GO FAST, GO SLOW: PLANNING EARLY FOR ZERO NET ENERGY

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Learning Objectives

- Explain the top 5 design considerations for ZNE that need to be considered before preparing an RFP
- Identify specific design questions that a project team needs the building energy modeling effort to answer as early as pre-design.
- Determine the appropriate tools to ensure that energy performance goals will be achieved on any project.
- Prepare a framework to effectively integrate early-stage building energy modeling within any firm's culture and design practice.

Presentation Overview

Learning Objectives

5 Questions to ask before writing your ZNE RFP

Case Studies

Conclusion

Perceptions of “Net Zero”

Defining Zero Net Energy (ZNE)

- **Many definitions.**
- **Compare "apples to apples."**

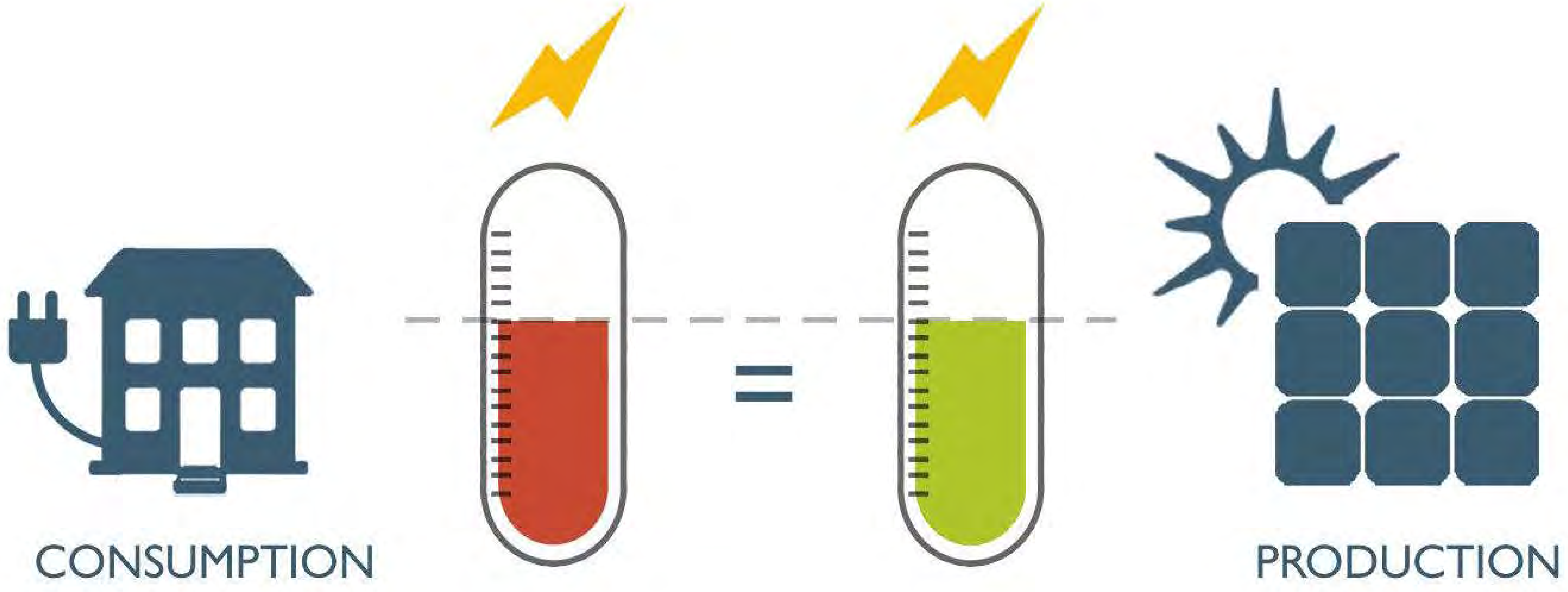
National Renewable Energy Laboratory (NREL) basic definitions:

1. Zero Net **SITE** Energy.
2. Zero Net **SOURCE** Energy.
3. Zero Net Energy **COST**.
4. Zero Net Energy **EMISSIONS**.

Defining Zero Net Energy (ZNE)

- **Zero Net Site Energy.**

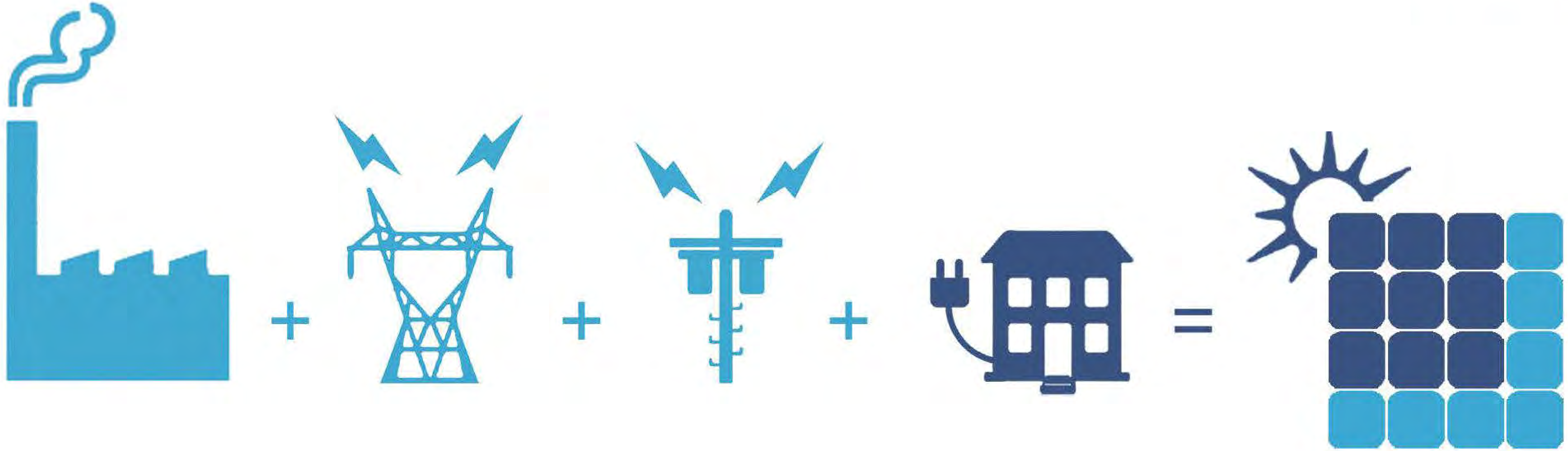
A building that generates (at least) as much energy as it uses on-site. This is the most common use of the "net-zero" term.



Defining Zero Net Energy (ZNE)

- **Zero Net Source Energy.**

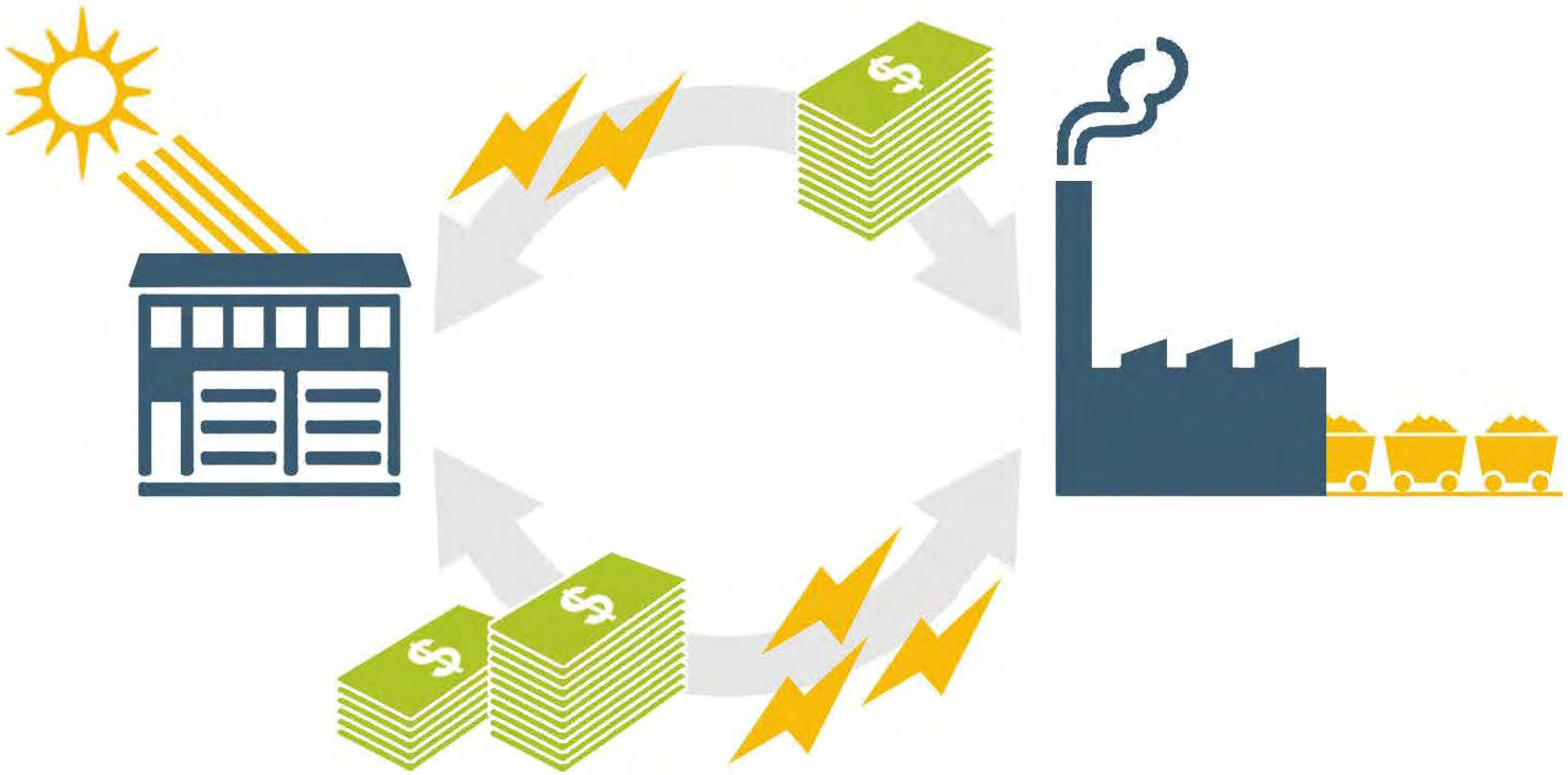
  A building that produces (at least) as much energy as it consumes when compared to the energy sed to **both generate and deliver** the energy to the site from a remote point of generation (such as a plant).



Defining Zero Net Energy (ZNE)

- **Zero Net Energy Cost.**

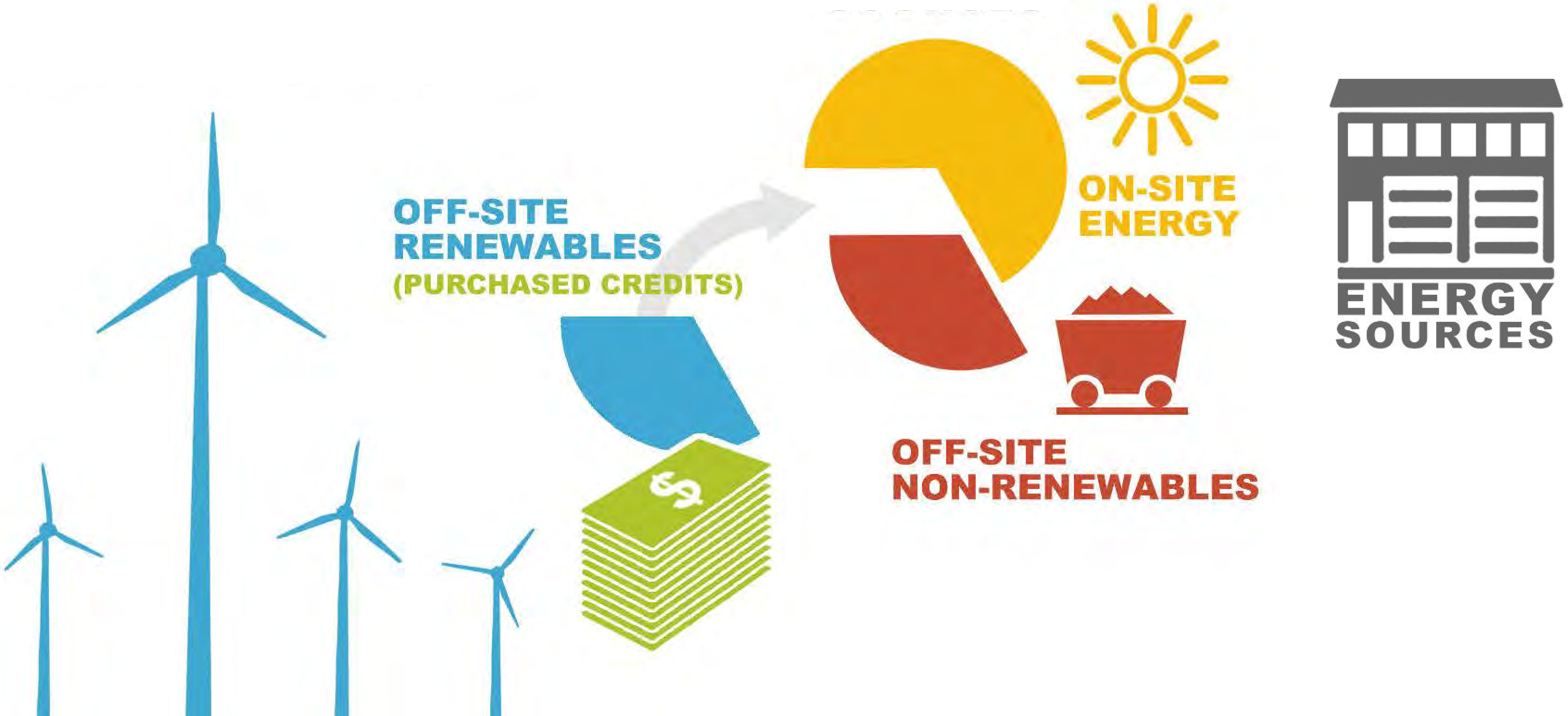
  A building that sells more power to the utility than it purchases. Utilities generally charge more than they pay for power.



Defining Zero Net Energy (ZNE)

- **Zero Net Energy Emissions.**

  A building that generates (at least) as much renewable energy as it consumes from non-renewable sources. This energy can be produced on-site or purchases. Buying renewable energy credits to offset non-renewable energy consumption counts.



Expanding the ZNE definition...

Zero Energy Campus

Zero Energy Communities

On-site ZNE

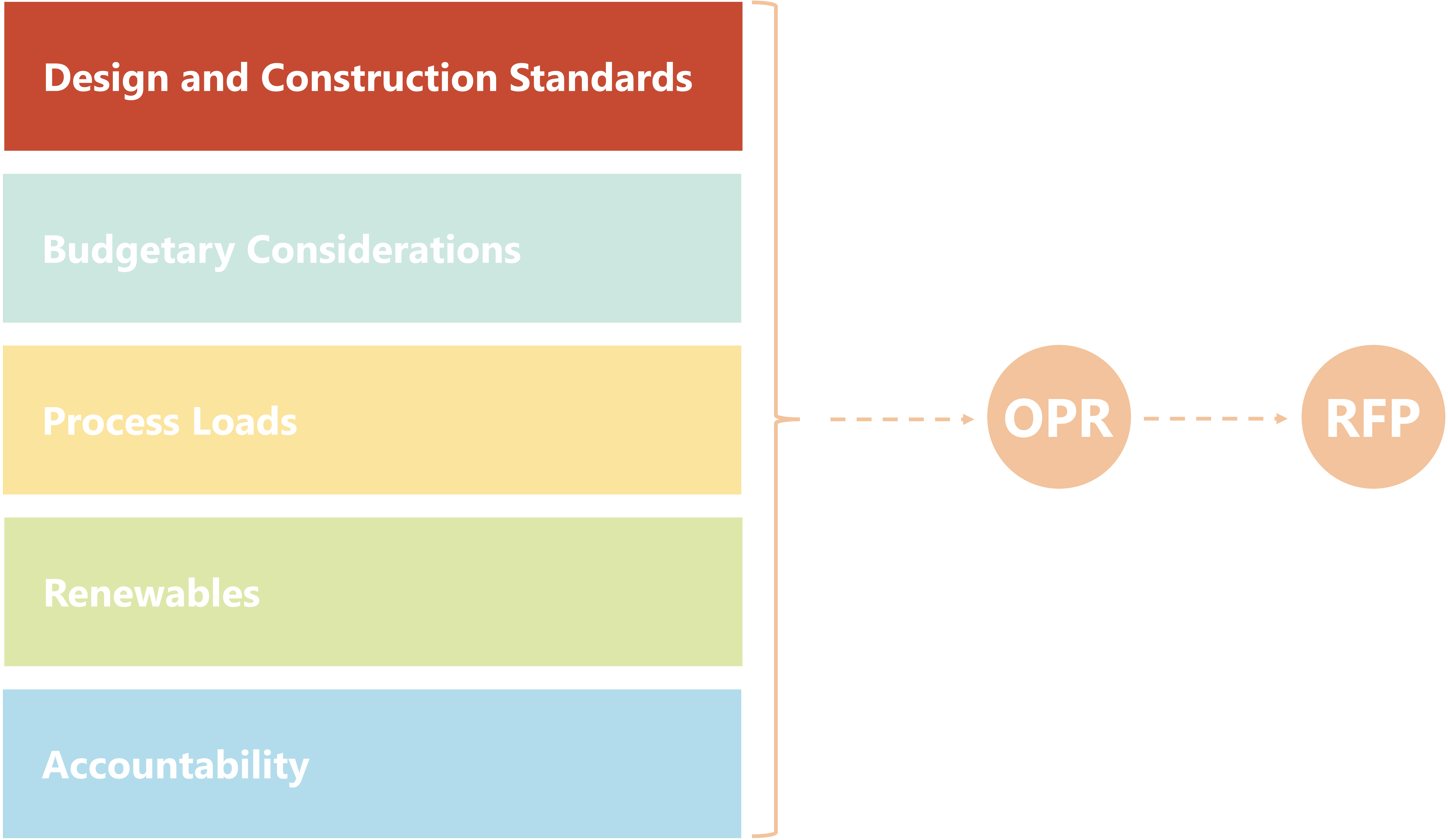
Zero Energy Buildings

Zero Energy Portfolio

Off-site ZNE

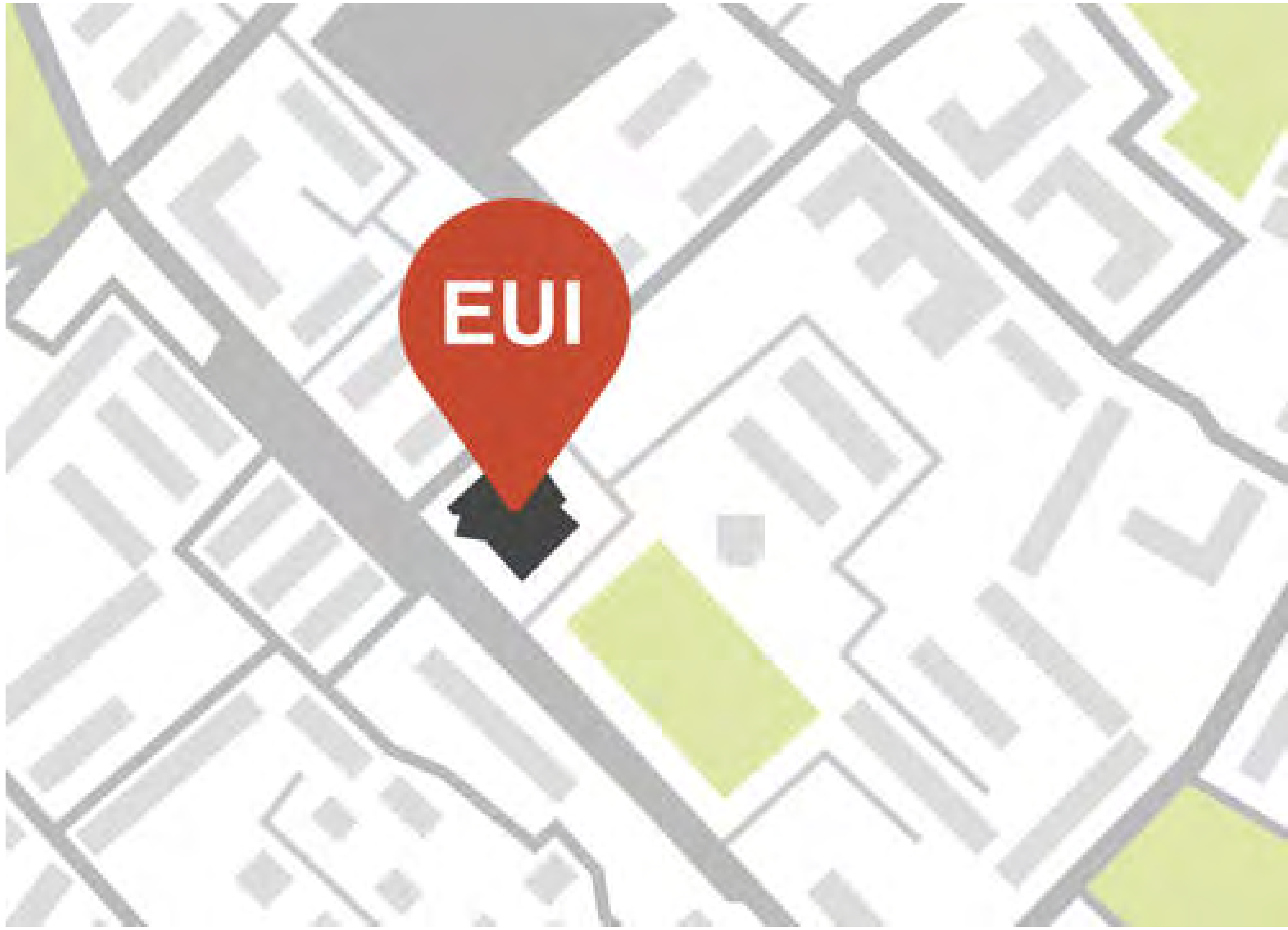
Generally speaking, there is no silver bullet for achieving net-zero energy.

