The Weidt Group®

The Company for Energy Decision Makers SM

twgi.com

In collaboration with:

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ZERO Carbon

The Common and the Differentials

Agenda

- Identify reasons for designing to net-zero carbon vs. net-zero energy
- Discuss participants needed for an integrated design approach
- Review high-level outline of phases in the integrative design process for achieving net-zero
- Illustrate, through a case study, the integration of analysis and design
- Discuss performance and implications of the completed design
- Q&A

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ZERO Carbon

The Common and the Differentials

Learning Objectives

- What are the three primary stages of integrative design and consulting to achieve net-zero carbon?
- What is the approximate value of good architecture in achieving net-zero carbon?
- Are all forms of energy used in a building of equal carbon intensity?
- Identify four major technologies/design factors that get you ¾ of the way to net-zero carbon for this building type.
- What is required for a building capable of being net-zero carbon to actually operate at net-zero carbon?

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The Common and the Differentials

ZEROCARBON

Onward to Zero.

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Ten Months…

Hundred of Unpaid hours…Why?

Commitment to 100% carbon neutral design

Gaining experience and developing replicable processes will make design of future buildings easier and more affordable…

Get REAL about opportunities and barriers in market

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LOTS OF TALK ABOUT
ZERO CARBON

ADOPTER
architecture
2030
CHALLENGE

WHY ZERO EMISSIONS INSTEAD OF ZERO ENERGY?

Emissions from buildings represents **39% of the U.S. total.**

Zero emissions forces us to think about the **environmental impact of the energy source,** which varies in different regions.

We must get to zero emissions to avoid **dangerous climate change.**

Zero emissions is fundamental to the **future of architecture.**

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What is a Zero Emissions Building?

"A building that produces and exports ***at least*** **as much emissions-free renewable energy as it imports and uses** from emission-producing energy sources annually."

Source: U.S. Department of Energy

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Too Small to Make an Impact…

Massive and Hopelessly Expensive…

The Lighthouse in England

Masdar City in Abu Dhabi

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Can we Design a

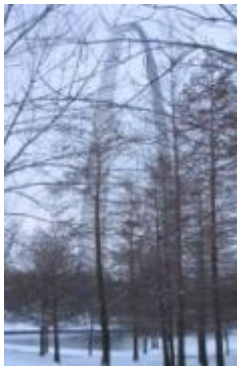
Market-rate Zero Emissions Office Building

in midtown St. Louis?

St. Louis was selected because:

- It has a challenging four-season climate.
- Electricity costs in Missouri are among the lowest in the country.
- St. Louis' electrical fuel profile is 81 percent coal.

The team believed that if they could create a market-rate carbon neutral design on this difficult site, the process could be replicated in any location.



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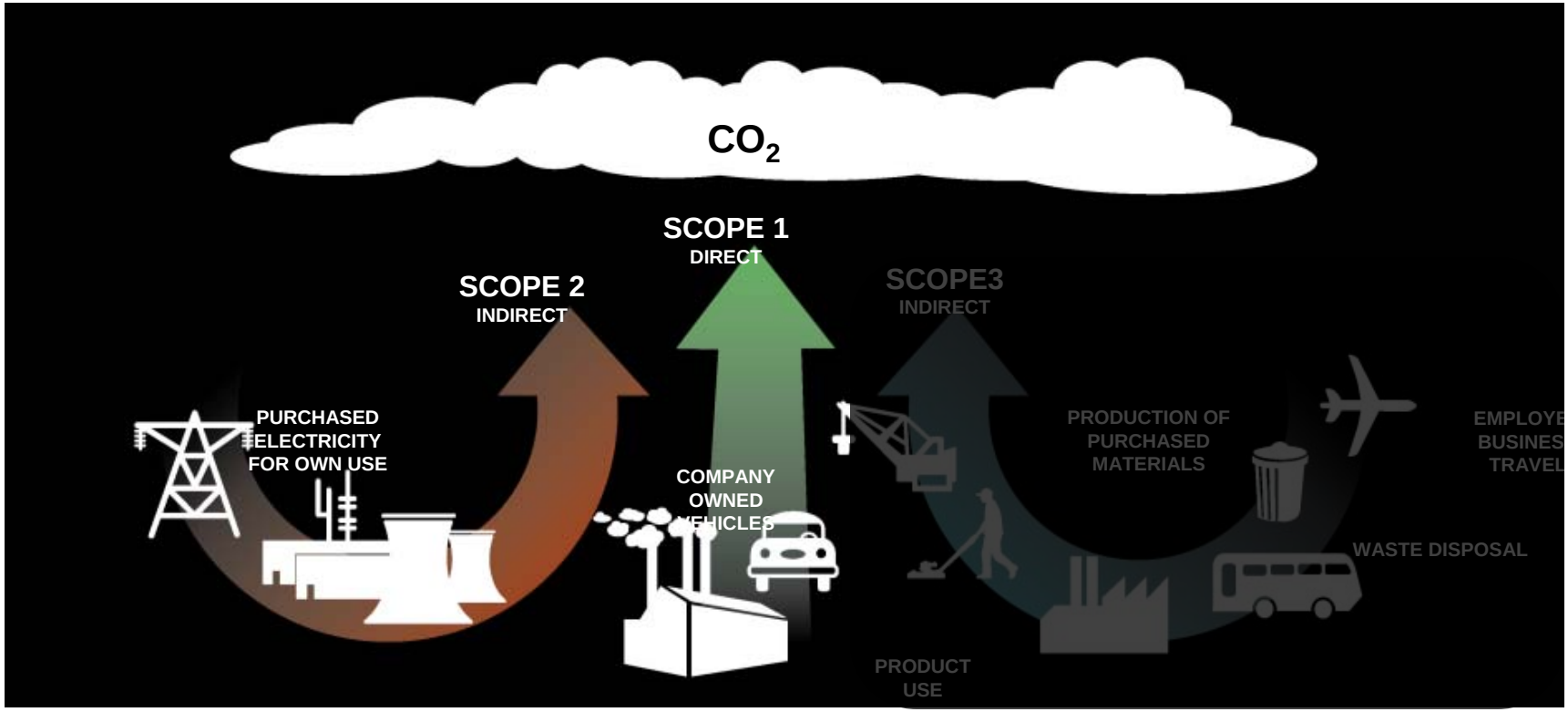
Global Greenhouse Gas

Measurement Protocol our Focus: Scopes 1 & 2



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The Site

The building site is part of an emerging biotech corridor. To the west is Barnes-Jewish Hospital at Washington University Medical Center, and to the east is Saint Louis University. Immediately to the north is the city's historic Central West End, a thriving commercial and residential district. The site is on a bus line and adjacent to the St. Louis MetroLink rapid transit system, near a new stop planned for the next improvement cycle.

- 150,00-200,000-sq.-ft. midrise
- Affordable *(10-year payback)*
- Marketable
- Use today's technology, materials, systems, codes
- Flexible and adaptable
- Sustainable
- Use 'Life's Principles' to inform design

COAL EMISSIONS FOR ELECTRICITY

MADE NATURAL LIGHT THE PRIME DESIGN DRIVER

Phase I, Step # 1

Organize for Zero Carbon Emissions

July 2009-May 2010

- Two kick-off meetings in St. Louis and Minneapolis
- 15 virtual full-team charrettes using HOK Advance Collaboration Rooms, WebEx
- Dozens of smaller meetings

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Fully Integrated Team

HOK
Architecture, engineering, sustainable design, landscape architecture, project management, cost estimating, Ecotect modeling

The Weidt Group
Energy and daylight modeling

Green Street Properties/ Michael Clark
Developer

Tarlton / Kozeny-Wagner
Construction cost estimating

The Biomimicry Guild
Biomimetic design

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Reality Checks

MICHAEL CLARK / GREEN STREET

A market-driven solution

What would tenants in the current St. Louis market support in this economy?

TARLTON / KOZENY WAGNER

Buildable + affordable

Detailed cost estimates – real numbers

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Mostly Common

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We have the Technology

We Know the Target, We Know the Process

- Pre-design
  Discovery + Definition
  - Organize for zero carbon emissions and develop a plan for learning and deciding
  - Accept your conditions and define your environmental, comfort and financial goals before beginning design
- Design and Construction
  Design Evaluate Revise + Deliver
  - Resolve the macro-scale and develop site and architectural strategies that reduce energy needs and optimize energy generation
  - Develop integrated solutions and define whole building systems to tunnel through cost barriers

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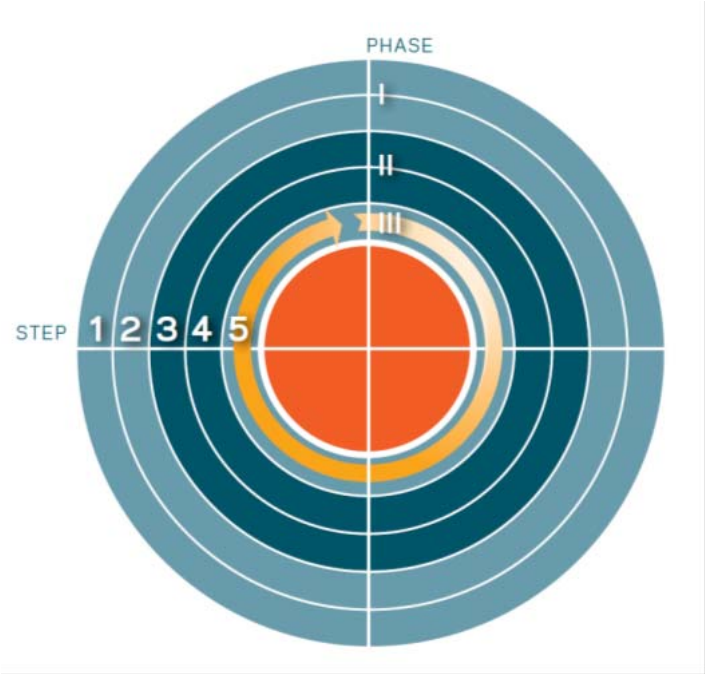
We have the Technology

We Know the Target, We Know the Process

- Stewardship
  Occupancy and Operation
  - Maintain zero and provide a plan that will equip the owner and tenants to occupy and operate the building with zero emissions



We need to do the math.

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Some Differentials

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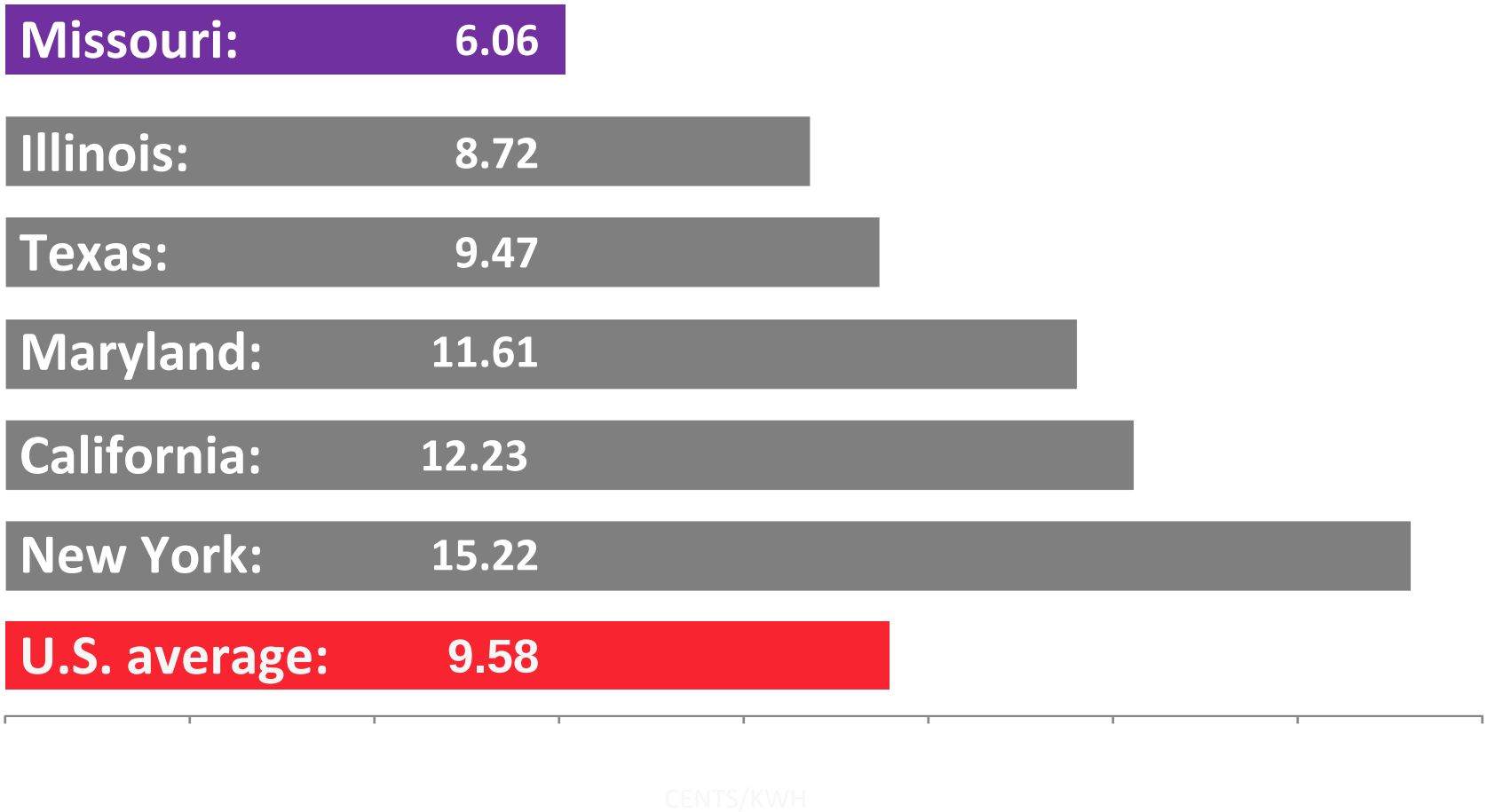
Primary Realities

Missouri Has Cheaper Electricity



Source: U.S. Energy Information Administration, January 2010, average retail commercial price

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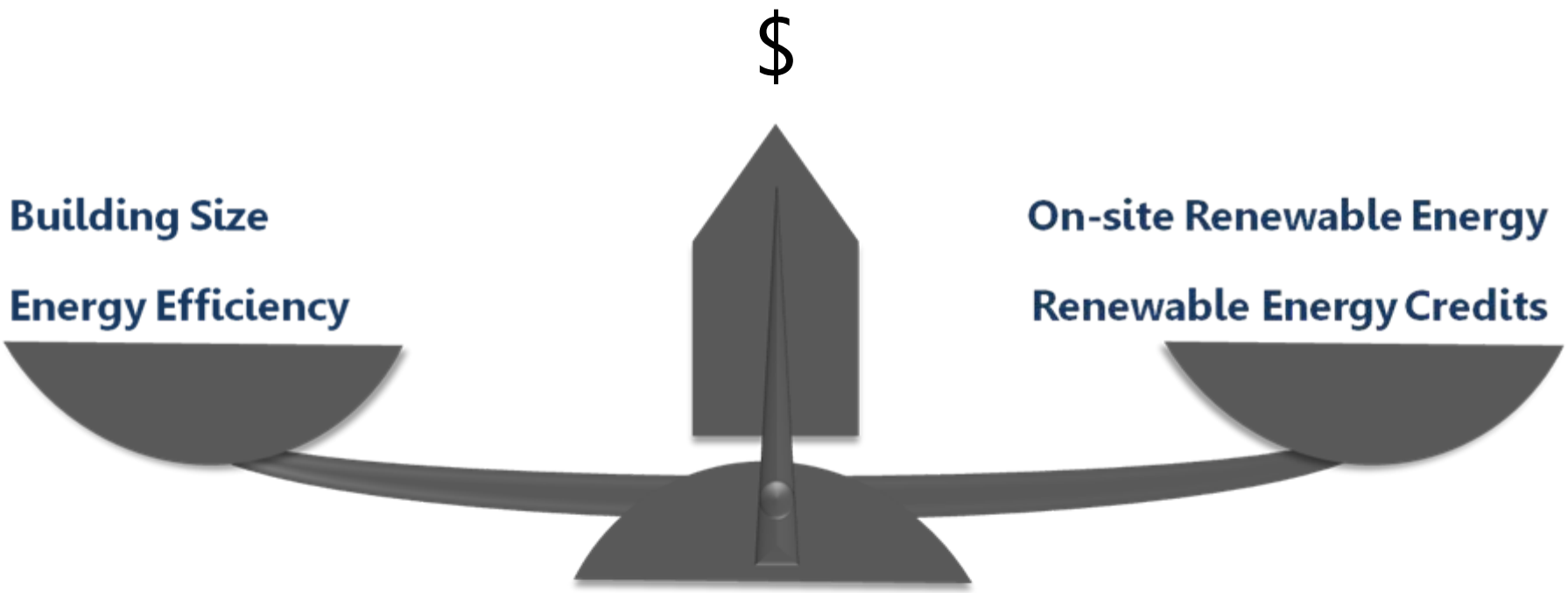
Reducing the Load

