AABC Commissioning Group

AIA Provider Number 50111116

Building Trek: The Next Big Thing in Energy Performance

Course Number: CXENERGY1623

Mark Gelfo

PE, CxA, EMP, LEED Fellow

TLC Engineering for Architecture

April 12, 2016

Continuing Education

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

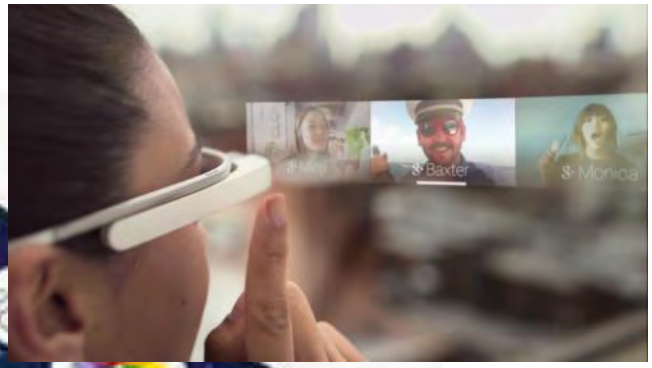
At the end of this session, participants will be able to:

1. Understand and discuss the history of building design and how **TECHNOLOGY** has impacted building design and construction - including unintended consequences of technology.
2. Understand how buildings use energy and the changing focus on **PERFORMANCE** as one of the Next Big Things, and apply performance based energy and water strategies such as measurement & verification, to new construction and existing building
3. Discuss the **RENEWABLE ENERGY** markets and advances in solar systems, fuel cells, wind, etc and their impact on have on grid parity. Also be able to understand the impact and importance of increased energy efficiency, building commissioning, on the future of building design.
4. Understand how **HEALTH & WELLNESS** and **RESILIENCY** including distributed generation, microgrids, solar and water storage will impact building design, construction and operations in the future.

The Search for…The Next Big Thing

A Brief History of Buildings and Technology

What is Technology ?



This is Technology

“If I had asked people what they wanted, they would have said ‘faster horses’.”

-Henry Ford

Buildings that Last

Buildings Worked with Nature

Buildings were Resilient

Infrastructure Saved the Day

1842 New York's **water system** established – an aqueduct brings fresh water from Westchester.

1857 NYC creates **Central Park**, hailed as "ventilation for the working man's lungs", continuing construction through the height of the Civil War

1881 Dept. of Street-sweeping created, which eventually becomes the **Department of Sanitation**

1901 **New York State Tenement House Act** banned the construction of dark, airless tenement buildings

1904 First section of **Subway** opens, allowing population to expand into Northern Manhattan and the Bronx

1916 **Zoning Ordinance** requires stepped building setbacks to allow light and air into the streets