Success must be pursued through an integrated process and a collection of coordinated strategies.


Design and Construction Standards
Budgetary Considerations
Process Loads
Renewables
Accountability
OPR
RFP

Design and Construction Standards

- **Does your campus have a set performance standard?**
  - Stand-alone or part of a comprehensive standard.
  - Energy-based vs holistic approach to sustainability.
  - Metering and benchmarking can open-up potential for performance contracts.
  - Should cover design and construction aspects.

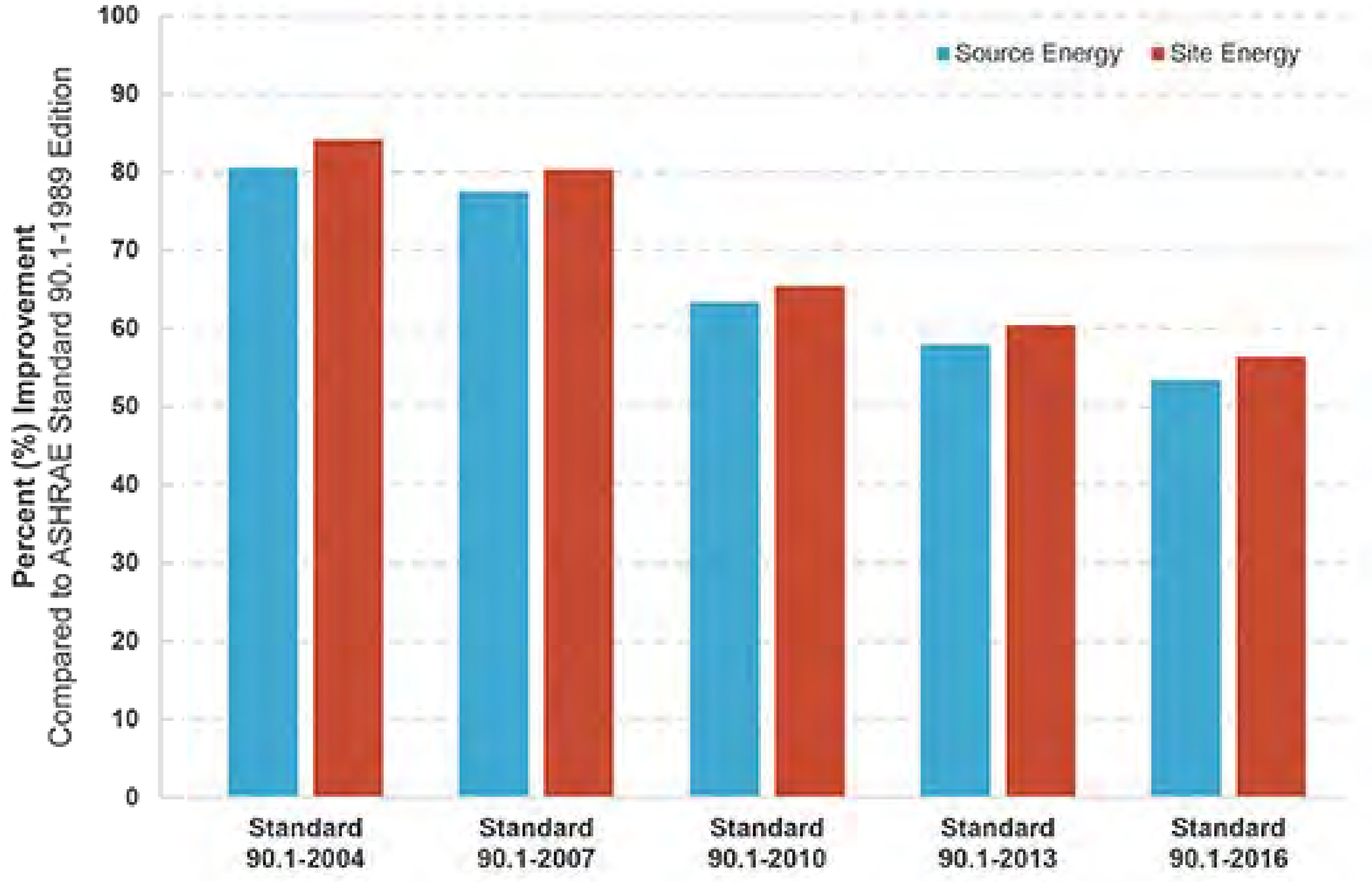


Design and Construction Standards

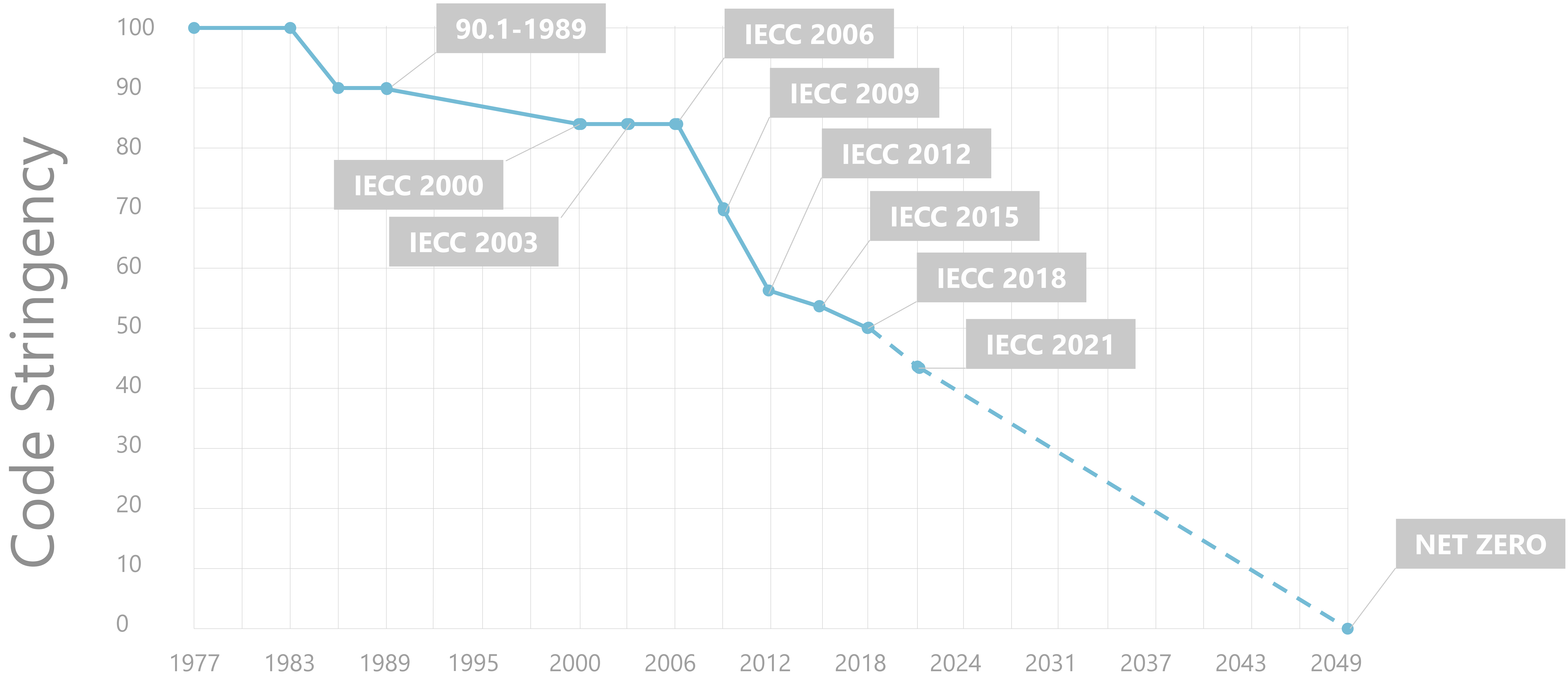
- **How will the performance standard be developed?**
  - Internally-developed versus third-party model standard.
  - Internally-developed allows the greatest control over scope and procedures.
  - Most model codes, standards, and rating systems leverage the consensus of expert bodies.

Design and Construction Standards

- **How will the performance standard be enforced and revised?**
  - "Be careful which horse you hitch your wagon to."
  - Is staff empowered to regularly develop an internal standard?
  - Most model codes, standards, and rating systems continuously update.



Design and Construction Standards



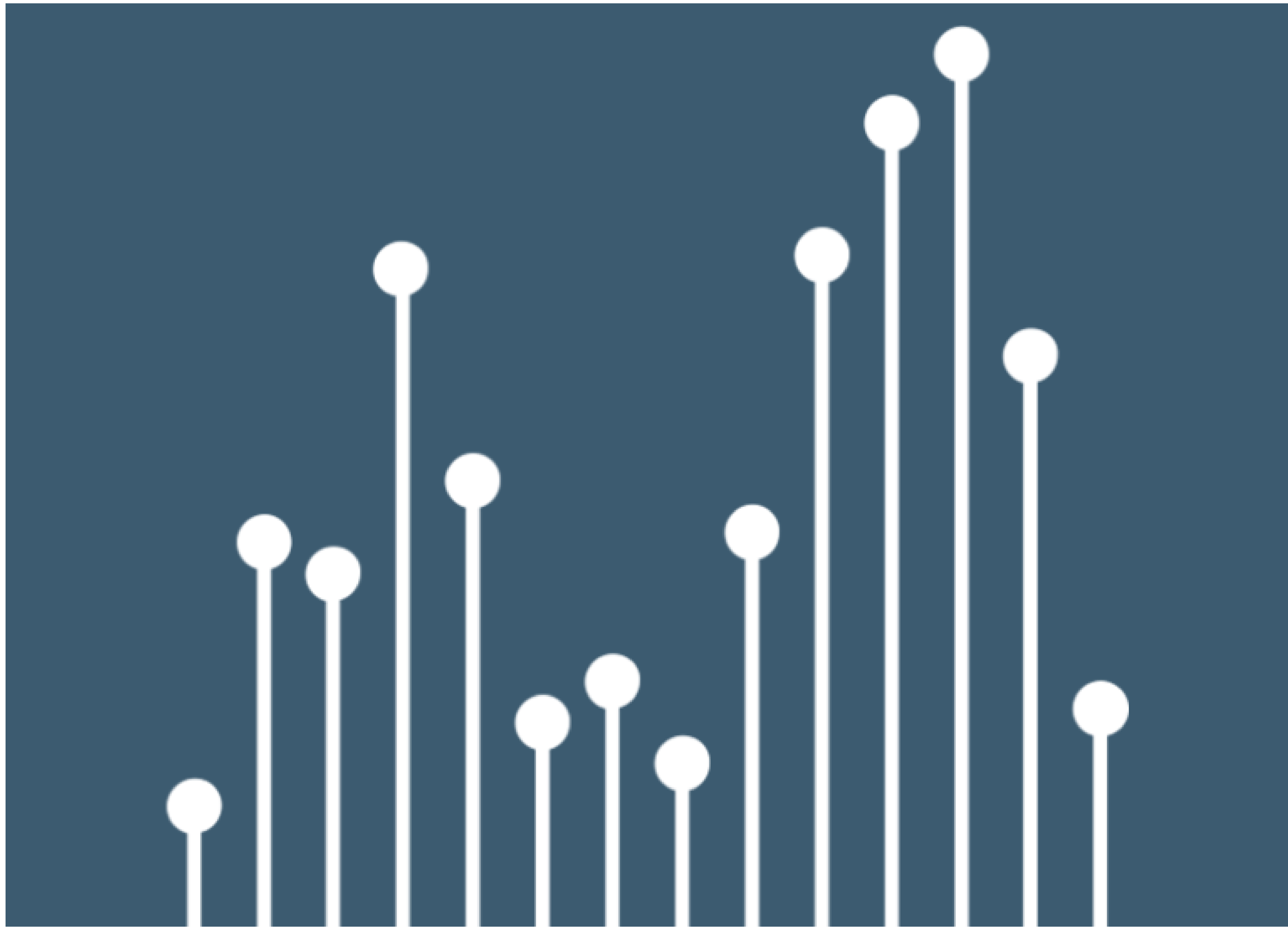
Base 100 = 1977 Energy Performance

Design and Construction Standards

- **Align performance standard with other institutional goals, standards, and expectations.**

  - Minimum insulation values
  - Ventilation rates
  - Structural system
  - Roofing system
  - Site lighting; internal light trespass

  - Think holistically:
    - Transportation energy use intensity
    - Electric vehicle spaces
    - Stormwater management
    - Outdoor water use
    - Operational carbon
    - Embodied carbon



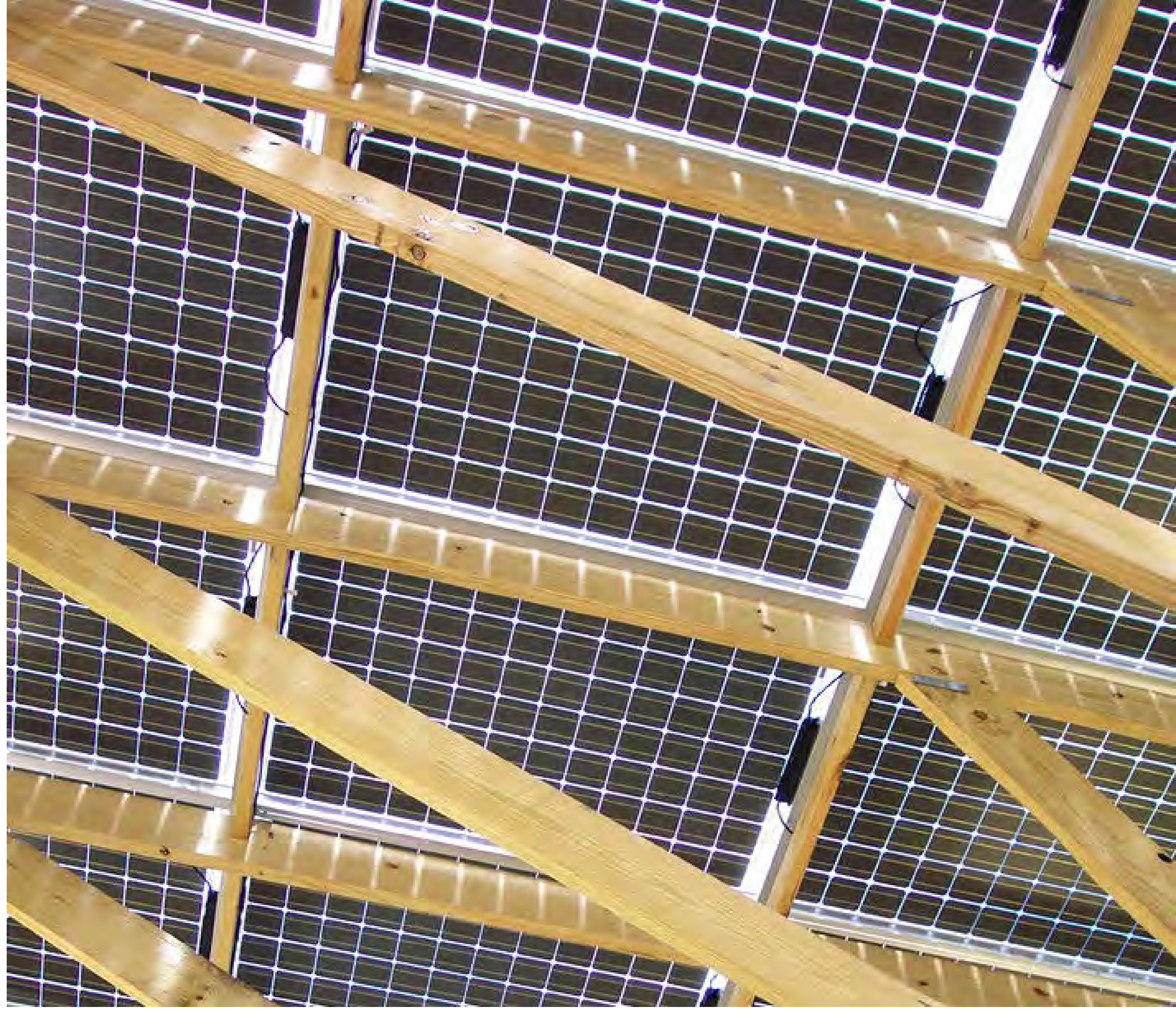
LINCOLN HERITAGE PUBLIC LIBRARY – CHRISNEY BRANCH

LOCATION	CHRISNEY, INDIANA
TYPE	PUBLIC LIBRARY
SIZE	2,413 GROSS SQUARE FEET
ECMs	OPTIMIZED ENVELOPE PERFORMANCE LOW LIGHTING POWER 8.9KW PHOTOVOLTAIC ARRAY