Finding the Right **ENERGY** Balances



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Managing the Cost

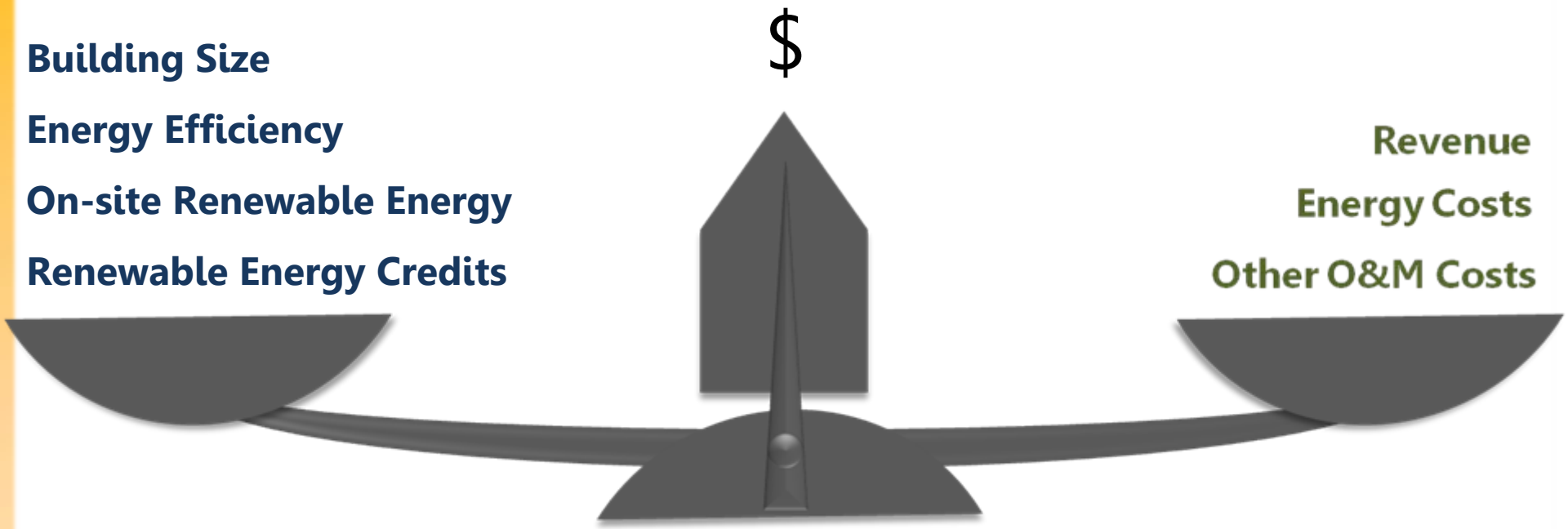
Finding the Right **COST** Balances

Building Size

Energy Efficiency

On-site Renewable Energy

Renewable Energy Credits



Revenue

Energy Costs

Other O&M Costs

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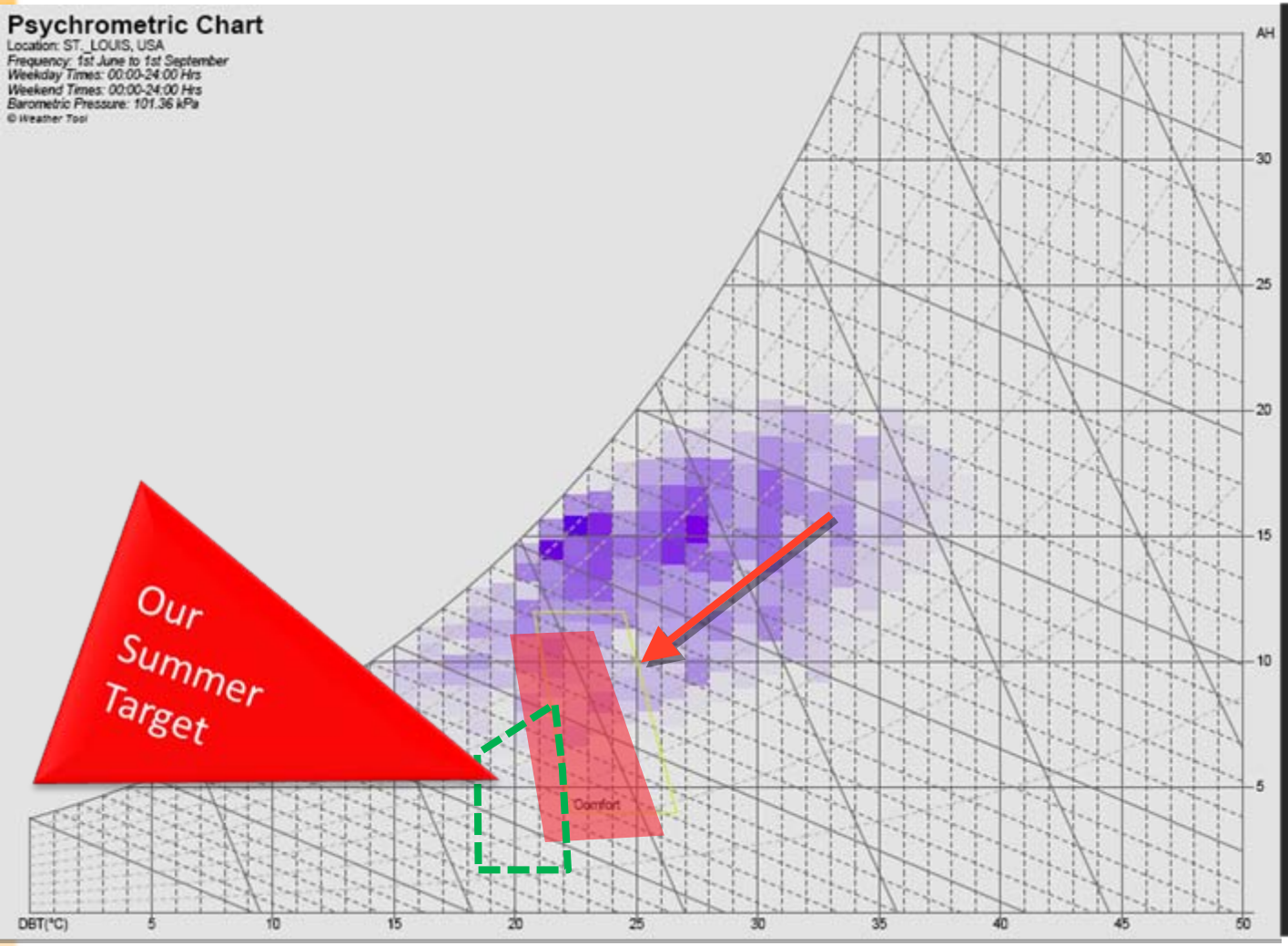
Temperature and Thermal Comfort

Summer Conditions and Strategies



1. Reduce lighting and equipment heat gain
2. Air movement
3. Reduce solar heat gain
4. Thermal mass to load shift

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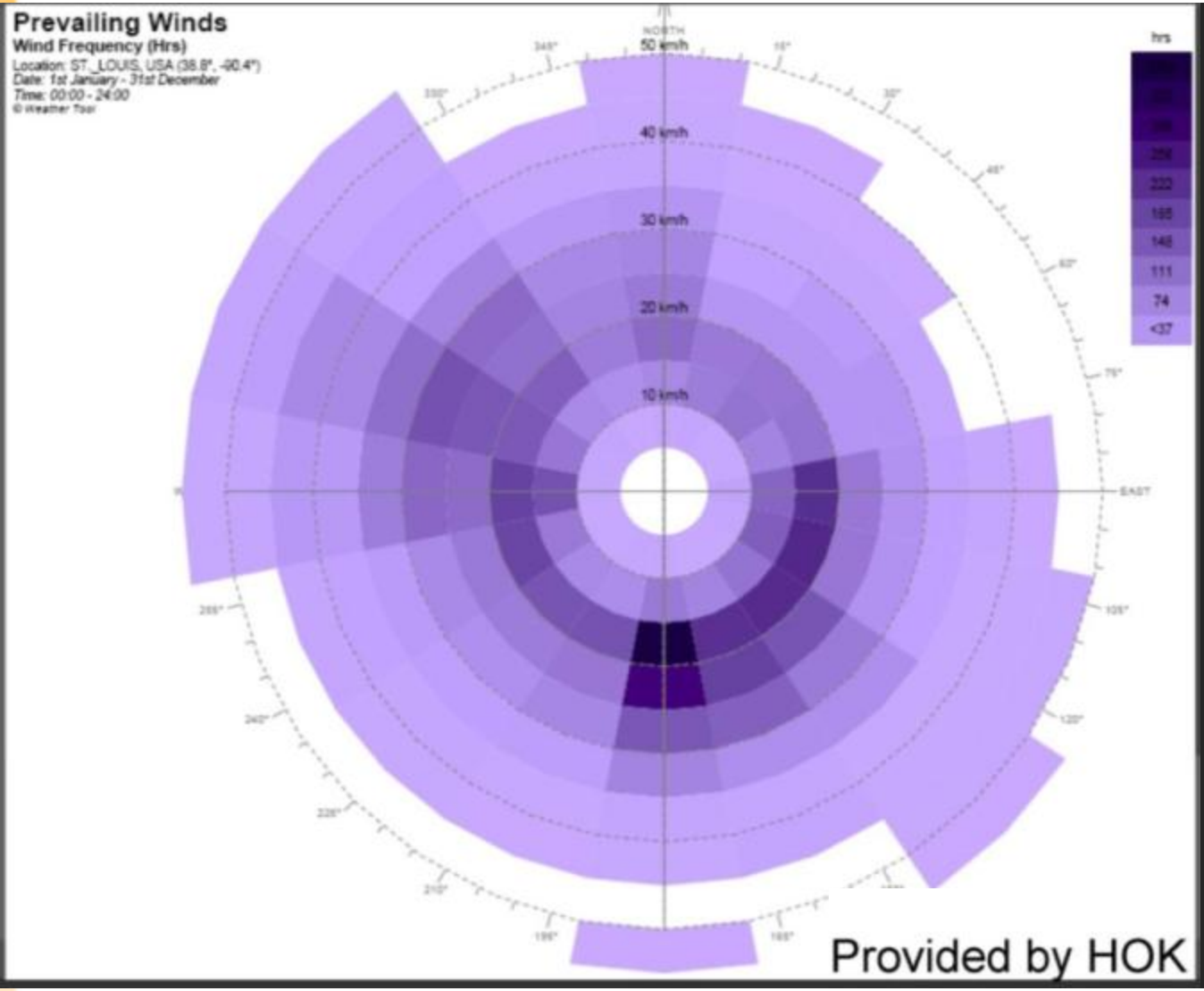
Why Photovoltaics

& Solar Thermal?



Wind power –

Difficult to get on site; low generation potential

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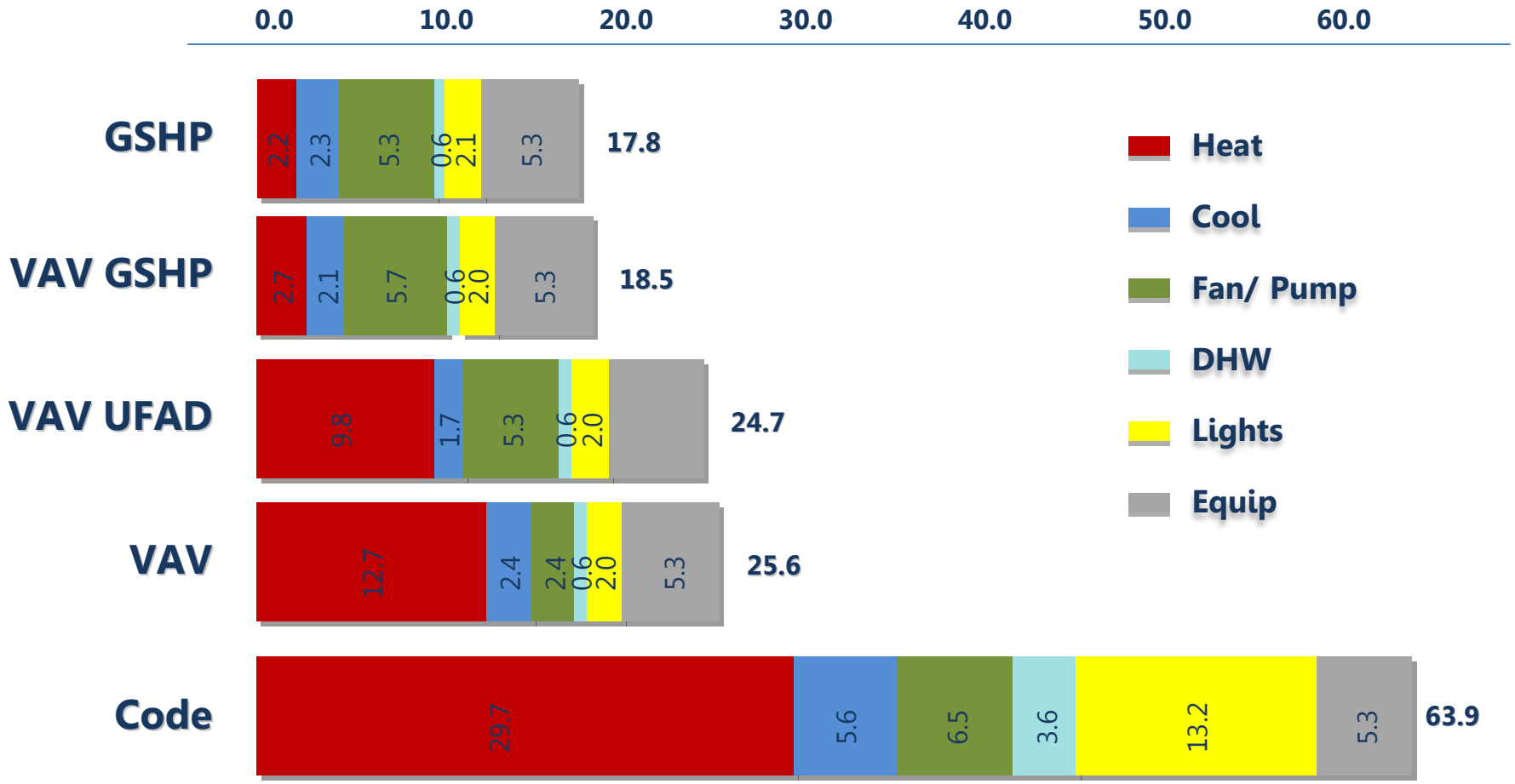
Primary Realities: Pre-design Charrette

Proof Of Principle Models for a heat-driven building might use photovoltaic & solar thermal to reach zero