Air Conditioning Changes Architecture

Windowless Workplace

Overcompensating Creates New Problems

Sick Buildings

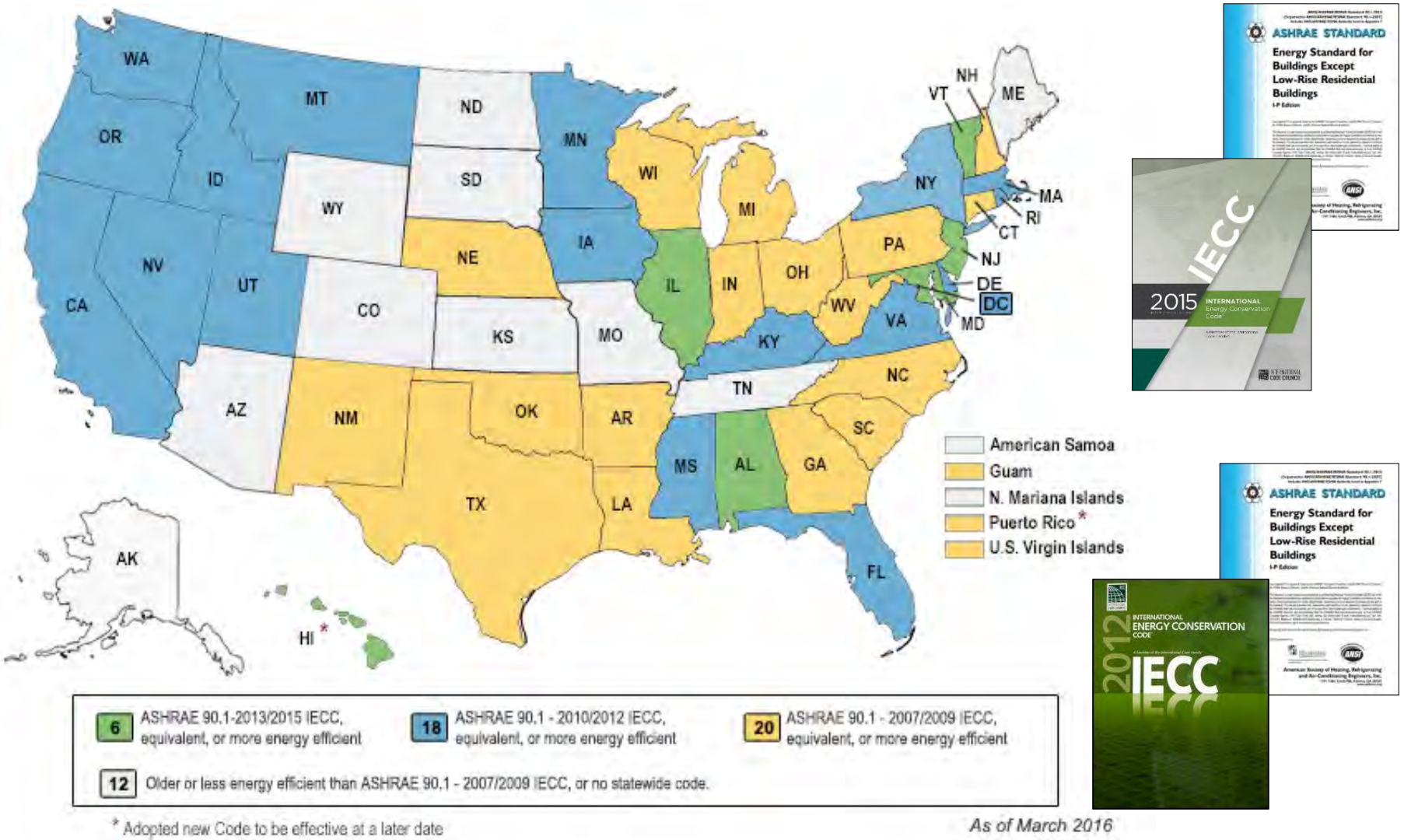
How We Design

Computer Aided Drafting

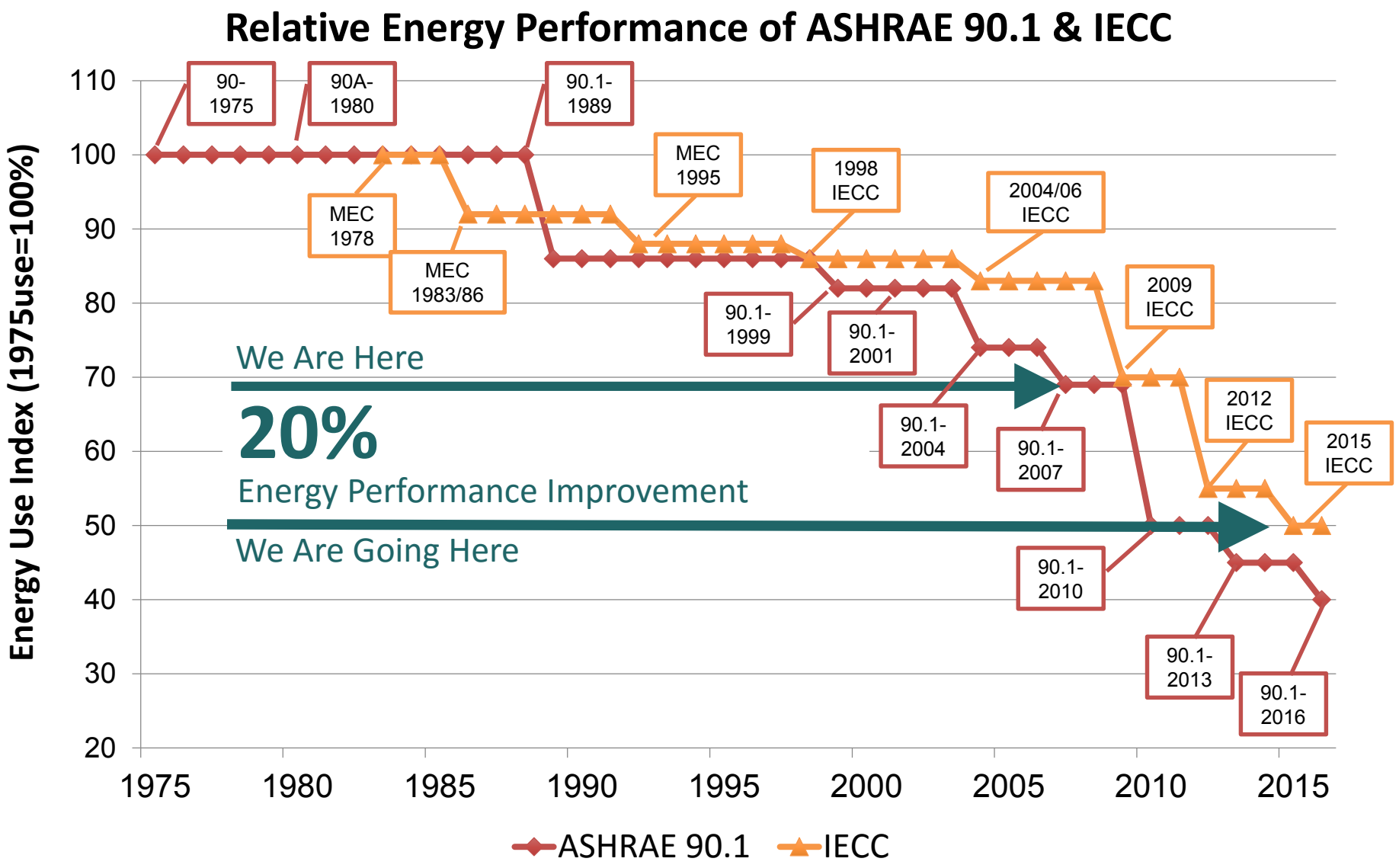
Uniformity of Design

The Next Generation

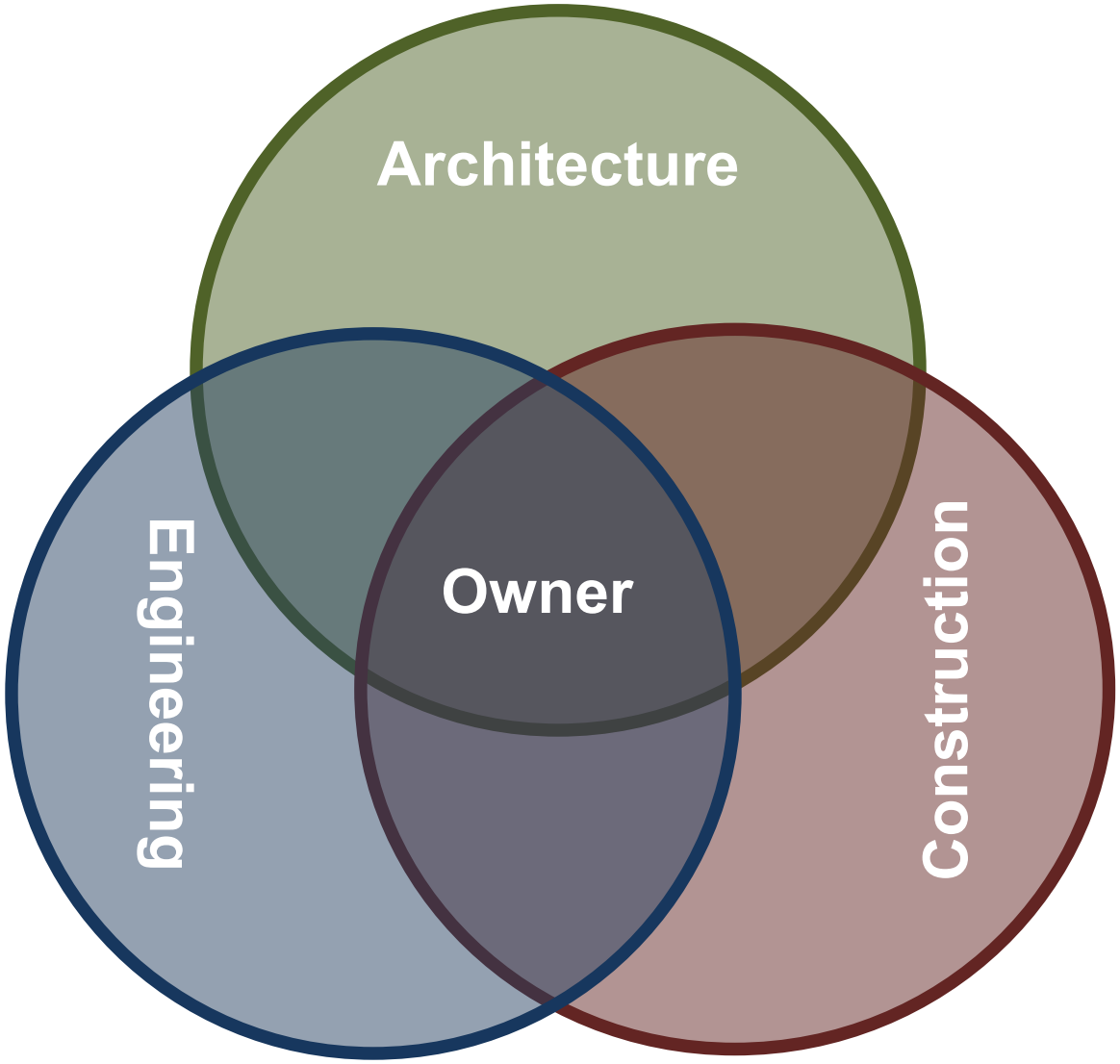
Energy Code Adoption by State



ASHRAE 90.1 and IECC Over Time

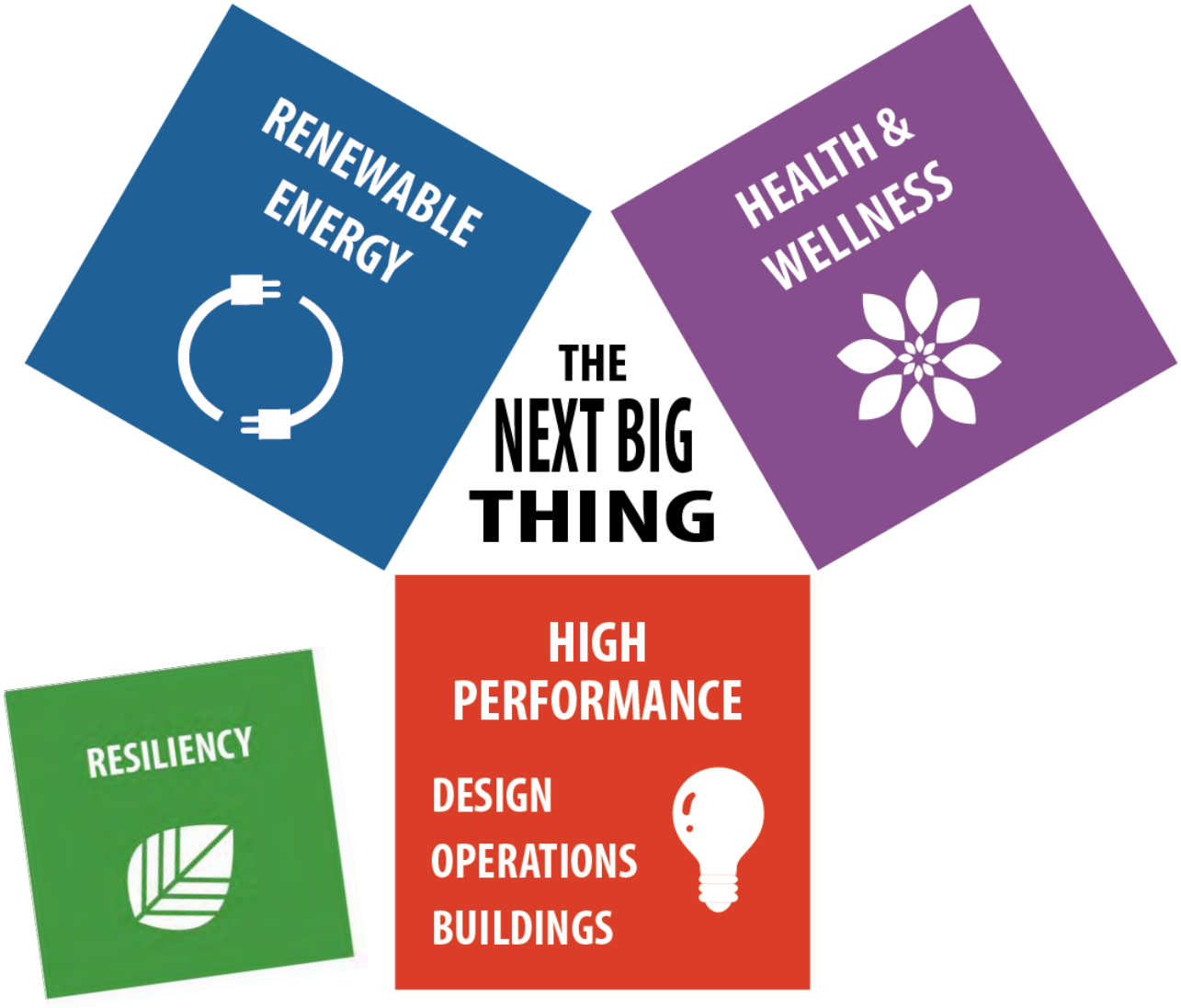


Integrated Approach

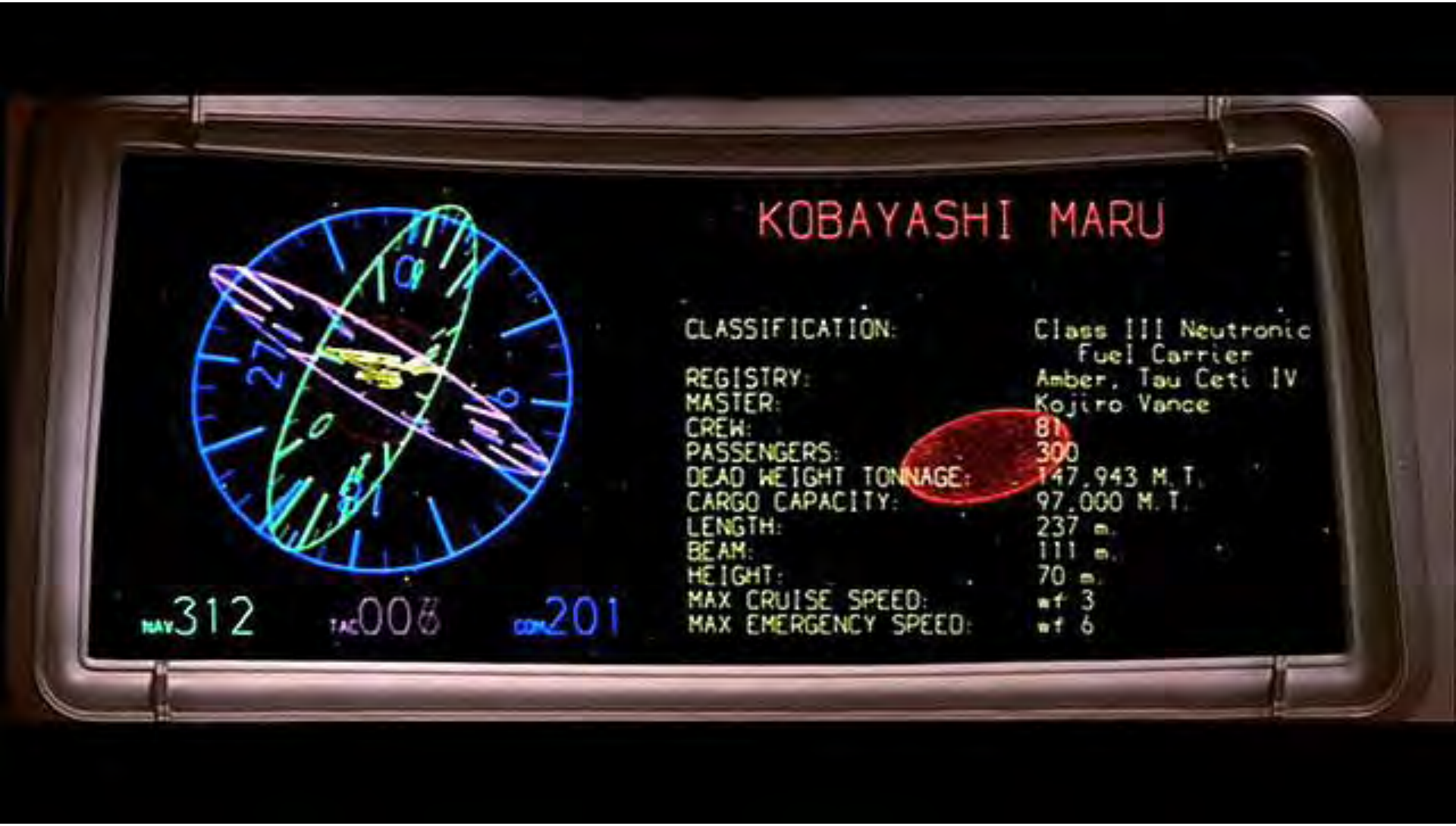


The Future

The Next Big Thing(s)