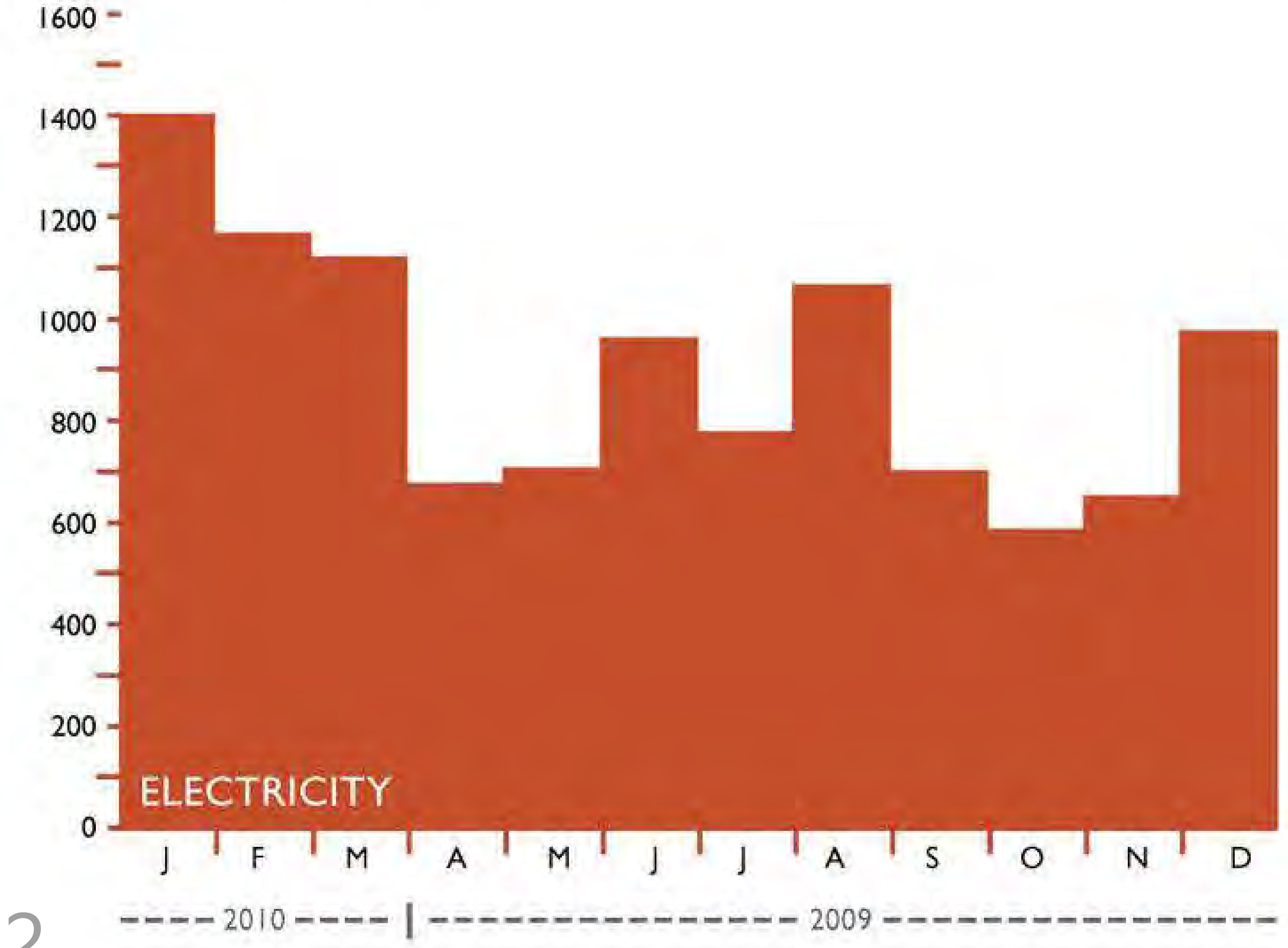
$155/SF

PROJECT COST EXCEPT FOR SITE DEVELPOMENT

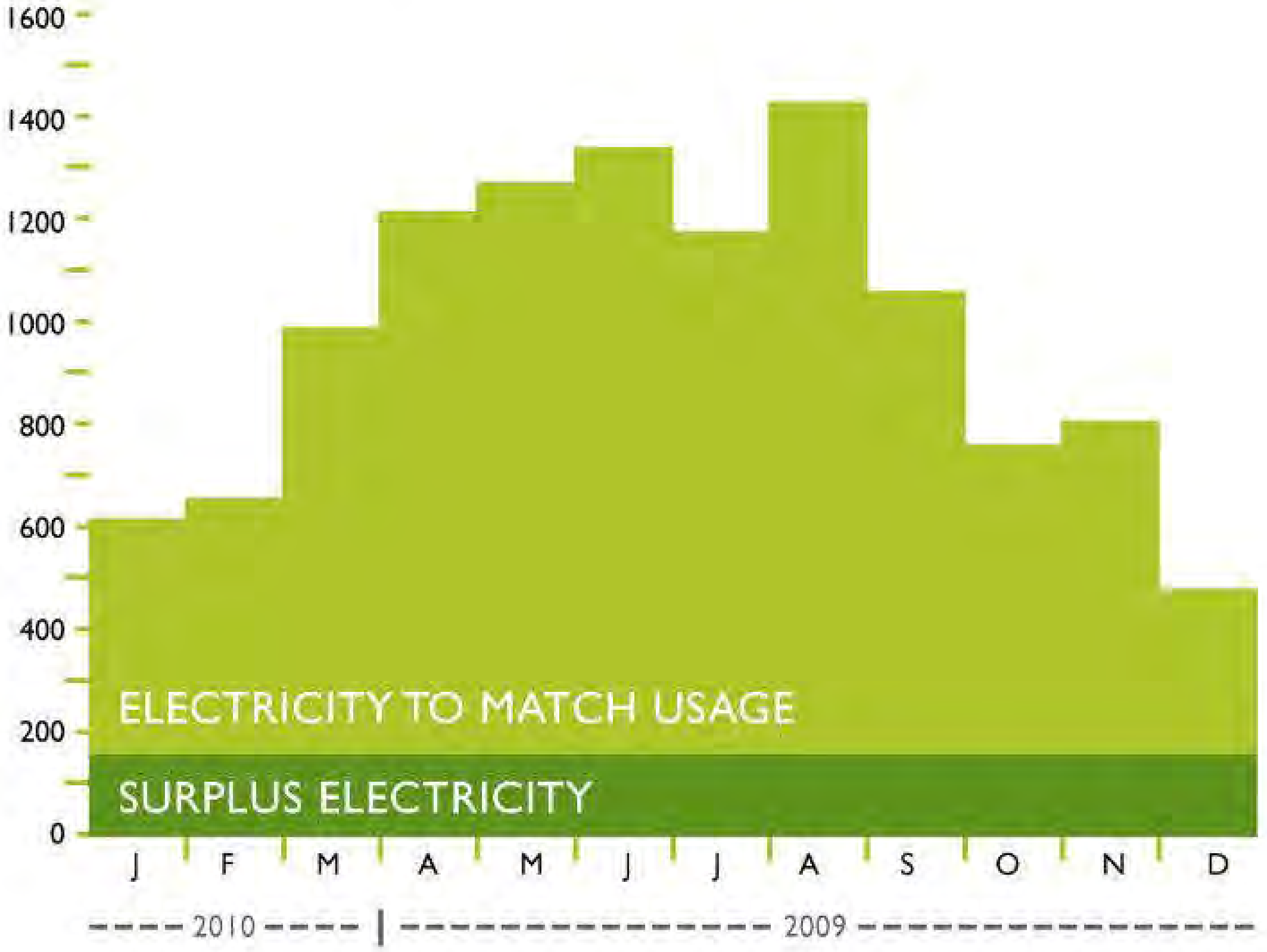
ZEROENERGY CERTIFICATION

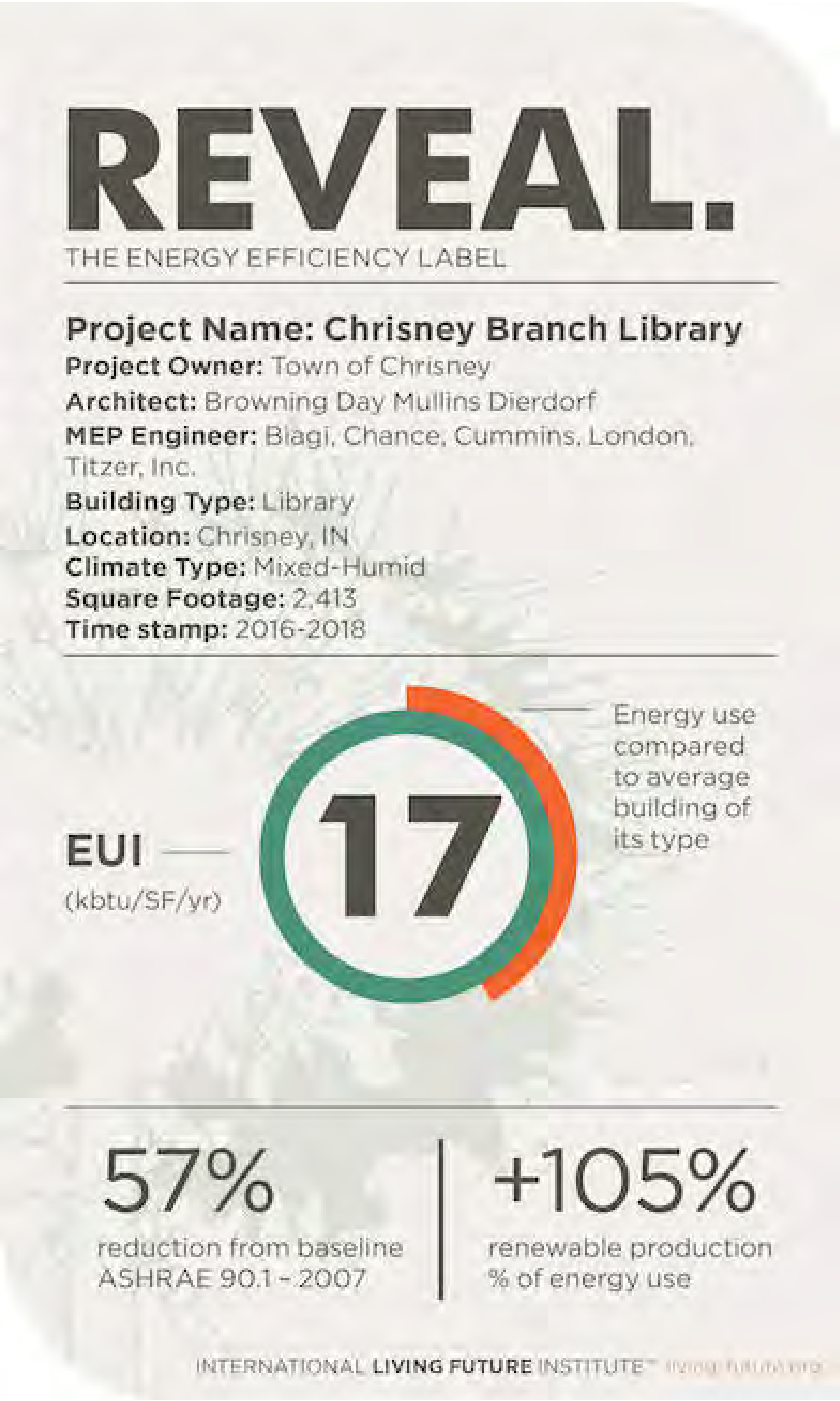


MONTHLY ENERGY USE
KILOWATT-HOURS TOTAL



MONTHLY ENERGY PRODUCTION
KILOWATT-HOURS TOTAL





Design and Construction Standards

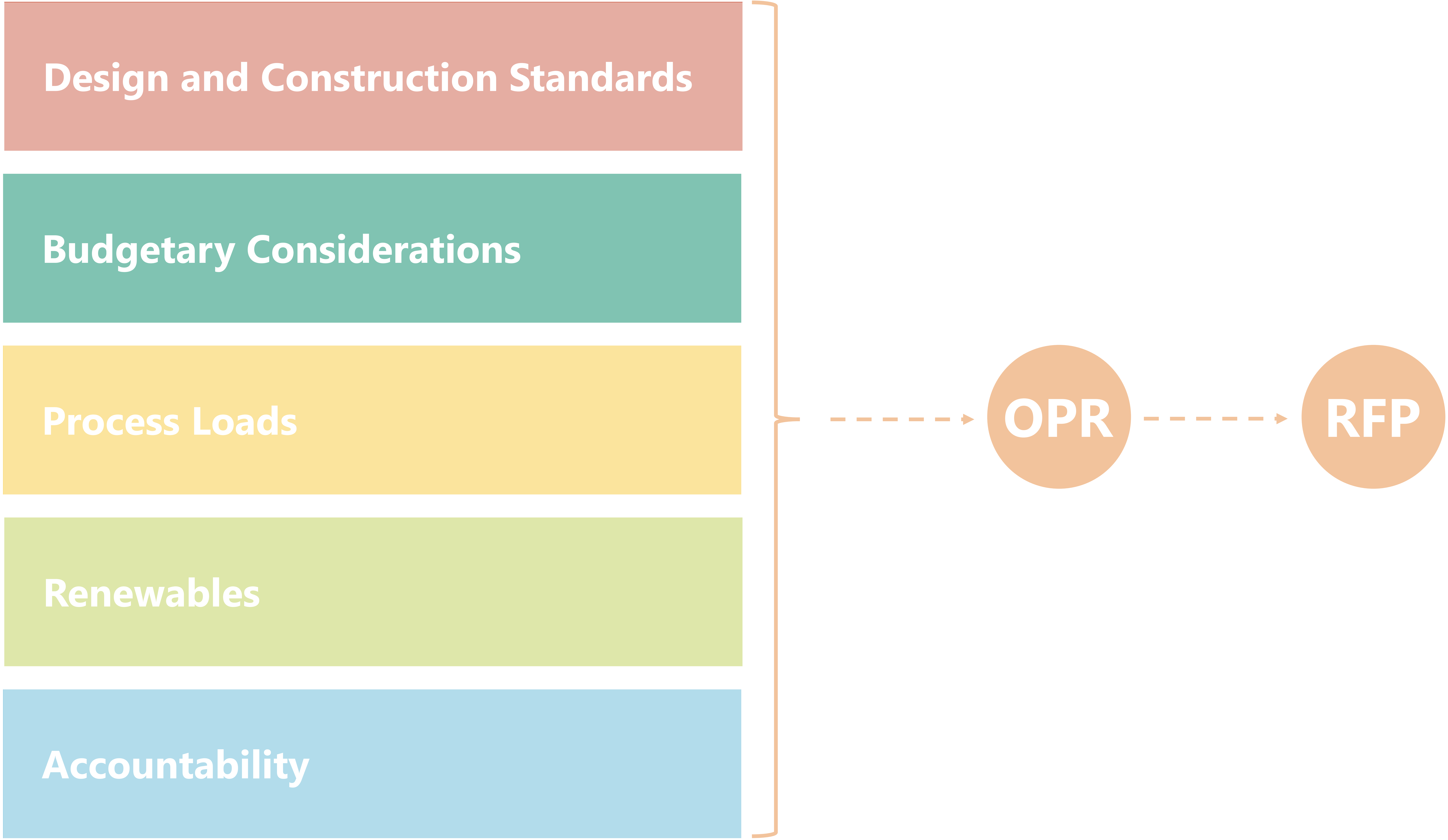
1. Develop a performance standard (as a component or stand-alone).

2. The standard may be internally-developed or reference a third-party model document.

3. Identify and empower personnel to enforce the standard.

4. If internally-developed, ensure that a framework is in place to update it regularly.

5. Align the other institutional goals, standards, and expectations with the performance standard.


Design and Construction Standards
Budgetary Considerations
Process Loads
Renewables
Accountability
OPR
RFP

Budgetary Considerations

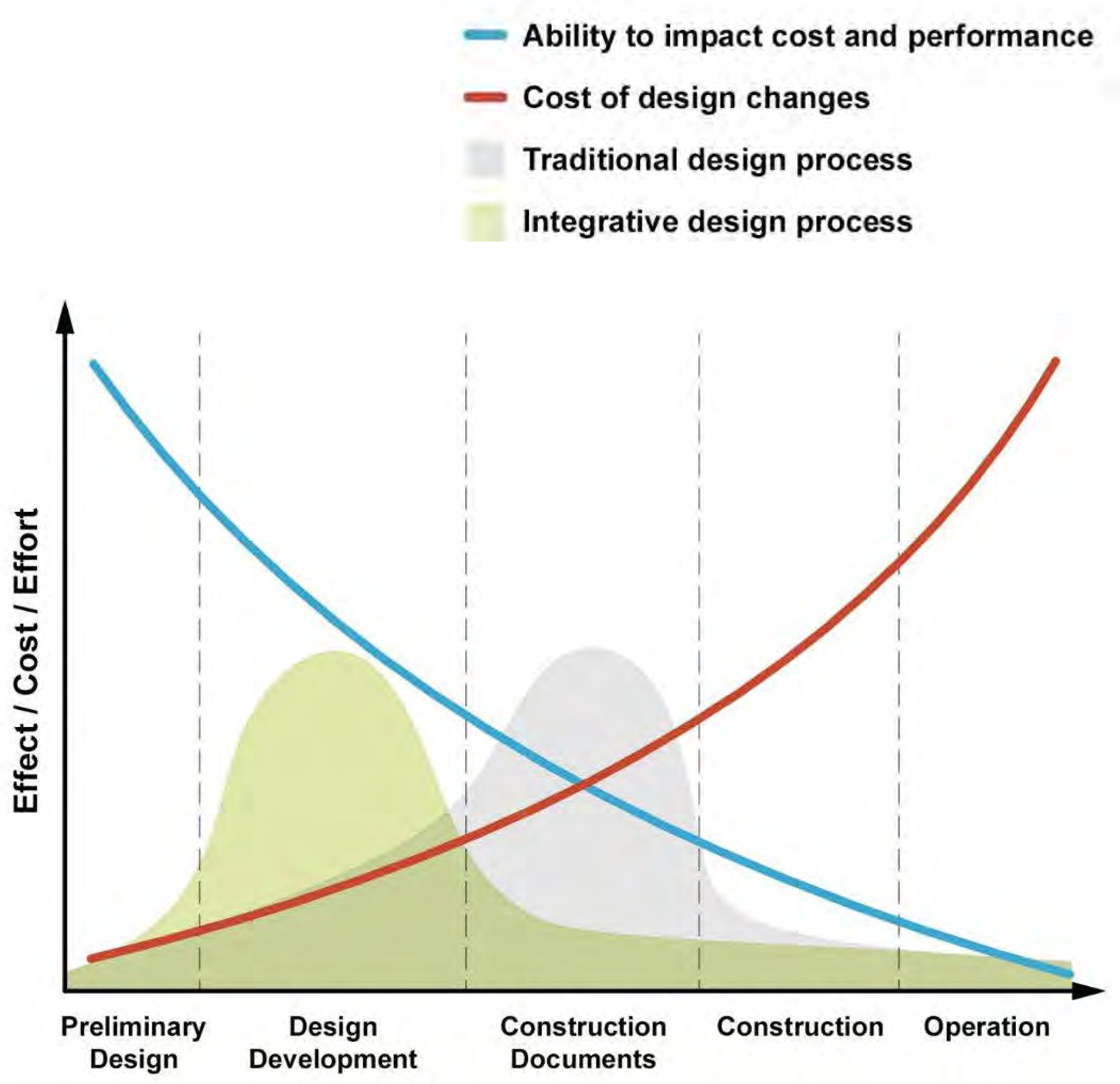
- **Is your cost model valid?**
  - How appropriate are the comparables?
  - Is the cost model adjusted for high-performance or ZNE?

Budgetary Considerations

- **If not, can the cost model and performance goals be reconciled?**
  - This will require a give-and-take process.
  - Process will test the priority of high-performance design and construction.
  - As such, the performance goal must be elevated in importance.

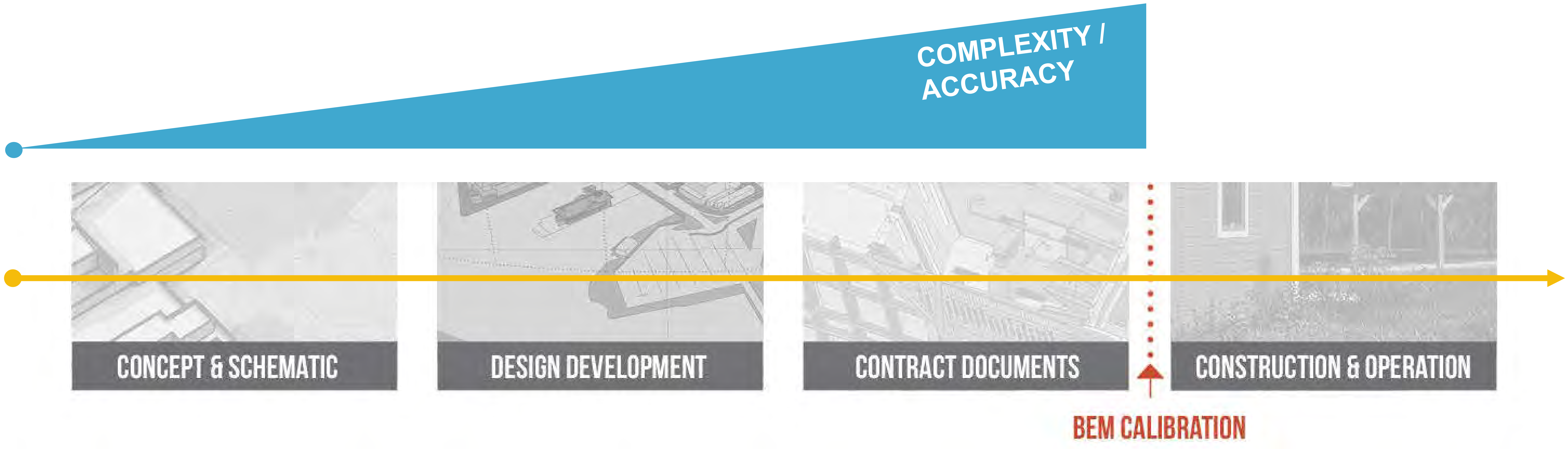
Budgetary Considerations

- **Is the project team prompted to leverage a high-performance protocol?**
  - There is gulf between modeled and measured performance.
  - Energy modeling tools now enable energy modeling to be advanced in lock-step with construction cost estimates.
  - Make it part of the standard. Reference documents such as ASHRAE 209.



Budgetary Considerations

- Is the project team prompted to leverage a high-performance protocol?