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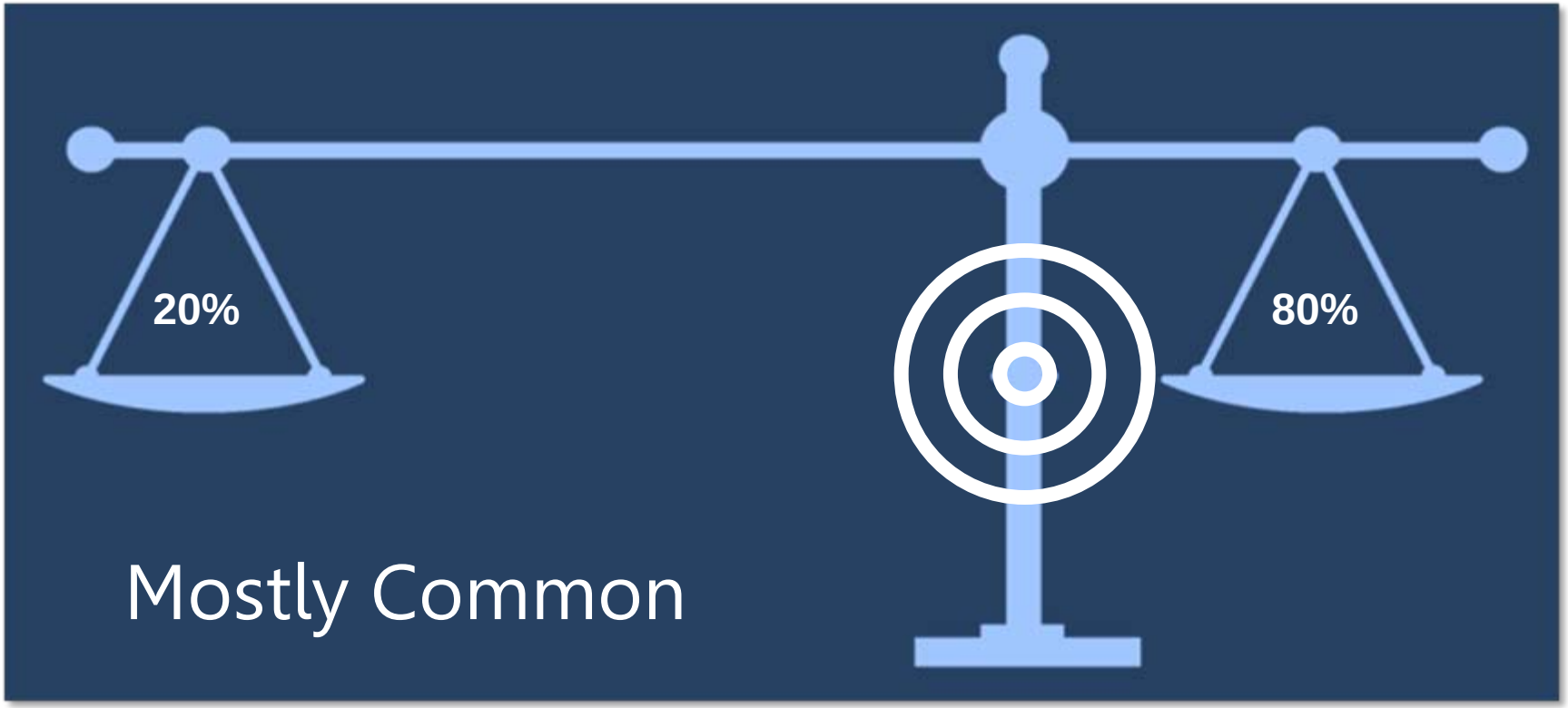
The 80-20 Balance

Exchanging Efficiencies for Renewables

"We have done 60 percent and 70 percent is doable. Reducing the load by 80 percent using today's technology will require a whole new type of architecture."
- David Eijadi, The Weidt Group



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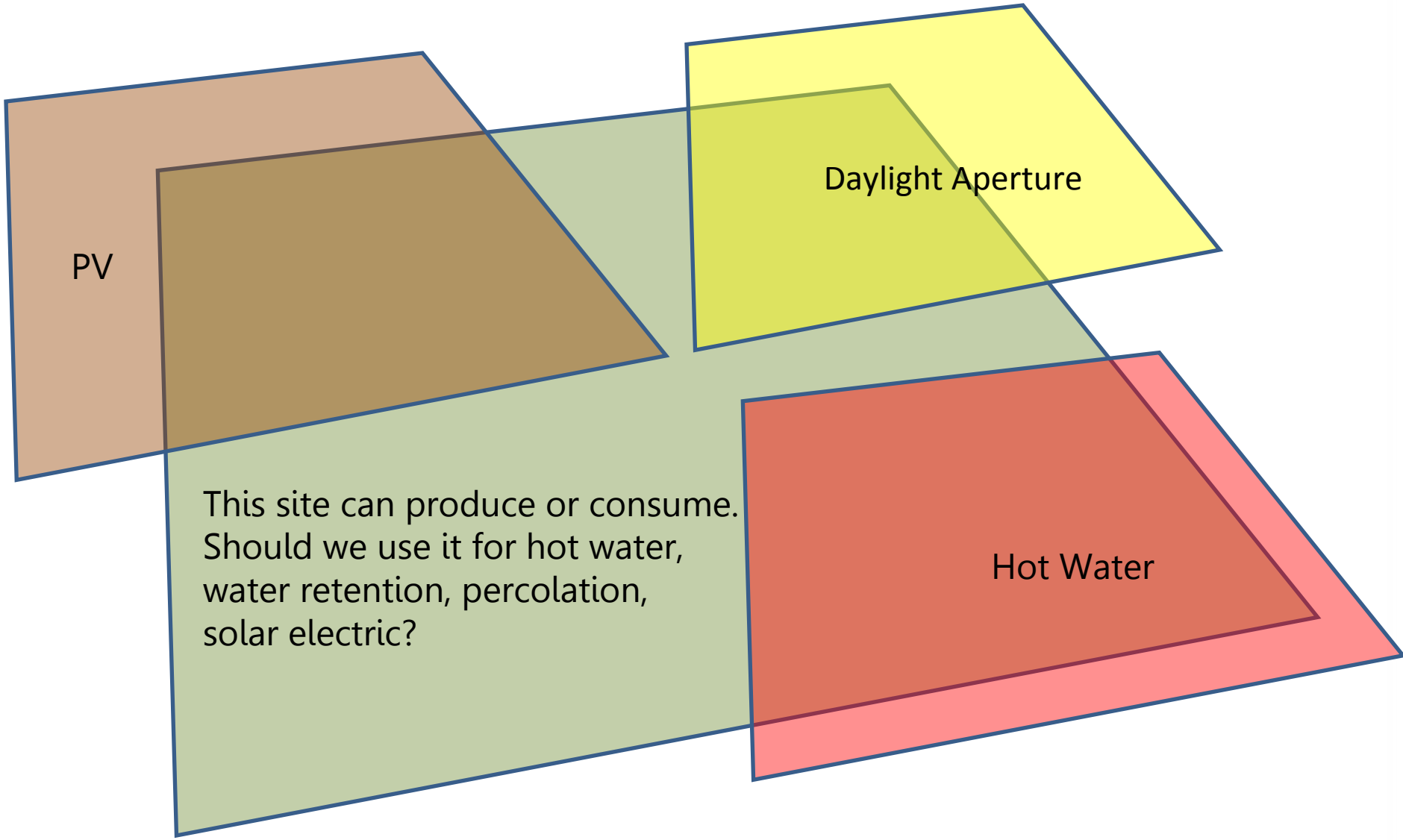
Primary Realities

What We Can Collect on the Site: PV Horizontal , PV Vertical South, East and West



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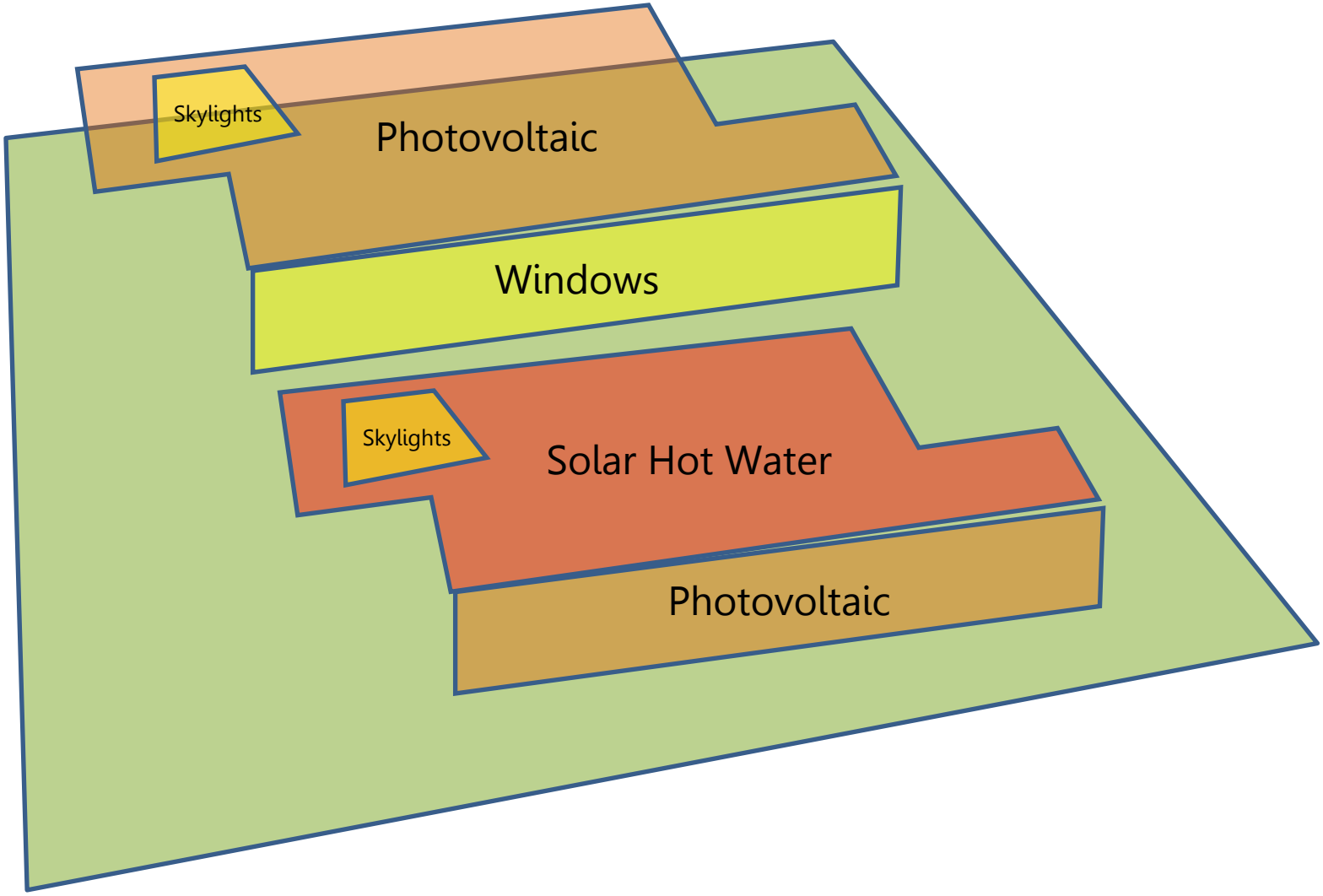
Primary Realities

How Much of Each Surface We Will Need for Each Purpose



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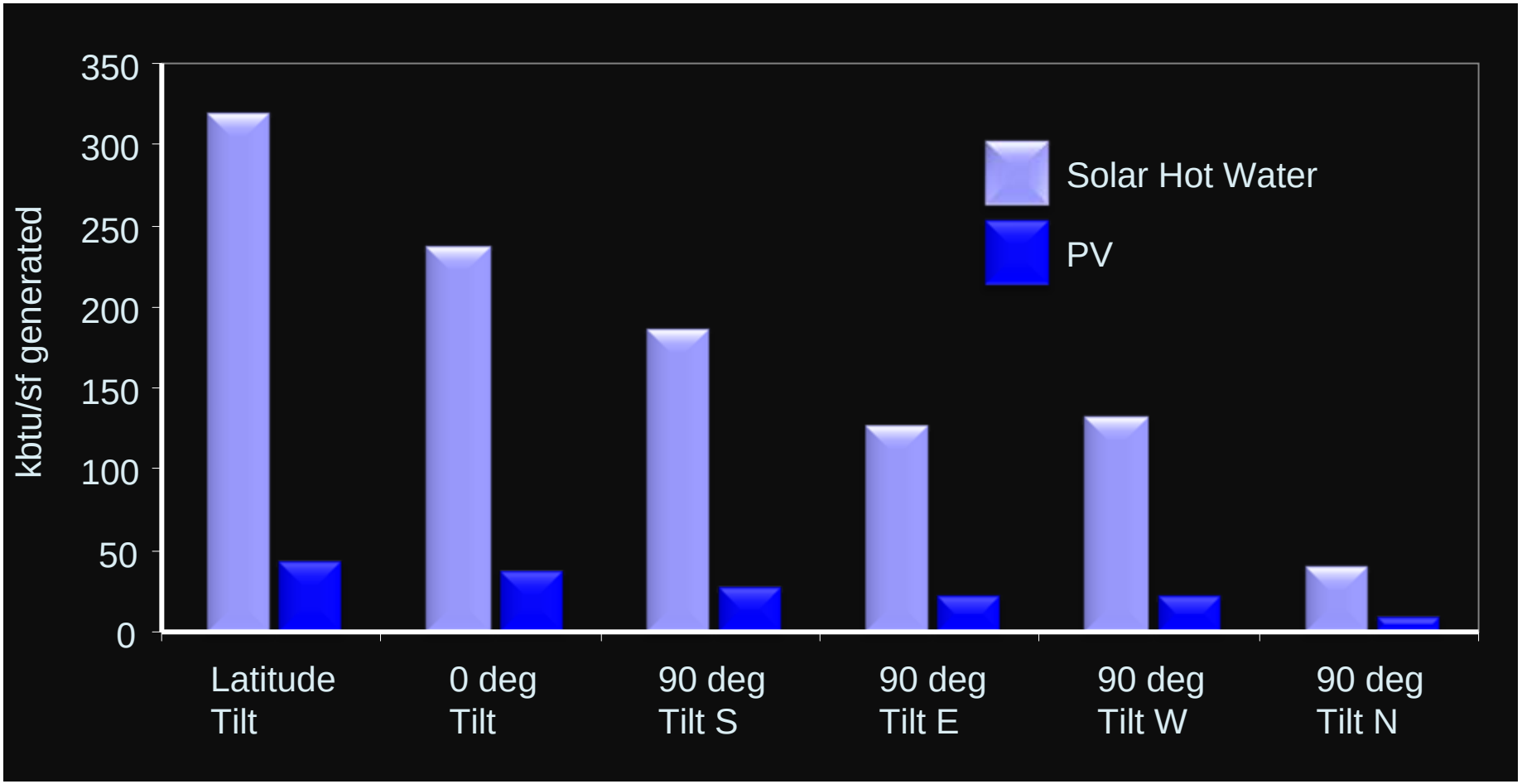
Solar Energy Generation Potential

Per SF of Panel Area



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Entropy

Use Energy in the Form It's In: Heat as Heat and Light as Light

Use energy in form it comes in. Otherwise dramatically lose efficiencies and add emissions.

