

# Energy Goals and Integrated Design

**November 14, 2018**  
**ASHRAE Salt Lake City Chapter**


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Produced By:

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 City of Seattle

 BETTERBRICKS  
Bottom line thinking on energy.

## Energy Goals and Integrated Design

**“...Set goals that command your thoughts, liberate your energy, and inspire your hopes.”**

**Andrew Carnegie**

**“What keeps me going is goals.”**

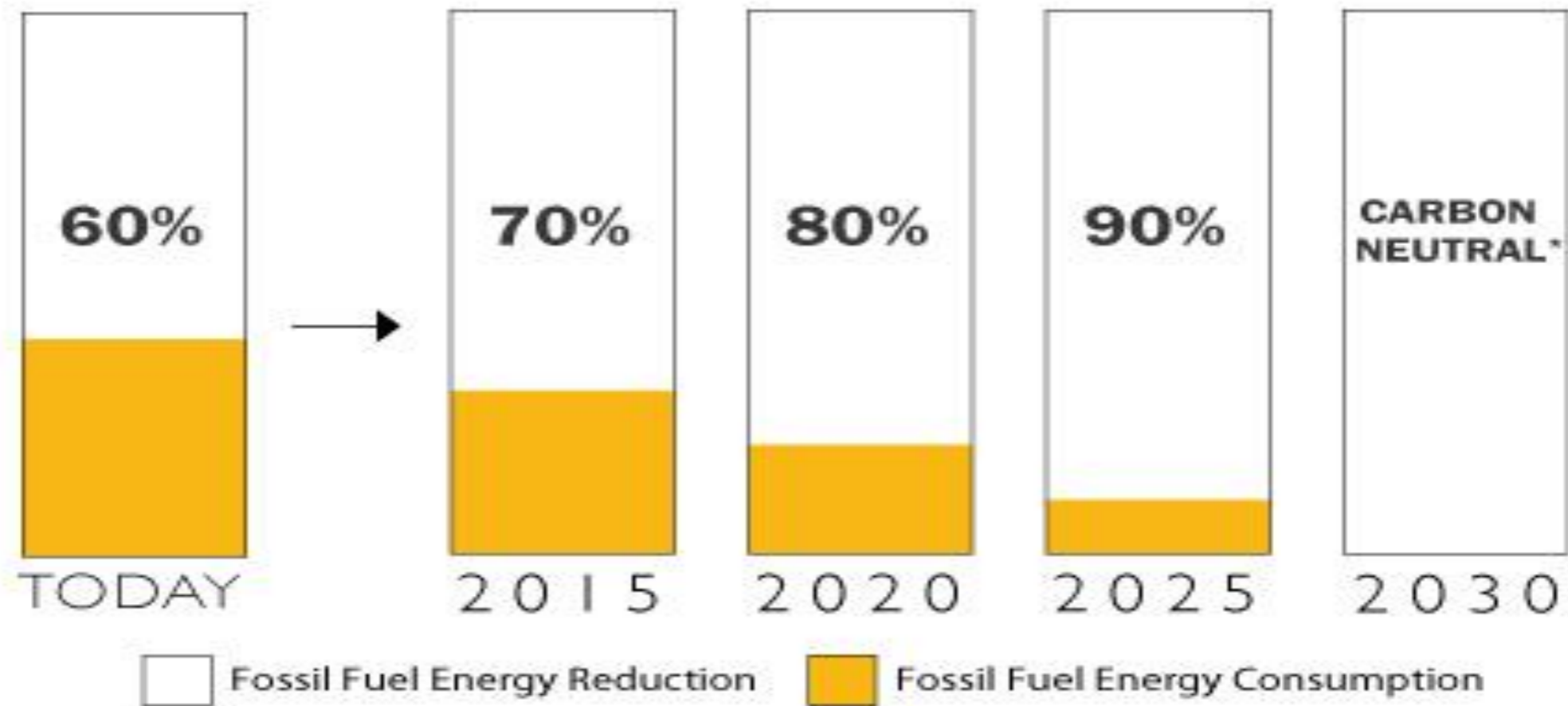
**Muhammed Ali**

## Energy Goals and Integrated Design

**A Sustainable Future is no longer just a topic for discussion but rather a serious global objective. It is now critical for definitive design guidance, innovative architectural and engineering applications and leading-edge research to be initiated as the principal focus of these global professional organizations.....**