Performance



Performance

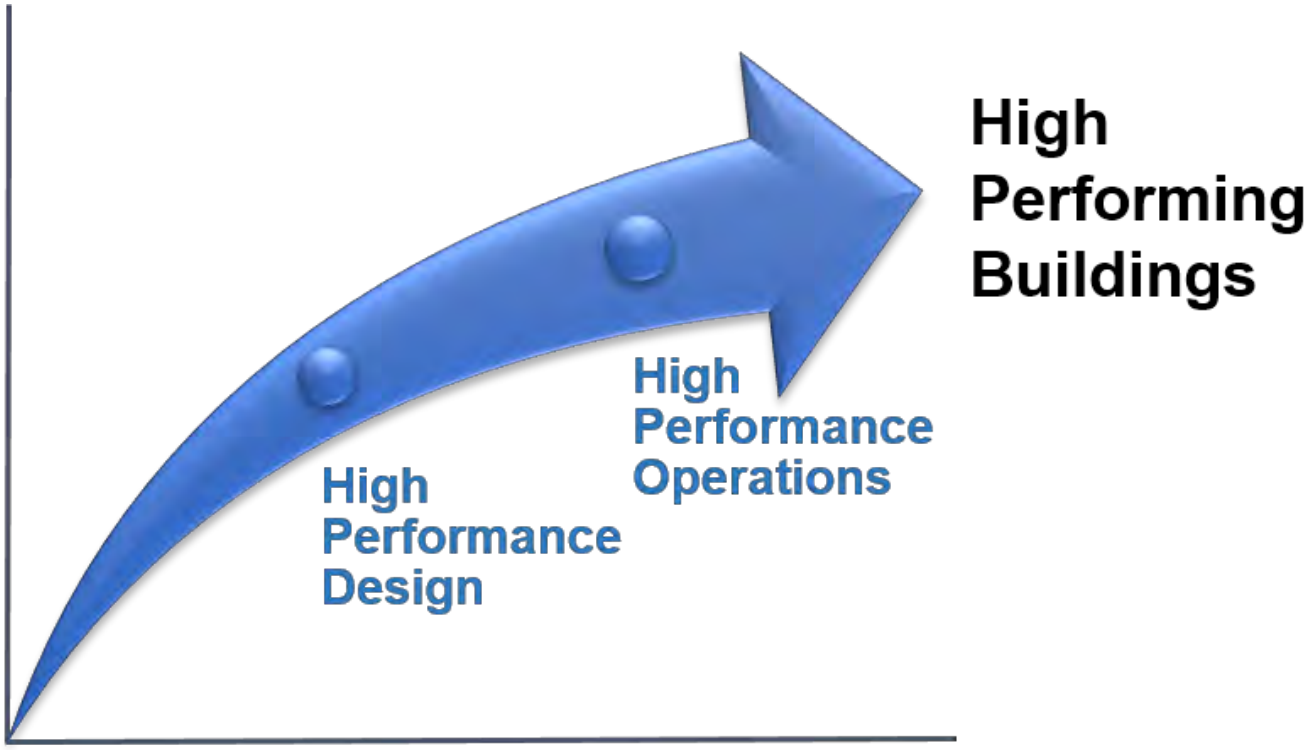
- Building Codes
- LEED v4
- Owner Demands
- Value & Cost of Energy Sources
- Cx, M&V, RetroCx
- Energy Modeling
- Data & Metrics

Stop selling…

Sustainability

It's about…

Performance

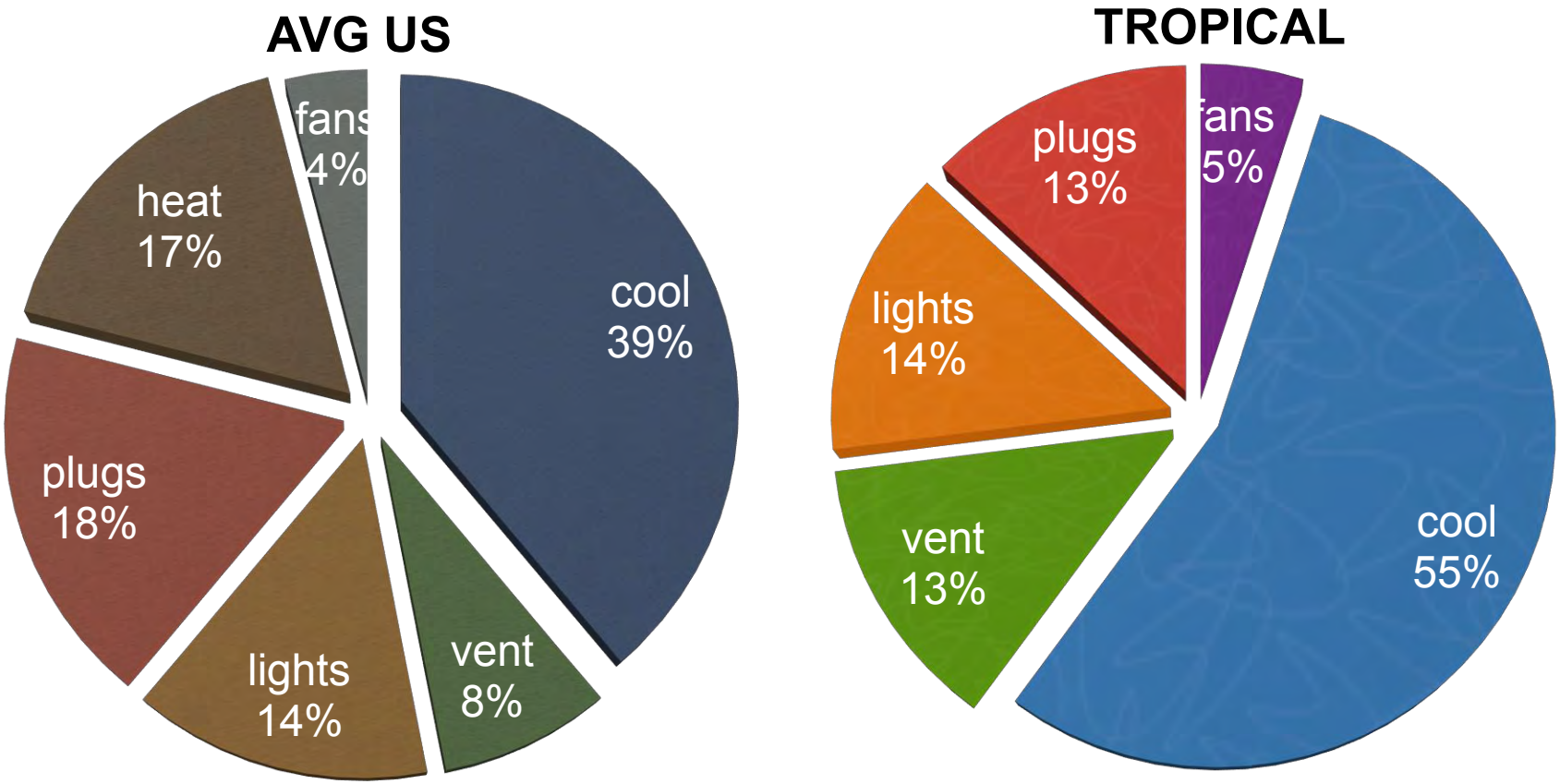


Buildings Use A Lot of Energy

40% US Energy

6.5T kBTU

74% US Electric

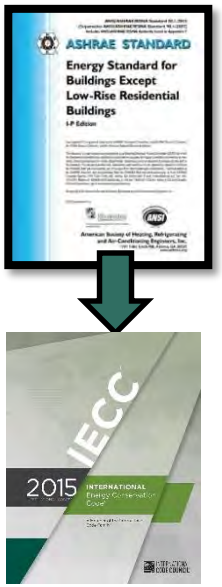


Source: Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey, Table E1A.

Commercial Compliance Options

Performance path

1 90.1-2013 OR 2 2015 IECC OR 3 2015 IECC



Prescriptive path

- C402 – Envelope
- C403 – Mechanical
- C404 – SWH
- C405 – Lighting

AND

- Pick One:

"Additional Efficiency Package Options"

C406.2	C406.3	C406.4
• Eff. HVAC Performance	• Eff. Lighting Systems	• Enhanced Lighting Controls

C406.5	C406.6	C406.7
• On-site Renewable Energy	• DOAS for HVAC	• Eff. SHW Systems

- C407 – Total Building Performance
- C402.4 – Air Leakage (Mandatory)
- C403.2 – Provisions applicable to all mechanical systems
- C404 – SWH
- Lighting Mandatory Sections
  - ✓ C405.2
  - ✓ C405.3
  - ✓ C405.4
  - ✓ C405.6
  - ✓ C405.7
- Building energy cost to be **≤85%** of standard reference design building

Performance Path: An Opportunity

Prescriptive Requirements…

Great Place to start

Not all make sense

Restrictive

Expensive

Energy Modeling Allows…

Creative Design Solutions

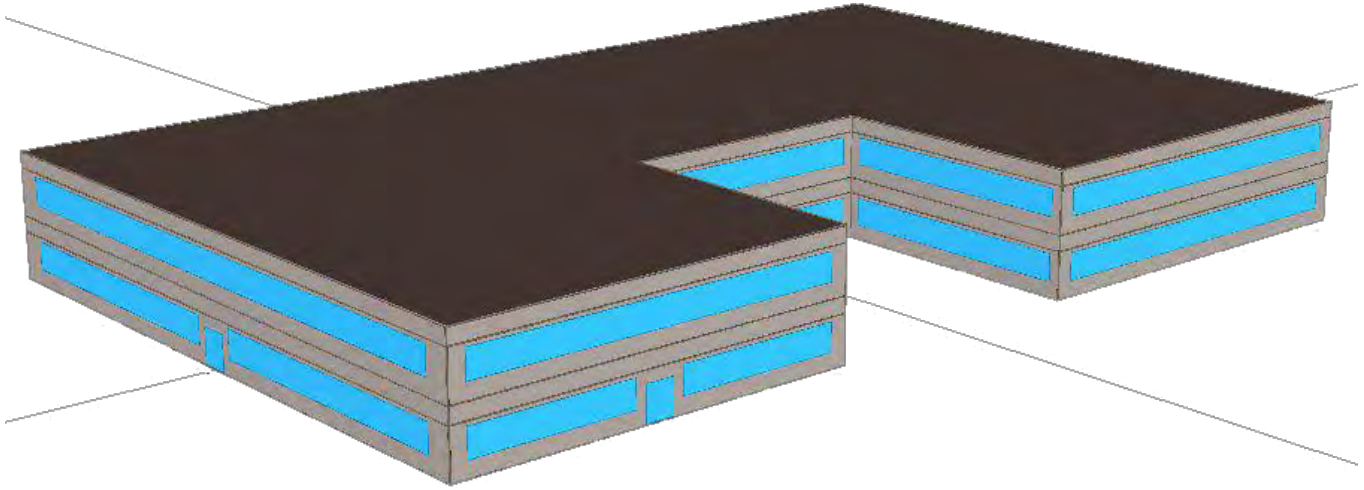
Project Specific

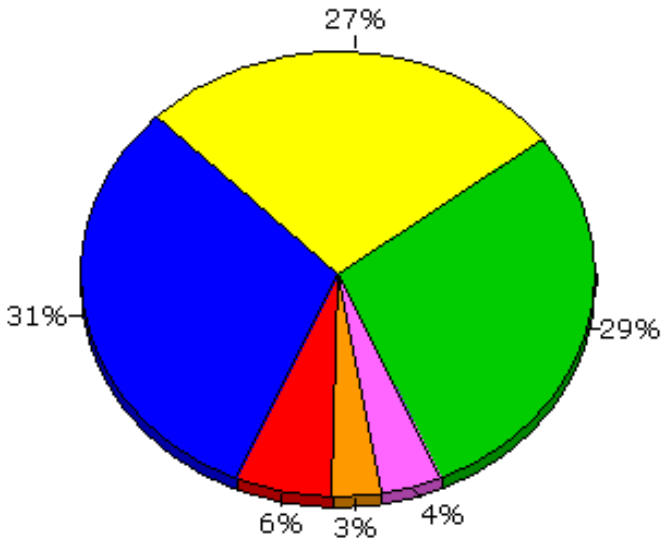
Best solutions

Synergistic

Flexible

Energy Modeling





Peaks

419 kW & 121 tons

437 MWh/yr

- Area Lighting
- Task Lighting
- Misc. Equipment
- Water Heating
- Ht Pump Supp.
- Space Heating
- Exterior Usage
- Pumps & Aux.
- Ventilation Fans
- Refrigeration
- Heat Rejection
- Space Cooling

Impact of Envelope on Energy Performance

Energy Model Example
100K Sf, 4 Story, Office Bldg
100'x250'
E-W Orientation
CZ 2

Cooling Demand (Tons)