Energy loses organization

Energy Types	Uses
ELECTROMAGNETIC *Light, Electricity*	Lighting, equipment, fans, pumps, heating cooling
KINETIC *Movement*	Fans, pumps, heating, cooling
CHEMICAL *Natural Gas, Batteries, Coal, Wood*	Heating Direct fired absorption cooling
HIGH GRADE HEAT *Steam*	Heating
LOW GRADE HEAT *Warm Water*	Absorption cooling Heating

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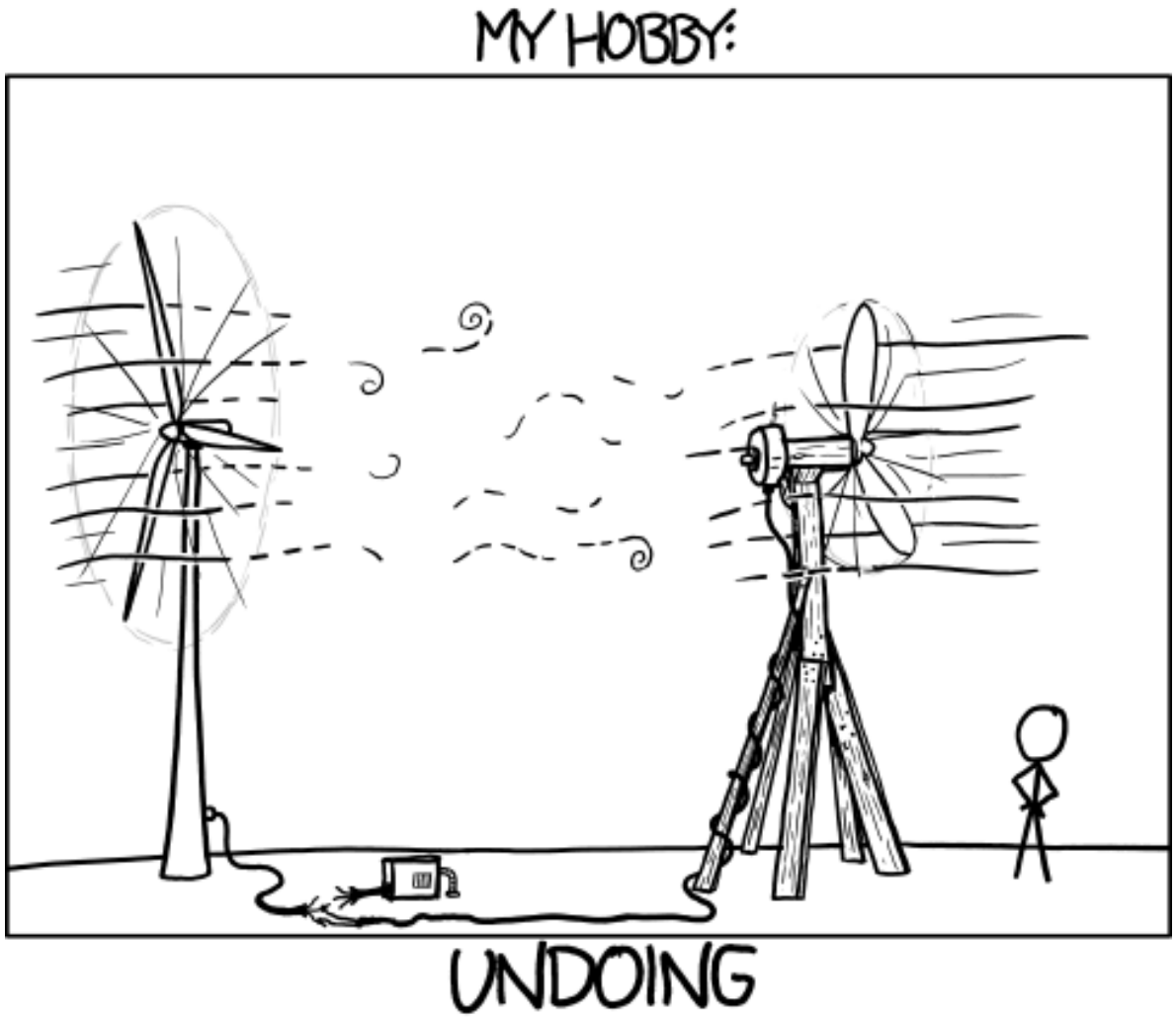
More Simply

Same as Having Solar Panels Power Lights



Source: XKCD.com

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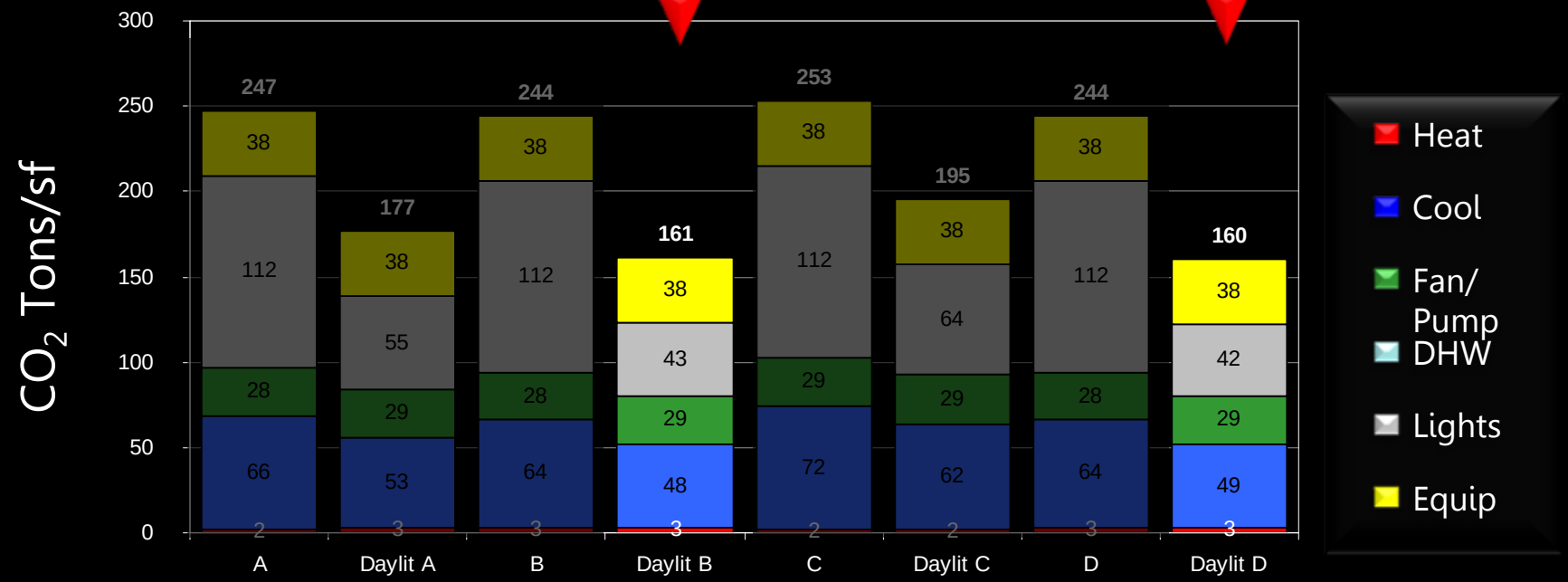
Net Zero Carbon Building

Distributed Single Zone Systems—Carbon



- Option B and Option D use the least carbon per square foot

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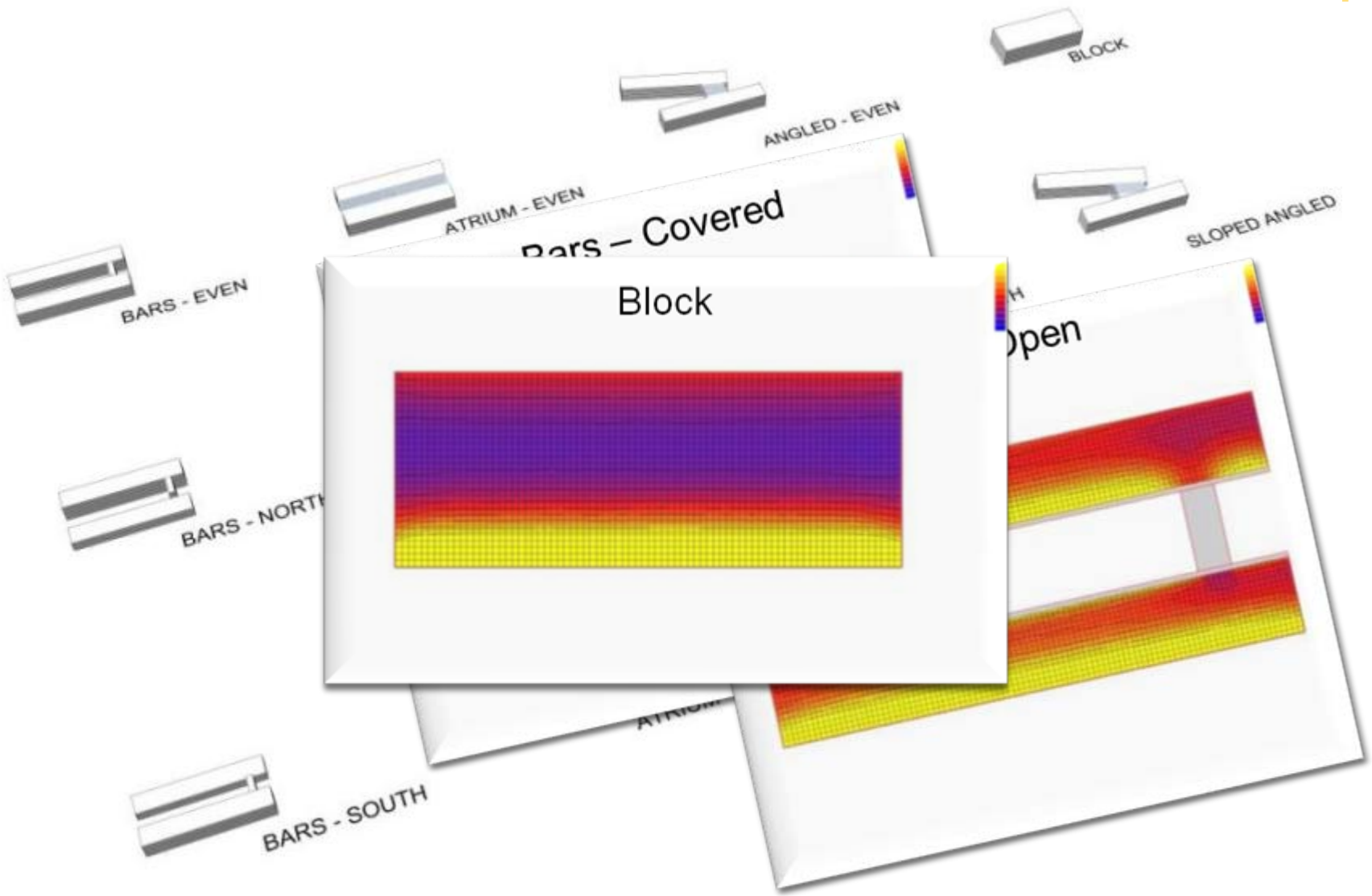
Rapid Prototyping and Modeling



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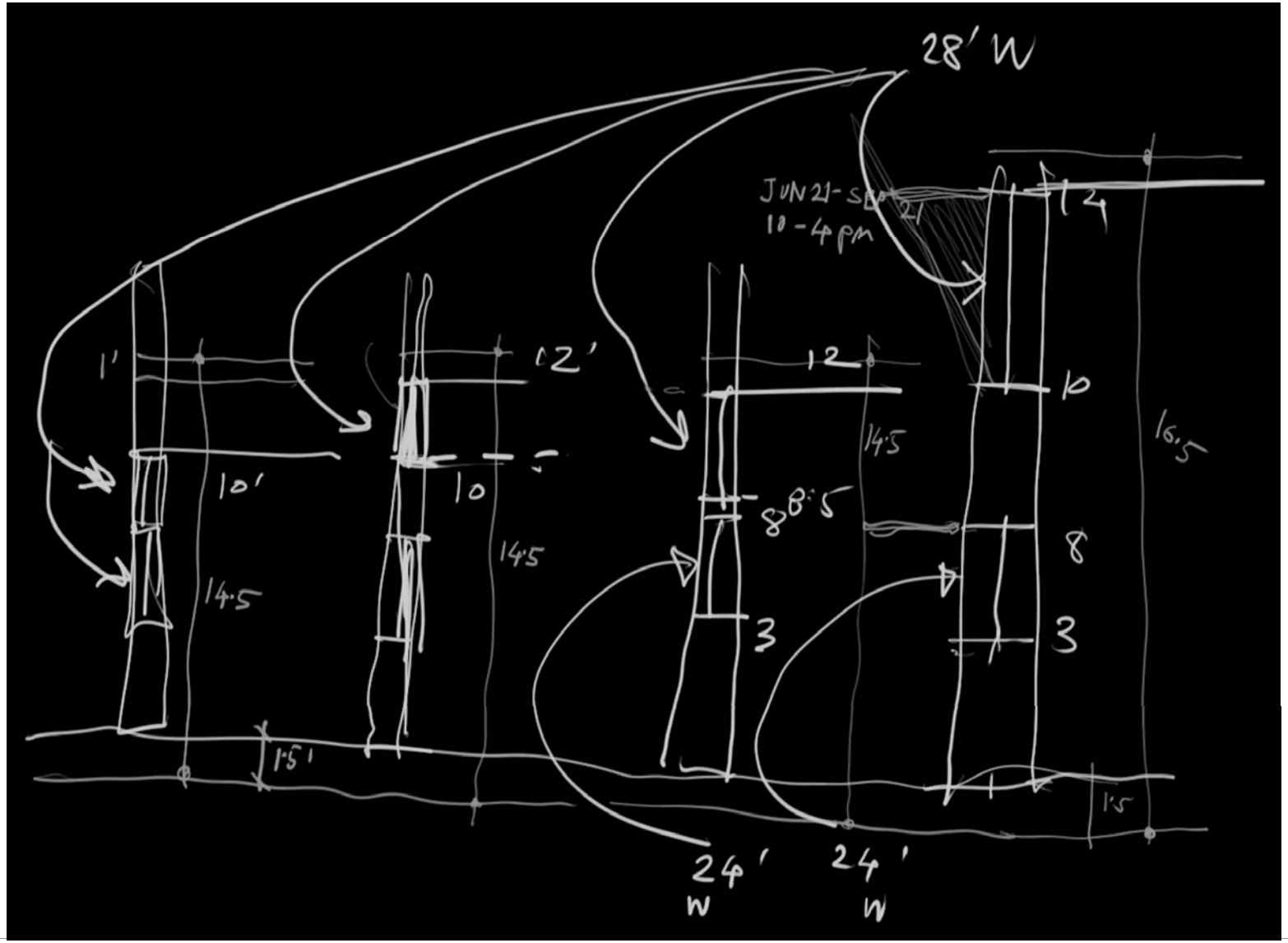
Daylighting Rules!



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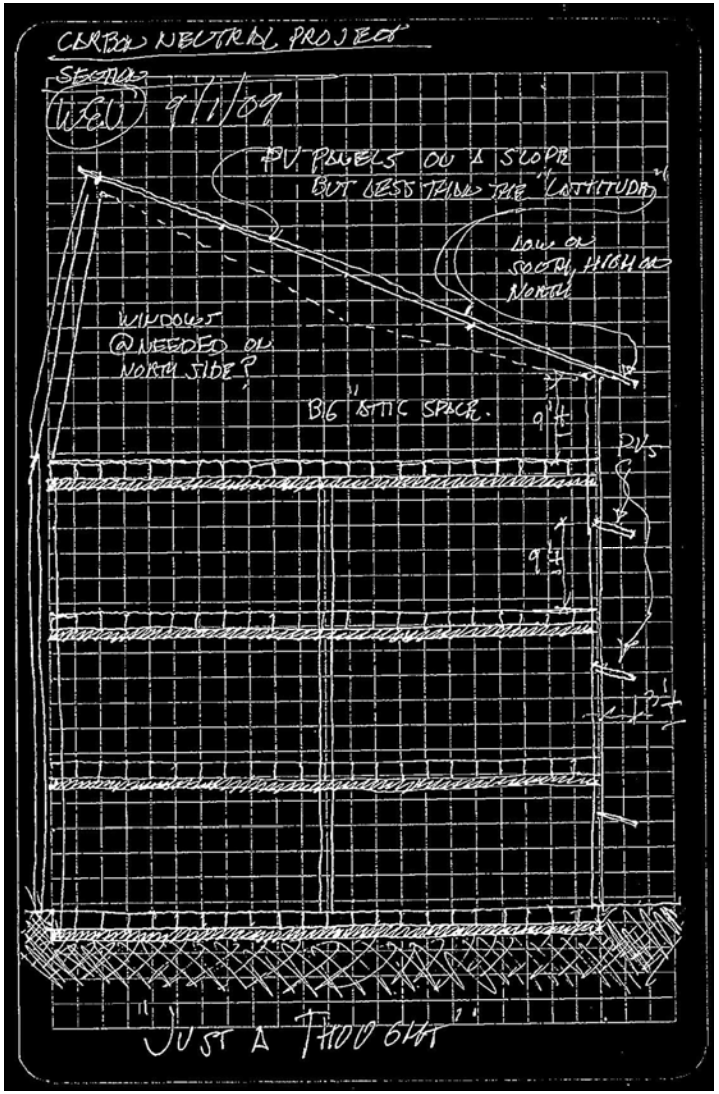
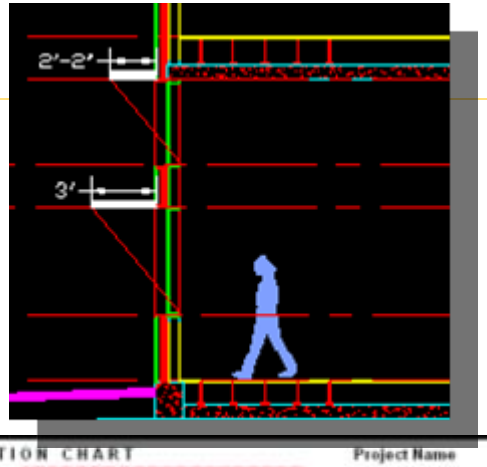
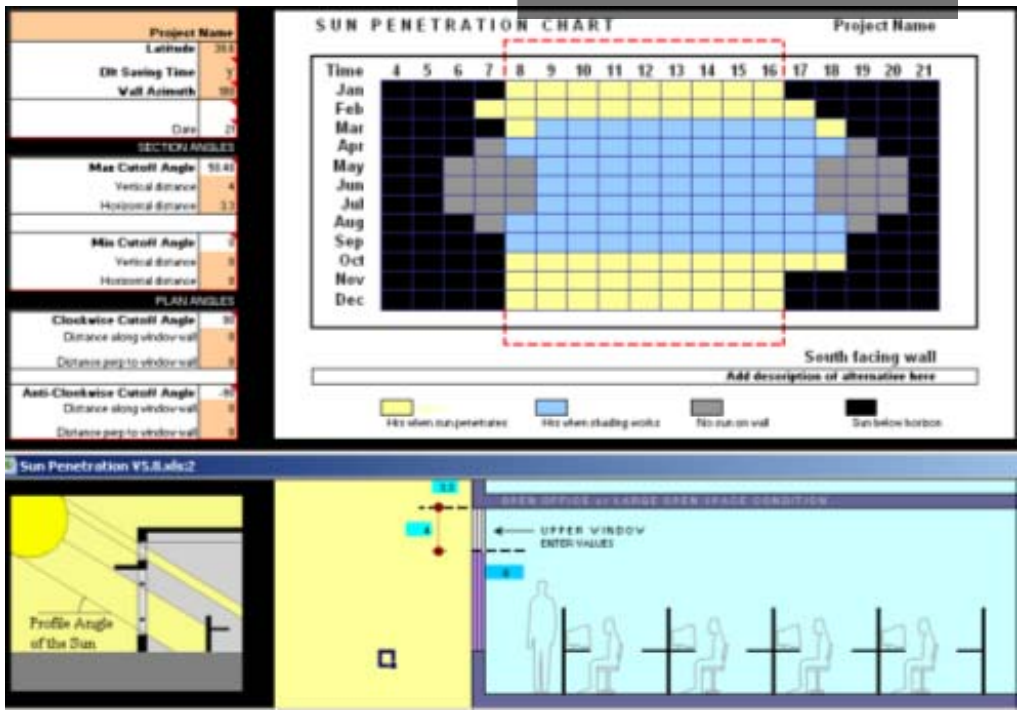
Section