Design Modeling Cycles

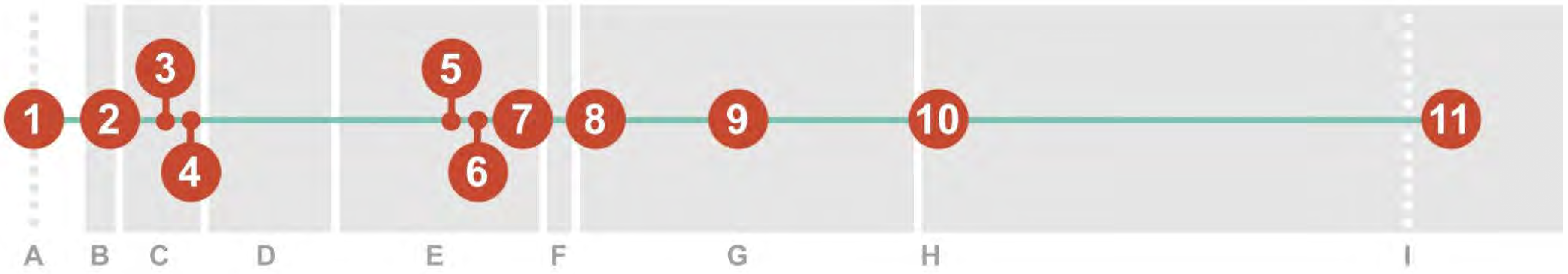
1 Simple Box Modeling
2 Conceptual Design Modeling
3 Load Reduction Modeling
4 HVAC Selection Modeling
5 Design Refinement
6 Design Integration and Optimization
7 Energy Simulation-Aided Value Engineering

Construction and Operations Modeling Cycles

8 As-Designed Energy Performance
9 Change Orders
10 As-Built Energy Performance

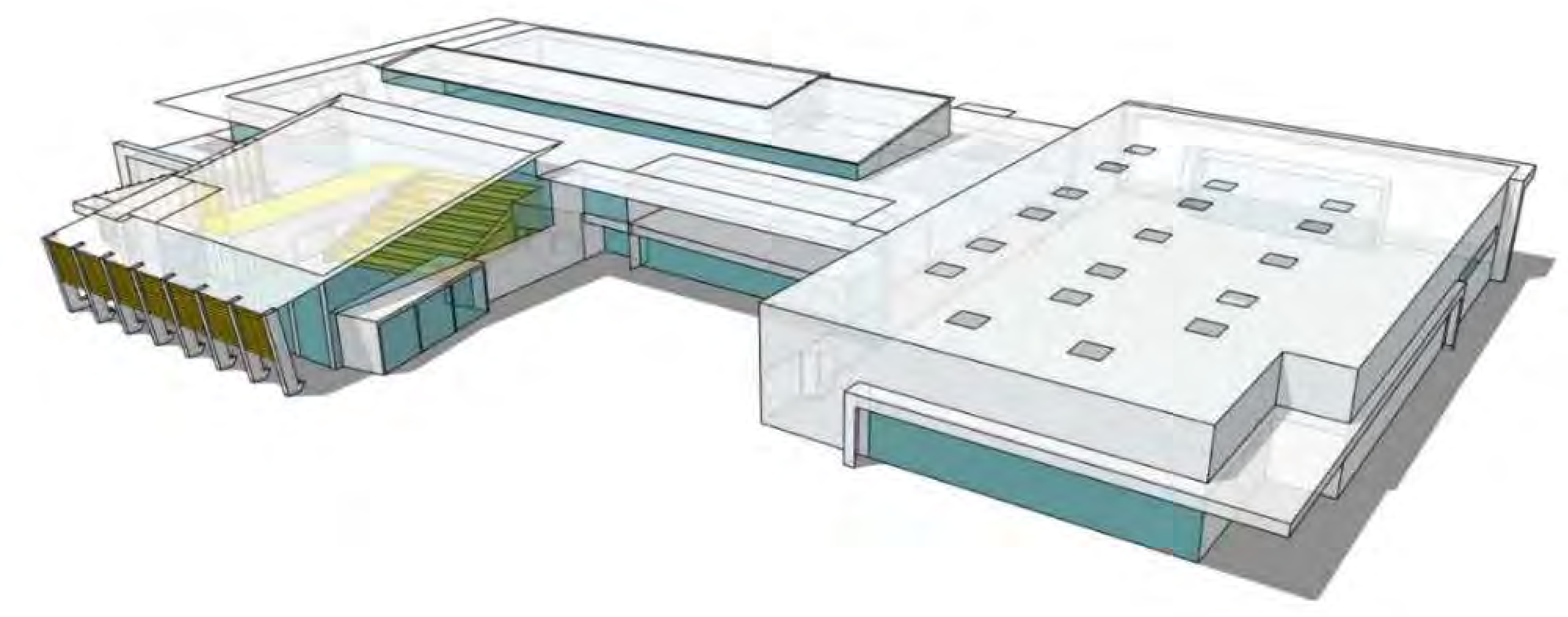
Postoccupancy Modeling Cycles

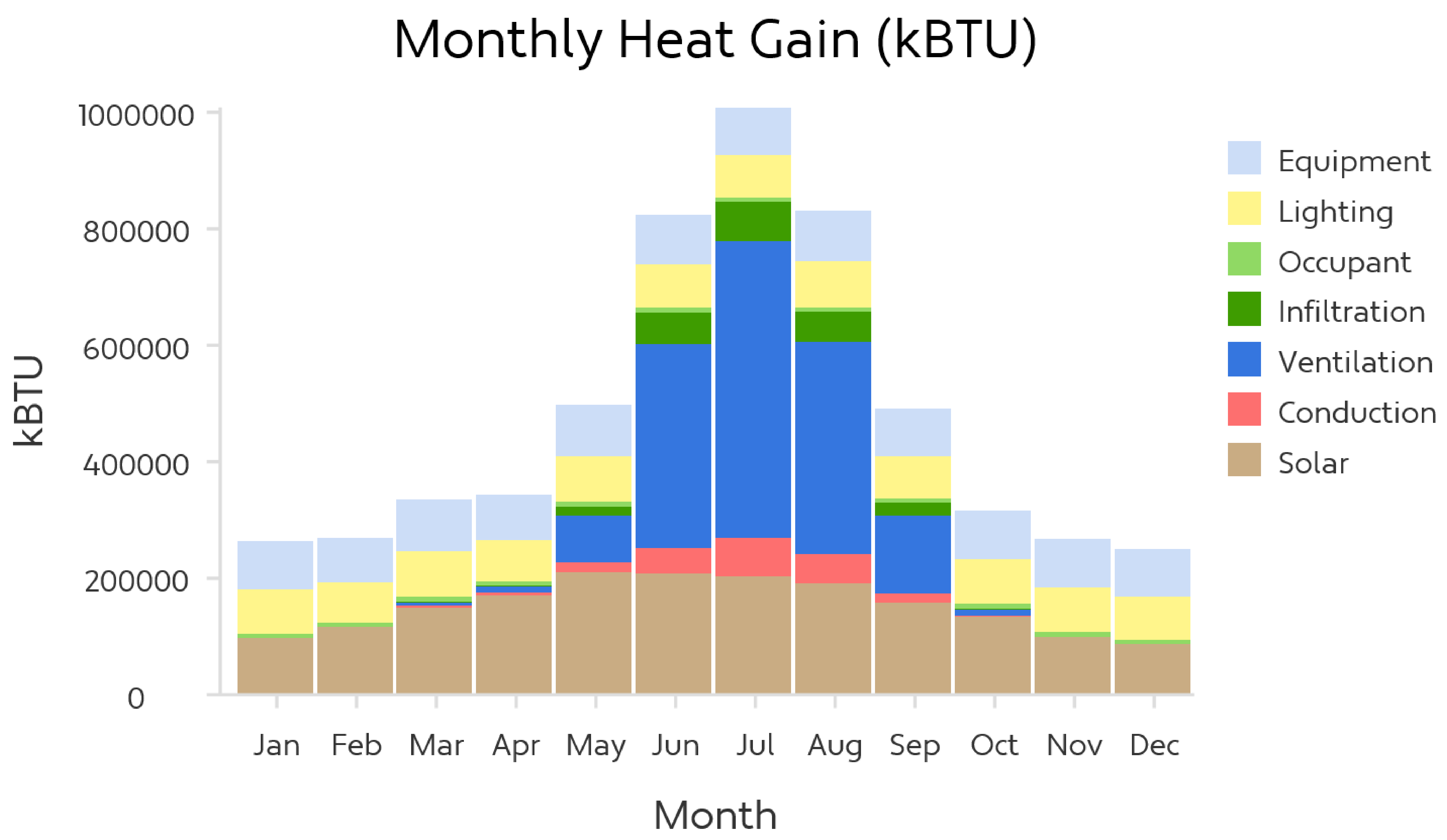
11 Postoccupancy Energy Performance Comparision



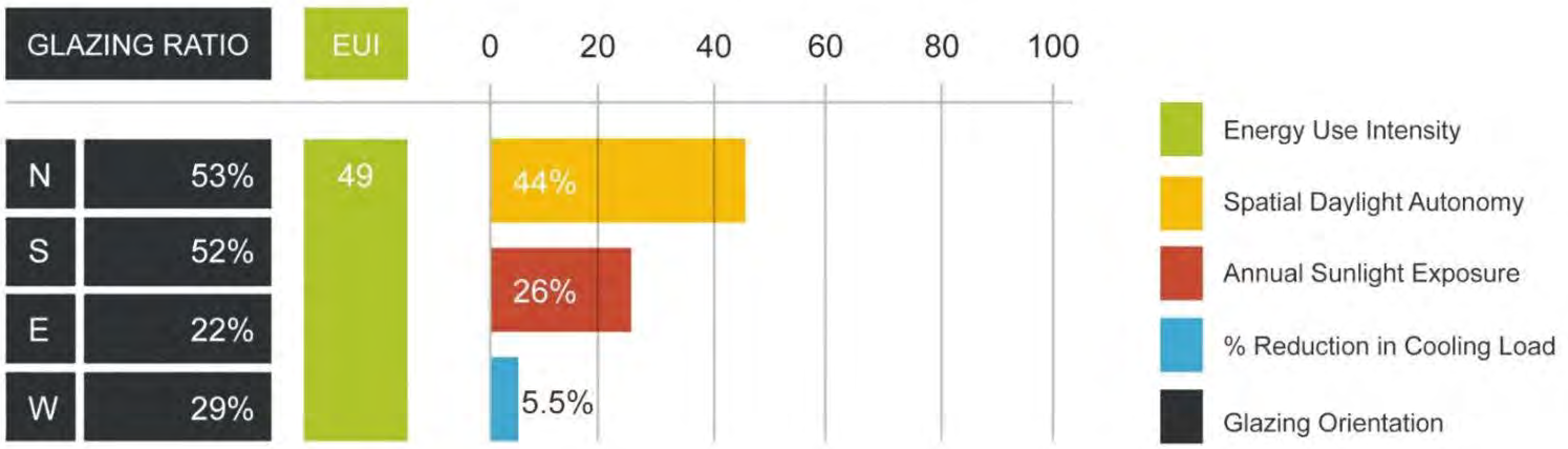
A Preconcept (Benchmarking / Climate and Site Analysis / Energy Charrette)
B Conceptual Design
C Schematic Design
D Design Development
E Construction Documents
F Bidding
G Construction
H Postoccupancy
I Twelve-Months of Occupancy

Information based on ANSI/ASHRAE Standard 209-2018.

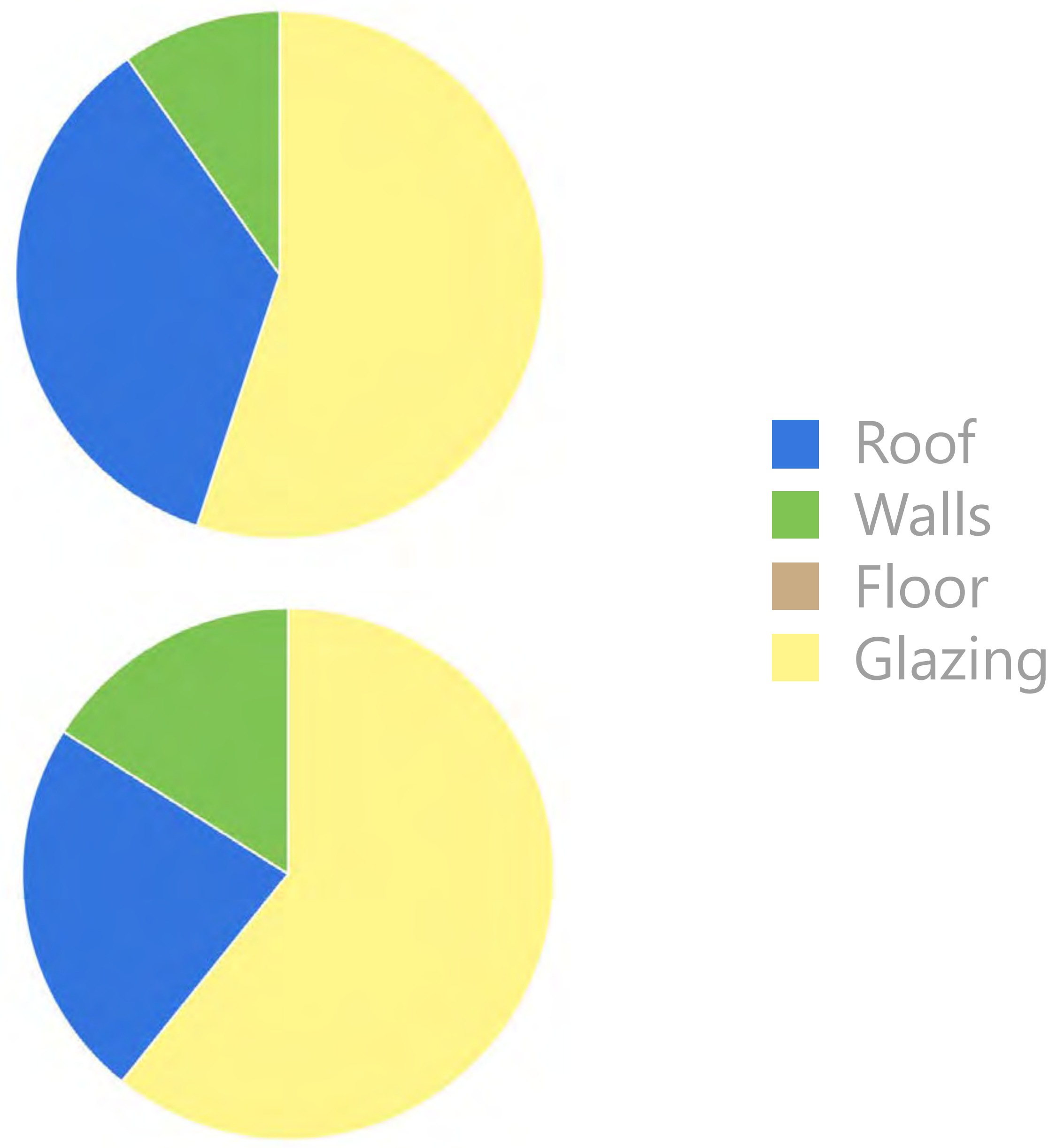




Monthly Heat Gain (kBTU)
kBTU
1000000
800000
600000
400000
200000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month
Equipment
Lighting
Occupant
Infiltration
Ventilation
Conduction
Solar



GLAZING RATIO
EUI
0 20 40 60 80 100
N 53%
S 52%
E 22%
W 29%
49
44%
26%
5.5%
Energy Use Intensity
Spatial Daylight Autonomy
Annual Sunlight Exposure
% Reduction in Cooling Load
Glazing Orientation



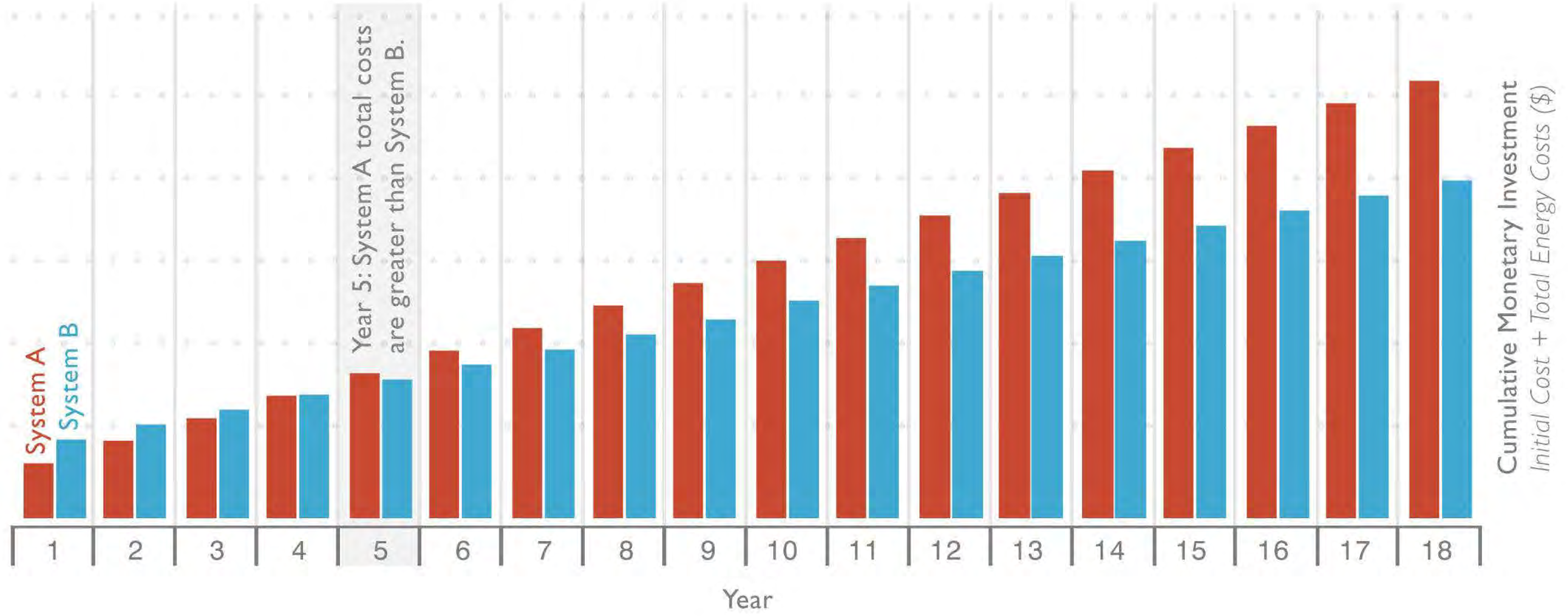
Roof
Walls
Floor
Glazing

Budgetary Considerations

- **What is an acceptable return when you operate the facility?**

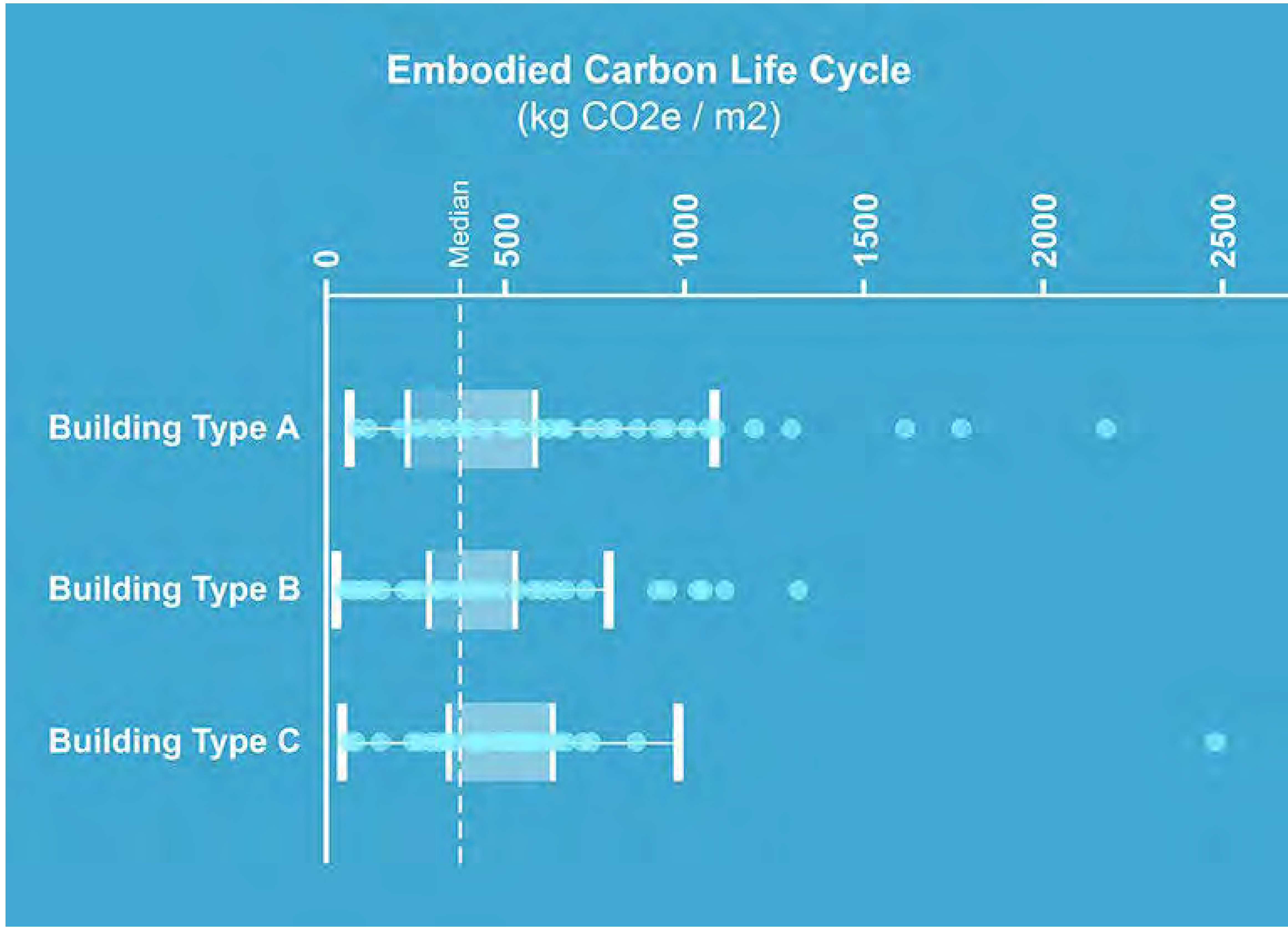
System A
Energy-code compliant system
= Greatest energy consumption costs.

System B
Initial cost = 20% premium.
Energy-efficiency = 30% savings.



