to a Regenerative Future

http://living-future.org/

INTERNATIONAL LIVING FUTURE INSTITUTE℠

Oregon Sustainability Center

Living Building Challenge

PUBLIC / PRIVATE
PARTNERSHIPS

OSC Board:

- City of Portland Bureau of Planning and Sustainability
- Oregon University System
- Portland State University
- Portland Development Commission
- Oregon Living Building Initiative

- Plus dozens of other organizations, researchers, companies and others

Gerding Edlen Development	DEVELOPER
GBD Architects, SERA	PARTNER ARCHITECTS
Interface Engineering	ENGINEER OF RECORD
PAE Consulting Engineers, Inc.	ENERGY MODELING
GLUMAC	COMMISSIONING
kpff	STRUCTURAL ENGINEER
Nevue Ngan Associates [nev-ü · non]	LANDSCAPE ARCHITECT
otak	CIVIL ENGINEER
SKANSKA	GENERAL CONTRACTOR
NSI	NATURAL WATER TREATMENT

SITE PLAN

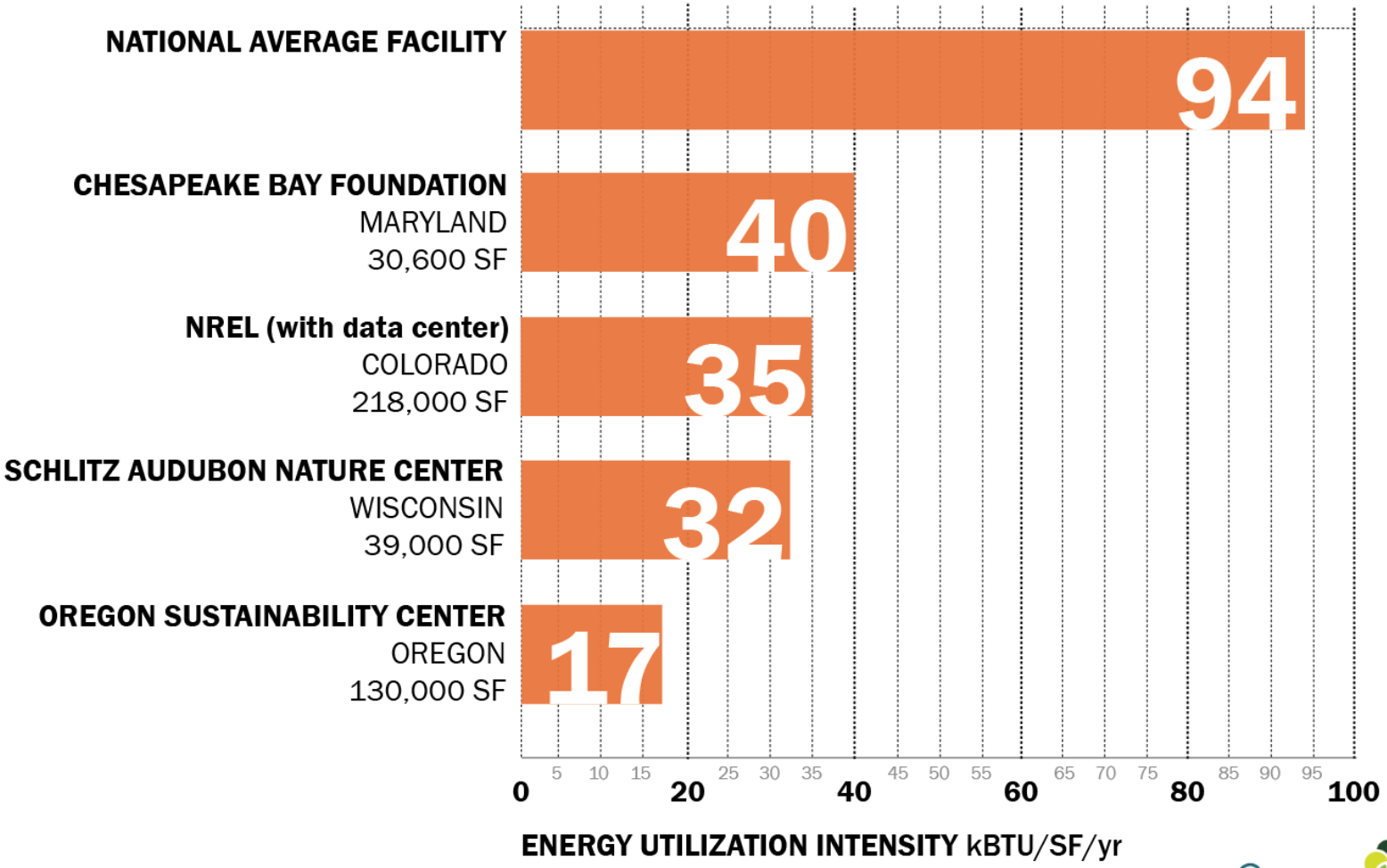
LRT
STREETCAR
STREETCAR STOP

GRID ALIGNED
20º W OF S

Oregon Sustainability Center

SECTION
PERSPECTIVES

ENERGY CHALLENGE
FLOOR TO ROOF AREA



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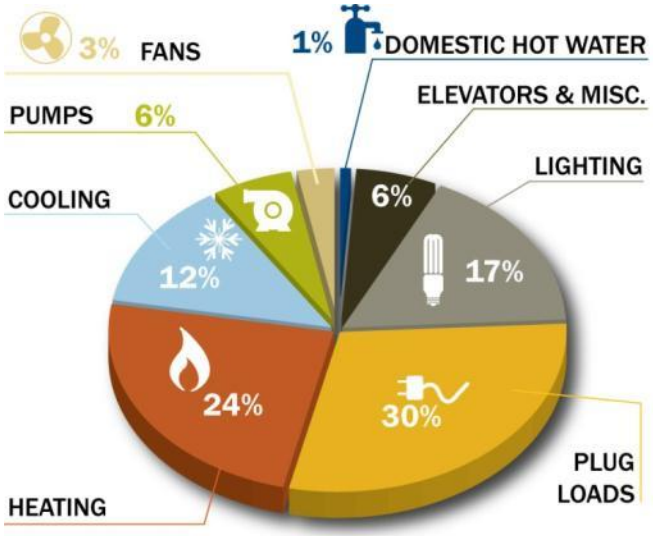
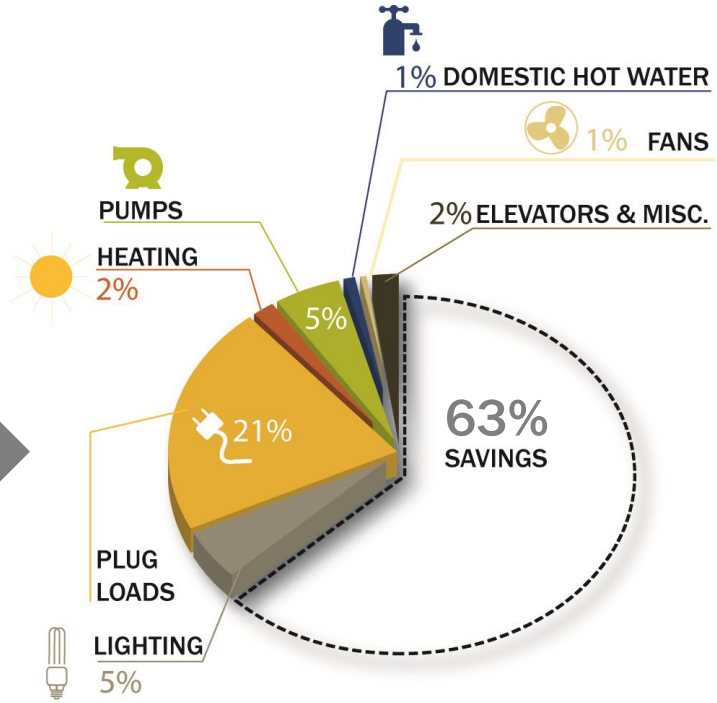
ENERGY USE
BEFORE TENANT ENGAGEMENT