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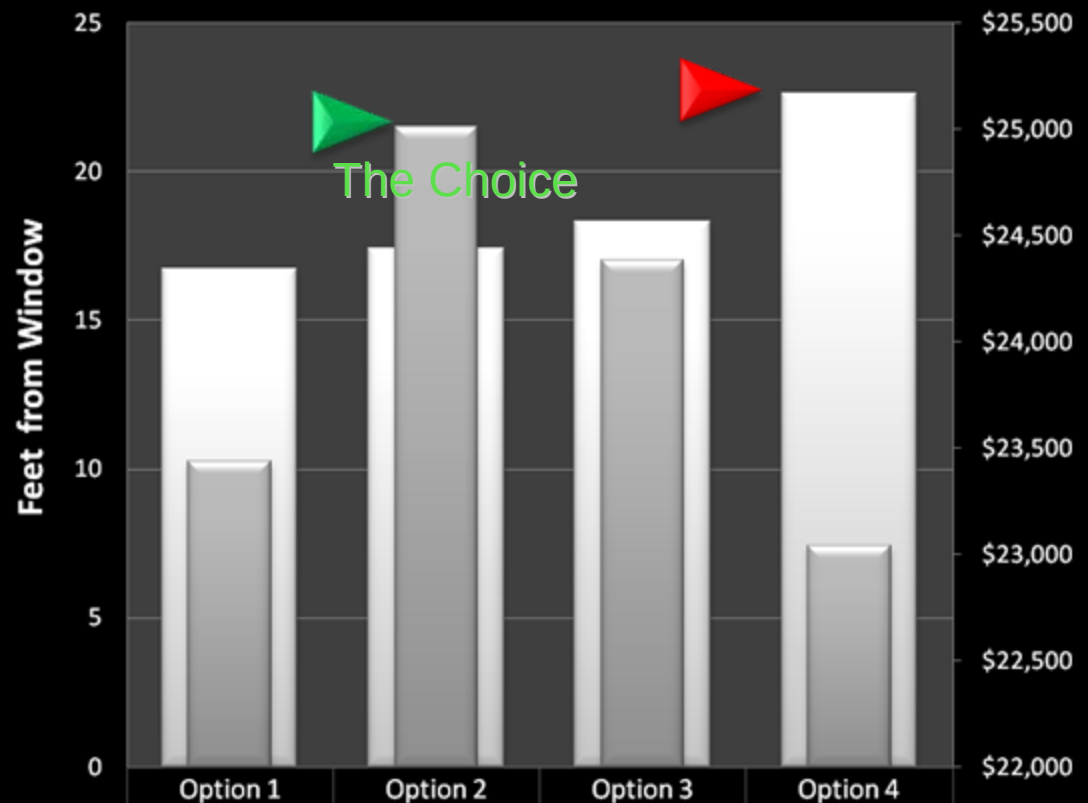
Primary Realities

Daylighting Rules! But not Alone…



	Option 1	Option 2	Option 3	Option 4
Distance from perimeter that 30 fc of daylight reach on a cloudy day	16.7	17.4	18.3	22.6
Energy Cost Savings	$23,439	$25,010	$24,382	$23,039

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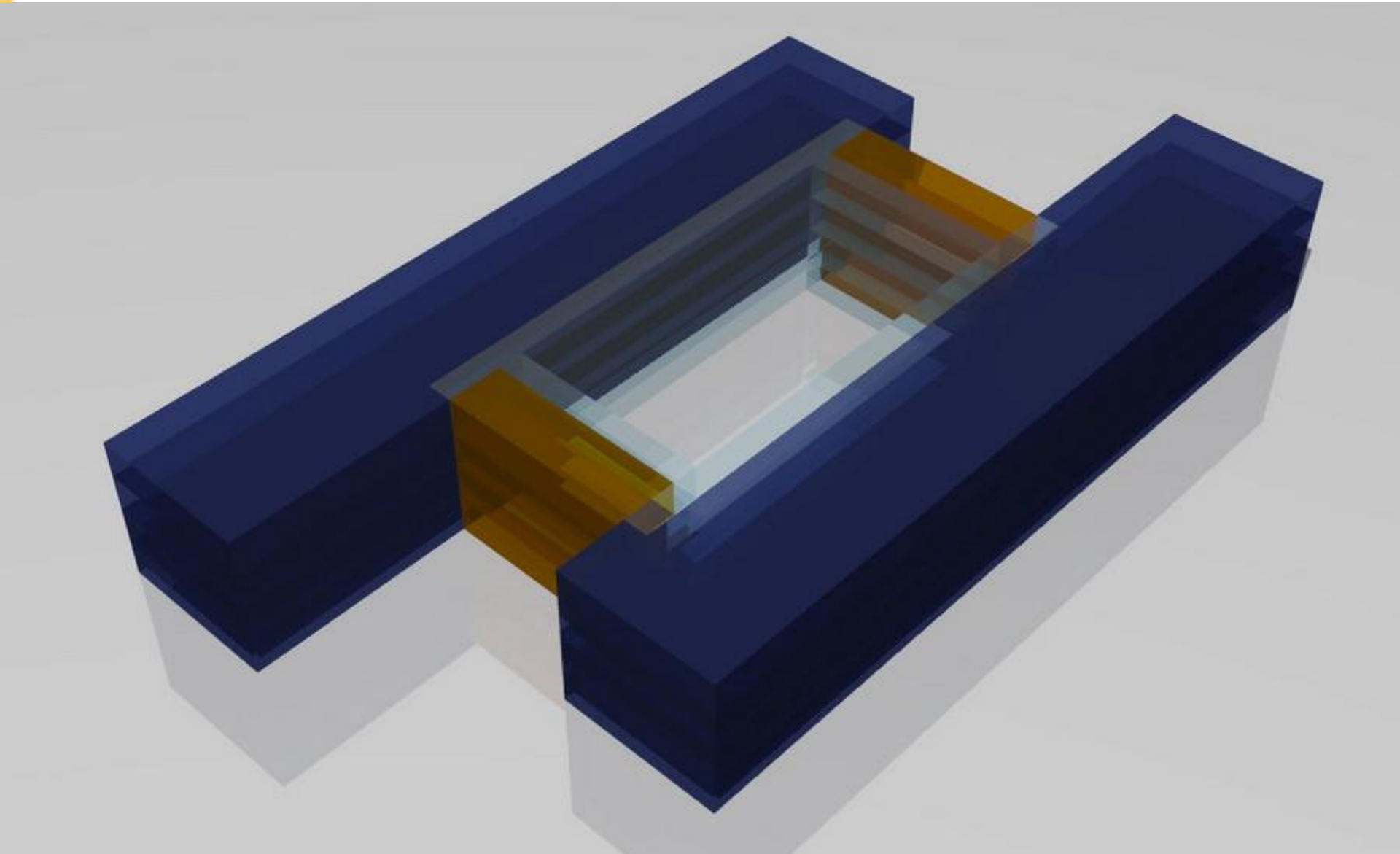
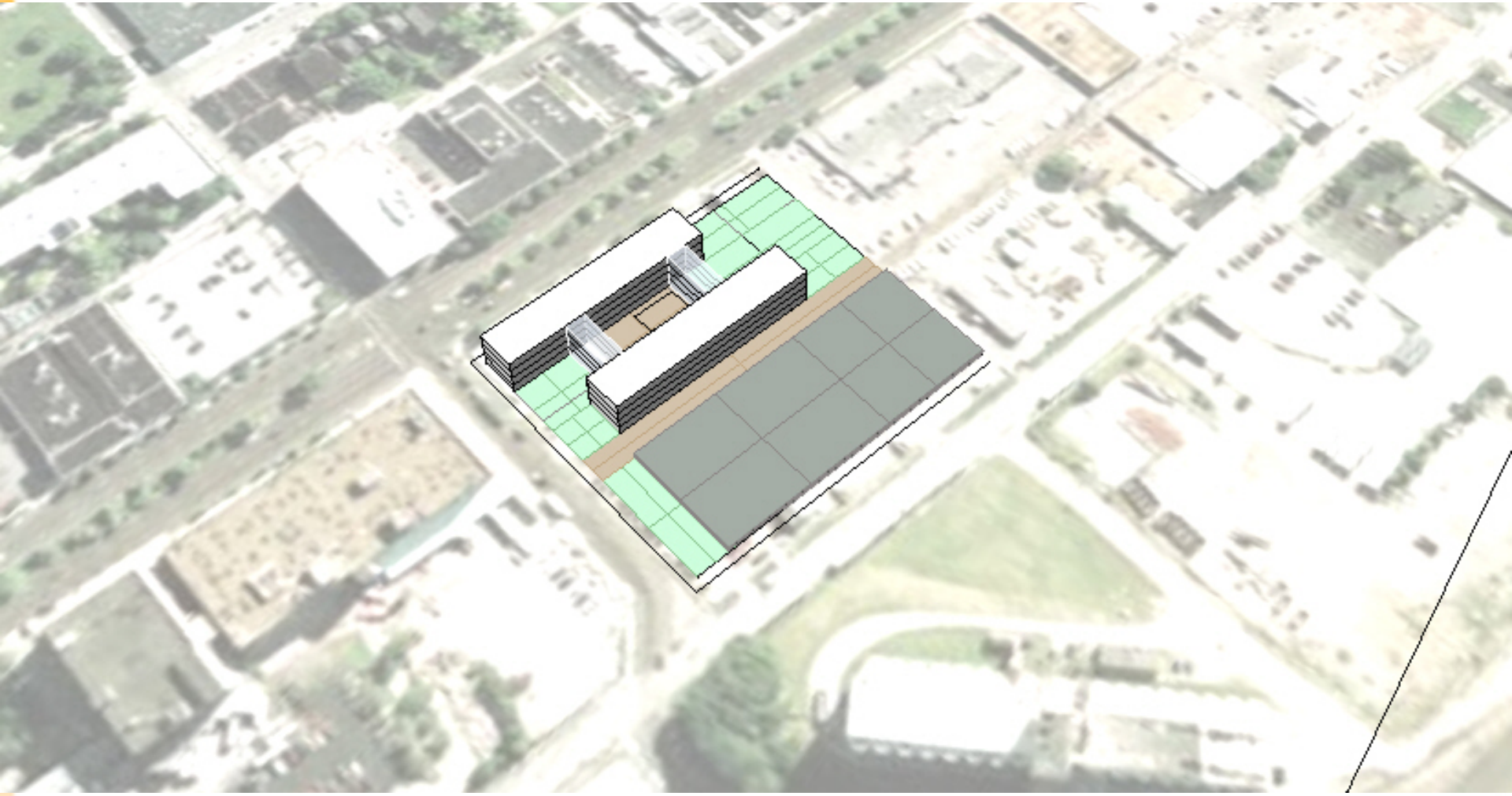
Settling on a Plan - Interior Corridor



Two-level Parking Structure

438 Parking Spaces (2 spaces/1000 gsf)



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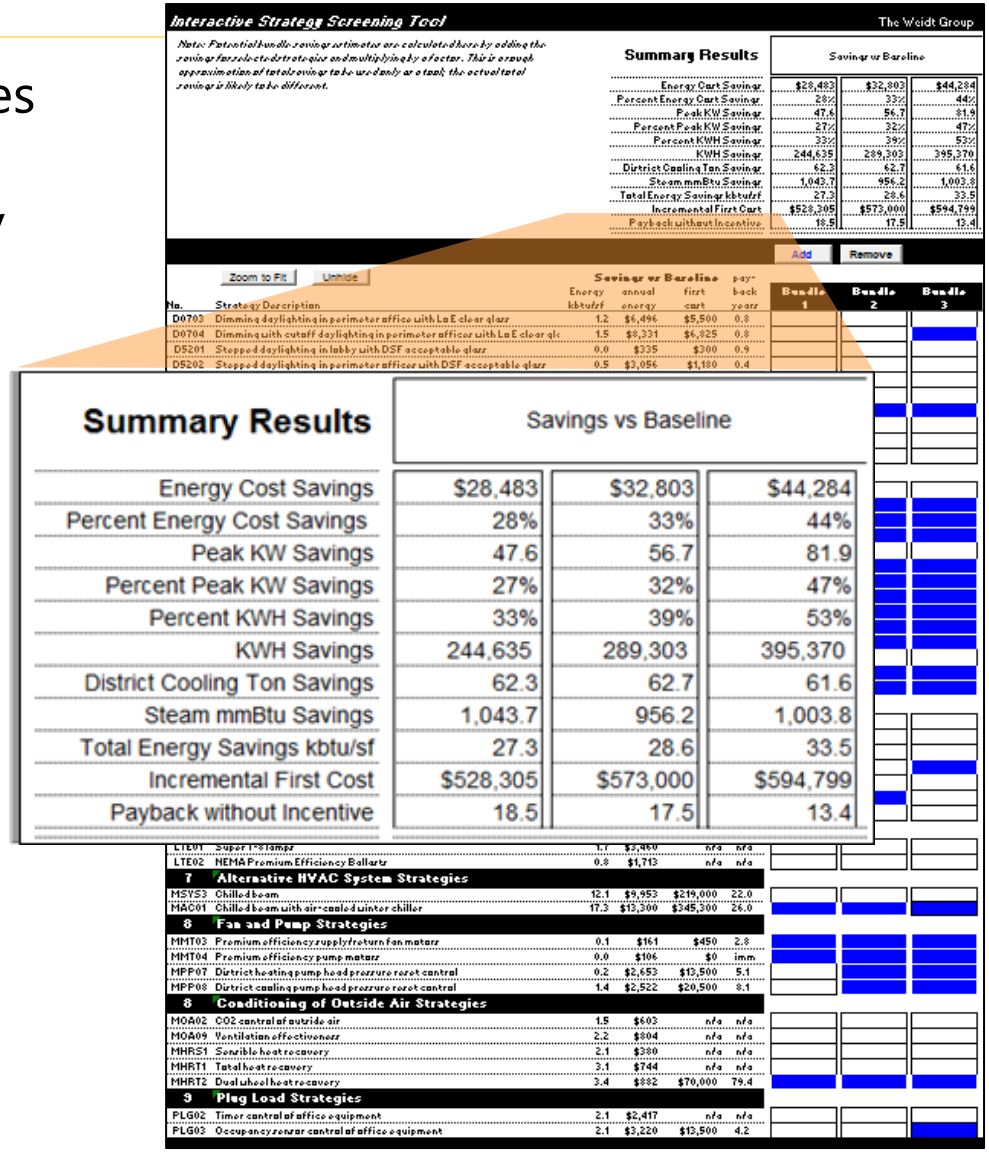
Building Systems Optimization