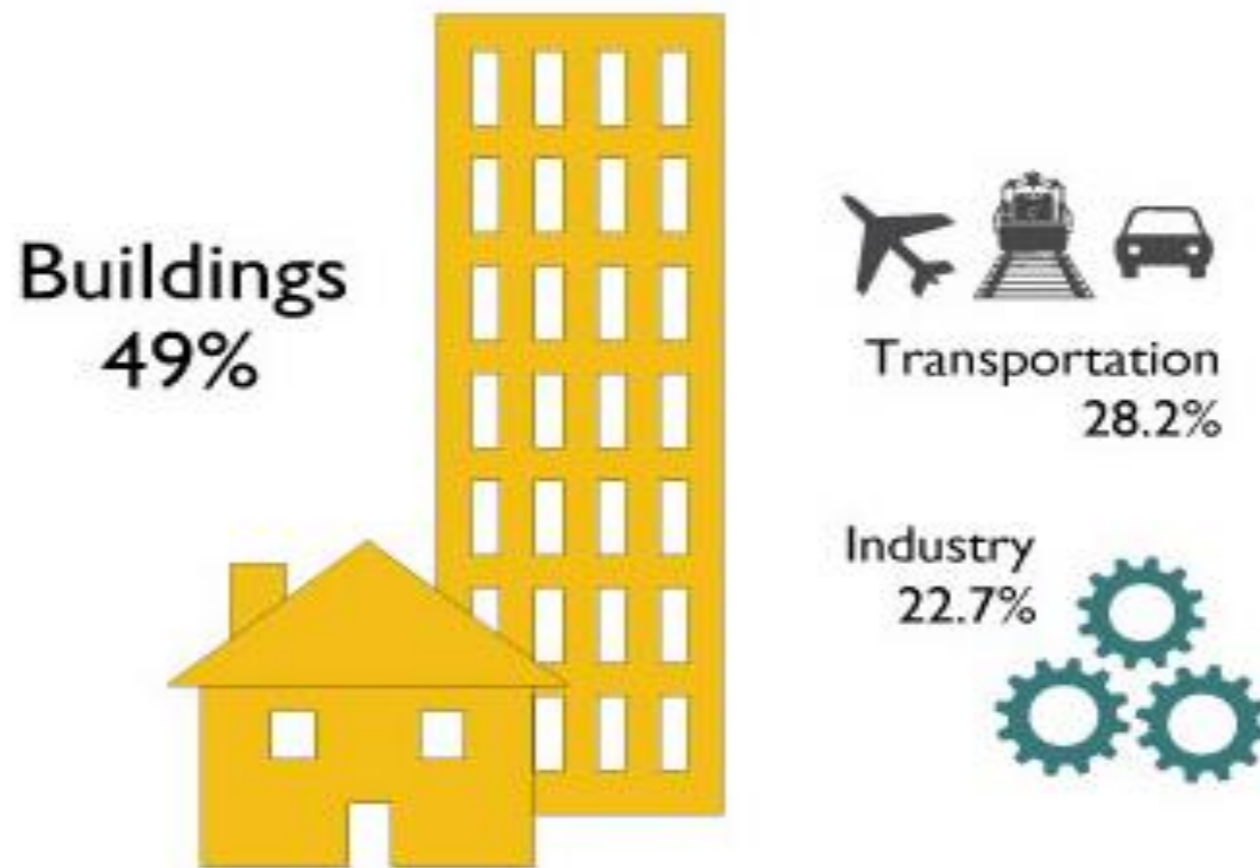
**AIA, ASHRAE, IES & USGBC**

## The 2030 Challenge



### The 2030 Challenge

## The 2030 Challenge



### U.S. Energy Consumption by Sector

Source: ©2010 2030, Inc. / Architecture 2030. All Rights Reserved.  
Data Source: U.S. Energy Information Administration (2009).