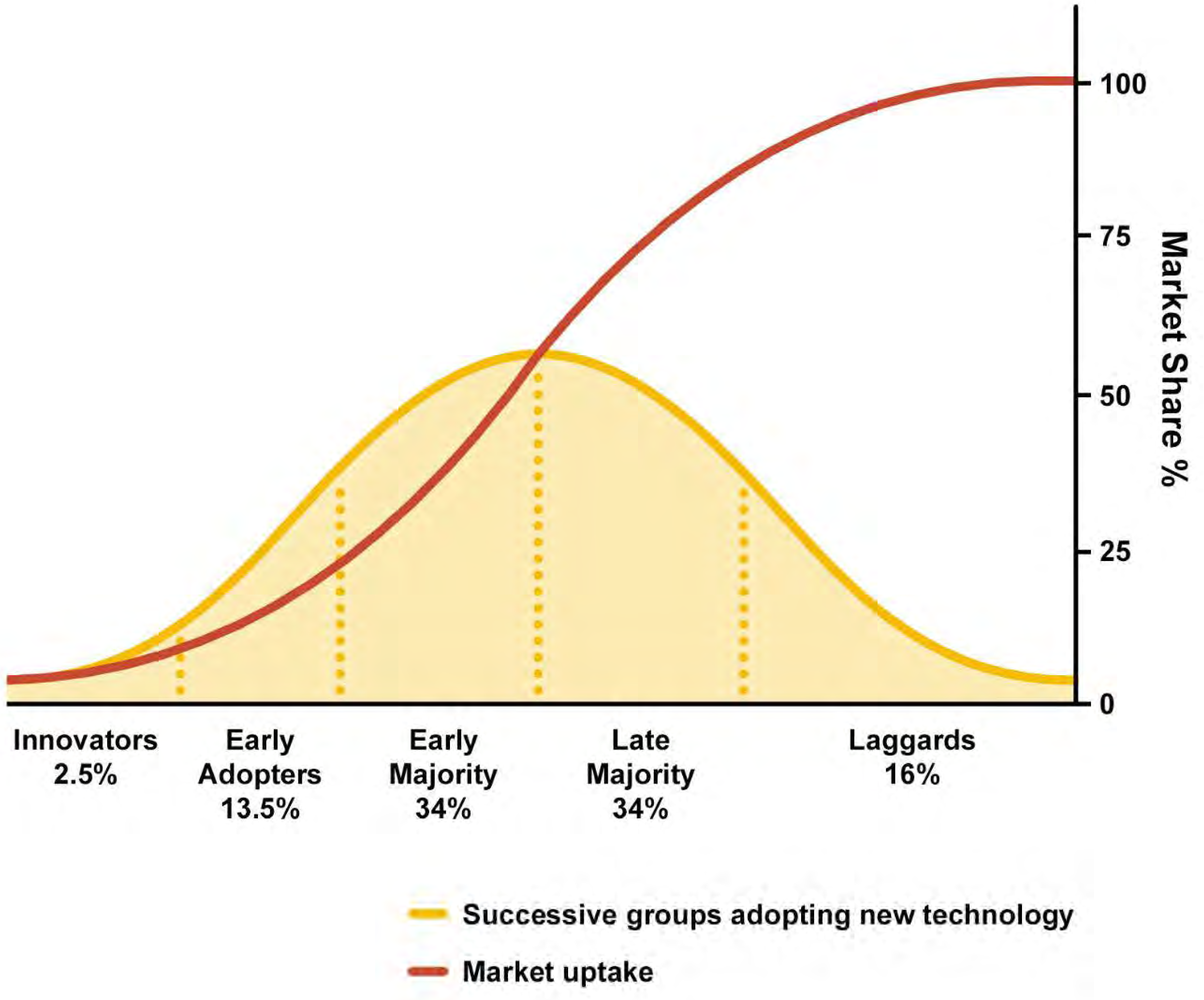
Budgetary Considerations

- **Are you prepared for the carbon economy?**
    - Emergence of carbon neutral campuses.
    - Current state of carbon offsets.
    - Continued commoditization of carbon.
    - Will expand from operational to embodied carbon.



Budgetary Considerations

- **Does “reputational capital” count?**
  - Opportunity to demonstrate leadership.
  - Marketing / PP / recruitment.
  - May consider third-party certification.

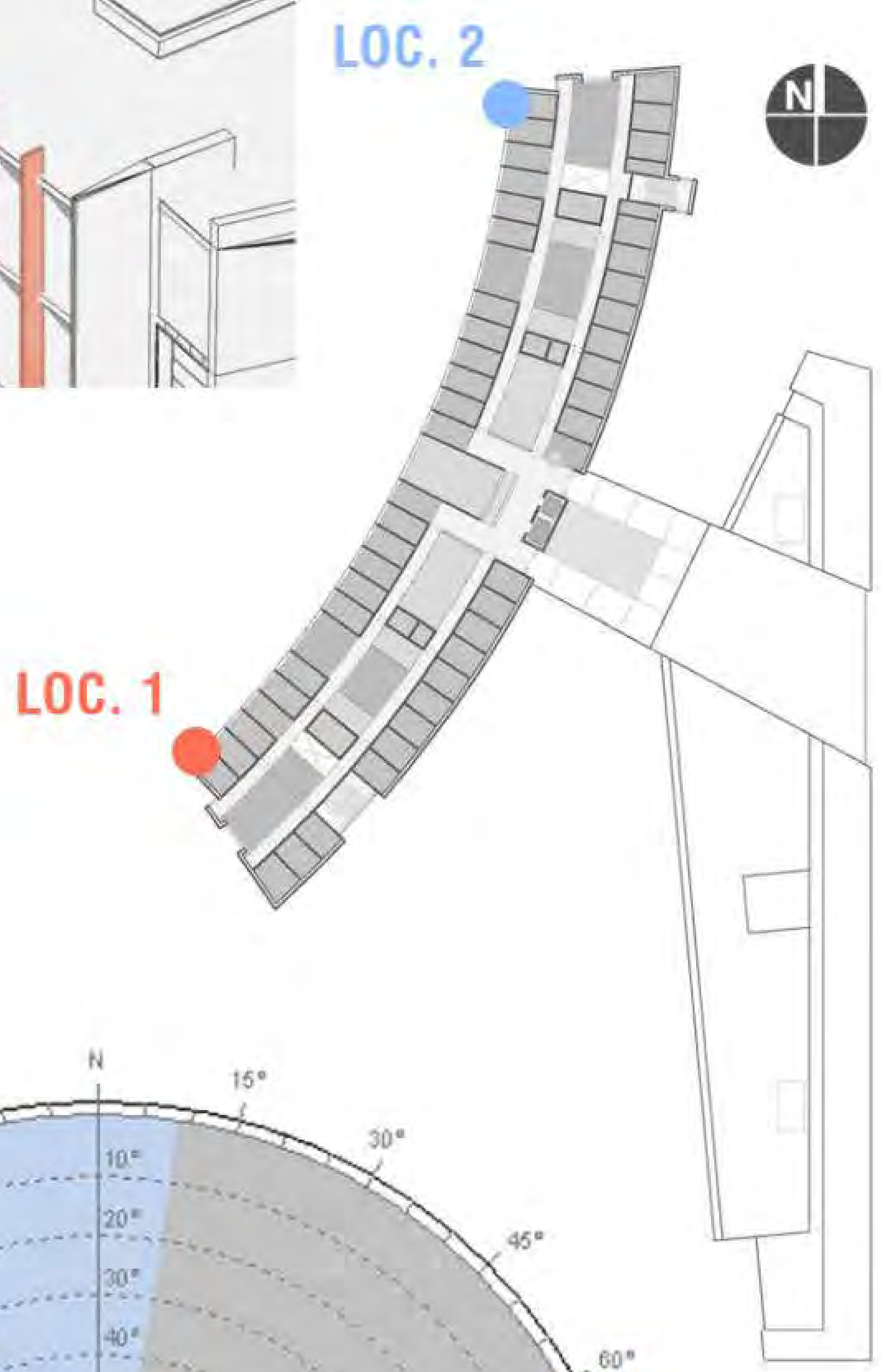


INDIANA UNIVERSITY GLOBAL AND INTERNATIONAL STUDIES BUILDING

LOCATION	BLOOMINGTON, INDIANA
TYPE	UNIVERSITY OFFICE, CLASSROOM
SIZE	165,000 GROSS SQUARE FEET
ECMs	ENERGY RECOVERY CENTRALIZED DEMAND CONTROL VENTILATION OPTIMIZED ENVELOPE PERFORMANCE LOW LIGHTING POWER

$30,800

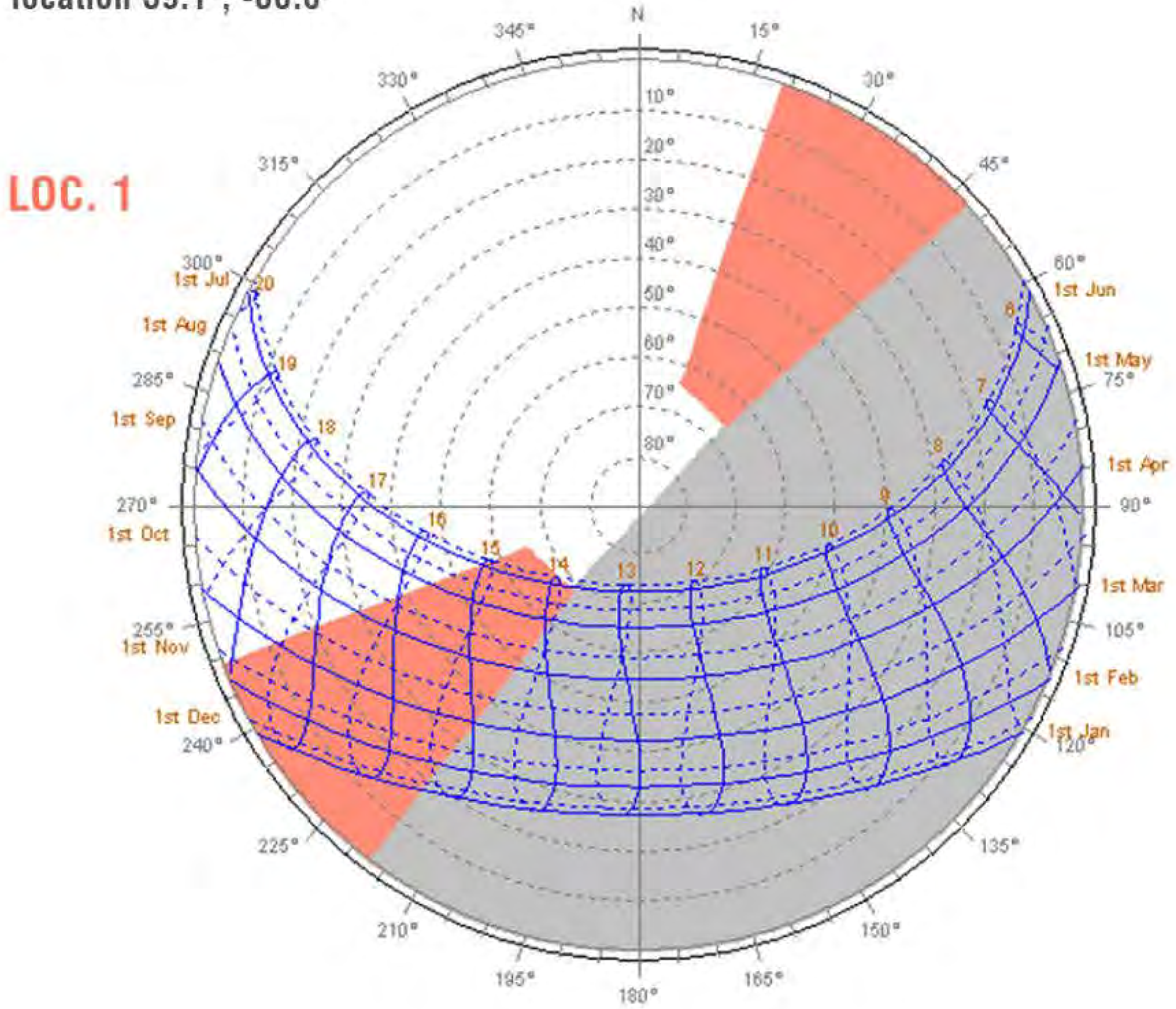
IN ENERGY COST SAVINGS PER YEAR (20%).