- Common strategy categories for standard Energy Design Assistance and Early Energy Design Assistance
  - Looks at strategies in
    - Envelope
    - Daylighting
    - Lighting
    - Mechanical
- Average savings
  - EDA: 30%
  - EEDA: 43%



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Tenants Matter … A Lot

0.5 W/SF plug load limit (vs. 0.75 per LEED)

Carrot and stick approach –
"Rollover BTUs" if they exceed purchase limits

Seek engaged tenants –
Requires different behavior and expectations

Tenant sub-metering –
is needed for monitoring lighting and plug load usage

Occupant engagement –
Provide education and information on energy management for tenants

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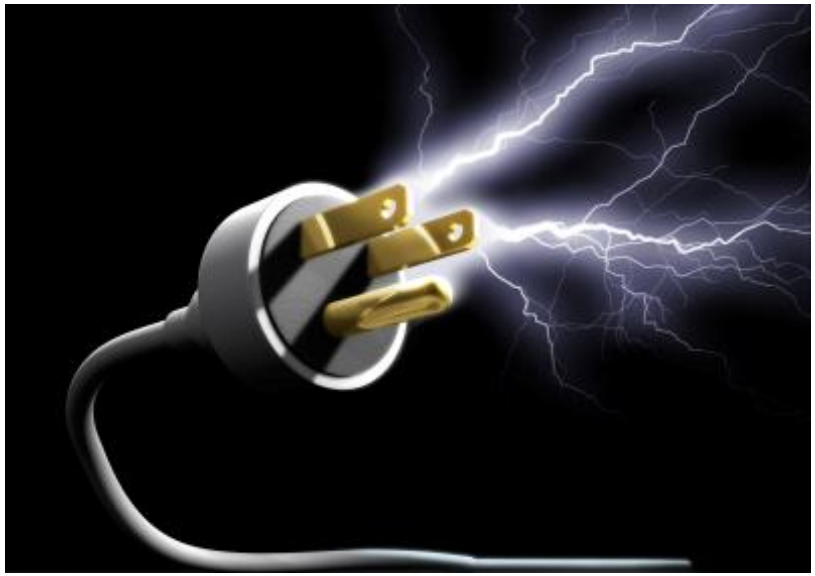
50-75%

of energy use in commercial buildings is attributable to **tenant consumption**



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Maintain Zero

- Buildings don't use energy, people do
- Provide a plan that will equip the owner and tenants to occupy and operate the building with zero emissions
- Occupant behavior will make or break net-zero
  - Rollover BTUs

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Failure is Multiplicative

Avoid Death by a Thousand Cuts

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WHAT DID WE DESIGN?

A first-generation Prius 170,000 GSF Office Building

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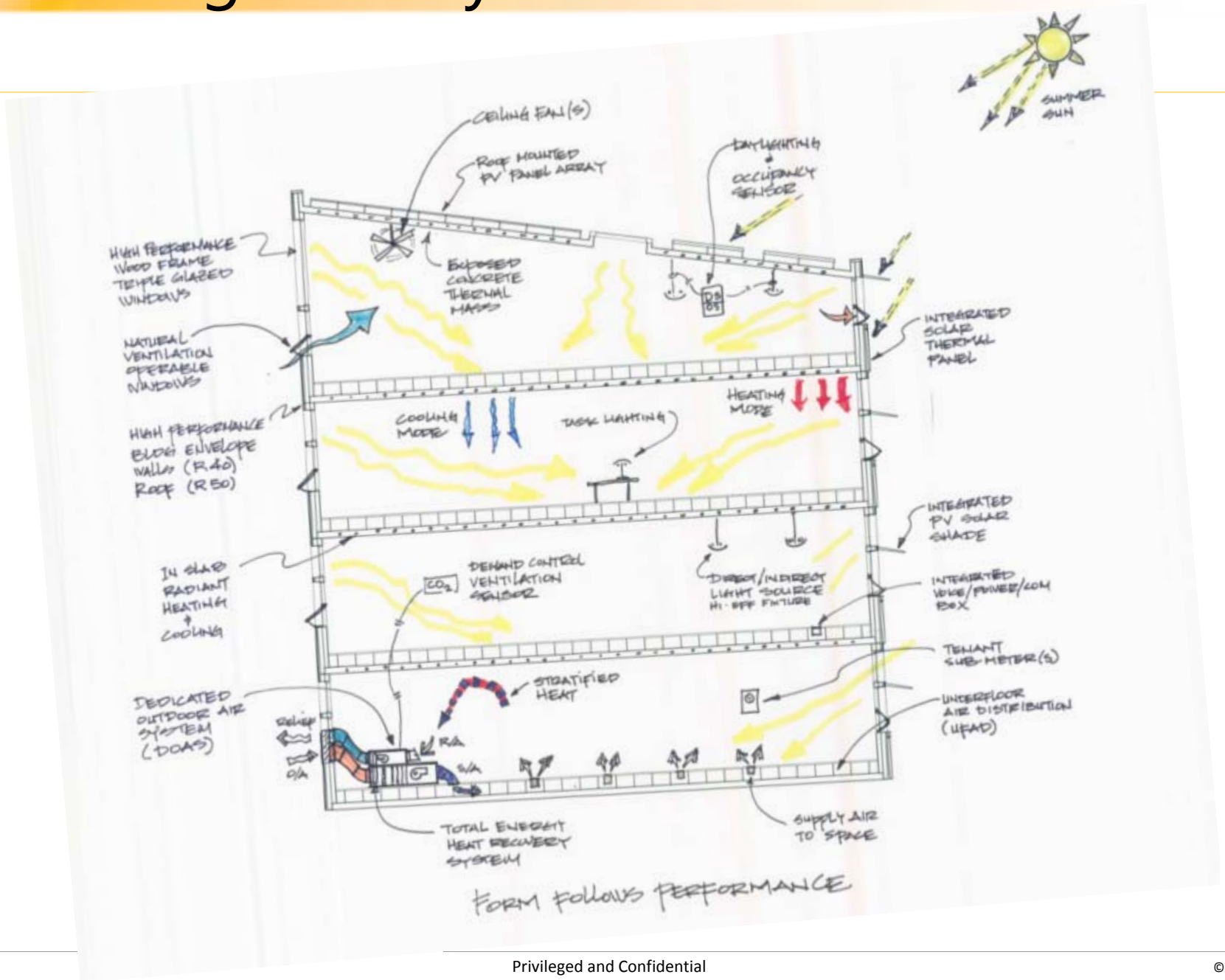
Integrated Systems



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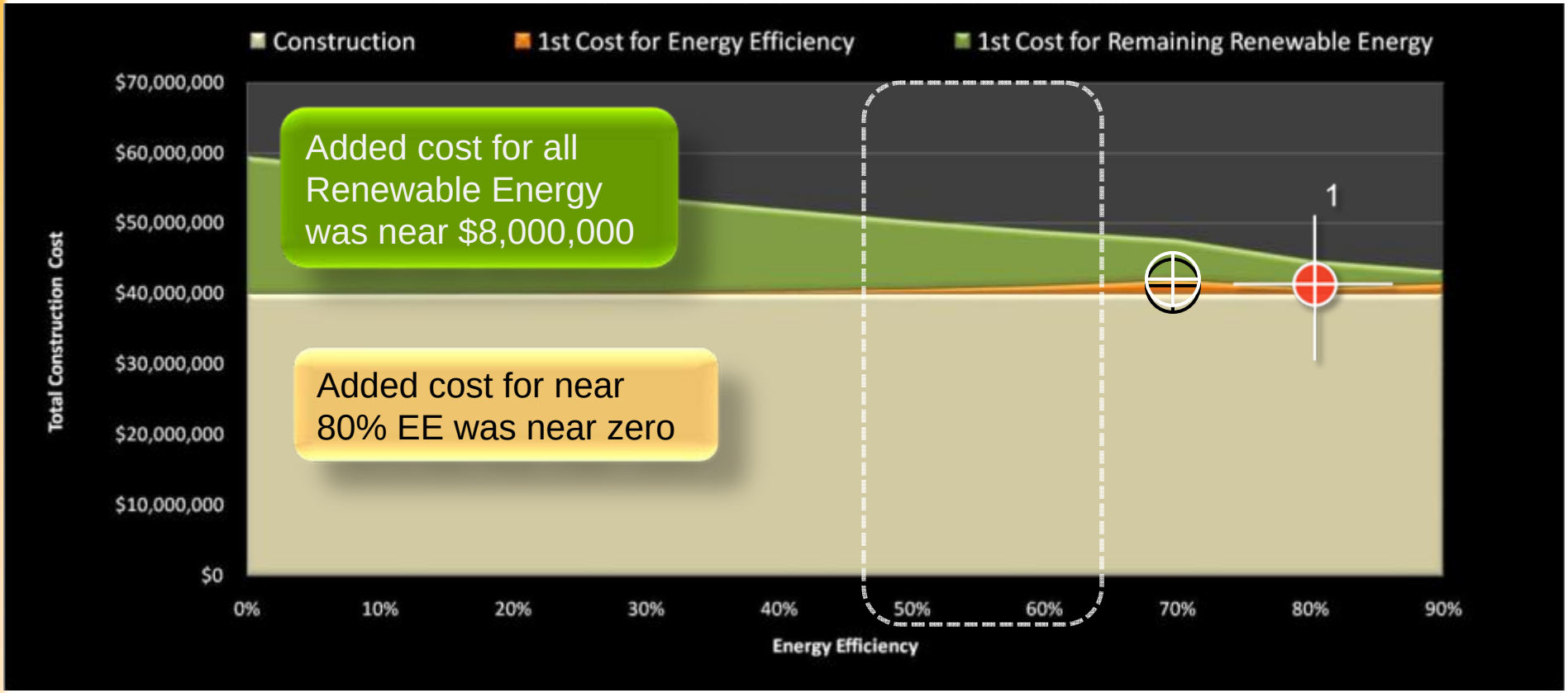
Primary Realities

Integrated Design and Exchanging Efficiency for Renewables

80% of the savings are from EE and 80% of the costs are from RE



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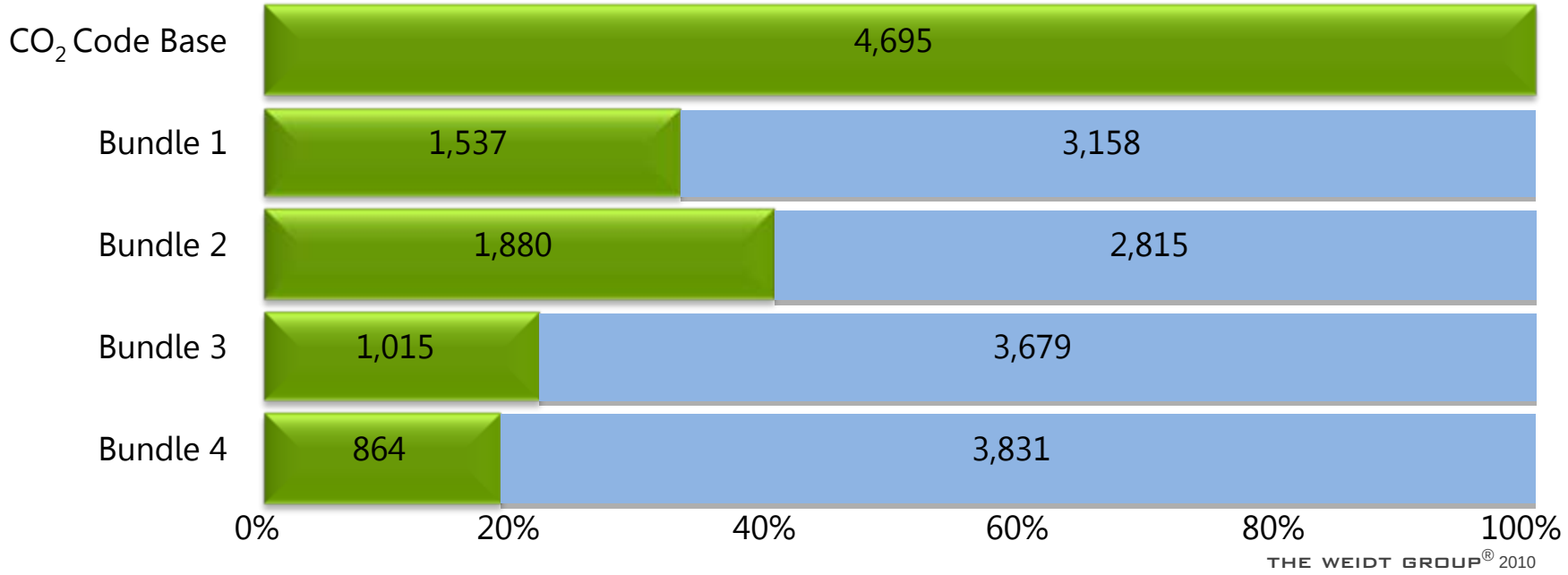
HOK—Zero Carbon Building CO_2

Bundles 3 and 4 meet the goal but 3 has a shorter payback by 4 years



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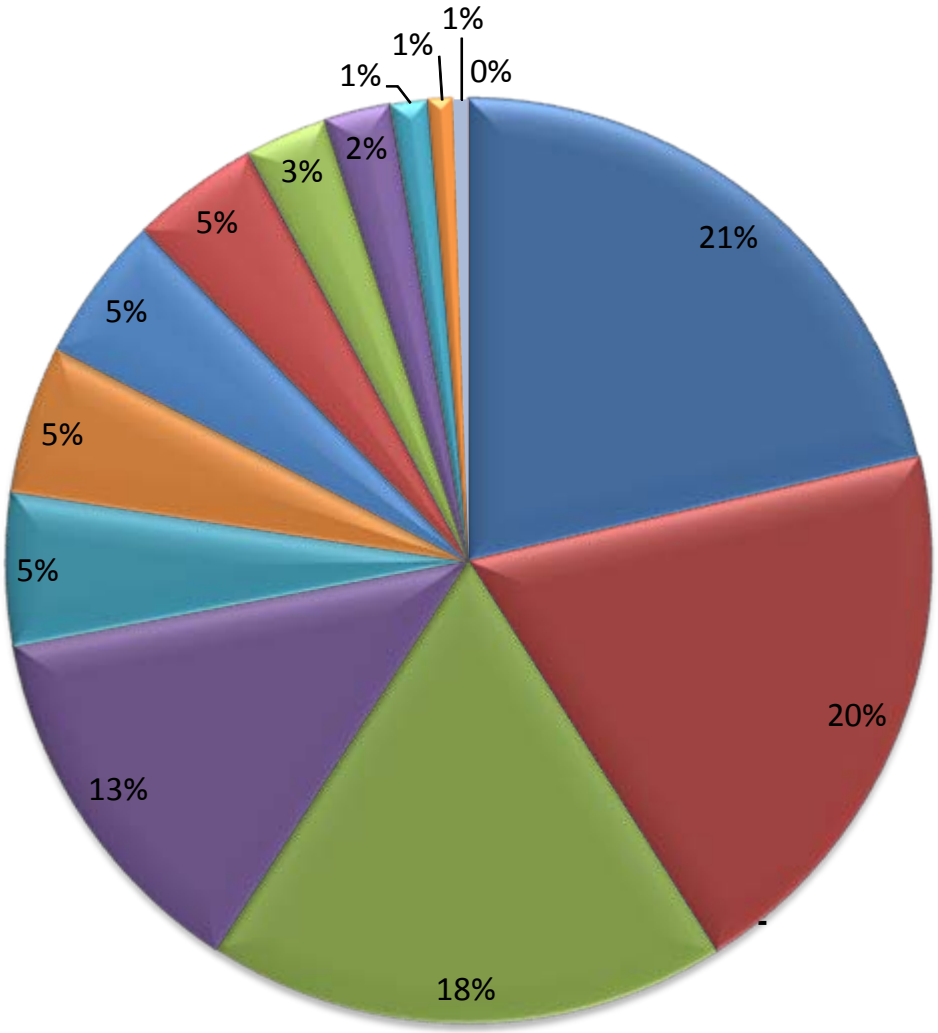
Primary Realities

Tons of CO_2 Savings Come from Many Choices



- Low Ambient Light with Task Lights High Efficiency Lighting Fixtures
- Photovoltaic electrical
- Radiant heating and cooling with Dedicated Outdoor Air System (DOAS),
- Daylighting and Occupancy Controls
- High Insulation Walls (40) and Roof (50)
- Wood Frame/Triple Glazed Windows
- Reduce equipment load allowance
- Solar thermal system
- Total heat recovery system
- Operable windows / ceiling fans
- Higher cooling temperature set points
- CO_2 controls
- Fixed shading
- High interior thermal mass

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HOW MUCH SOLAR?