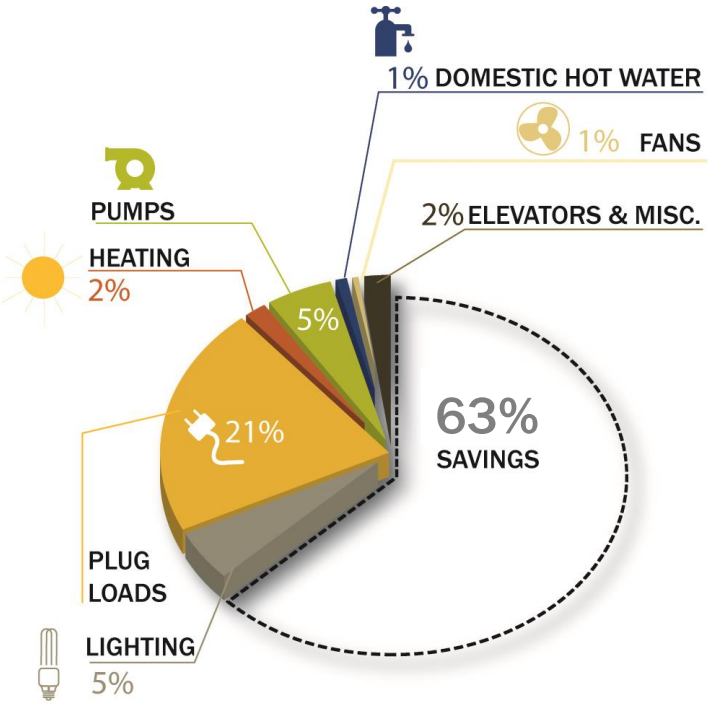
TYPICAL BUILDING ENERGY USAGE



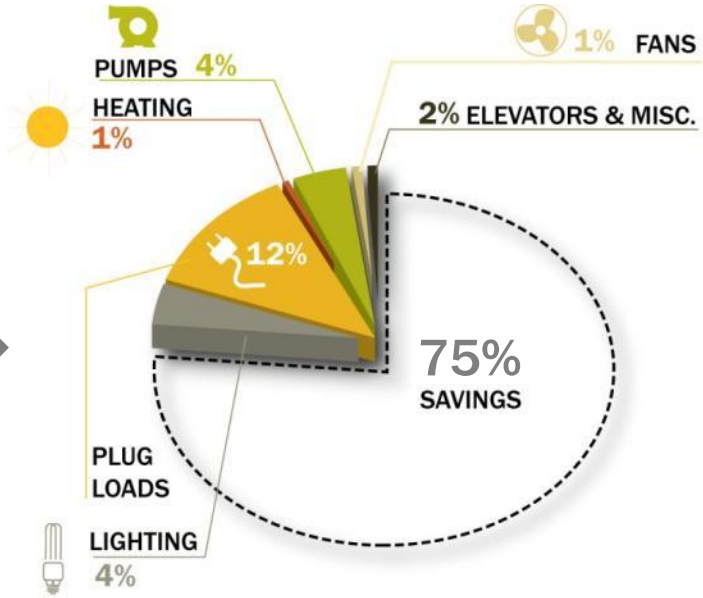
POTENTIAL ASHRAE SAVINGS Without Tenant ECMS

Oregon Sustainability Center

ENERGY DISTRIBUTION
WITH TENANT ENGAGEMENT



POTENTIAL
ENERGY SAVINGS
Without Tenant ECMS



ENERGY SAVINGS
GOAL
With Tenant ECMS

Oregon Sustainability Center

FEEDBACK MECHANISMS

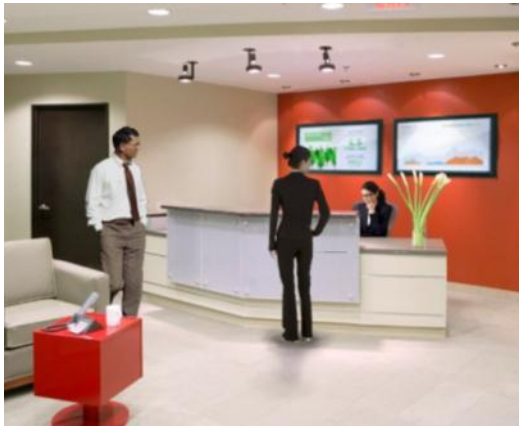
"FRACTAL DASHBOARDS"