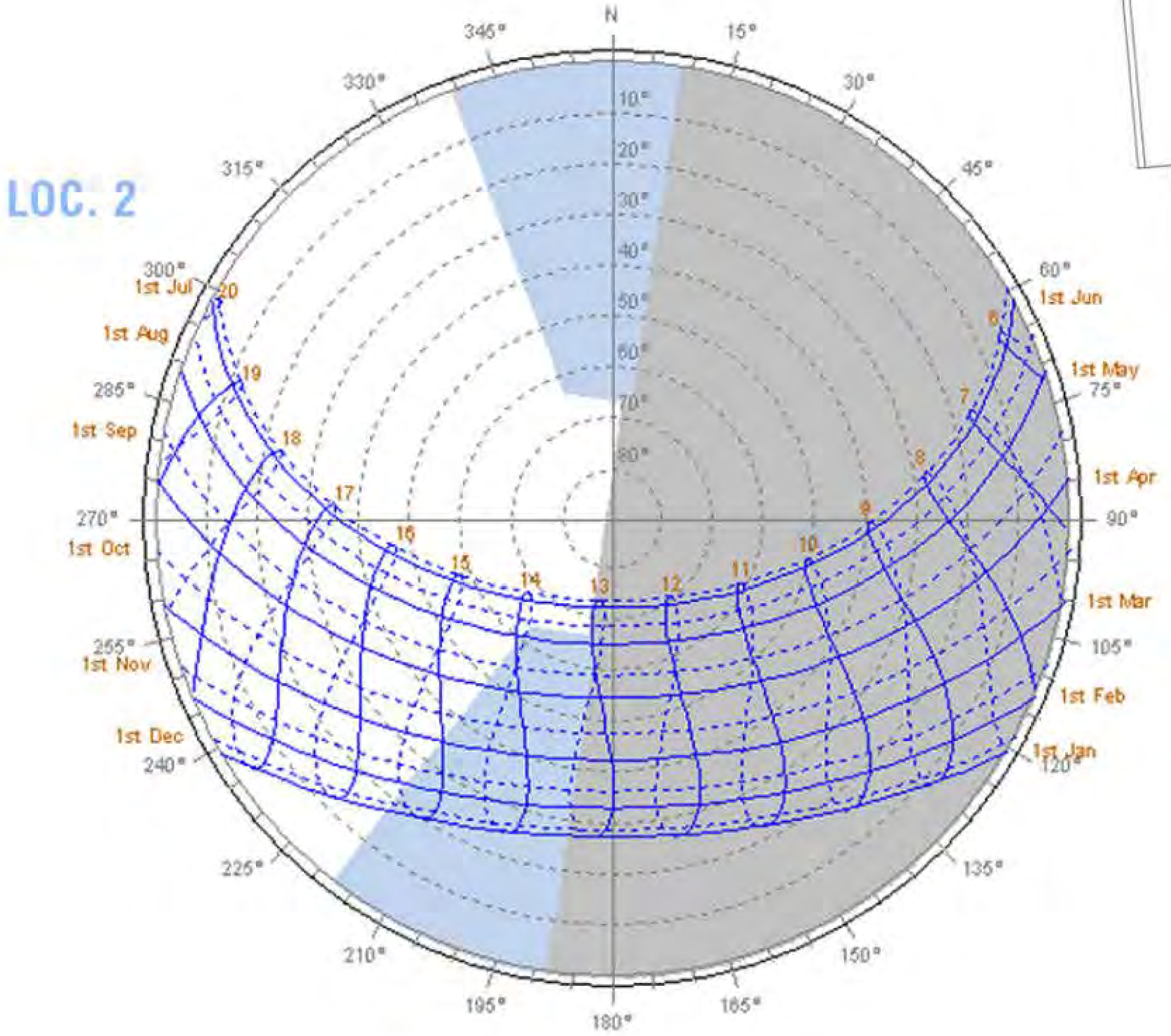


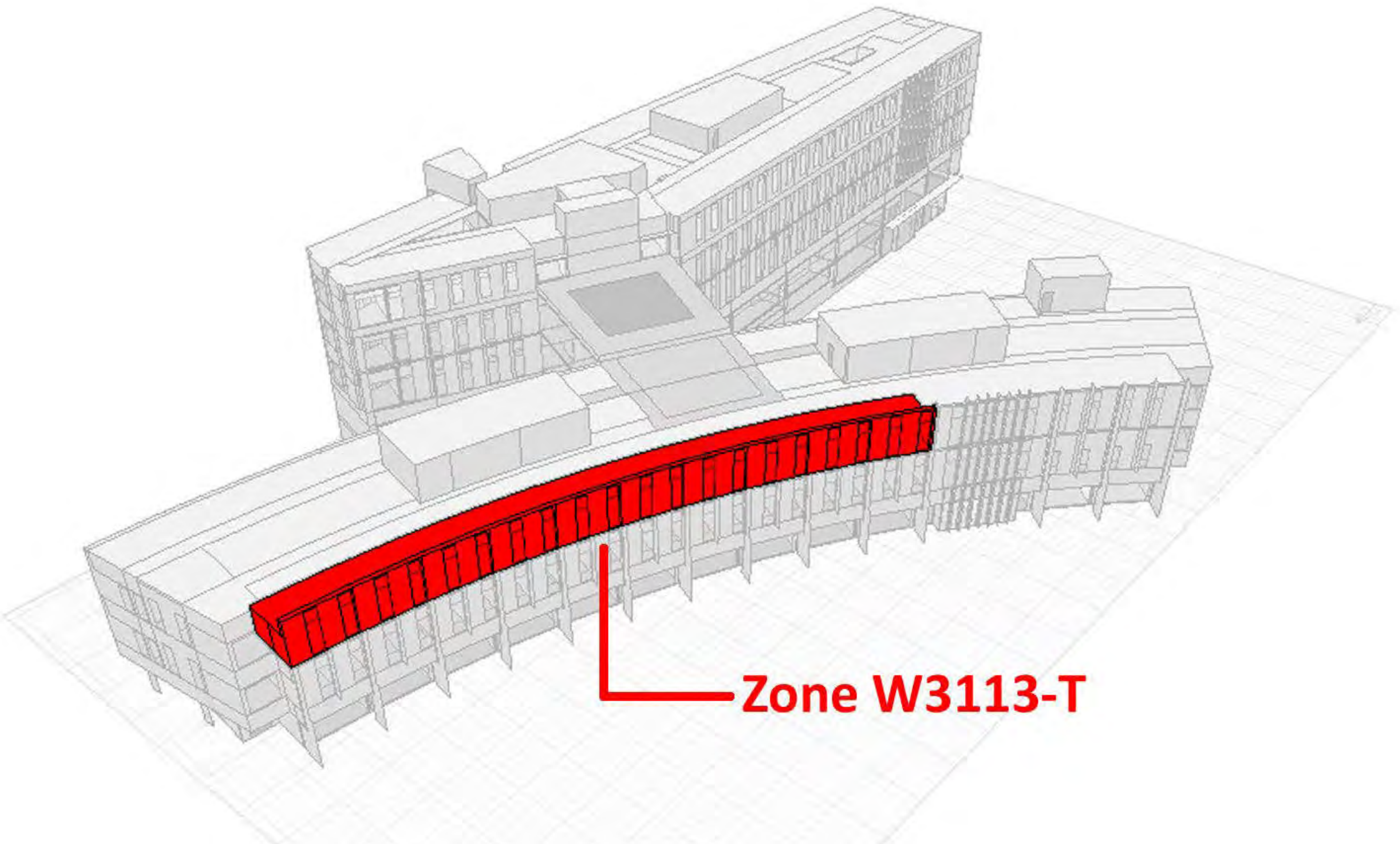
SOLAR ACCESS STUDIES

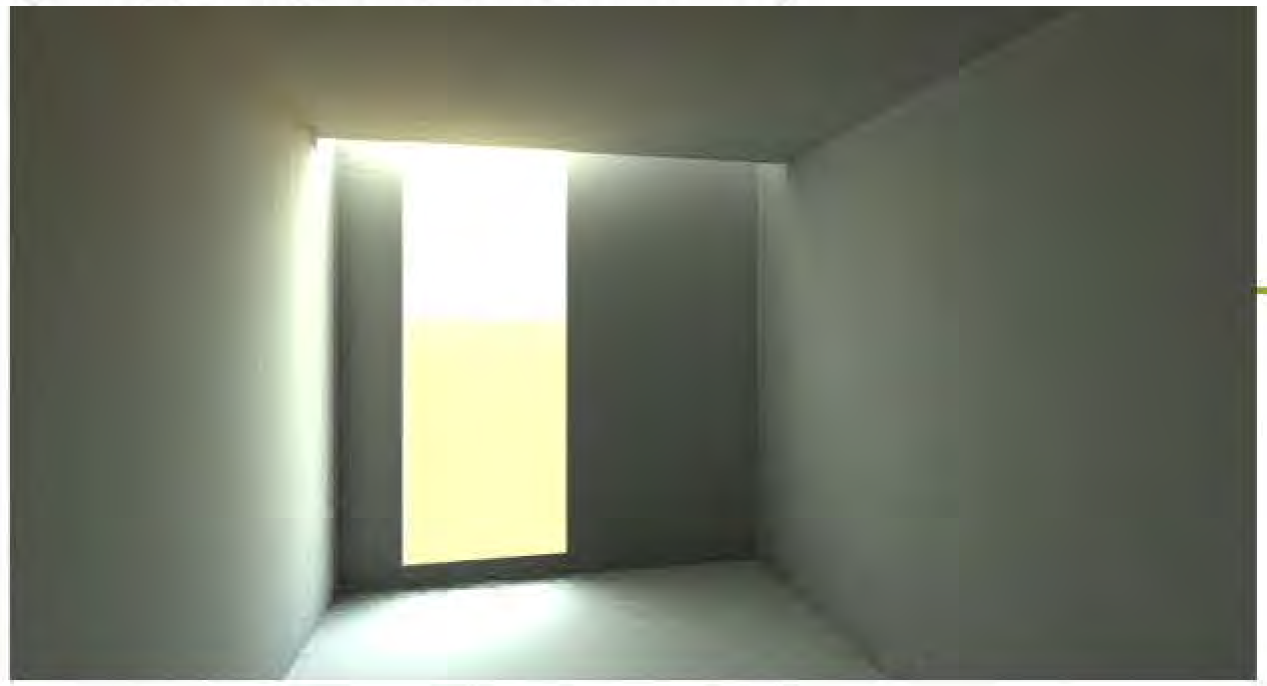
SUN PATH DIAGRAMS

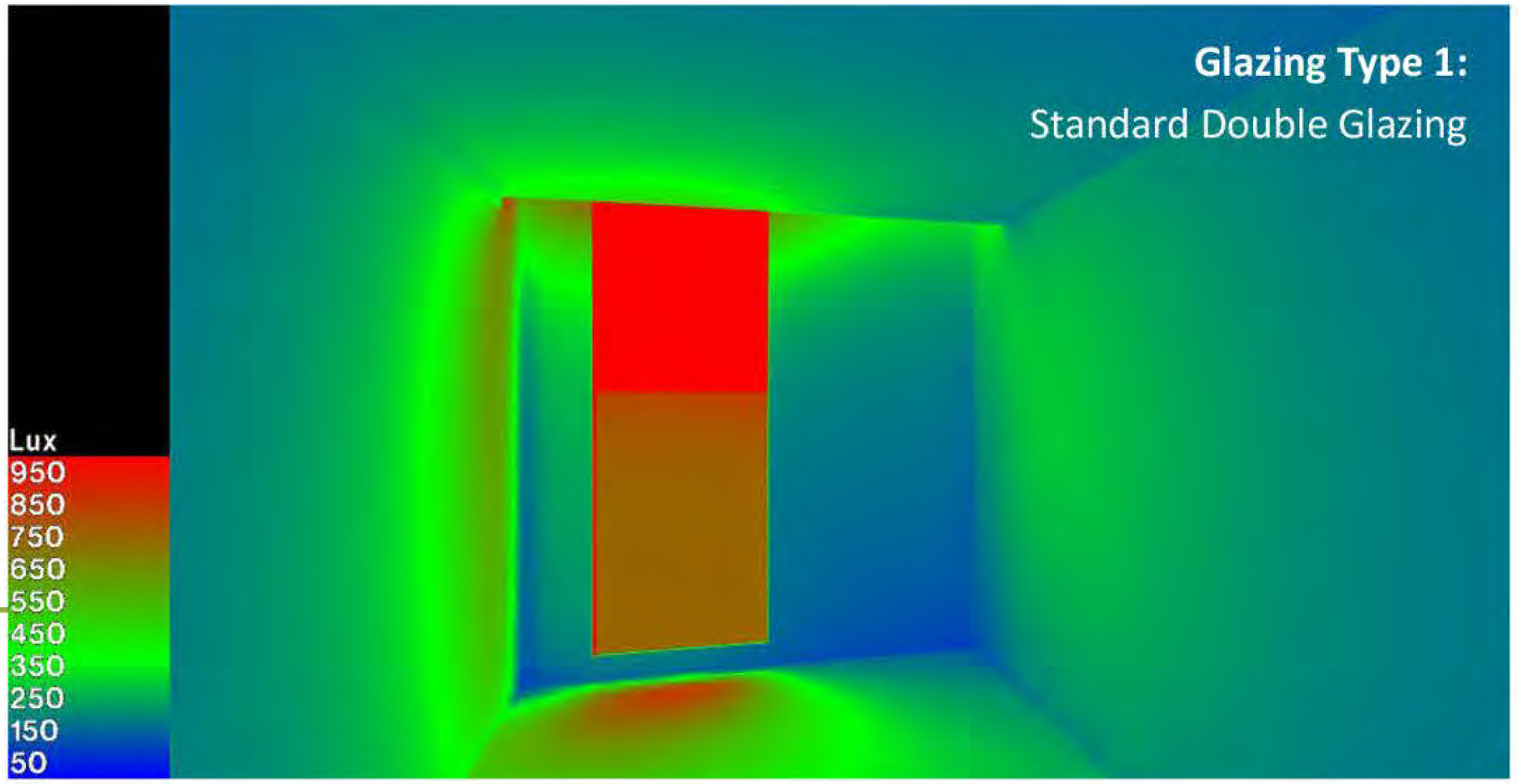
location 39.1°, -86.6°

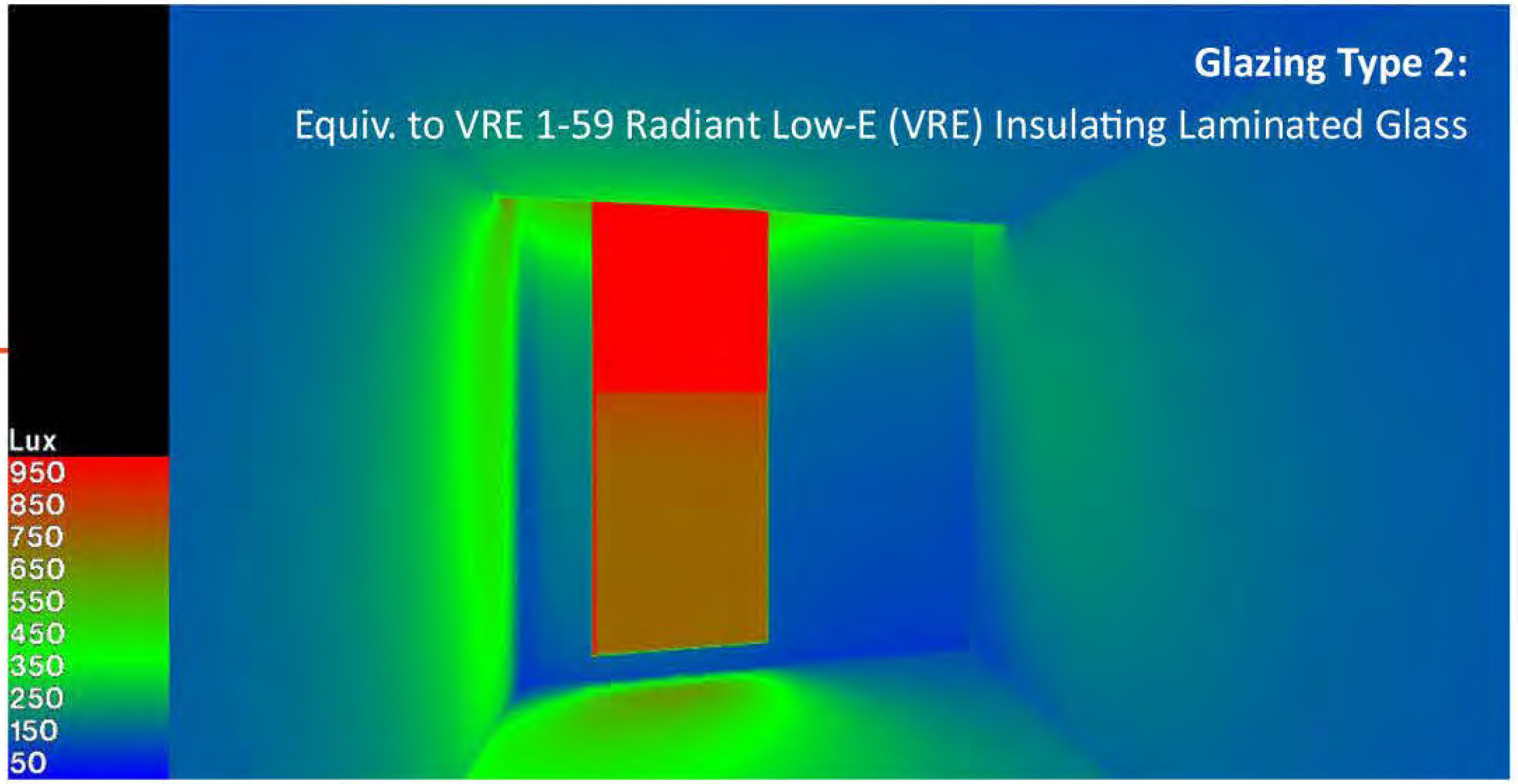


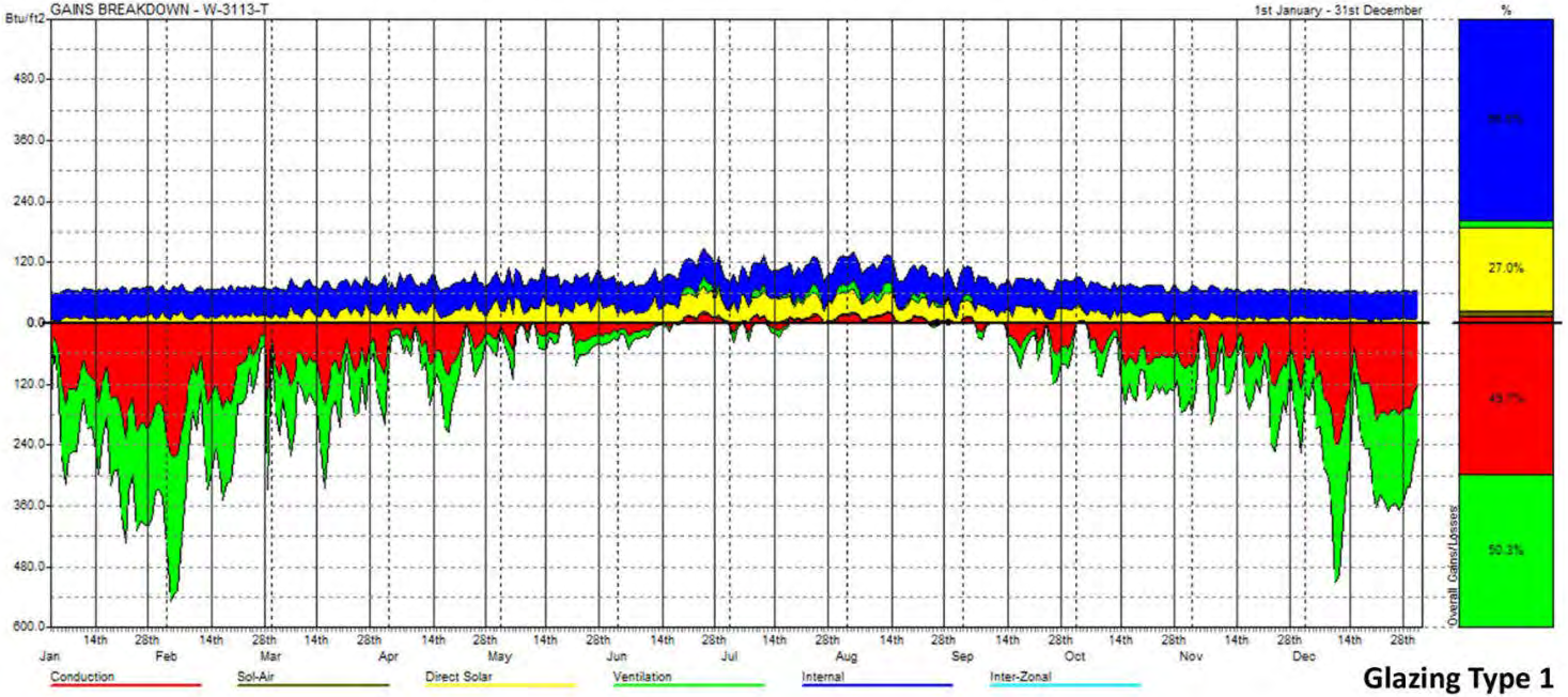



Zone W3113-T

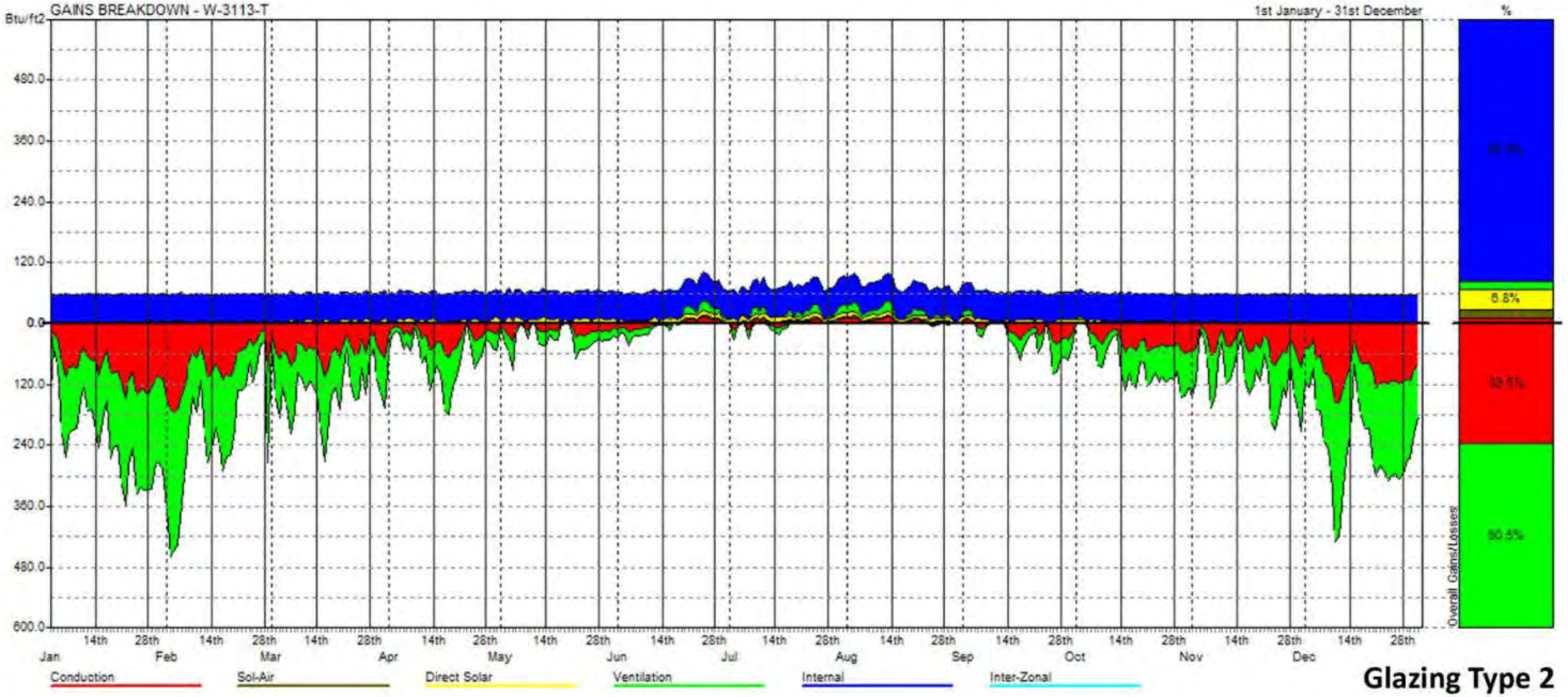



Glazing Type 1:
Standard Double Glazing
Lux
950
850
750
650
550
450
350
250
150
50


Glazing Type 2:
Equiv. to VRE 1-59 Radiant Low-E (VRE) Insulating Laminated Glass
Lux
950
850
750
650
550
450
350
250
150
50



Glazing Type 1



Glazing Type 2

INDIANAPOLIS PUBLIC LIBRARY – EAGLE BRANCH

LOCATION	INDIANAPOLIS, INDIANA
TYPE	PUBLIC LIBRARY
SIZE	20,100 GROSS SQUARE FEET
ECMs	OPTIMIZED ENVELOPE PERFORMANCE LOW LIGHTING POWER 66KW PHOTOVOLTAIC ARRAY

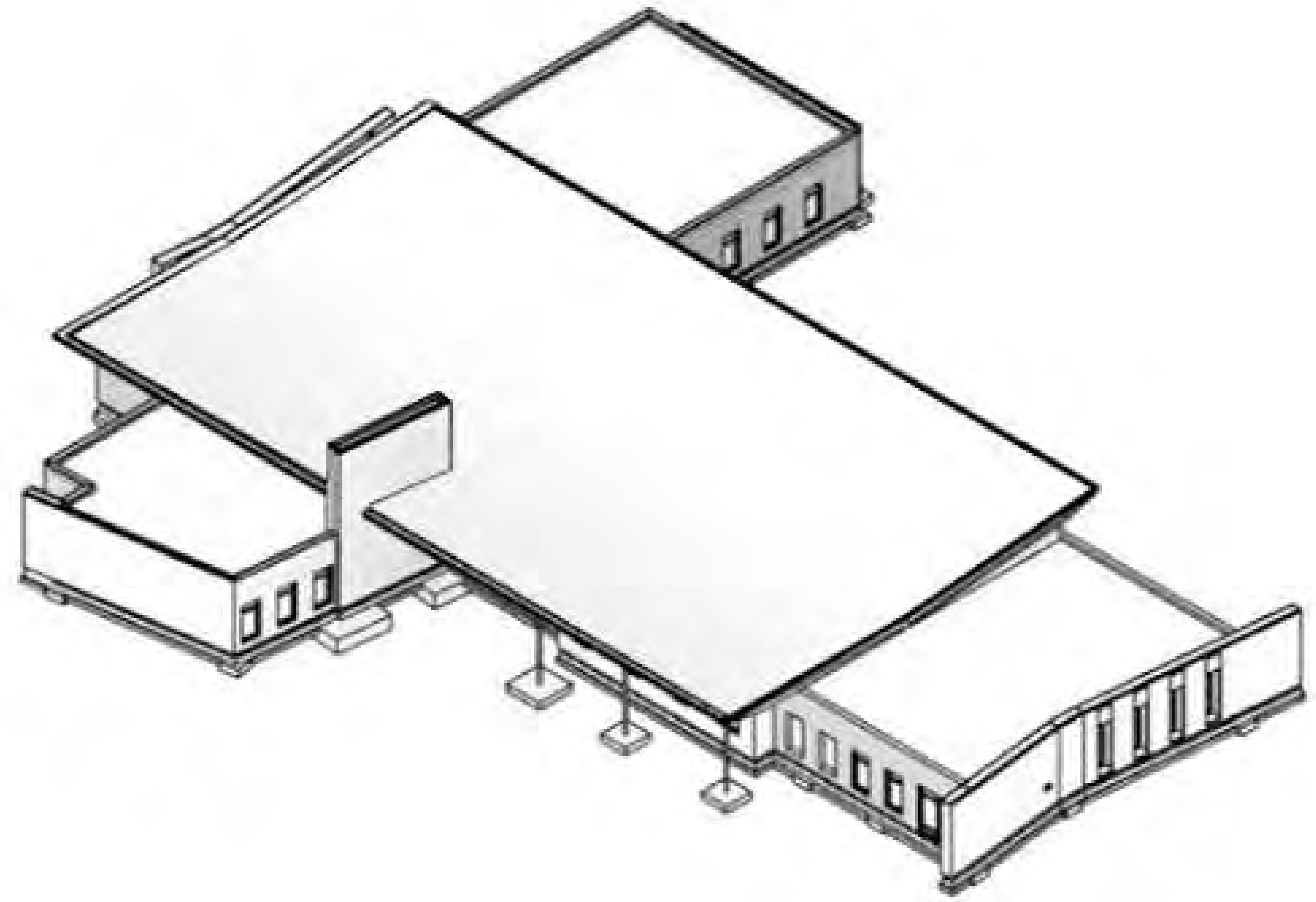
$10,500

ENERGY COST SAVINGS PER YEAR (38.5%).