And will it fit on the building?

170,000 GSF building with 17,375 SF parking structure

South -facing shading devices: **4,050 SF** of PV panels

Parking structure shading: **18,172 SF** of PV panels

Office roofs: **31,308 SF** of PV panels

15,000 SF of solar thermal collectors

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Ultra-Efficient Building Skin

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Roof Tilted to South

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WHAT DID WE LEARN?

Iterative analysis & commitment to performance-driven solution got us 80% there with low added costs.

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WHAT DID WE LEARN?

Low emissions = low electric = daylight-driven massing = long bars east to west.

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WHAT DID WE LEARN?

Use energy in the form it is in and all glass buildings are ***not*** the future of low-energy solutions.

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WHAT DID WE LEARN?

Future tenants will need to understand potential benefits of open offices and plug load limits…but high ceilings and emissions story enhance pr/marketability.

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Mostly Common

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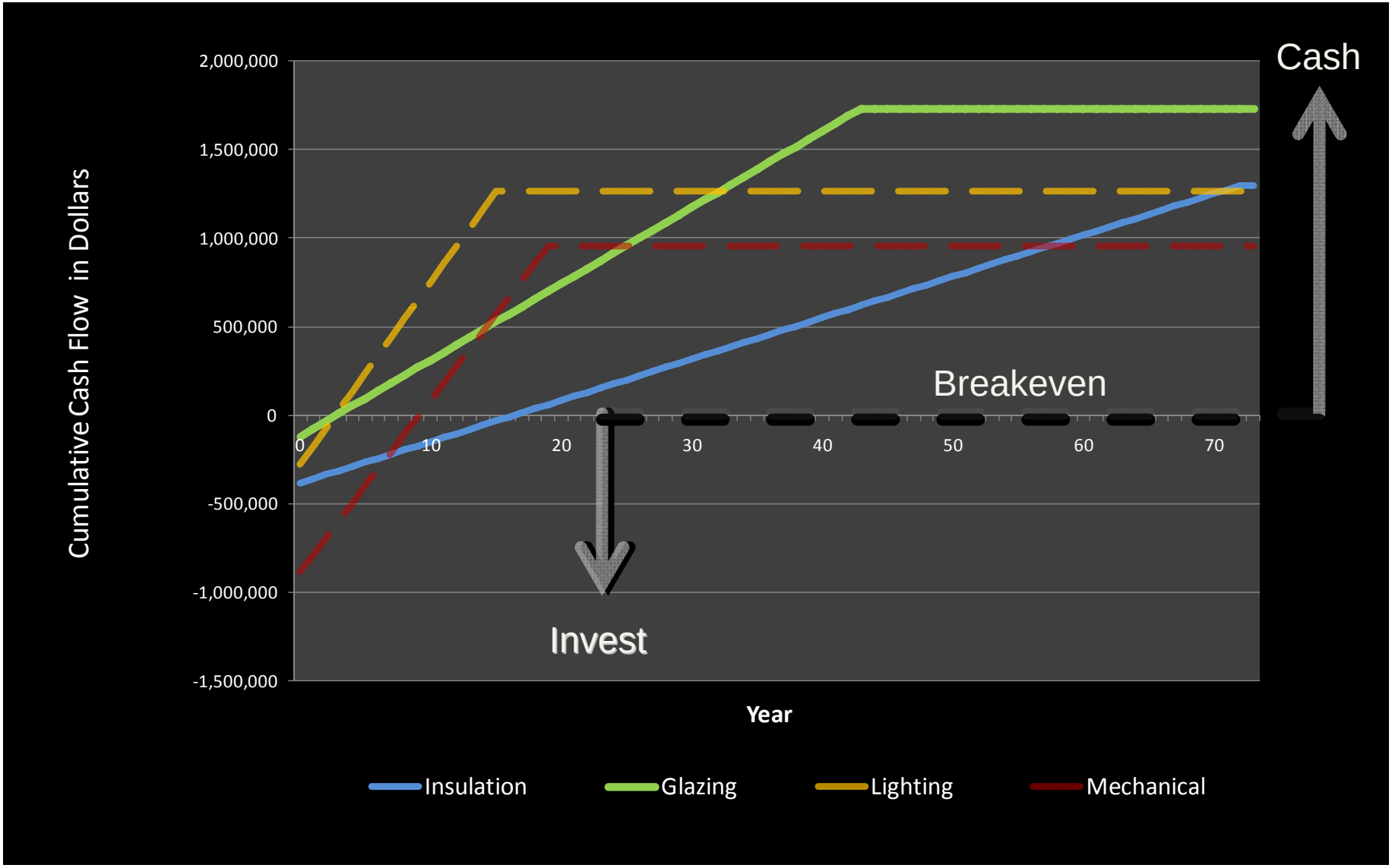
Cash Flow Over Time



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Modeling Accuracy

For Groups of Buildings ± 1% to 3%

For Individual Buildings ± 5% to 7%

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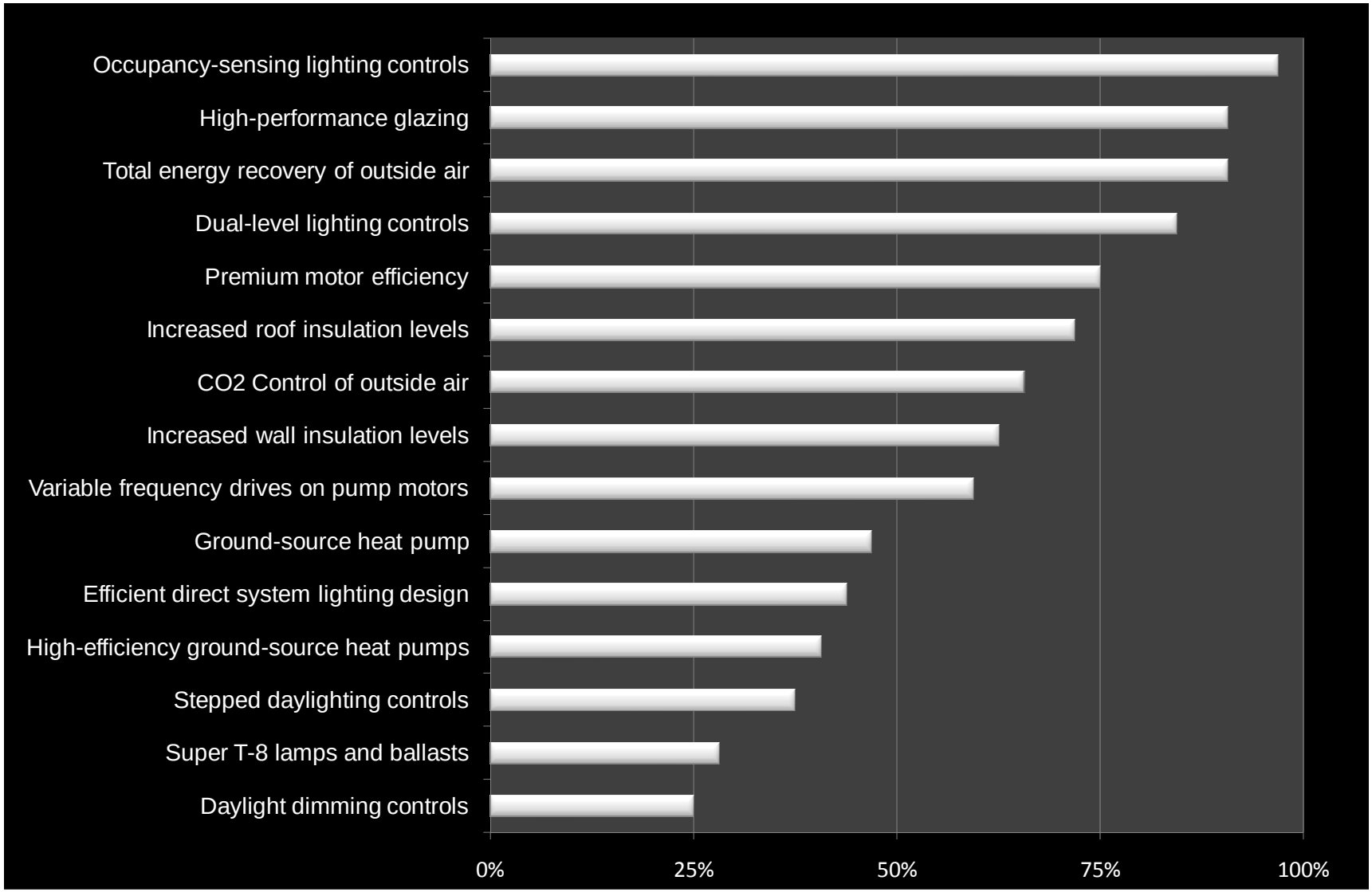
Frequency of Occurrence

Projects that Saved 60%+ or NZE ready



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Some Differentials

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Incremental Cost Range

Roughly

For Groups of buildings ± 50%

For Individual Buildings ± 5% to 10%

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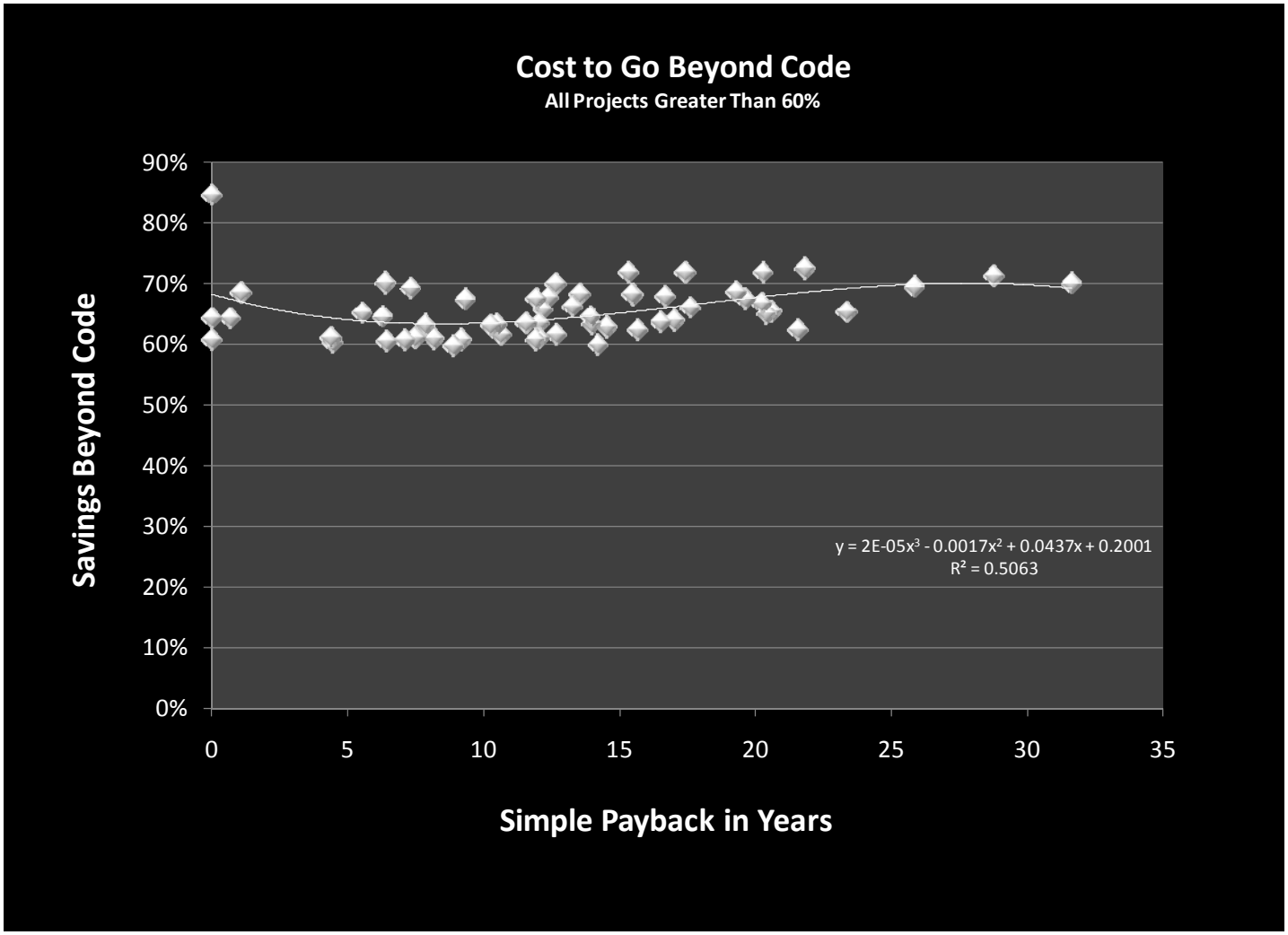
Reported Cost to Go Beyond Code

All Projects Greater Than 60%



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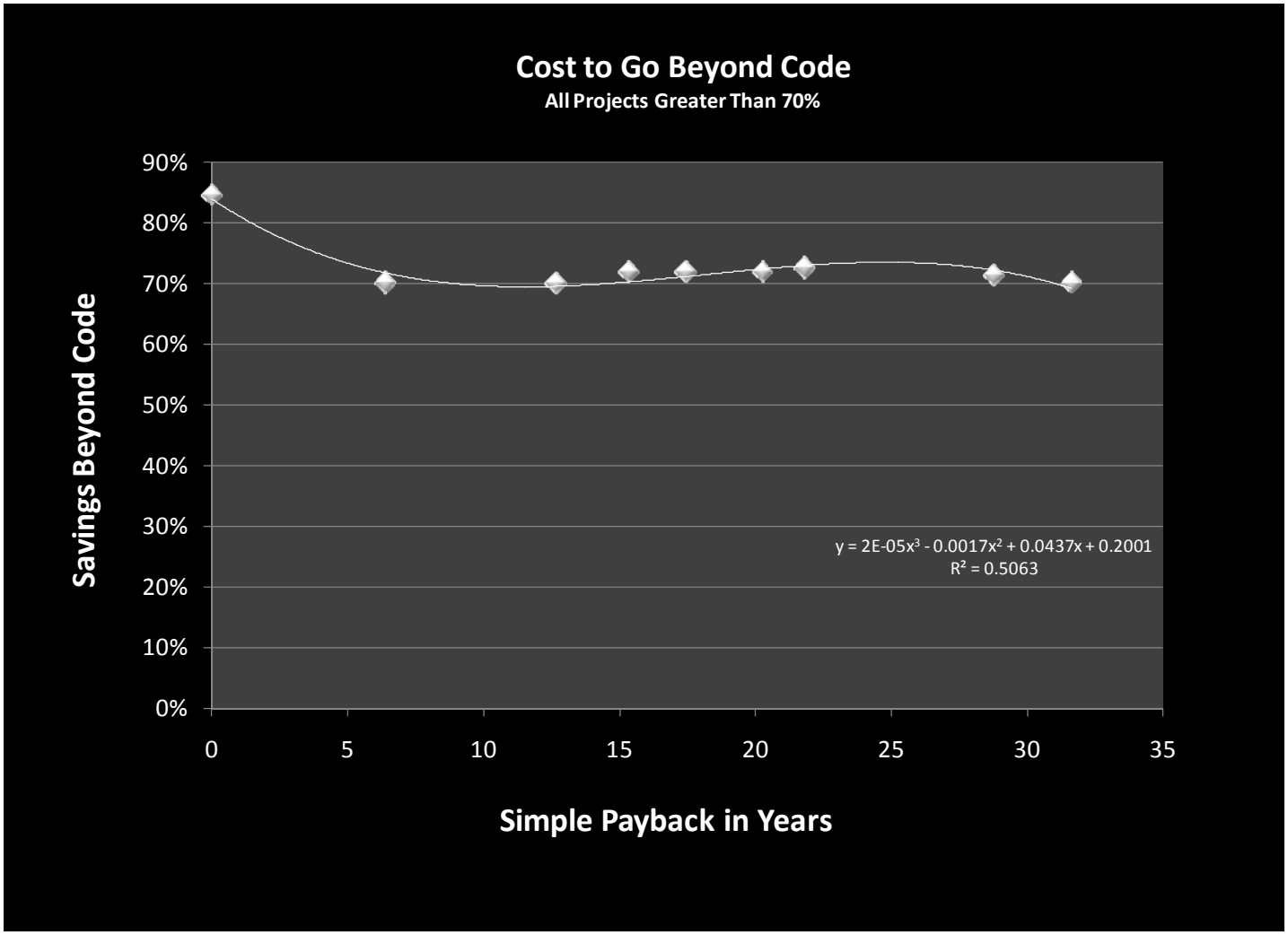
Reported Cost to Go Beyond Code