BUILDING FAÇADE

Compare to other buildings

BUILDING LOBBY

Compare floors within the building



DEPARTMENT/OFFICE

Create inter-office competition

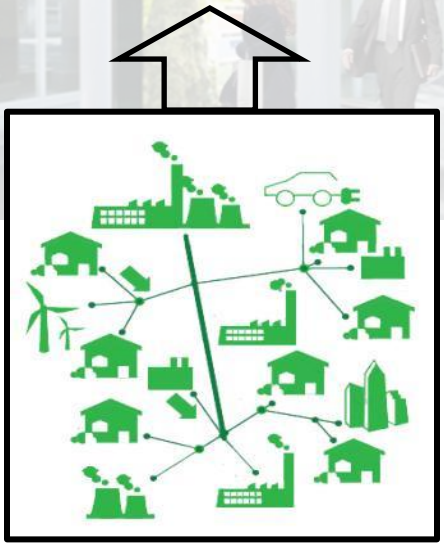
INDIVIDUAL

Understand personal contribution

Oregon Sustainability Center

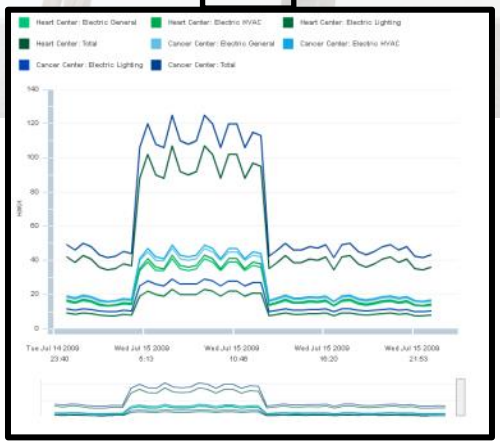
FEEDBACK MECHANISMS

INFORMATION SOURCES



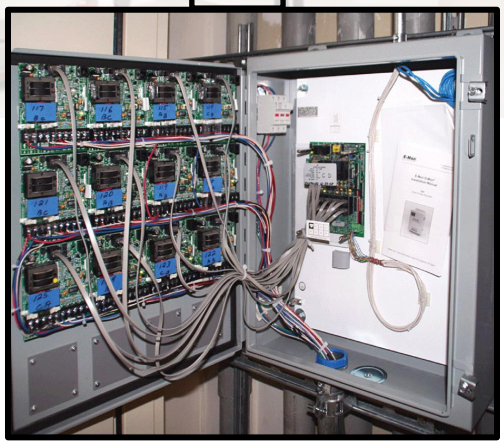
BUILDING FAÇADE

Smart Grid Connections



BUILDING LOBBY

Building Management System



DEPARTMENT/OFFICE

Utility Submetering

INDIVIDUAL

Plug Load Monitors

(Enmetric Systems Power Port shown)