180%
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%

280
230
180
130
80

143
149
162
174
172
188
224
256
137
134
131
129

100%
103%
111%
119%
116%
126%
148%
168%
97%
94%
95%
92%

All Prescriptive, Differing WWR

30% WWR | 40% WWR | 66% WWR | 90% WWR

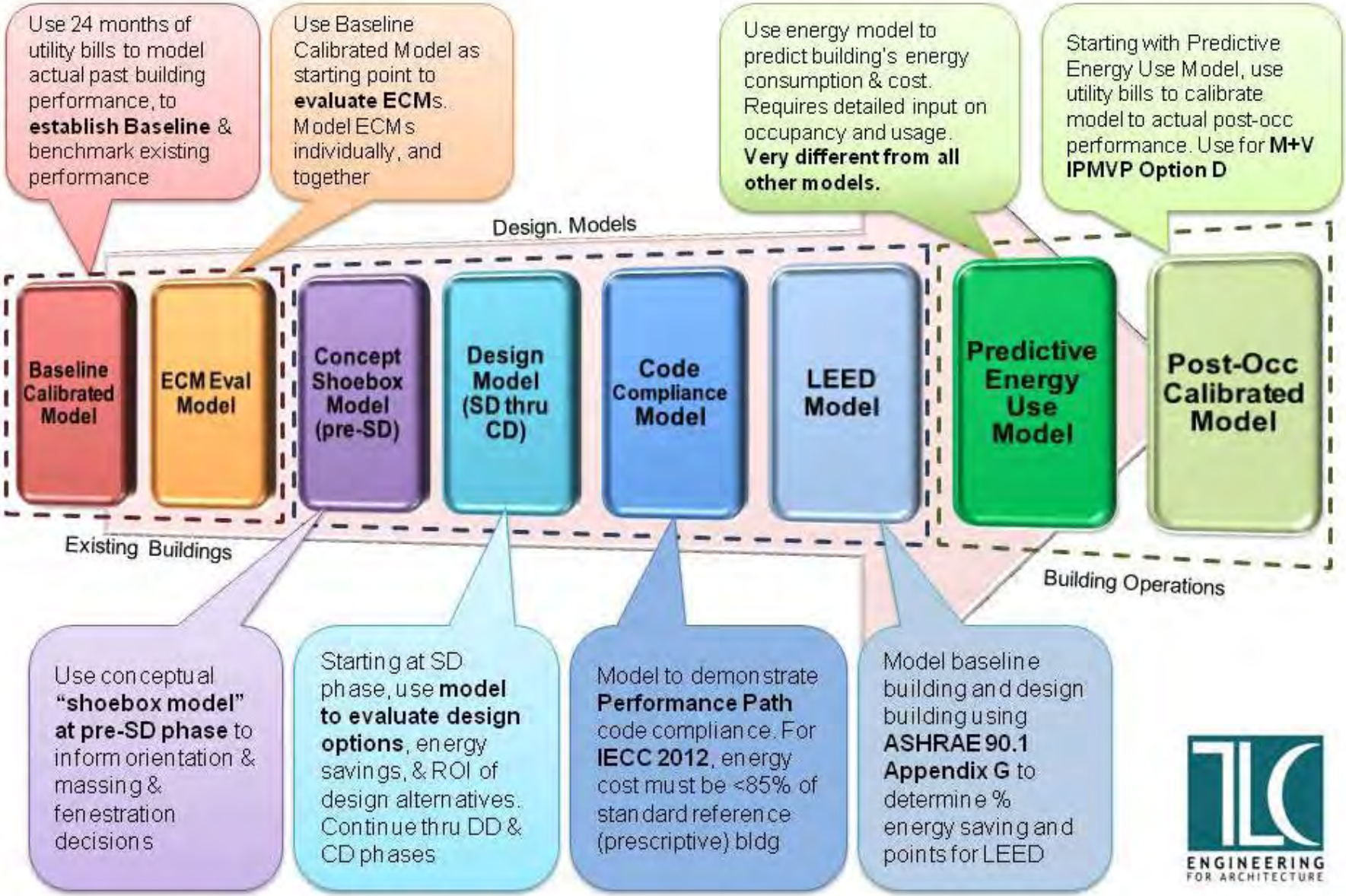
"Bad Glass", Differing WWR

30% WWR | 40% WWR | 66% WWR | 90% WWR

"Improved Envelope"

20% WWR | 30% WWR ^Glass | 30% WWR ^Insul | 20% WWR ^Glass ^Insul

Types of Energy Models

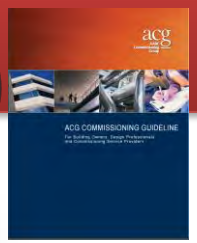


ENGINEERING FOR ARCHITECTURE

Mandatory Requirements

Commissioning is REQUIRED (C408)

Code Required Cx (C408)



Commissioning Process

Best Practice Cx

Code Min Cx Requirements

Pre-Design Phase

- Owner Goal Setting
- Prelim OPR
- **Select CxA**
- OPR Workshop

Design Phase

- Review OPR/ BOD
- **Cx Specs**
- **Develop Cx Plan** (draft)
- Design Reviews
- Update OPR
- Cx Scheduling
- **TAB Required in Const Docs**

Construction Phase

- Cx Kickoff
- Review Submittals
- **Refine Cx Plan**
- Site Observation
- Lead Cx Meetings
- **Start-up Testing**
- Issues Logs

Acceptance Phase

- **Test & Balance**
- **Functional Testing**
- Integration of Systems Testing
- Troubleshooting & Diagnostic
- Issues Logs
- **Prelim Cx Report**

Post-Occupancy Phase

- **O&M Manual**
- Owner Training
- Track open issues
- **Deferred Testing**
- 1 Yr Site Visits
- **Final Cx Report**
- **Record Drawings**
- **Final Balancing Report**

Commissioning is REQUIRED by CODE !!

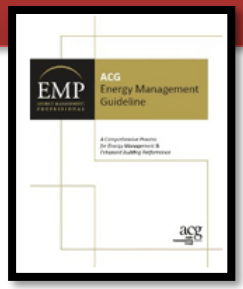
Mechanical Systems Commissioning (C408.2)
Service Water Heating Systems, Pools, Spas (2015, C408.2)
Lighting Controls Functional Testing (C408.3)

Code Minimum Cx Process:
Preliminary Commissioning Report

You can't pass the **final mechanical inspection** without the **Preliminary Cx Report**

Every Building is an Existing Building

ENERGY MANAGEMENT ASSOCIATION
The #1 Resource of Energy Management Professionals



Existing Building Energy Auditing & EBCx Process

Phase 1: Project Assessment

- Project Initiation
- Client Consultation
- Preliminary Assessment
- Initial Benchmarking

Phase 2: Energy Use Exploration

- Obtain Detailed Energy Information
- Energy Use Index
- Utility Rate Analysis
- Annual Energy Balance
- Historical Energy Use

Phase 3: Site Investigation

- Planning
- Site Visit
- O&M Staff Interviews
- Trend-Log Data Collection
- Functional Observation / Testing
- ECM / FIM Development
- Preliminary Reporting

Phase 4: ECM / FIM & EBCx Analysis

- Engage Project Team
- Cost & Savings Analysis
- Develop Business Case
- Summarize Options
- EBCx Plan
- Detailed ECM/FIM Report
- Client Approval

Phase 5: Implement-ation

- Planning
- Implement Approved ECMs & FIMs
- Construction Documents
- EBCx Activities
- Measurement & Verification Planning

Phase 6: Final Acceptance

- Final EBCx Testing
- As-Builts
- Systems Manual
- Changes to O&M
- Staff Training
- Final Report
- Owner Acceptance

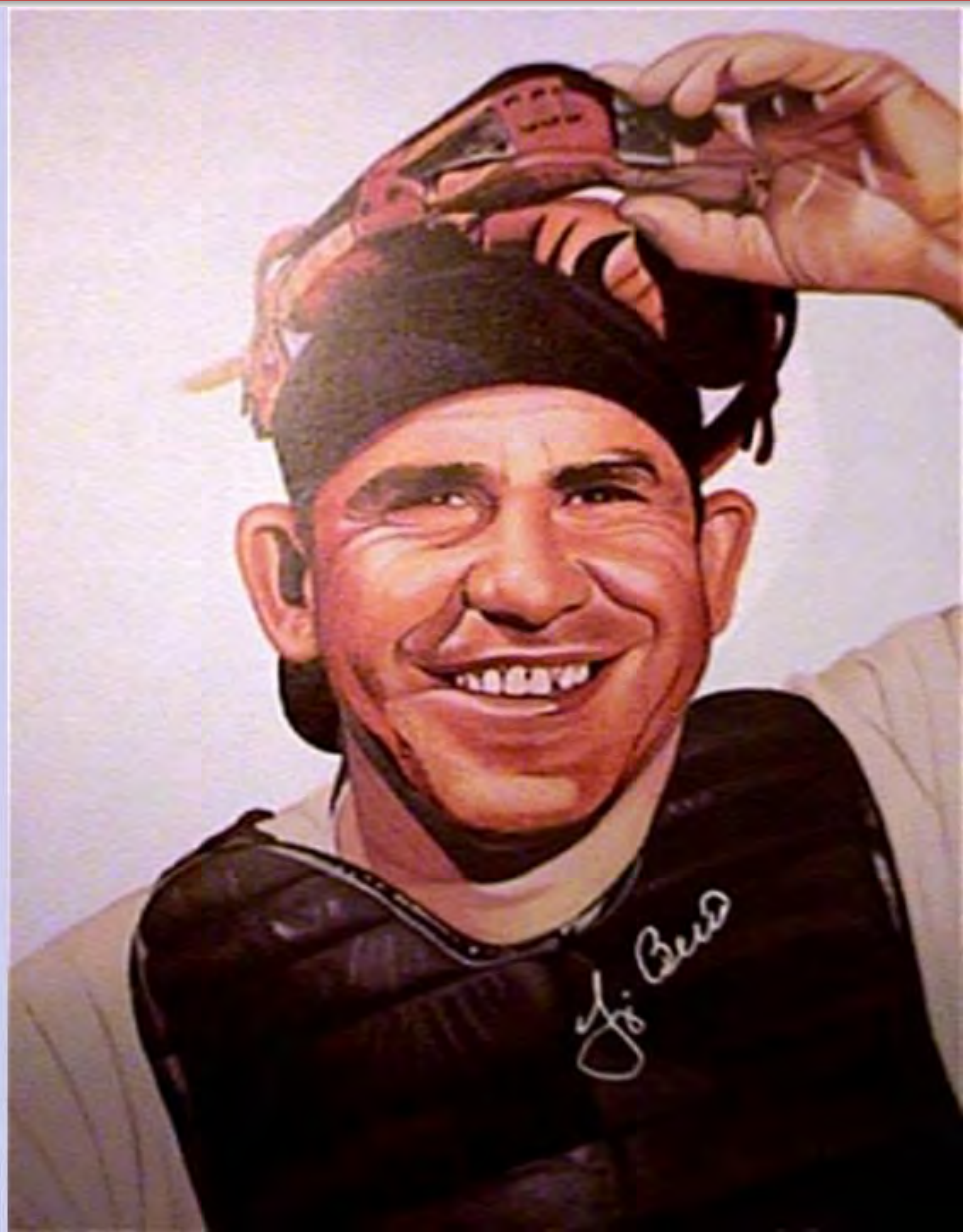
Phase 7: Continuous Energy Management

- Planning
- Ongoing Cx Plan
- Measurement & Verification
- Enhancing Operations & Maintenance
- Periodic Benchmarking
- Sustaining Performance
- EnergyStar