## The 2030 Challenge

- **Buildings consume:**
  - **49%** of all energy used and over 70% of electrical energy that is generated
  - **17%** of all fresh water
  - **25%** of wood produced
- **Buildings produce 33% of CO<sub>2</sub> emissions**
- **Buildings generate 30% of waste in landfills**

## Energy Targets & EUIs

### Two Types of Targets Should be Developed:

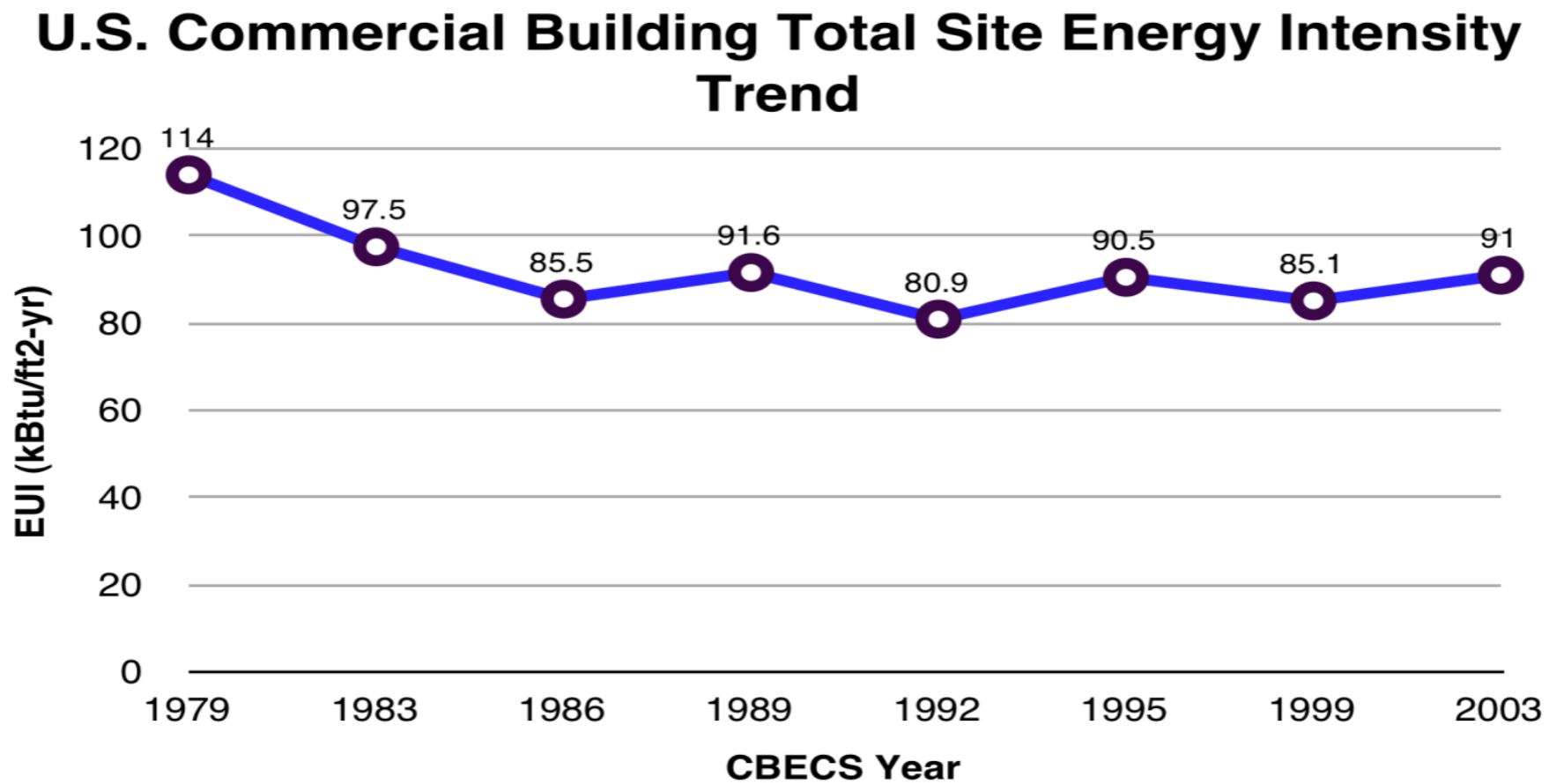
\* Energy Use Index/Intensity (EUI) – includes no on-site renewable energy generation

$$\text{EUI} = \frac{\text{Total Annual Energy Use (kBtu/SF-yr)}}{\text{Gross Floor Area}}$$

\* Net Energy Use Intensity (NEUI) – includes photovoltaic and other on-site renewable energy production

$$\text{NEUI} = \frac{\text{Net Annual Energy Use (kBtu/SF-yr)}}{\text{Gross Floor Area}}$$

## Energy Targets & EUIs



Energy Information Administration  
Commercial Buildings Energy Consumption Survey