Oregon Sustainability Center

buildingdashboard

CIVIC

Seattle 2030 District

Find buildings

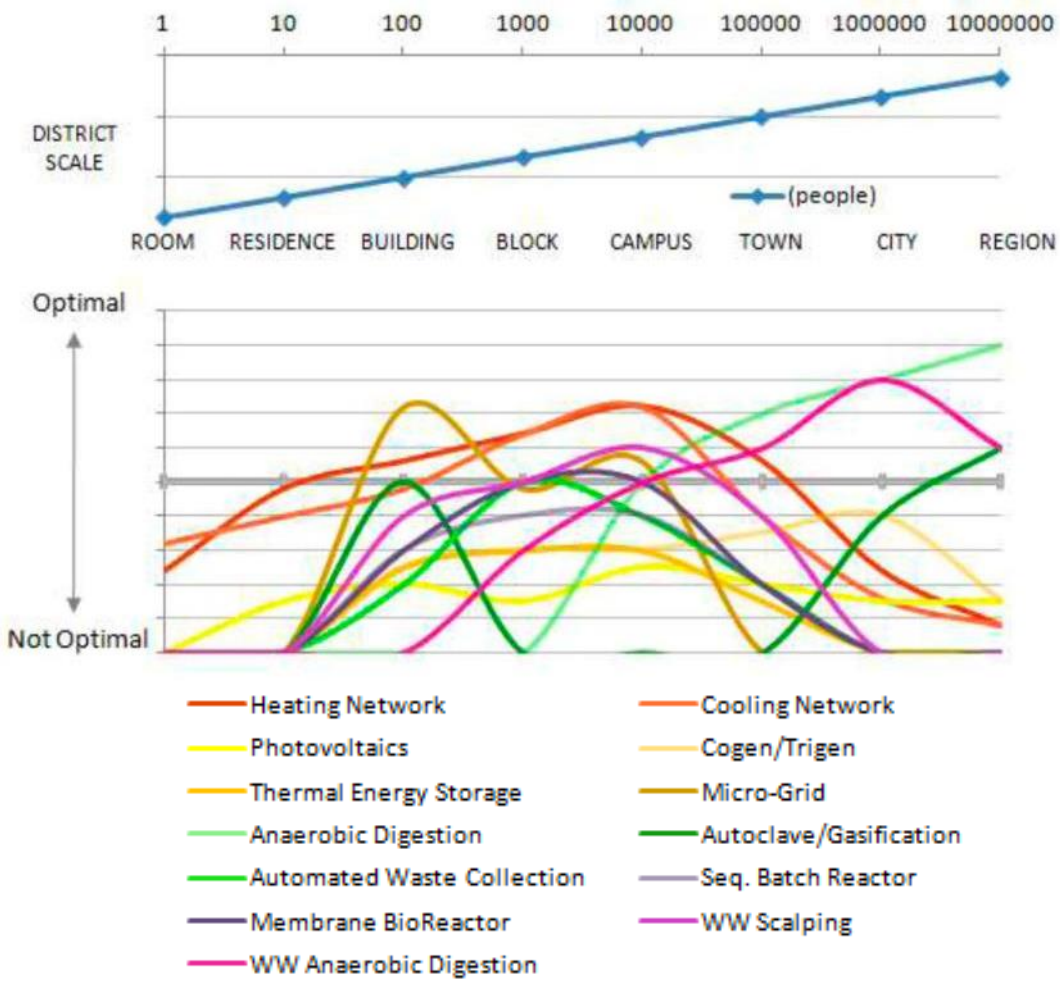
SEATTLE 2030 DISTRICT

Homepage

Welcome to the Seattle 2030 District, a ground-breaking, high-performance building district in downtown Seattle. By targeting a district-wide reduction in energy and water use in buildings and CO2 emissions from commute trips, we will work collaboratively to meet a 50% energy reduction by the year 2030. The progress below represents actual data tracking of these three metrics in the Seattle 2030 District member base:

- 23.6 million Square Feet of Building Space
- 73 Buildings - Office, City, County, Hotel, and Healthcare

OPTIMAL SCALES ALL



EcoDistricts Institute

Ecodistricts.org

http://www.sera-architects.com/blog/wp-content/uploads/documents/Making_EcoDistricts.pdf

CONTRIBUTIONS

EcoDistricts Institute: http://ecodsitricts.org/

Arup: http://www.arup.com/

Sherwood Design Engineers: http://www.sherwoodengineers.com/

International Living Future Institute: http://living-future.org/

Living Building Challenge: http://living-future.org/node/24

Living Building Challenge Financial Study: http://living-future.org/node/265

Achieving Water Independence in Buildings: http://living-future.org/node/275

Center for the Built Environment
http://www.cbe.berkeley.edu/

Making EcoDistricts - Civic Ecology: http://www.sera-architects.com/blog/wp-content/uploads/documents/Making_EcoDistricts.pdf

AIA 2030 Challenge: http://network.aia.org/2030Commitment/Home

THANK YOU!

Questions / More Information:

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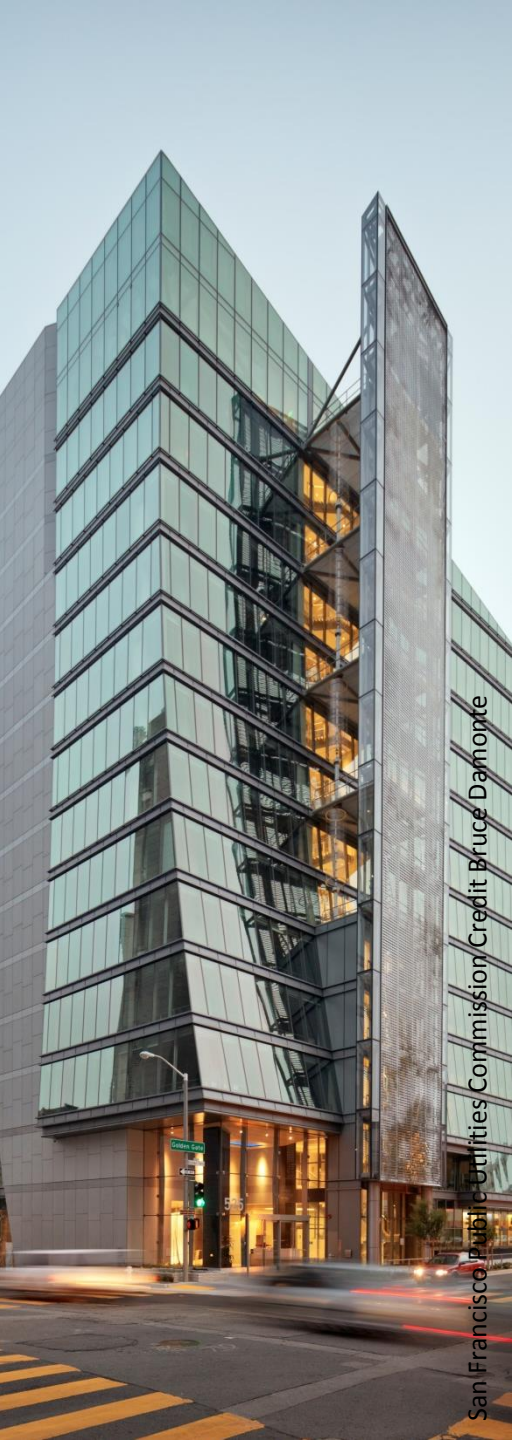
San Francisco Public Utilities Commission/Credit Bruce Damonte

nbi new buildings institute

Thank you!

http://newbuildings.org/zero-energy

http://newbuildings.org/webinars