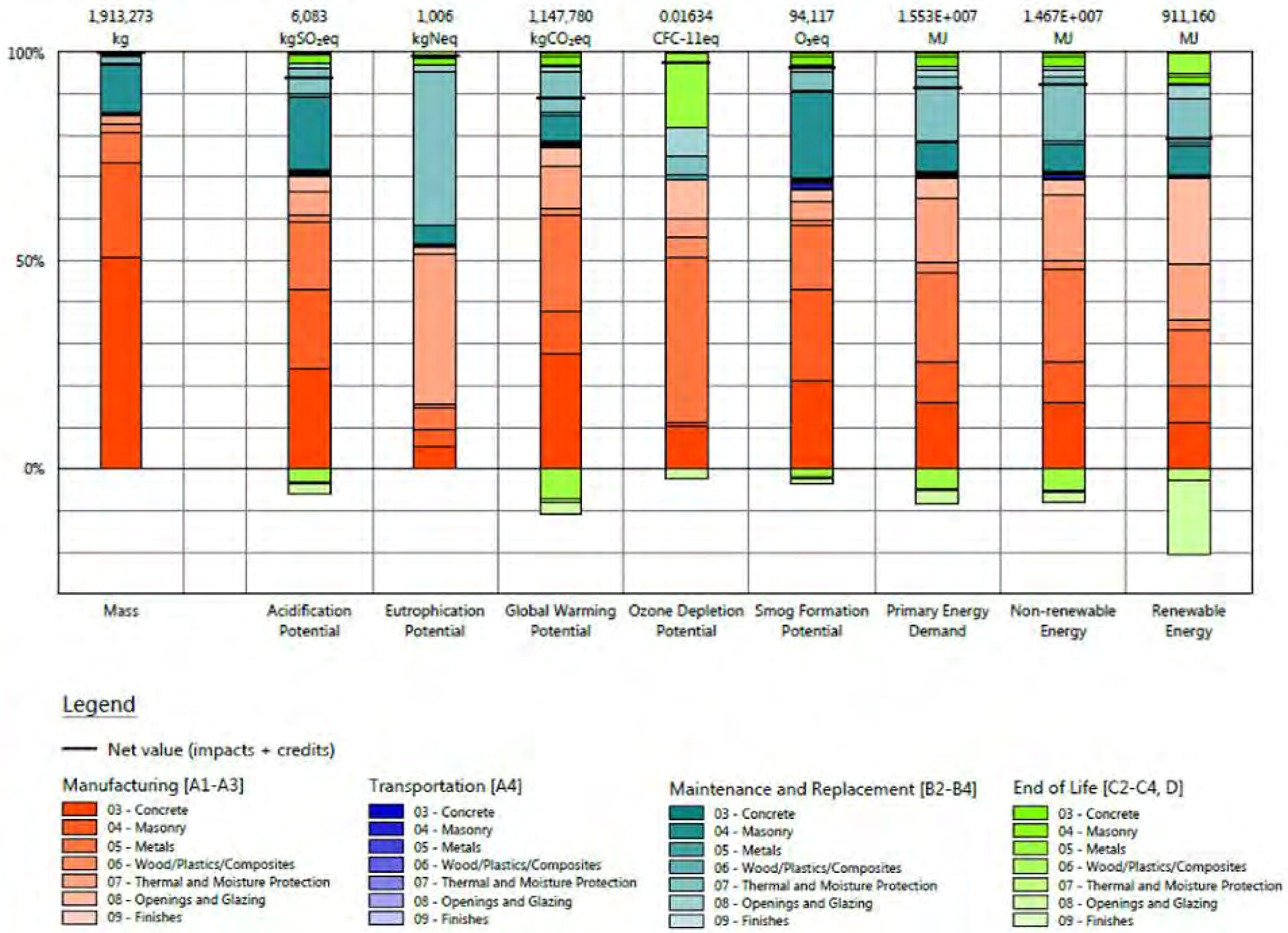
U.S. GREEN BUILDING COUNCIL LEED GOLD USGBC

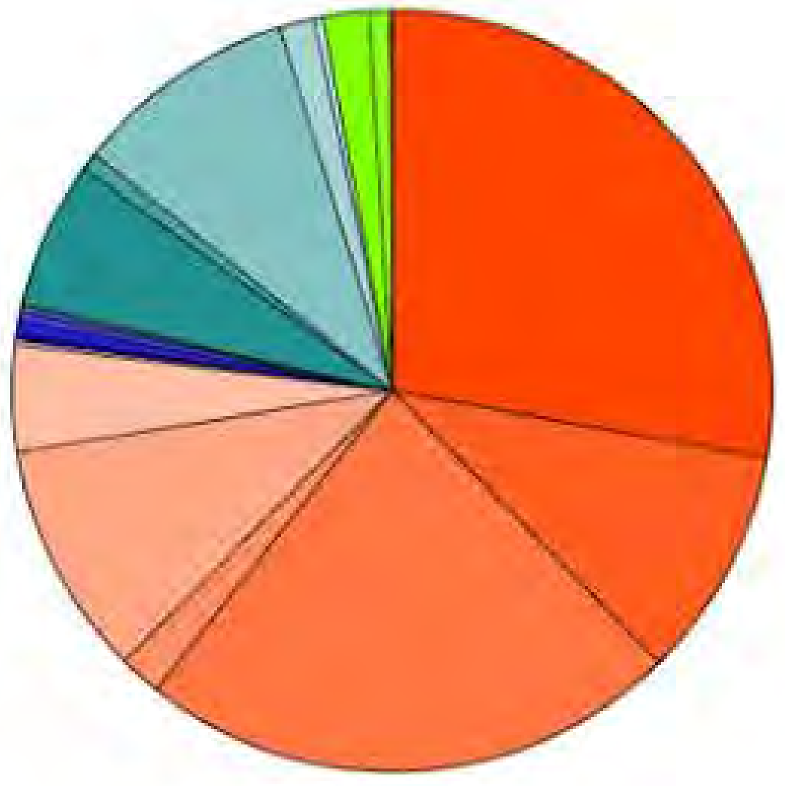

TEENS

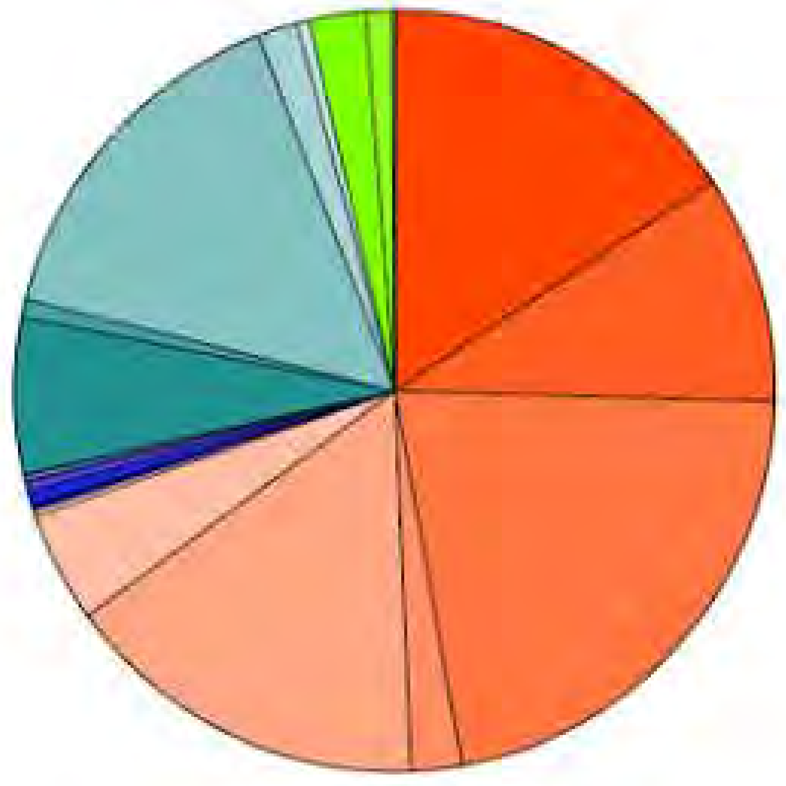

3905
The Library
Eagle Branch



Results per Life Cycle Stage, itemized by Division




Global Warming Potential


Primary Energy Demand

Budgetary Considerations

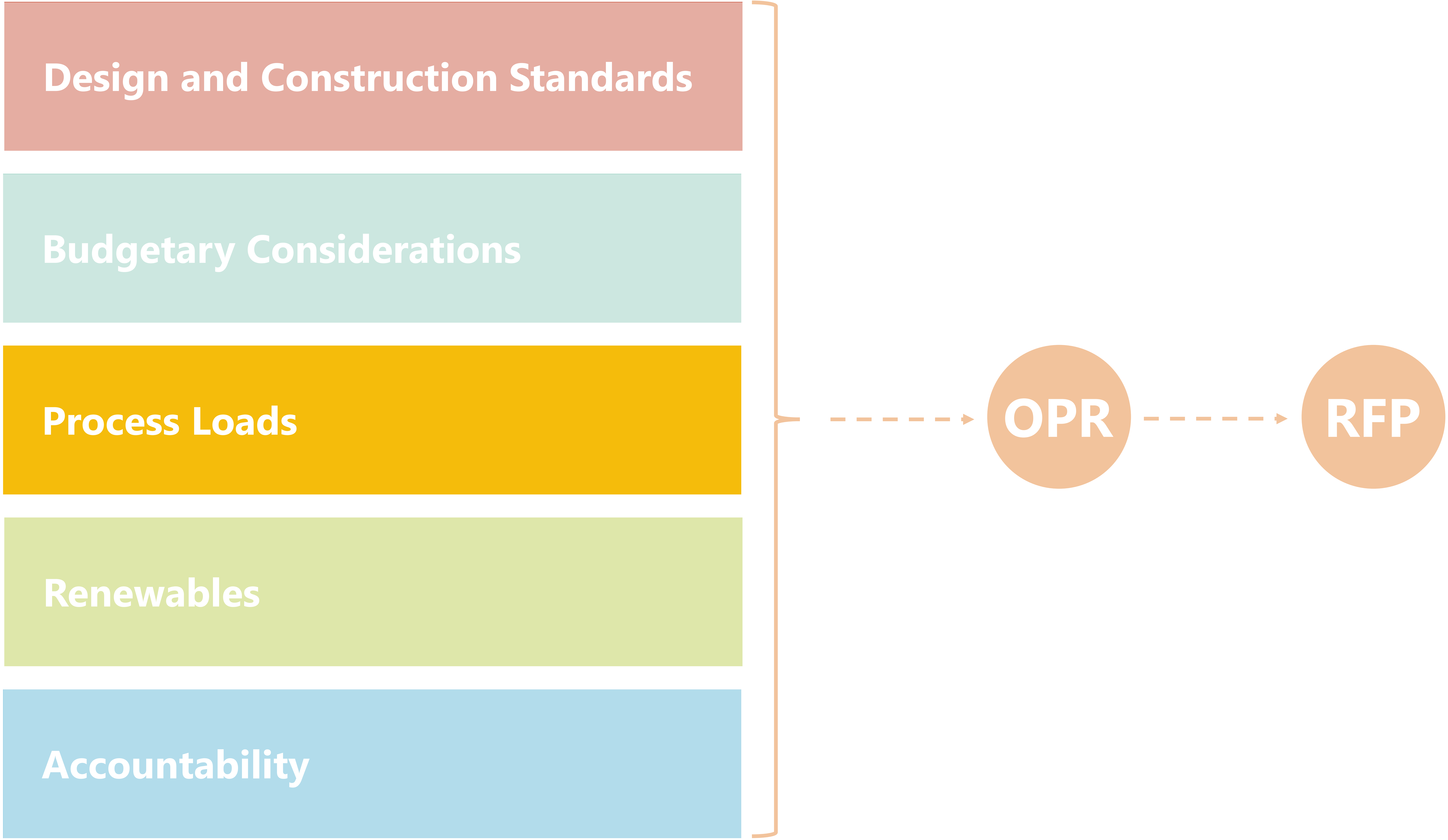
1. Validate the cost model to account for high-performance design, especially ZNE.

2. Reconcile the project budget with the performance goals of the project when necessary.

3. Leverage performance-modeling protocol. This can be part of the standard. Consider high-performance strategies for their return on investment.

4. Account for value-added services like envelope and MEP commissioning and energy modeling.

5. Anticipate the emerging carbon economy as campuses drive toward carbon neutrality.


Design and Construction Standards
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Process Loads

- **What processes will occur in your buildings?**
  - Define all major programming elements that will require high-energy consumption.
  - Consider how user power requirements will change over time.
  - Contemplate occupancy-based receptacle controls.

Process Loads

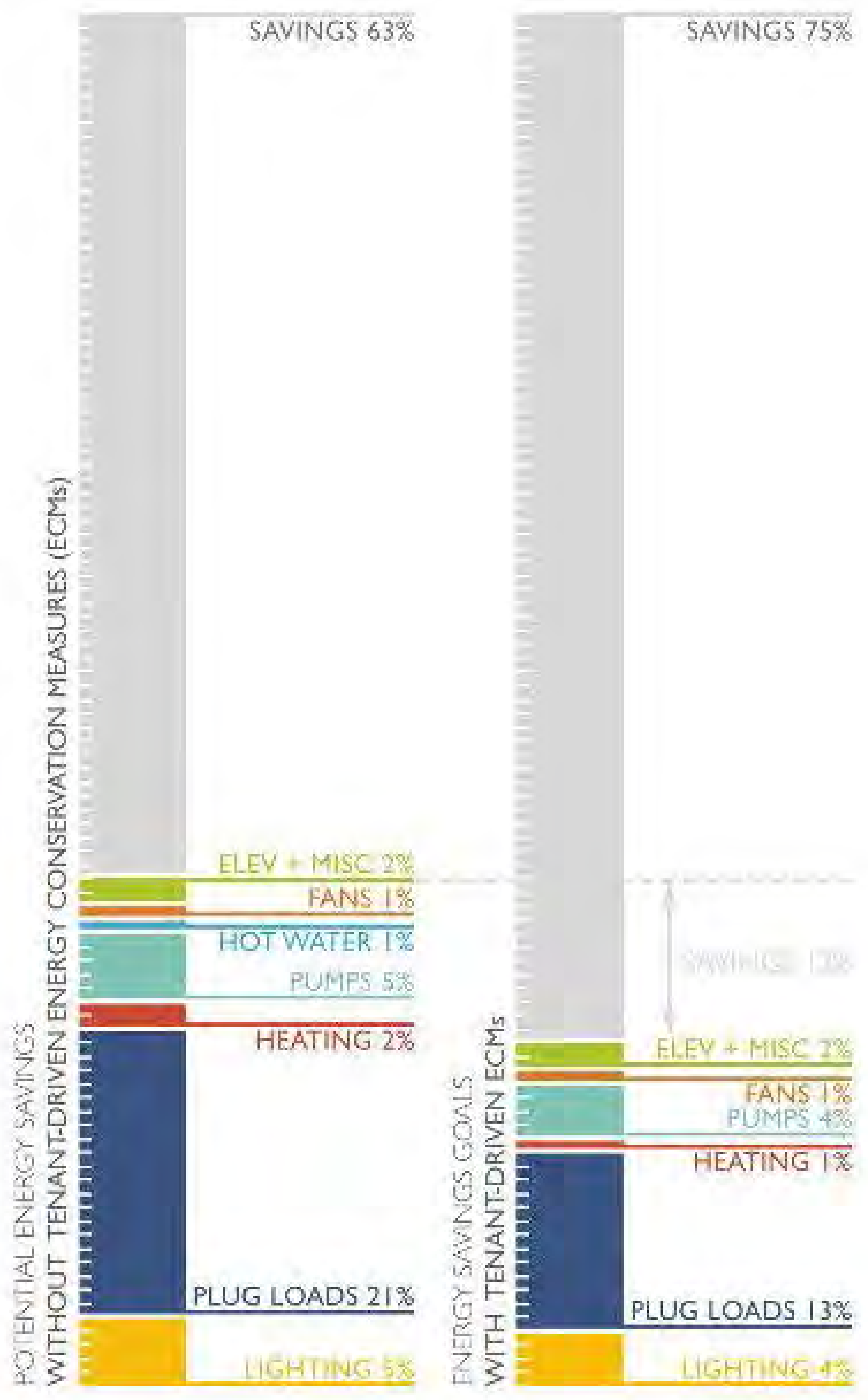
- **Will the program include a kitchen?**
  - Define if the kitchen be a warming kitchen or a commercial-grade cooking kitchen.
  - Determine if new equipment be installed or if existing equipment be relocated to new project.
  - Consider requiring an all-electric kitchen.

EUI = 50 $kBtu/ft^2yr$

EUI = 150 $kBtu/ft^2yr$

Process Loads

- **How will users interact with the building?**
  - Incentivize occupant behavior to reduce process/plug load energy consumption.
  - Develop energy awareness programs and use them.
  - Provide occupants data-based feedback loops to empower them to make better choices.
  - Allocate space for active stairs.



Graphic adapted from Cockram, Michael.
"Targeting Net Zero: Architect, engineers, and researchers strive to propel net-zero buildings into the mainstream."
GreenSource Magazine. September/October 2010.

GRAND VALLEY STATE UNIVERSITY

LOCATION: ALLENDALE, MICHIGAN

KINDSCHI HALL OF SCIENCE

U.S. GREEN BUILDING COUNCIL LEED GOLD USGBC

ROBERT KLEINER COMMONS

U.S. GREEN BUILDING COUNCIL LEED SILVER USGBC

LAKER MARKETPLACE

U.S. GREEN BUILDING COUNCIL LEED GOLD USGBC

HOLTON-HOOKER LEARNING AND LIVING CENTER

U.S. GREEN BUILDING COUNCIL LEED SILVER USGBC

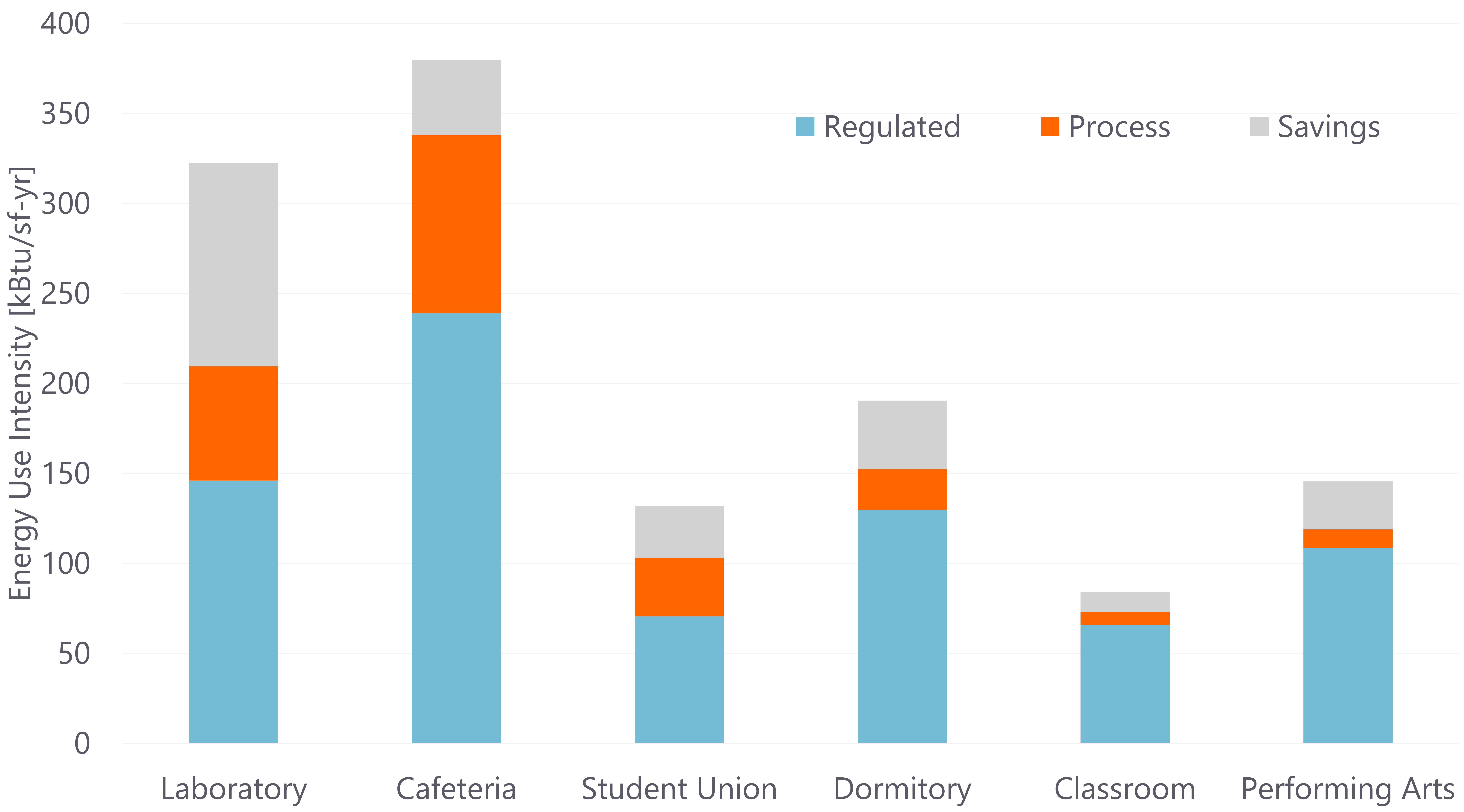
LAKE HURON HALL

U.S. GREEN BUILDING COUNCIL LEED SILVER USGBC

certification pending

HAAS CENTER FOR PERFORMING ARTS

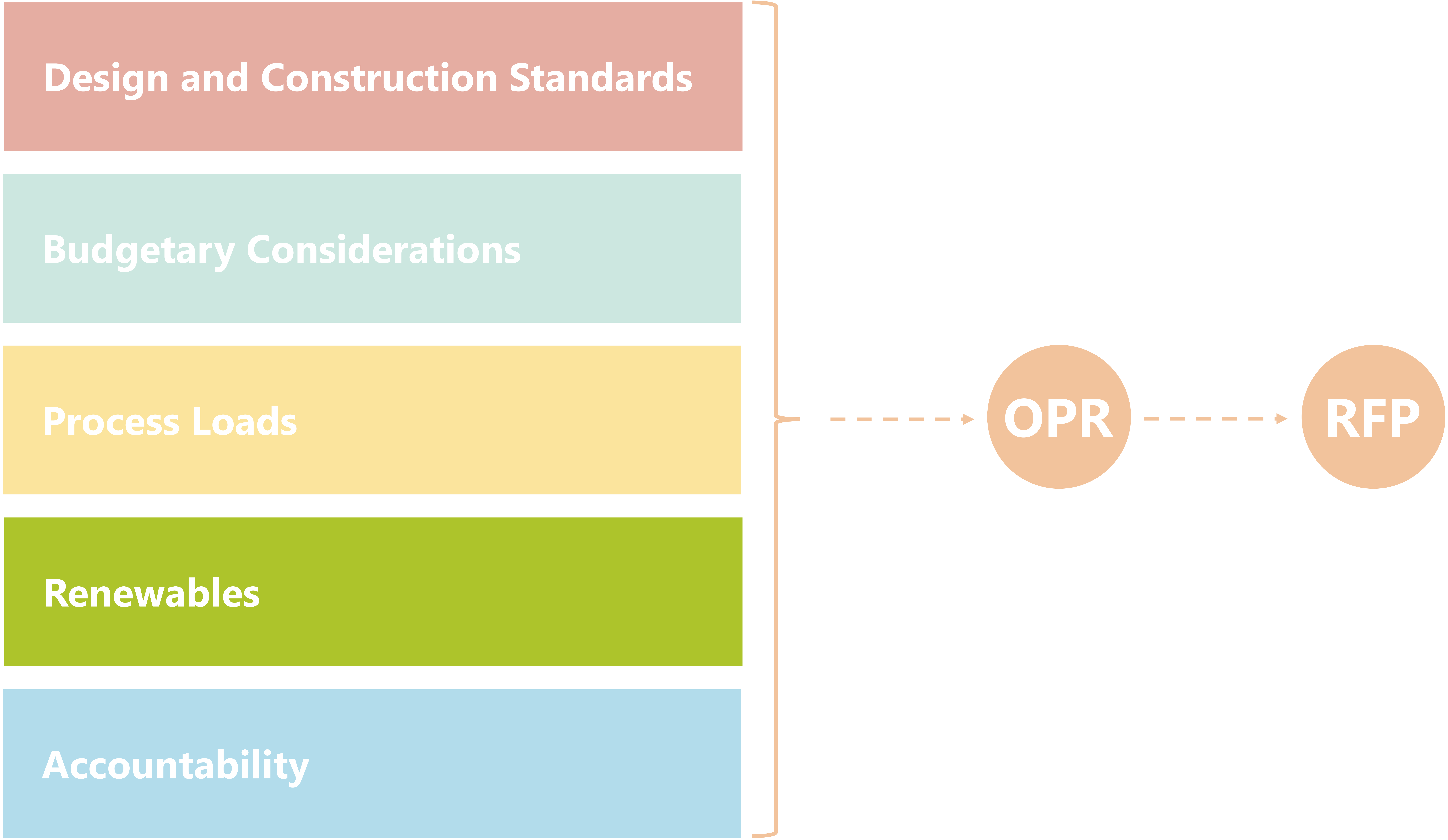
U.S. GREEN BUILDING COUNCIL LEED SILVER USGBC



Energy Use Intensity [kBtu/sf-yr]
400
350
300
250
200
150
100
50
0
Regulated
Process
Savings
Laboratory
Cafeteria
Student Union
Dormitory
Classroom
Performing Arts

Plug and Process

1. Recognize that each building type will have different plug/process energy needs.
2. Identify all major programming elements that will require high-energy consumption.
3. Develop an equipment purchasing policy that aligns with net-zero goals.
4. Contemplate control strategies that allow you to minimize plug loads.
5. Implement strategies to leverage user engagement.