## Energy Targets & EUIs

- Commercial Buildings Energy Consumption Survey (CBECS)
  - \* U.S. National Sample Survey Conducted Every 4 Years
  - \* Based Upon a Sample of 5,215 Buildings
  - \* Information Provided is Weighted to Represent the Entire Stock of Commercial Buildings
  - \* There are 18 Classifications of Buildings

## 2030 Energy Targets & EUIs (kBTU/SF/Yr)

<u>Building Type</u>	<u>50%</u>	<u>60%</u>	<u>70%</u>	<u>80%</u>	<u>90%</u>
College/Univ.	60.0	48.0	36.0	24.0	12.0
Restaurant	151.0	120.8	90.6	60.4	30.2
Churches	23.0	18.4	12.8	9.2	4.6
Healthcare	62.0	49.6	37.2	24.8	12.4
Malls	53.5	42.8	32.1	21.4	10.7

## The 2030 Challenge EUI Targets

### ASHRAE 90.1/189.1

2010 – 36 kBtu/ft<sup>2</sup>/yr

2013 – 30

2016 – 25

2019 – 20

2022 – 15

2025 – 10

2028 – 5

**2030 – Net 0**

### Architecture 2030

2010 – 36 kBtu/ft<sup>2</sup>/yr

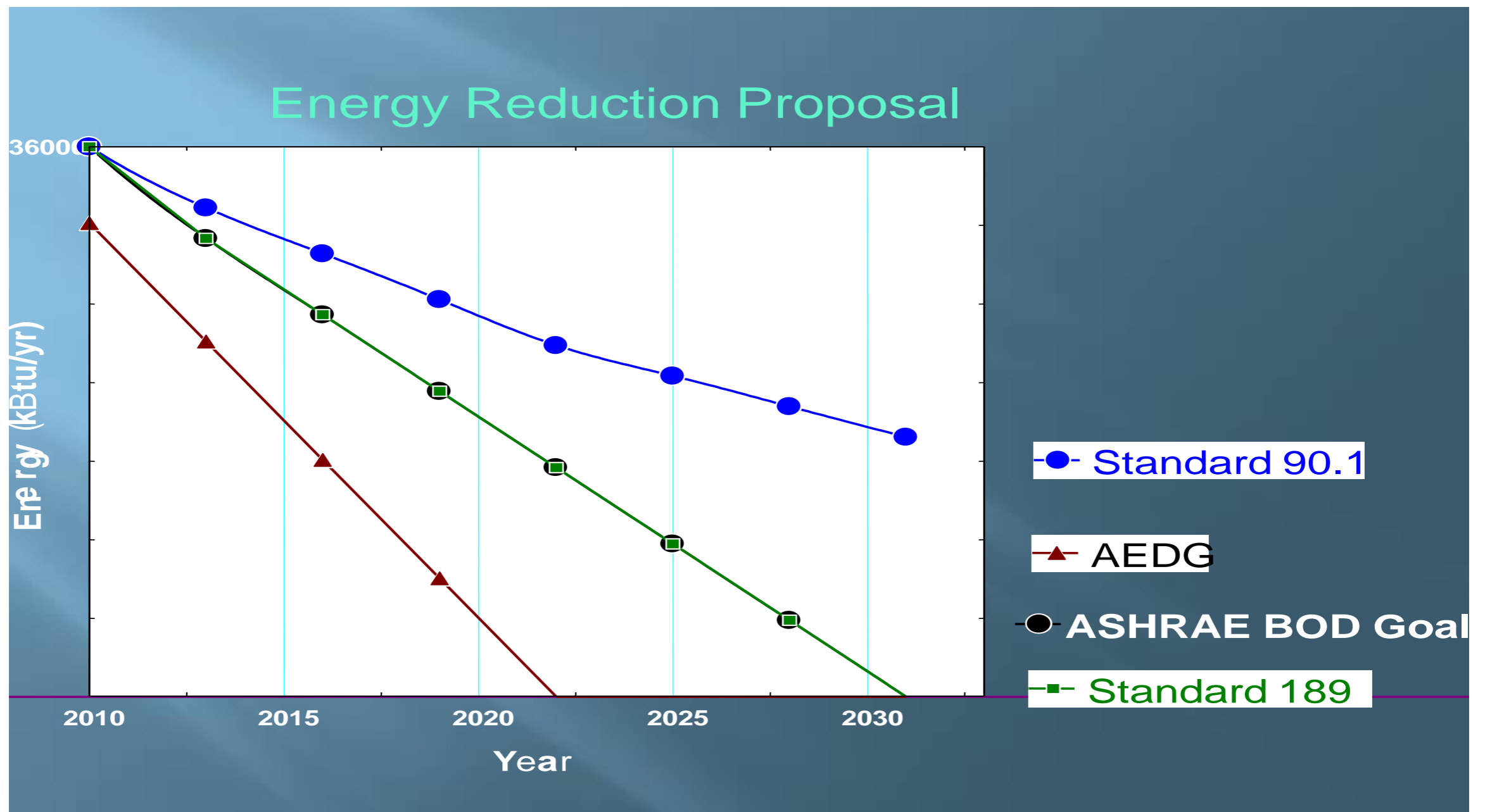
2015 – 27

2020 – 18

2025 – 9

**2030 – Net 0**

## The 2030 Challenge EUI Targets



## **Integrated Design**

### **Optimization for 21<sup>st</sup> Century Design Sequence Rocky Mountain Institute**

(Suggested Design Steps)

1. Expand comfort considerations – radiant temperatures, turbulent air movement, ventilative chairs, etc...
2. Reduce unwanted heat gains/losses of space

## Integrated Design

### Optimization for 21<sup>st</sup> Century Design Sequence Rocky Mountain Institute

3. Exploit passive cooling (ventilative, radiative, ground-coupling, etc...)
- 4 Utilize non-refrigerative alternative cooling (evaporative, desiccant, absorption and hybrids)
5. **Choose efficient building components** (normal starting point)

## Integrated Design

- A Successful Integrated Design Approach Provides the Best Energy Performance at the Least Cost and is Characterized as Follows:
  1. It is Resourceful – Proper Building Orientation, Form, and Layout Provide Substantial Energy Savings
  2. It is Multi-disciplinary – Process Requires Cross-Disciplinary Design and Validation at ALL Phases of the Process

## Integrated Design

3. It is Goal Driven – Early in the Design Process Goal Setting can Identify Strategies to Meet Energy Efficiency and Other Building Goals in Accordance with the Owner's Project Requirements/Mission