Performance Verification

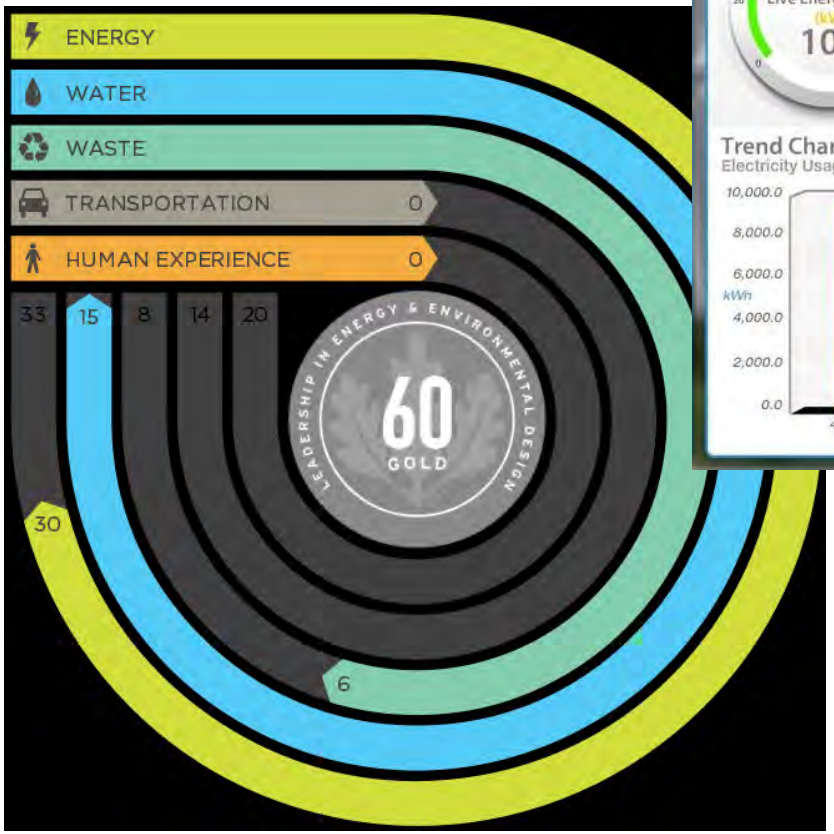
You can observe a lot just by watching.

Yogi Berra



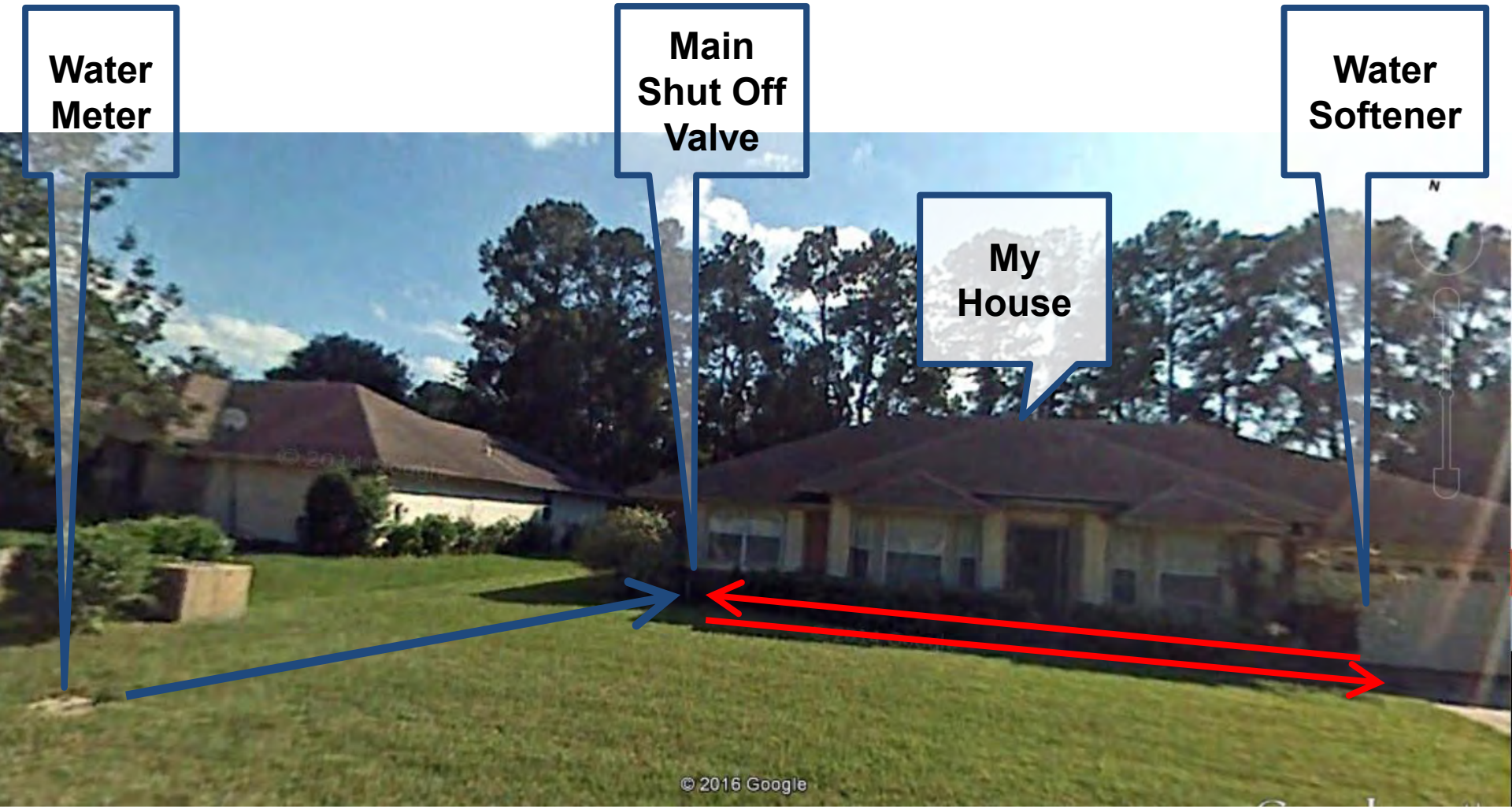
Measuring Performance

The Two Biggest Things you can do to improve the Energy Performance of your Building are :



1. Commissioning
2. Measurement & Verification

My Water M&V Example



My Water M&V Example

My Water M&V Example

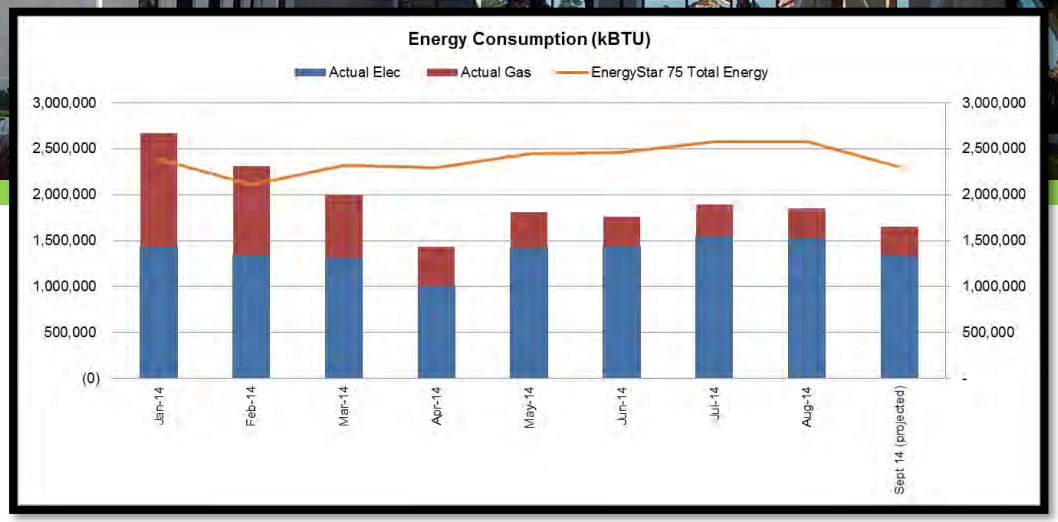
Proven Results

St. Vincent's Medical Center Clay County

Middleburg, Florida

97

ENERGY STAR



Architect:
HKS Architects

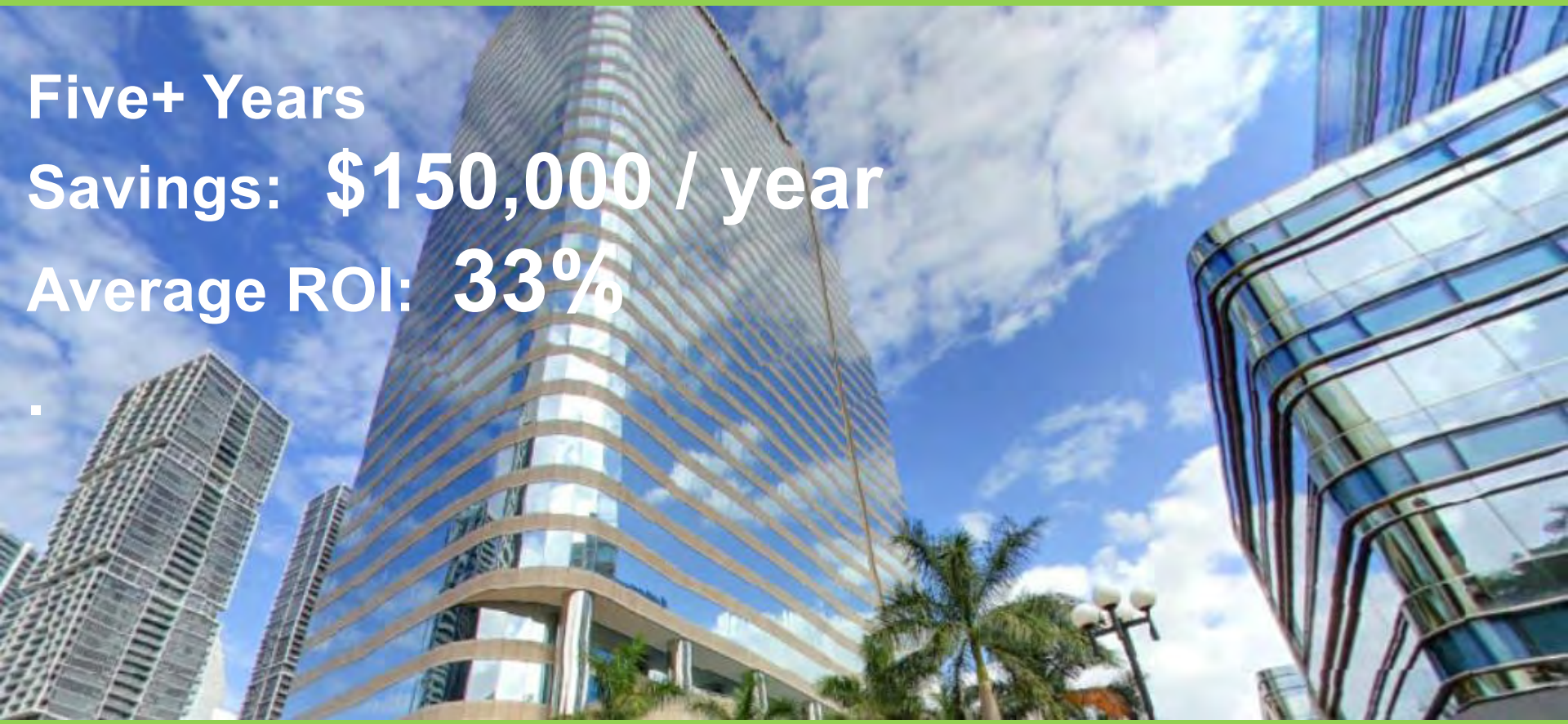
Constructor:
Brasfield & Gorrie

$45 Million
155,000 sf

TLC ENGINEERING FOR ARCHITECTURE

701 Brickell Avenue

Miami, Florida



Five+ Years

Savings: $150,000 / year

Average ROI: 33%

.