Design and Construction Standards
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Renewables

- Allocated space on-campus for renewables.
- Indicate acceptable types of renewable technology.
- Determine if ground exchange systems will be classified as renewable.
- Campuses may be better served by district scale solutions.

Renewables

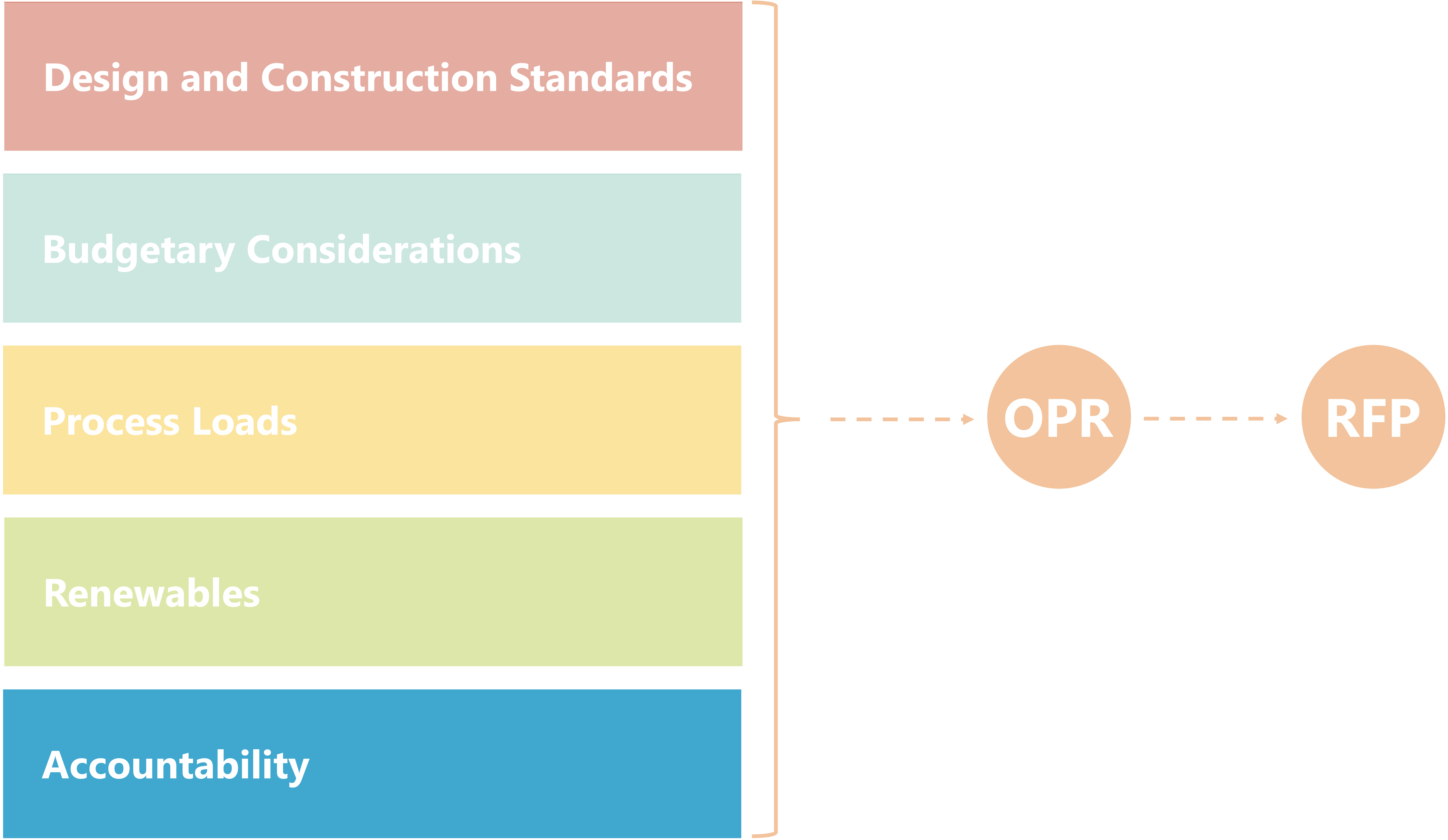
1. This is the **<u>last</u>** piece in the net-zero design process.

2. There are a variety of renewable types; you must consider what is right for your location and budget, with an eye toward emerging technologies.

3. There are other factors to consider beyond installed cost of PV. Local utility may have alternative rate structures.

4. Reputational capital: On-site PV can be highly visible.

5. You might need district level or utility-scale renewables to get to "net zero."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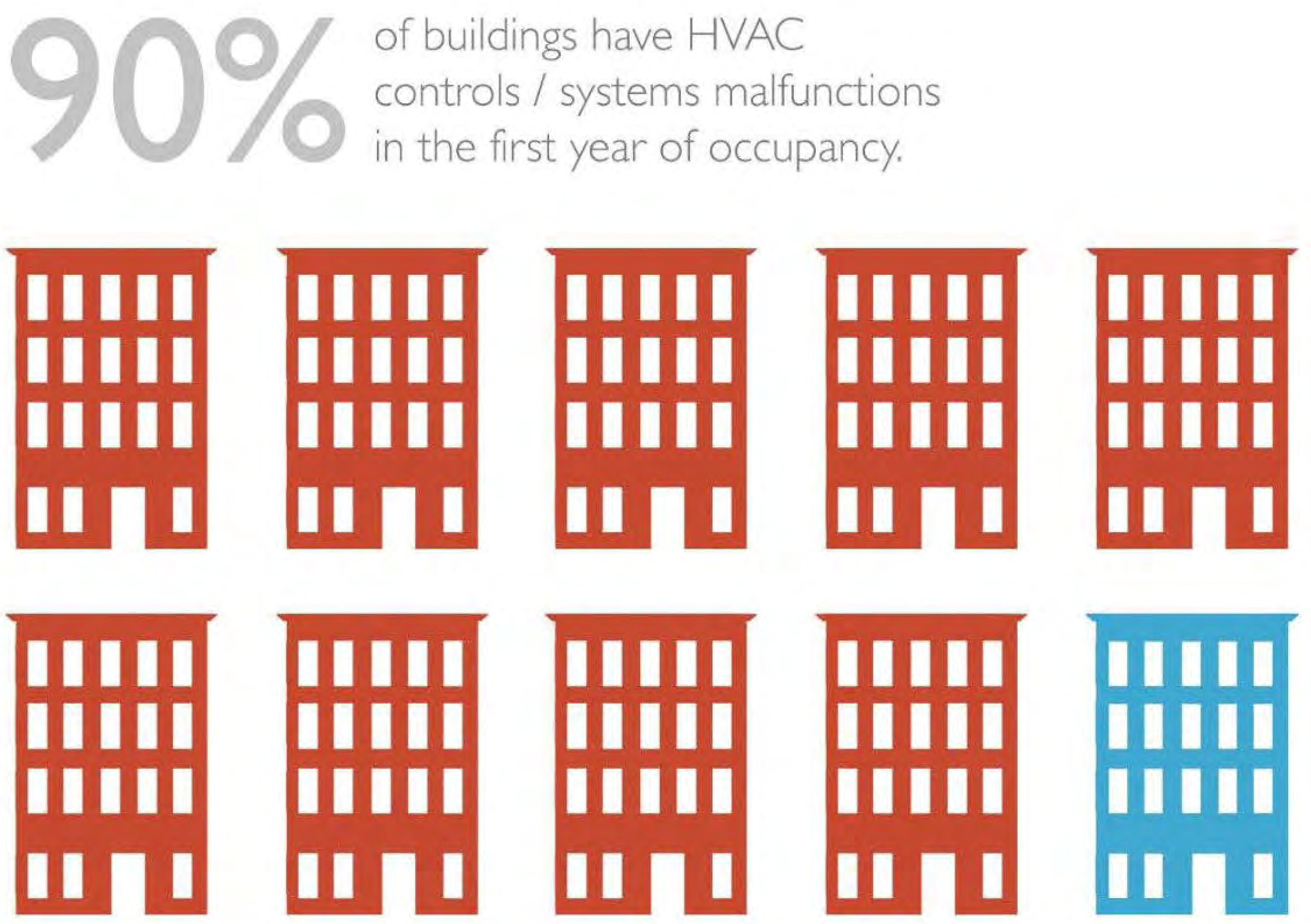
Accountability

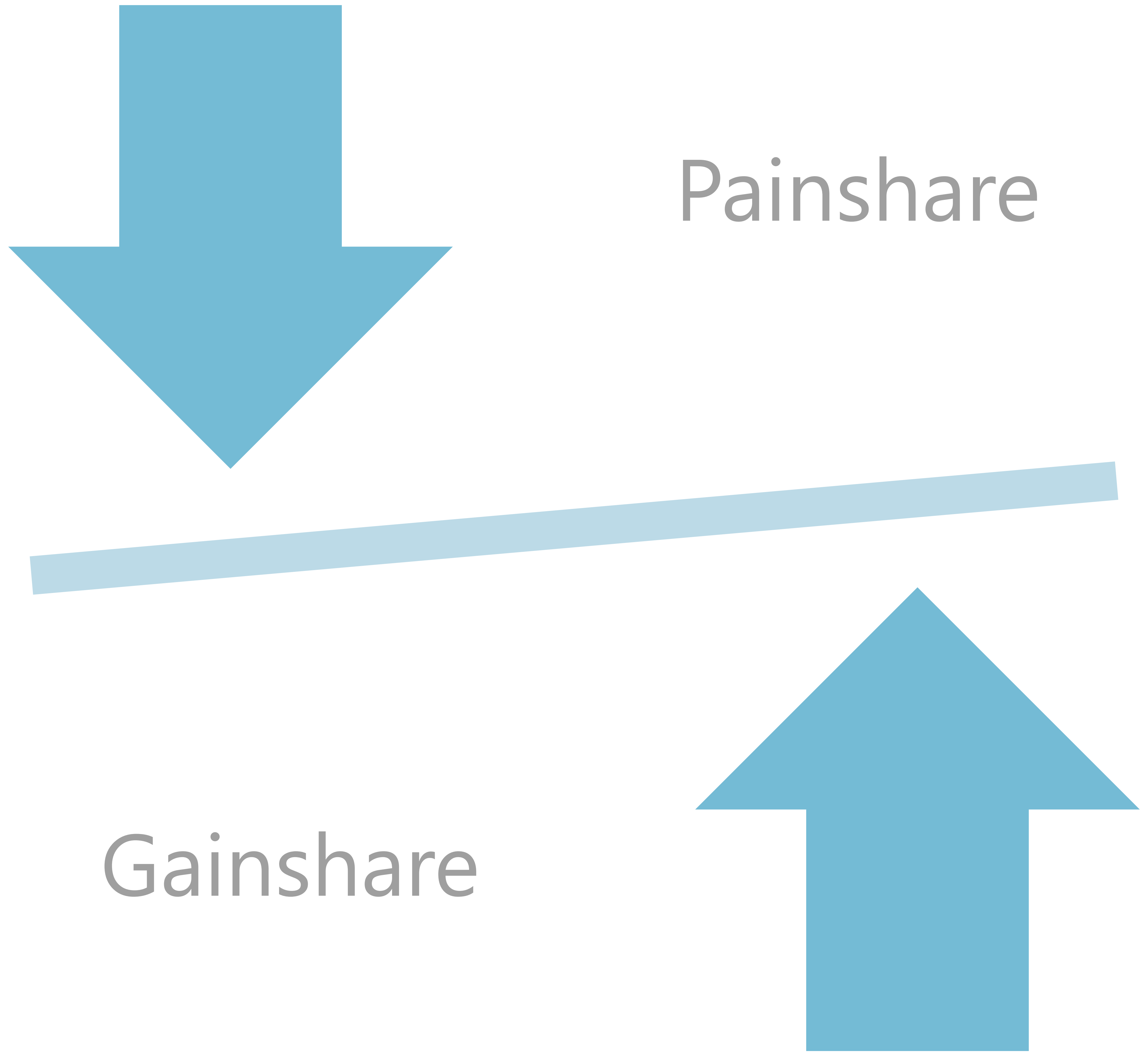
- **Are the mechanisms in place to better ensure that you are getting what you think you are paying for?**
  - Fundamental commissioning should be a part of the performance standard.
  - This is beyond basic design services and the CxA should be a third party.
  - After all, the performance is what counts: Measurement and Verification (M+V).



Sources: Peter Rumsey, "Out-of-Control Controls," *GreenSource Magazine*, September 2011, McGraw-Hill Construction.

Accountability

1. Report monthly chilled water, electrical, process load consumption to energy champion.
2. Collect building performance data for one year of operation.
3. Analyze collected data.
4. Calibrate design-phase energy model.




Predicted Total Annual Energy Cost
Actual Total Annual Energy Cost
Gainshare
Predicted
Actual
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec

Predicted Total Annual Energy Cost
Actual Total Annual Energy Cost
Painshare
Predicted
Actual
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec

COLORADO STATE UNIVERSITY TRANSLATIONAL MEDICINE

LOCATION	FORT COLLINS, COLORADO
TYPE	UNIVERSITY OFFICE, LAB, EQUINE SURGERY, EQUINE BARN
SIZE	130,000 GROSS SQUARE FEET
ECMs	ENERGY RECOVERY CENTRALIZED DEMAND CONTROL VENTILATION OPTIMIZED ENVELOPE PERFORMANCE LOW LIGHTING POWER

$90,900

ENERGY COST SAVINGS PER YEAR (20.5%).

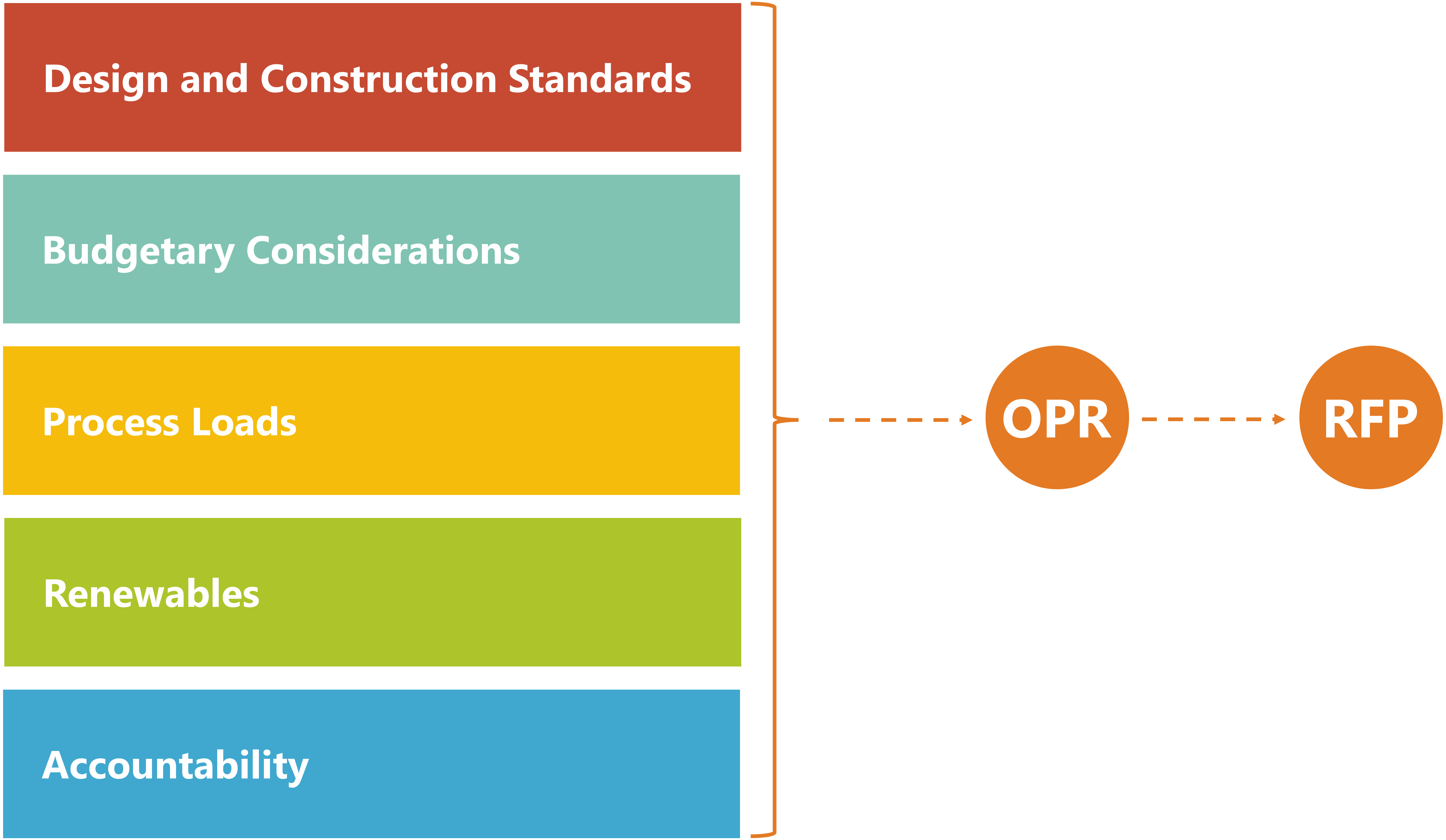


Tracked Data Points

- Fume Hood Status
- OA Temp & RH
- CHW Loop dT
- Plug Load
- Exhaust Flow Rate
- CHW Pump Speed
- Fan Flow & Speed
- Zone Temp
- Terminal Unit Airflow
- HRU Status
- Lighting Load
- Zone Occupancy Status
- CHW BTU

Accountability

1. Invest in envelope and MEP commissioning services.
2. Account for additional costs of submetering in budgetary planning.
3. Execute a measurement and verification plan.
4. Articulate how M&V data will be used and transferred between parties.
5. Implement painshare/gainshare provisions in your contracts.


Design and Construction Standards
Budgetary Considerations
Process Loads
Renewables
Accountability
OPR
RFP

“

There is a great need for the introduction of new values in our society, where bigger is not necessarily better, where slower can be faster, and where less can be more.

GAYLORD NELSON, founder of Earth Day

GO FAST, GO SLOW: PLANNING EARLY FOR ZERO NET ENERGY

AMANDA BOGNER
PE, BEMP, LEED AP
FOUNDER, ENERGY STUDIO

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Energy studio

BROWNING DAY MULLINS DIERDORF

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