4. It is Iterative – Goal Setting is Just the Beginning; The Design Concept Needs to be Tested Throughout the Design Process, Optimized for Maintenance Requirements and Adjusted to Provide Acceptable Life-Cycle Costs



## High Performance Integrated Design

### Pre-Design Phase

#### Activities

#### Responsibilities

- |  |                    |
|--|--------------------|
| • Selection of Core Team   | Owner              |
| • Adopt Energy & Project Goals   | Owner & Designers  |
| • Assess the Site<br>(e.g. Community, Access to Transp.<br>On-site Energy, Bldg Orientation) | Owners & Designers |

## High Performance Integrated Design

### Pre-Design Phase

#### Activities

#### Responsibilities

- Define Functional & Spatial Requirements
- Define Energy & Budget Benchmarks
- Prepare Design & Constr. Sch.
- Determine Preferences – Bldg Envelope & Systems

Owner & Designers

Owner & Designers

Owner & Designers

Owner & Designers

## High Performance Integrated Design

### Pre-Design Phase

#### Activities

- Perform Cost/Benefit Analyses for Energy Strategies
- Identify Applicable Energy Code Requirements

#### Responsibilities

Owner & Designers  
  
Owner & Designers

## High Performance Integrated Design

### Design Phase

#### Activities

#### Responsibilities

- |  |                   |
|--|-------------------|
| • Prepare Bldg Plans per Functional Program Requirements/OPR | Designers         |
| • Develop Specific Energy Strategies                         | Owner & Designers |
| • Develop Site Plan – Best Use of Orientation & Daylighting  | Designers         |
| • Select Bldg Systems per OPR                                | Owner & Designers |
| • Develop Bldg Plans, Sections & Details                     | Designers         |

## High Performance Integrated Design

### Design Phase

#### Activities

#### Responsibilities

- |  |                          |
|--|--------------------------|
| • Develop Arch. & Ltg. Details   | Designers                |
| • Perform Design Reviews at Each Phase for Conformance to OPR Energy Targets | Owner & Designers<br>CxA |
| • Calc Bldg Loads & Energy Models to Optimize Designs                        | Designers                |
| • Match Equip Capacities to Loads  | Designers                |