All Projects Greater Than 70%



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Lets Take it for a Spin

And See What We Learn

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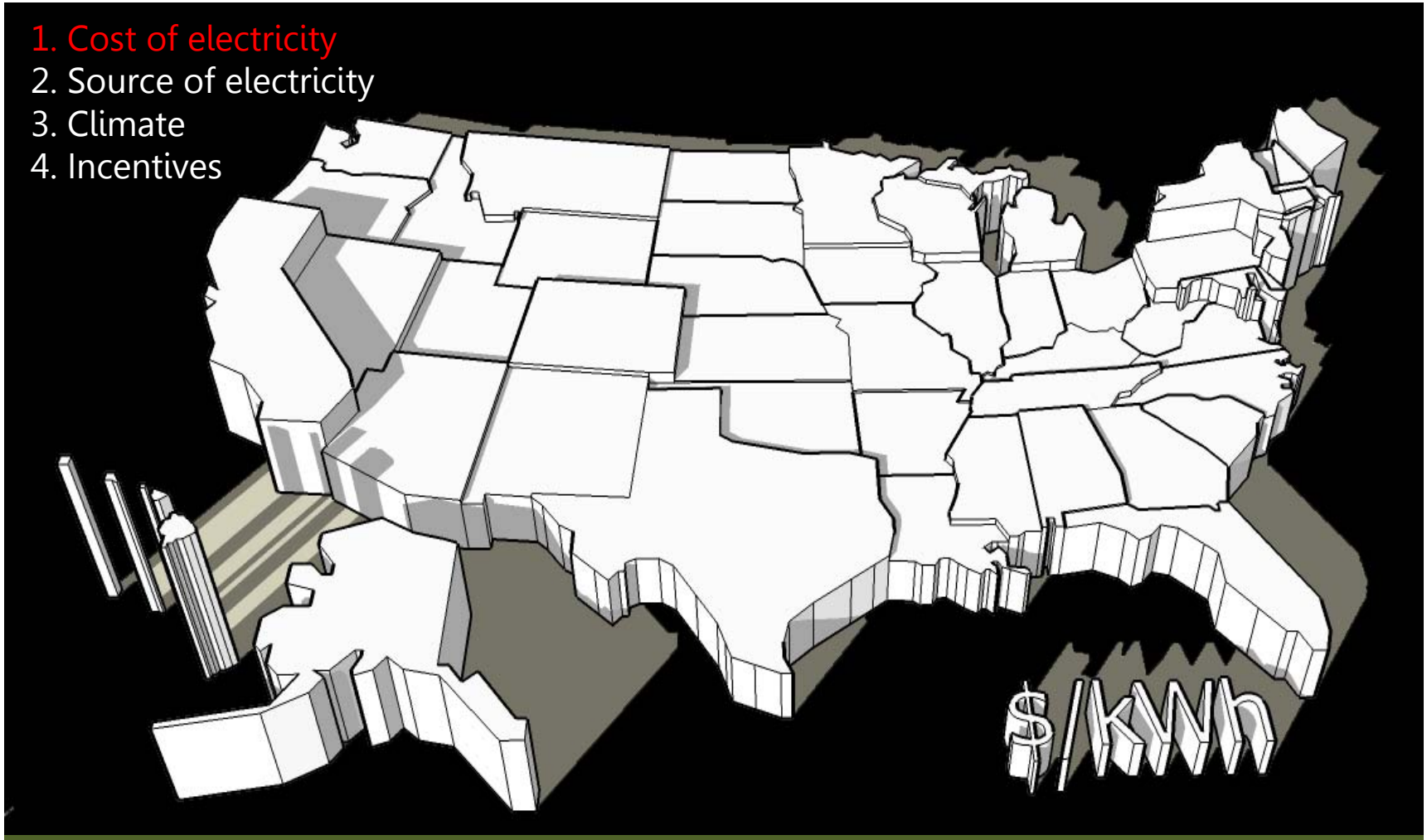
Regional Differences Dictate Outcomes



When it comes to electrical costs, some states are more advantaged than others!

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Regional Differences Dictate Outcomes

1. Cost of electricity
2. Source of electricity
3. Climate
4. Incentives

When it comes to carbon, some states are more (dis)advantaged than others!

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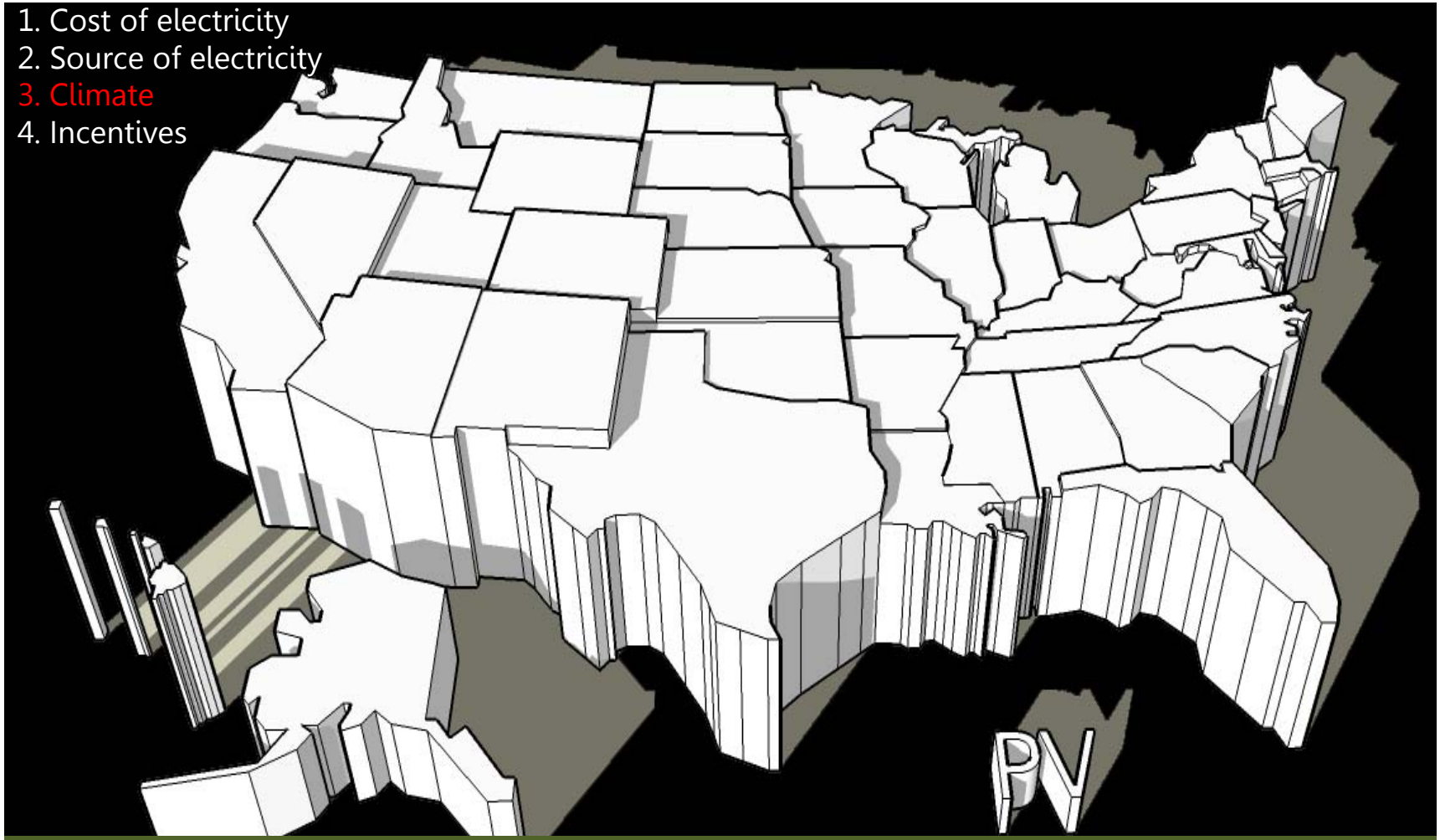
Regional Differences Dictate Outcomes



When it comes to PV generation, some states are more advantaged than others!

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Regional Differences Dictate Outcomes

When it comes to incentives, are some states more advantaged than others?

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Lets Take it for a Spin

and See What We Learn

- 123 ZeroBuild is a free tool for calculating the performance of a market-ready, carbon-neutral office building design. This application estimates the discounted payback for constructing a zero emissions office building in any U.S. location
- Use 123 ZeroBuild to calculate the investment needed for photovoltaics to offset annual carbon emissions in your location. The payback calculations include estimated first costs for a highly energy-efficient building, photovoltaic costs, discount rates and user-specified fuel escalation rates. Federal tax incentives also are included in the calculations. Local incentives to offset first costs can be added to the calculation by the user.

- Cities used for 15 ASHRAE climate zones
  - Miami
  - New Orleans
  - Little Rock
  - Nashville
  - Omaha
  - Minneapolis
  - Duluth
  - Barrow
  - Honolulu
  - Phoenix
  - San Diego
  - Albuquerque
  - Denver
  - Helena
  - Anchorage
  - Fairbanks
  - San Francisco
  - Portland
  - Spokane
  - Yukatat

Used kWh and gas average costs from EIA

Used state average utility and emission rates

We are paying off both EE and RE from savings against the base design, a LEED certified office building

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Payback on the investment in EE and PV is based on the reduced carbon emissions at the location.

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We know how to make net zero buildings;
We need to work on affordability and integrative financial decision-making

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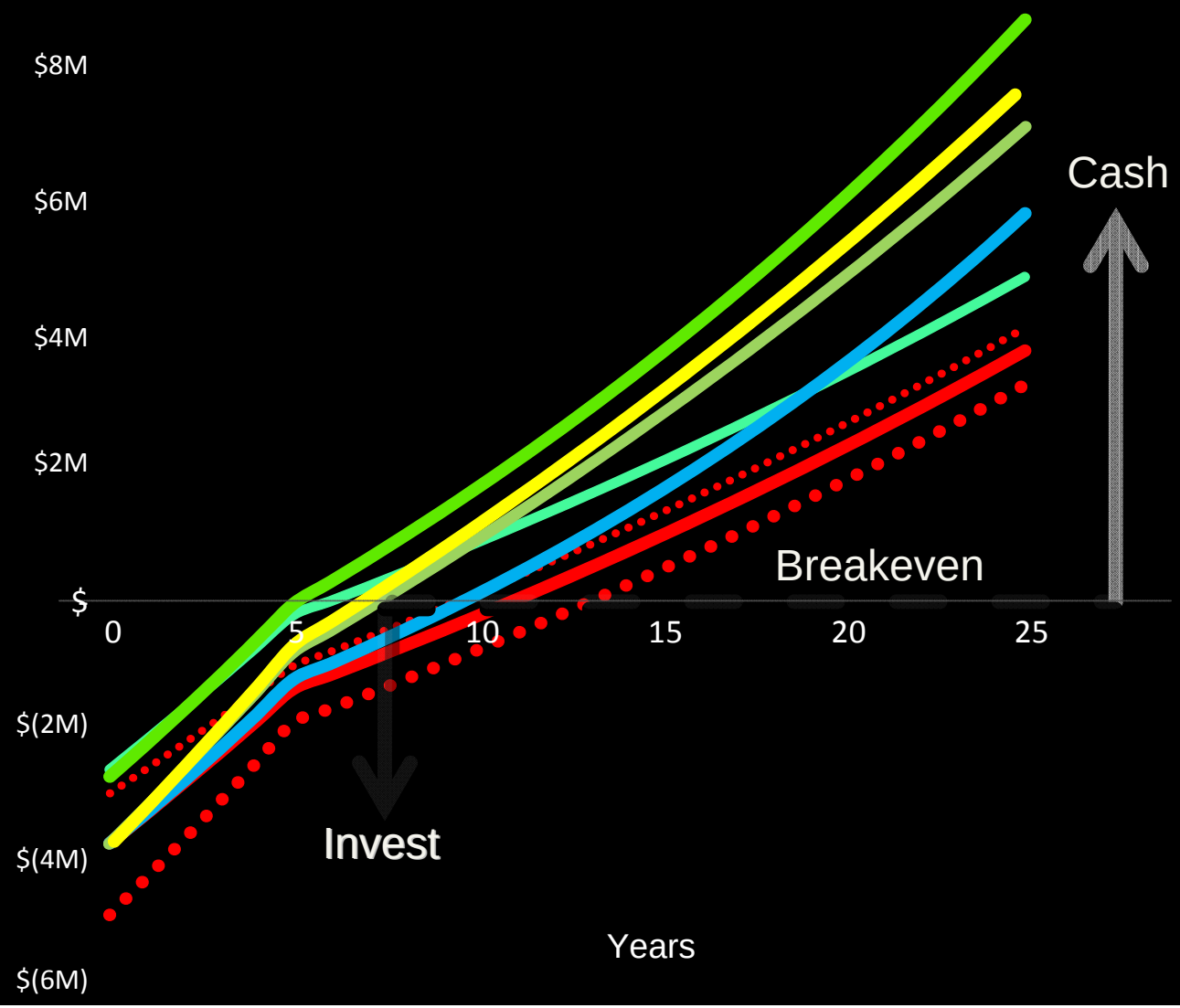
Integrated Cost Possibilities



- Base Case 2011 w/ 2% Fuel Escalation
- Base Case 2009 w/ 2% Fuel Escalation
- Solar Cost Down another 30%
- One-time Cost Reduction or Incentive of $1.1m
- Fuel Escalation of 4%
- $0.13/kWh Electricity
- Lease Premium of $0.60 /sf
- 3% fuel, 10 cent Electrical One time reduction 500k, $0.30/sf, another 20% Solar Cost Reduction

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Conclusion and Policy

Recommendations

- Early decisions have a smaller annual impact than design development decisions—but those impacts last longer than lighting or mechanical impacts and therefore have a sustained return on investment
- Assistance and incentive programs should include influencing early design decisions to increase energy efficiency impacts
- Codes and standards need to be amended to allow for early decisions to be credited
  - Fixed shapes
  - Fixed window-to-wall area ratios
  - Move towards benchmarking systems that compare different designs to a common baseline so all decisions can be counted

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Thank You

The Weidt Group®

The Company for Energy Decision Makers SM

twgi.com

Jason Steinbock, BEMP, LEED AP BD+C
jasons@twgi.com

Chris Baker, AIA, PE, BEAP, BEMP LEED AP BD+C
chrisb@twgi.com

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ZERO Carbon

The Common and the Differentials

Learning Objectives

- What are the three primary stages of integrative design and consulting to achieve net-zero carbon?
- What is the approximate value of good architecture in achieving net-zero carbon?
- Are all forms of energy used in a building of equal carbon intensity?
- Identify four major technologies/design factors that get you ¾ of the way to net-zero carbon for this building type.
- What is required for a building capable of being net-zero carbon to actually operate at net-zero carbon?

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