Constructor:

CanAm Electrical Contractors, Douglas Orr Plumbing and JCI

$1.75 Million

740,000 sf

ENGINEERING FOR ARCHITECTURE

Tyndall Air Force Base Fitness Center & Energy Demonstration Project

Panama City, Florida

Architect:
Atkins North America

Constructor:
Carothers Construction

$18 Million
75,278 sf

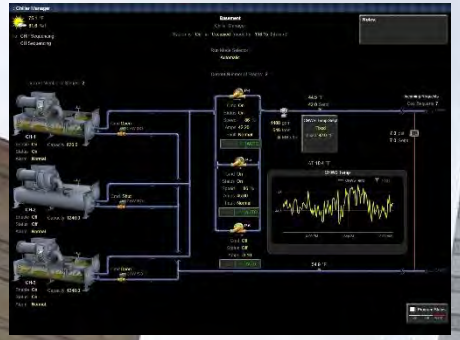
ENGINEERING
FOR ARCHITECTURE

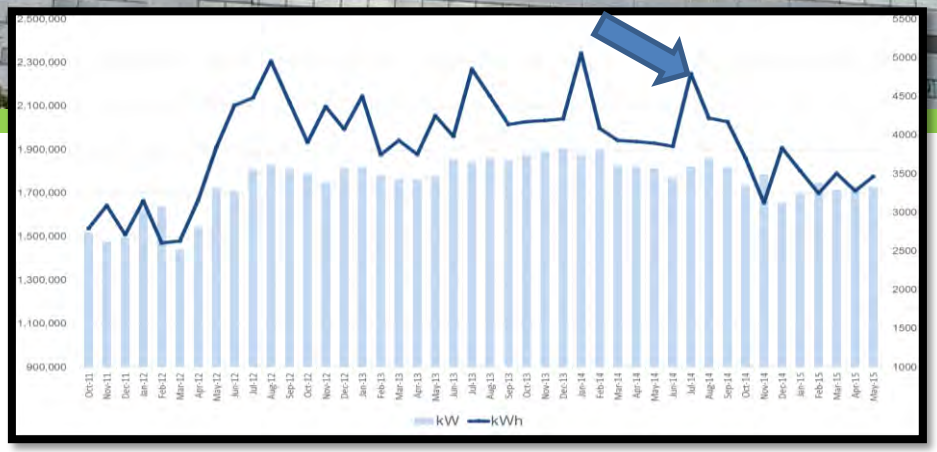
Everbank Center

Jacksonville, Florida

85

ENERGY STAR





Before

81 EUI

82 EnergyStar

After

75 EUI

85 EnergyStar

8% Savings

$154,000/yr

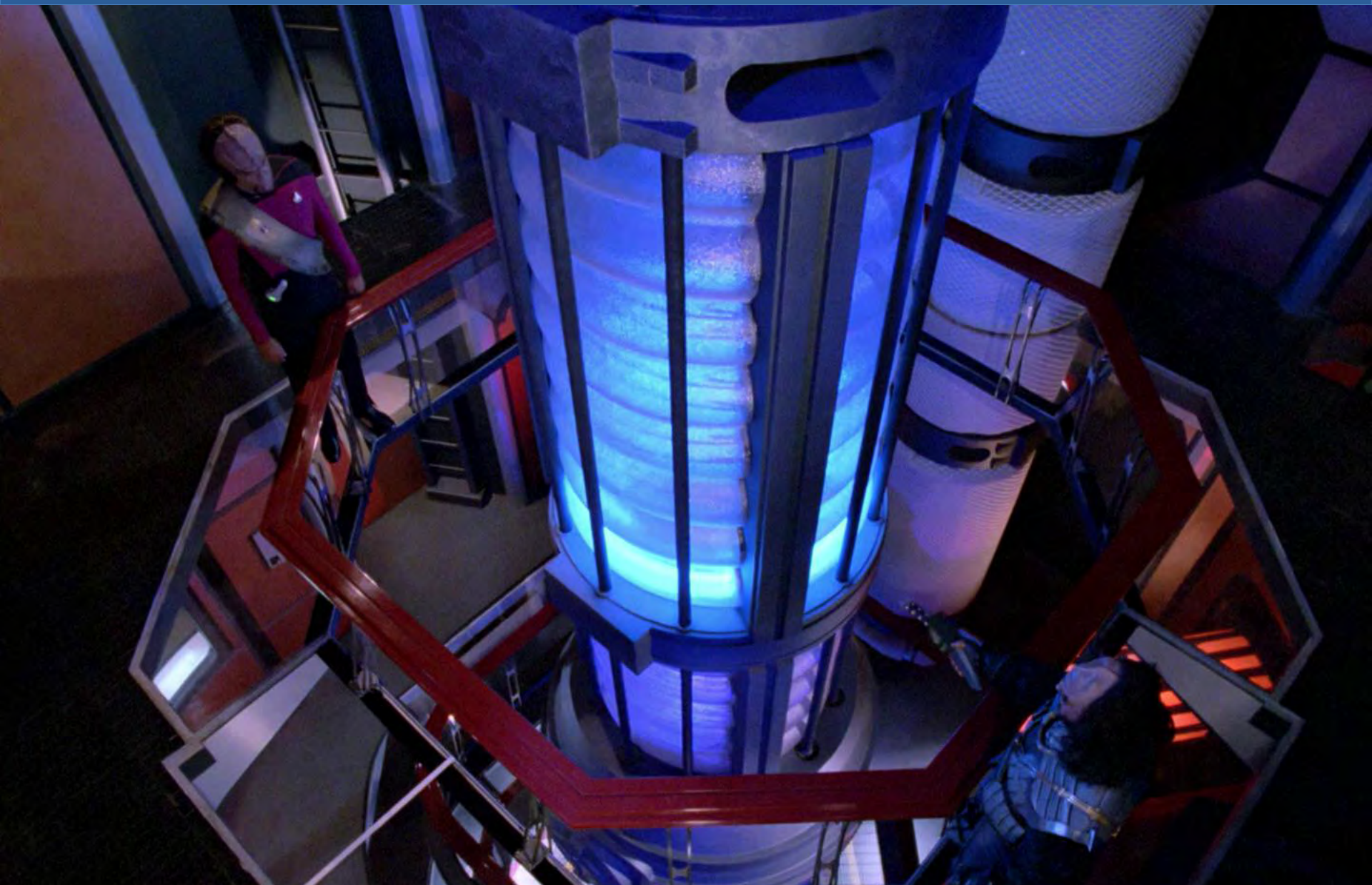
Architect:
Amkin, LLC

Constructor:

1M sf
32 Floors
1984

ENGINEERING FOR ARCHITECTURE

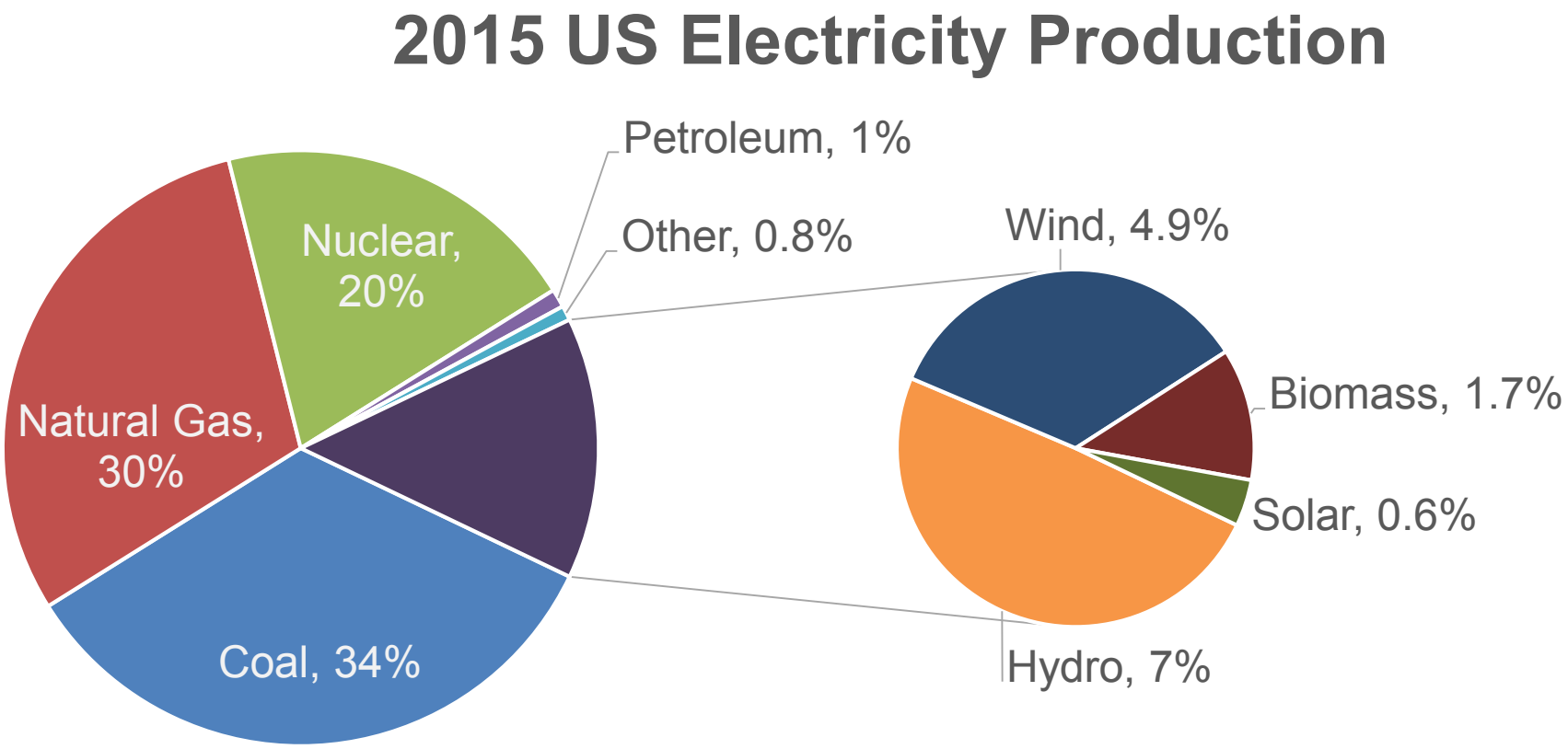
Renewable Energy



Renewable Energy

- Falling Solar Costs
- Rising Fossil Fuel Costs
- Growth of Solar
- Drive to Net Zero
- Grid Parity by 2020
- Energy Storage