## High Performance Integrated Design

### Design Phase

#### Activities

#### Responsibilities

- |  |                       |
|--|-----------------------|
| • Perform Coordination and Integration of Arch & MEP Systems | Designers             |
| • Prepare Specifications                                     | Designers             |
| • Integrate Cx Into Specifications                           | Designers & CxA       |
| • Prepare Cost Estimates at Each Design Phase                | Estimators & CM       |
| • Review/Revise Final Design Documents                       | Owner, Designers, CxA |

## High Performance Integrated Design

### Construction Phase

#### Activities

- At Pre-Bid – Emphasize EEMs
- At All Job Meetings – Review EEMS & Cx Procedures
- Verify Bldg Envelope Follows Drawings & Specs
- Verify MEP Systems Meet Specs
- Conduct Pre-Functional Tests

#### Responsibilities

- Owner, Designers & CxA
- Owner, Designers, CxA & CM
- Designers & CxA
- Designers & CxA
- Owner, CxA, CM, GC & Subcontractors

## High Performance Integrated Design

### Acceptance Phase

#### Activities

#### Responsibilities

- |  |  |
|--|--|
| • Prepare Pre-Occupancy Punch List     | Owner, Designers, CxA & CM               |
| • Conduct Functional Performance Tests | Owner, CxA, CM, GC & Subcontractors      |
| • Submit O&M Manuals                   | CxA, GC & Subcontractors                 |
| • Provide Training to Facility Staff   | CxA, GC & Subcontractors                 |
| • Establish Bldg O&M Program           | CxA, GC, Subcontractors & Facility Staff |



## High Performance Integrated Design

### Acceptance Phase

#### Activities

#### Responsibilities

- |   |                                 |
|---|---------------------------------|
| • Resolve Any Open Cx Issues from Construction & Occupancy Phases | Owner, CxA, GC & Subcontractors |
| • Certify Bldg as Sustainably Complete                            | Owner, Designers, CM & CxA      |
| • Purchase Eqmt per Energy Star                                   | Owner & Staff                   |
| • Monitor Post-Occupancy Performance                              | CxA & Staff                     |
| • Create Post-Occupancy Punch List                                | CxA & Staff                     |
| • Grant Final Acceptance  | Owner, Designers, CM & CxA      |

## High Performance Integrated Design

### Post-Occupancy Phase

#### Activities

#### Responsibilities

- |  |                        |
|--|------------------------|
| • Set Up Performance Tools, Dashboards & Verification Data Protocols | Owner, Staff & CxA     |
| • Validate Performance per O-Cx Plan                                 | Owner, Staff & CxA     |
| • Develop Improvement Opportunities                                  | Staff & CxA            |
| • Implement Corrections & Meas. Perform.                             | Staff & CxA            |
| • Record Improvements Results  | Owner, Staff & CxA     |
| • Update O-Cx Plan   | Staff & CxA            |
| • Update CFR   | Owner, Designers & CxA |

## Building Systems Commissioning

- **Process Cx** utilizes First Party Validation = Paper-based procedures
- **Technical Cx** utilizes Third Party Validation = Testing-based procedures
- Phases of a **Technical Cx** Platform –
  1. Design Phase
  2. Construction Phase
  3. Post-Occupancy Phase
  4. “On-Going” Cx Activities

## Building Systems Commissioning

- **Technical Cx Design Phase Deliverables:**
  - a. Owner's Project Requirements (OPR)
  - b. Issues Log
  - c. Commissioning Plan
  - d. Updates to the Basis of Design (BOD) documentation

## Building Systems Commissioning

- **Technical Cx Construction Phase Deliverables:**
  - a. Site Observation Inspections & reports
  - b. Pre-Functional Tests (PFTs)
  - c. Functional Performance Tests (FPTs)
  - d. Issues Log & Deficiency Resolutions
  - e. Owner Training in O&M and functions of building's systems
  - f. Systems' Manual
  - g. Final Technical Cx Report

## Building Systems Commissioning

- **Technical Cx Post-Occupancy Phase Deliverables:**
  - a. Deferred Tests (PFTs and FPTs)
  - b. Performance Verification Testing (PVT)
  - c. Updated Final Technical Cx Report with Deferred Tests and PVTs
  - d. Development of an On-going Technical Cx Plan and Program for Facility O&M Staff.

## Building Systems Commissioning

- **Technical On-Going Cx Phase Activities:**
  - a. Deploy Performance Tools, Dashboards & Reports
  - b. Set Up Verification Data Protocols
  - c. Conduct Operator Training (as required)
  - d. Validate Performance per O-Cx Plan
  - e. Deliverables = Develop Improvement Opportunities; Implement Corrections; Re-measure Performance; Record Results of Improvements; Update O-Cx Plan; Update CFR

## **New Whitmore Lake High School**

- 150,000 sq.ft. in Whitmore Lake MI
- Classrooms, Natatorium, Admin. & General Offices, Cafeteria, Science Labs, Gym, Media Center, Auditorium and Large “Main Street” Common Spaces
- 1<sup>st</sup> High School in MI - LEED Silver Rating



## **New Whitmore Lake High School**

### **Energy Efficiency**

- Htg & Clg → Geothermal-based HVAC w/Var. Speed Pumps Circ. Glycol Solution & By-pass Valves (Reduce Total Pumping Energy)
- 46 Miles of HDPE in Horizontal & Pond (14 Ac) Loops; Pond Level Maintained (w/Well) for HVAC & Fire Protection Requirements
- All Kitchen Refrigeration Eqmt Connected to Loop Field
- VAV ERVs – Pre-condition O/A w/WSHPs

# New Whitmore Lake High School

## Indoor Air Quality

- Air Velocities  $\leq$  150 FPM
- Low Level R/A Inlets Increase Vent. Effectiveness
- VAV Boxes Control O/A to each WSHP per BAS/CO2 Levels
- Gym & Auditorium – Demand CO2 Vent Strategy (100% Capability)
- Absenteeism Decreased 12.5%  $\rightarrow$  5%; ACT Scores Now Exceed MI State Averages (3 years in a row)

## **New Whitmore Lake High School**

### **Maintenance & Operation**

- Better Equipment Accessibility – Equipment Mezzanines
- Repair/Remove/Replace Equipment w/o Disruptions
- Reduced Filter Changeout Times
- All Geo Loop Branches – Balancing Valves, Press. Differential Readings & Thermometers (Monitor of Heat Exchange Effectiveness)
- Centralized Control of Entire Facility

## **Additional Sustainable Facilities To Check On**

- Fossil Ridge High School – 290,000 sq.ft.
- Abbotsford Regional Hospital and Cancer Center – 678,000 sq.ft.  
LEED Gold
- Mountain Equipment Co-op Retail Outlet – 22,600 sq.ft. LEED Gold
- IKEA Distribution Center & Offices – 857,700 sq.ft.
- Tanimura and Antle Memorial Library – 136,000 sq.ft. LEED Silver
- Northwest Maritime Center – 26,550 sq.ft. LEED Gold
- Battelle Biological Sciences – 144,000 sq.ft. LEED Gold

## Net-Zero IDeAS Z<sup>2</sup> Design Facility

### PROJECT DESCRIPTION

- 7,200 sq.ft. Gross Area
- Commercial Office Space for  
Electrical Consulting  
Engineering Firm
- 3,100 sq.ft. 1-story Open Studio  
Space
- 4,100 sq.ft. 2-story Office Section
- Z<sup>2</sup> Design Goals:
  1. Net-zero Energy
  2. Zero CO<sub>2</sub> Emissions