Renewable Energy



Coal: Declining Fast

Nat Gas: Up, Now Holding

Nuclear: Steady

Hydro: Up slightly

Wind: Big Growth since 2008

Solar: Fastest Growing

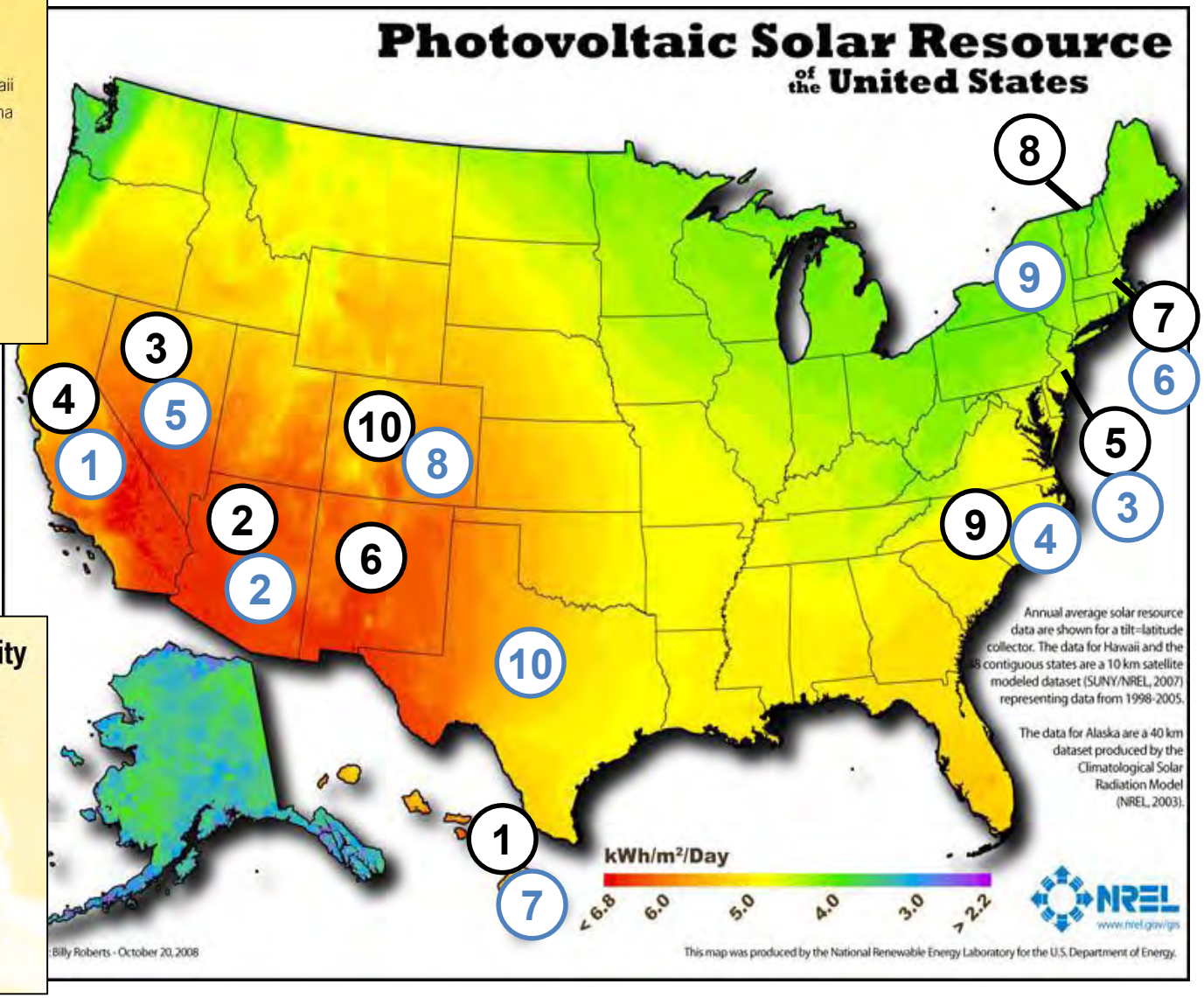
Top Solar States in 2015

Solar Capacity Per Capita (watts/person)[4]

1	321	Hawaii
2	316	Arizona
3	286	Nevada
4	262	California
5	163	New Jersey
6	156	New Mexico
7	113	Massachusetts
8	112	Vermont
9	98	North Carolina
10	77	Colorado

Cumulative Solar Capacity Installed (MW)[1]

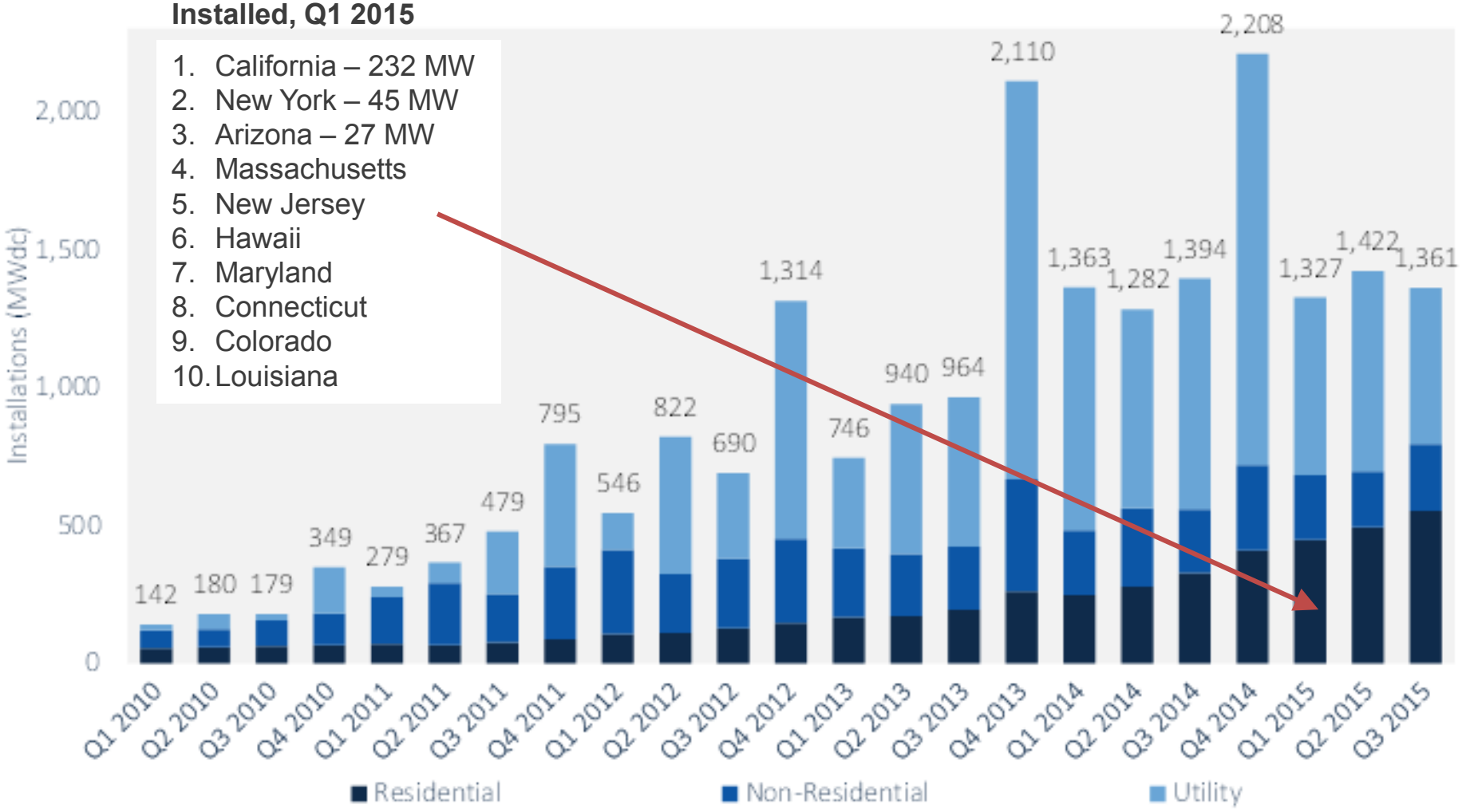
1	9,977	California
2	2,069	Arizona
3	1,451	New Jersey
4	953	North Carolina
5	789	Nevada
6	751	Massachusetts
7	447	Hawaii
8	398	Colorado
9	397	New York
10	330	Texas



U.S. PV Installations 2010 - 2015

Top 10 States: U.S. Residential Solar Installed, Q1 2015

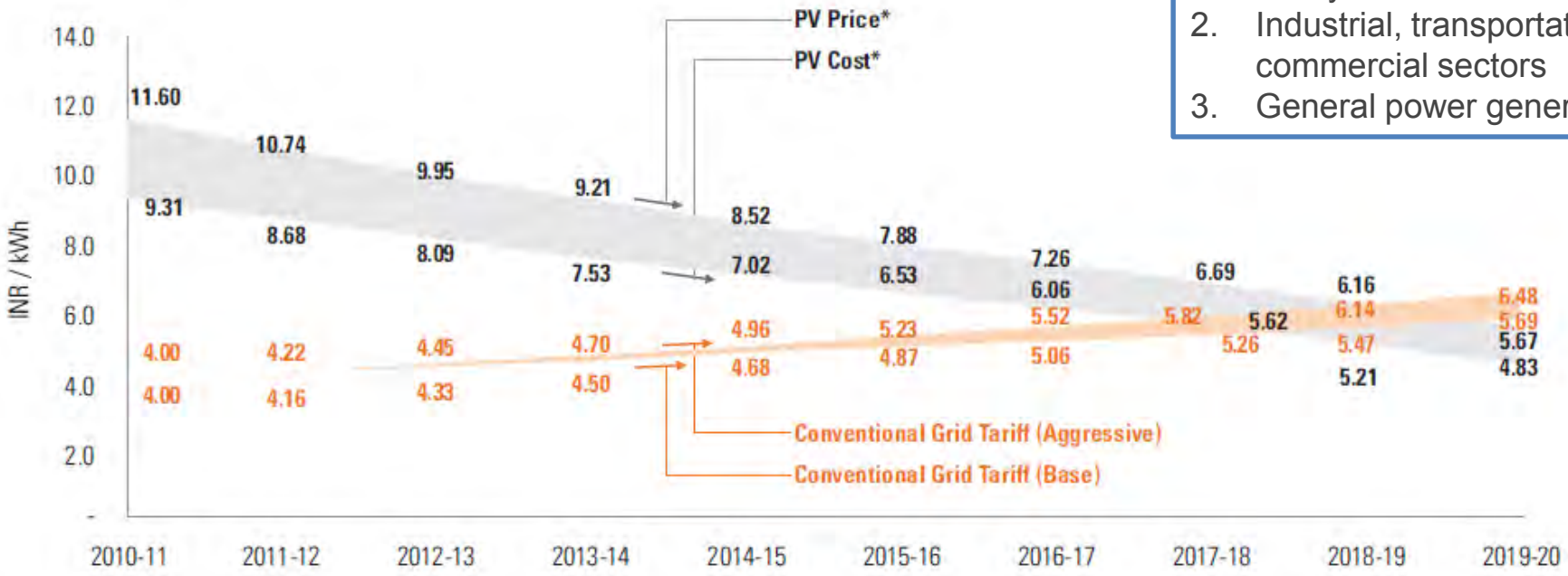
1. California – 232 MW
2. New York – 45 MW
3. Arizona – 27 MW
4. Massachusetts
5. New Jersey
6. Hawaii
7. Maryland
8. Connecticut
9. Colorado
10. Louisiana



Grid Parity is Coming

Three phases of Power Parity

1. Residential grid-connected PV systems
2. Industrial, transportation, commercial sectors
3. General power generation



Grid Parity Year	Aggressive Case	Base-Case
Utility PV Price	2017-18	2019-20

What is Grid Parity?

Levelized Cost Comparison of Utility-Scale PV vs Conventional Power at Grid

Does Solar Pay Back?

PV Quick Calcs

MONOCRYSTALLINE SOLAR MODULE
STP275S / STP270S - 20/Wem

High module conversion efficiency
Module efficiency up to 16.9% achieved through advanced cell technology and manufacturing capabilities

Positive tolerance
Positive tolerance of up to 5% delivers higher outputs reliablity

Extended wind and snow load tests
Module certified to withstand extreme wind (3800 Pascal) and snow loads (5400 Pascal) *

Rules of Thumb:

5-10 watts / sf of array

$3-ish per watt installed… but dropping

30% Fed Tax Credit extended to 2021!