Model Showed 60% Reduction  
from ASHRAE 190.  
PV Produced More than  
Consumed

## Net-Zero IDeAS Z<sup>2</sup> Design Facility

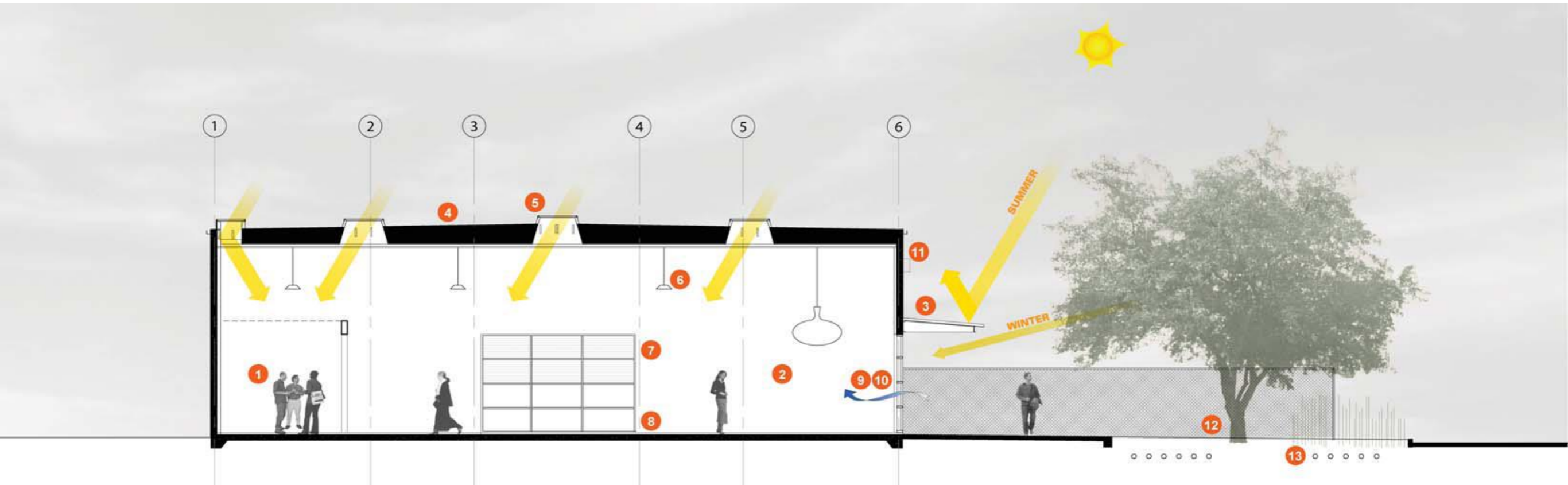
### NZEB STRATEGIES

- Slab Radiant Tubing – Heating & Cooling
- Ground-source Heat Pumps → Chilled Water & Space Heating Water
- Natural Ventilation – O/A Temps fall within Acceptable Range
- Natural Daylighting
- East Electrochromic Window Wall – No Moving Parts
- R-19 (Walls); R-30 (Roof)

## Net-Zero IDeAS Z<sup>2</sup> Design Facility

### NZEB STRATEGIES

- 30 kW Building Integrated PV (BIPV) System → 56 MWh/yr (100% of Bldg's Energy Requirement)
- BIPV = White Roof Membrane Integrated PV Monocrystalline Solar Cells
- 2<sup>nd</sup> BIPV = Sunshade @ Main Entrance
- High Efficiency Interior & Exterior Lighting
- Occupancy Sensors – Lighting and Workspace Appliances & Task Lights





## Net-Zero IDeAS Z<sup>2</sup> Design Facility

### NZEB STRATEGIES

- Office Spaces @0.15 cfm/sf vs 62.1 = 0.13 cfm/sf
- DOAS = 100% O/A to all spaces
- AHUs → MERV 13 filters
- Displacement Ventilation → Assists Radiant Heating & Cooling
- Natural Ventilation → Operable Windows & Large Swing-Open Patio Style Doors
- IEQ Bldg Survey → 90%+ Satisfaction

## Net-Zero IDeAS Z<sup>2</sup> Design Facility

### NZEB STRATEGIES

- Building Management DDC System – Automatically Makes Operational Mode Changes
- Monitor Actual Energy Consumption – Circuit-by-Circuit Basis; Weather Data from PV → Fine Tune Systems' Efficiencies
- Choice of Plants – Reduces Irrigation Requirements and Maintenance

## Net-Zero IDeAS Z<sup>2</sup> Design Facility

### NZEB STRATEGIES

- Utility Incentives & Rebates + Tax Credits + State/Federal Incentive Programs and PV Production = 7.6 Year Payback
- Plumbing Fixtures → Ultra Water Efficient
- Bioswale (Rain Collector) Reduced Heat Island Effect → Recharges Water Table
- Façade of Original Building was Reused in the Courtyard

## Net-Zero IDeAS Z<sup>2</sup> Design Facility

### LESSONS LEARNED

- Reduce energy level before adding renewable energy sources
- New technologies can/will fail initially
- Radiant heating and cooling + natural ventilation provide low energy consumption & exceptional comfort levels

## Your Role, Your Duty and Your Responsibility

*“Don’t be put off by people **who know** what is not possible. Do what **needs to be done**, and then check to see if it was impossible only after you are done.”*

Paul Hawken  
University of Portland Graduation Address  
May 2009

## Your Role, Your Duty and Your Responsibility

*“Success Means Doing the Best We Can With What We Have; It’s Reaching for the Highest That is in Us and Becoming All That We Can Be.”*

**Zig Ziglar**

*“Learning is an Experience. Everything Else is Just Information”*

**Albert Einstein**