275 W Module
65” x 39” x 1.4” (17.5 sf)
STC Rating (Wp) = 275 W
NOCT Rating = 202 W

Solar Thermal Quick Calcs

Solar HW

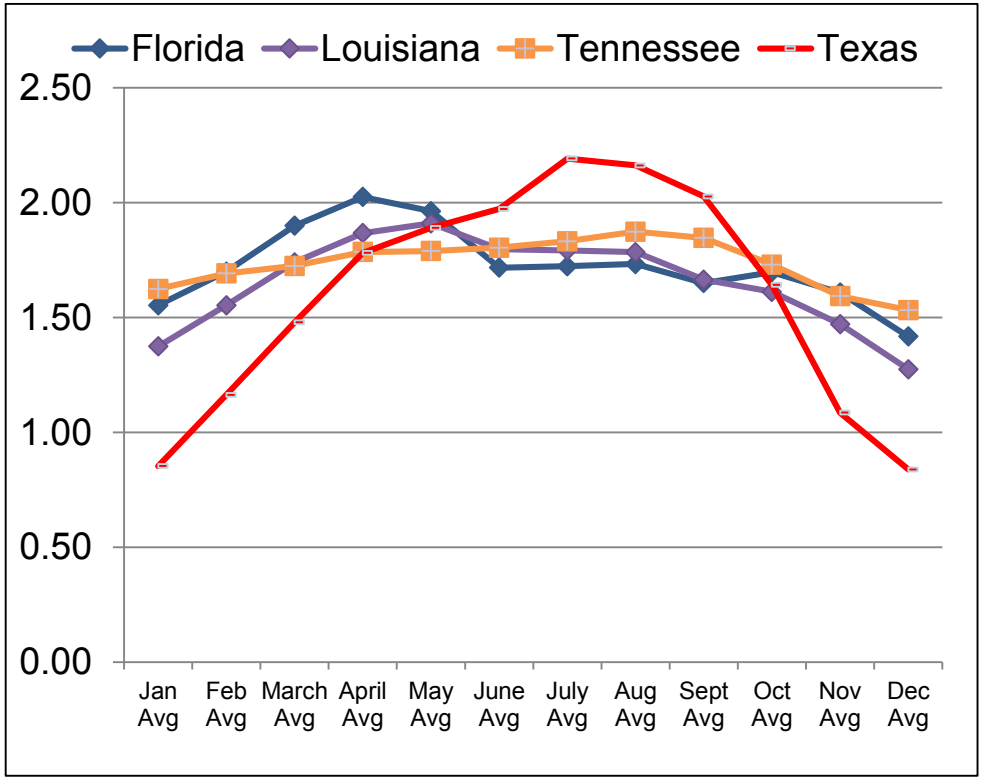
SE Avg

1.7

kBTU/sf/yr

	Lat / Tilt Angle	Avg Annual kBTU/sf/day
Florida	28	1.72
Louisiana	31	1.65
Tennessee	36	1.74
Texas	31	1.59

kBTU/sf/day from NREL



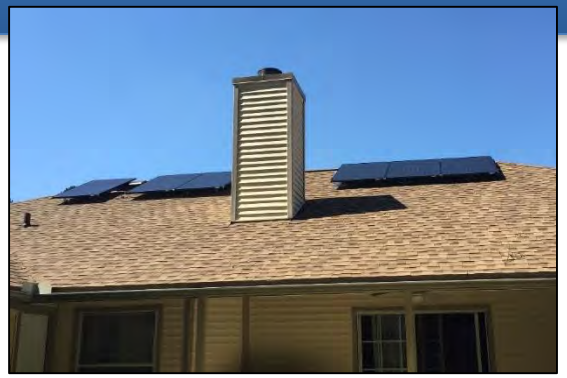
Ex: TitanPower-ALDH29
85”x50”x4” (28sf)
82% efficient
10 Panels
In FL, mtd at 28 deg tilt
South Facing

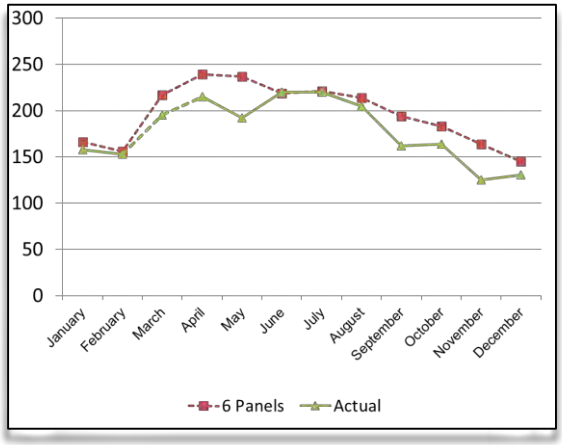
<u>Rough Estimate</u>

10 x 28sf x 1.72 kBTU/sf/day x 82% eff x 90% (10% sys loss) =

355 kBTU/day; 129,729 kBTU/yr

My Solar Example





In 2015

- 6 Panels
- 275 W / Panel
- 1.65 kW
- 2140 kWh/yr
- $3.94/W Installed
- $2.75/W 30% Fed Tax Credit
- **$0.18 / kWh** to Produce
- **$0.13 / kWh** from JEA

For Grid Parity

- Add 10,000 kWh/yr

To achieve **$0.12/kWh** I need:

✓ Battery **<$1 / kWh** Installed

✓ PV **< $2 / W** Installed

✓ **>500W** / Panel

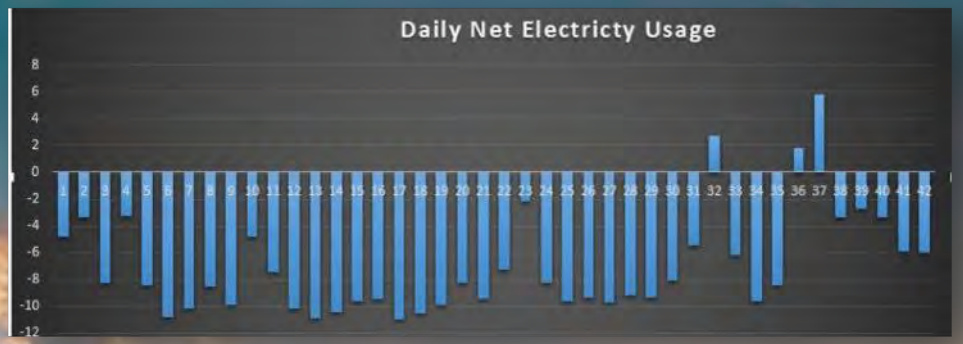
How to Get to NET ZERO

Net Zero Energy Building – Prototype
Haskell Company

1. Reduce Demand
2. Take Advantage of Free Energy
3. Capture Waste Energy
4. Equipment Efficiency & Controls
5. Add Renewables

Can't have Net-Zero Building without Net-Zero Tenants

Don’t Forget Commissioning



Cx of 2.8 kW PV Array

Josey Pavilion

Decatur, Texas

Lake | Flato

NET ZERO ENERGY

Turn Rooftops & Parking Lots into Power Plants

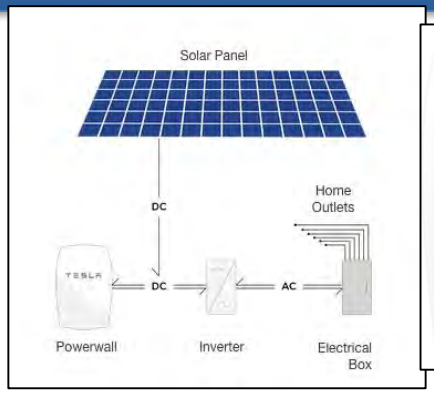
Darden HQ
Orlando, FL
1.1 MW PV Array

Physical Fitness Center
Camp Lejeune, NC
150 kW PV Array

Net Zero Homes of the (Near) Future

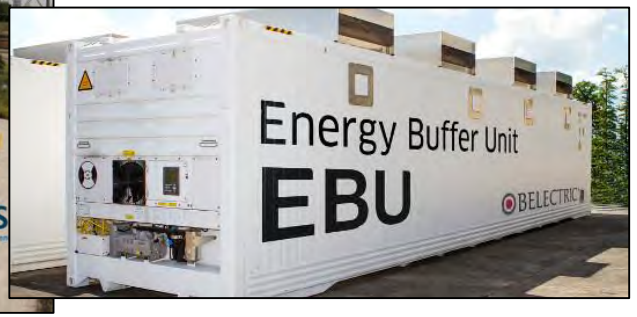
Energy Storage is the Silver Bullet

Residential



Commercial

Utility



Health & Wellness

Health & Wellness

- Biophillic Design
- Active Design
- WELL Building Standard
- IAQ & Controllability
- Productivity & Cost

New Health & Wellness Challenges

THE 19th CENTURY:

Infectious Diseases

19th Century codes, planning and infrastructure as weapons in the battle against contagious disease

These strategies were built into the city fabric, and they were effective

THE 21st CENTURY:

Chronic Diseases,
many of which are
"Diseases of Energy"

The emerging design solutions for health parallel sustainable design solutions

Effective designs will have to be an invisible, pervasive, and inevitable part of life

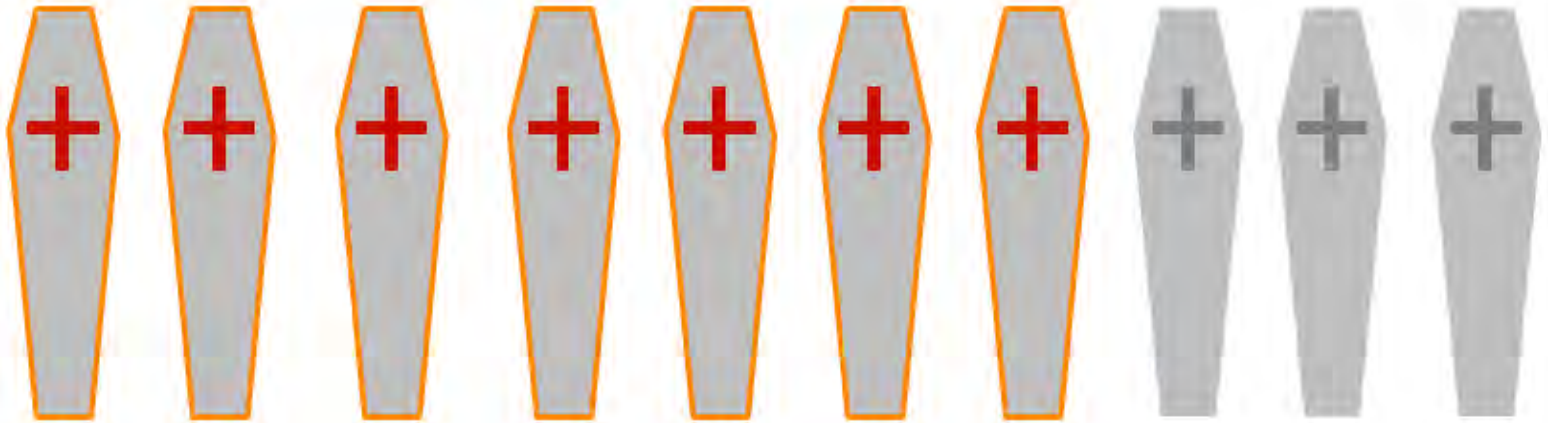
Source: U.S. Centers for Disease Control and Prevention (CDC)

Medical Costs = $147B per yr

Today……. over

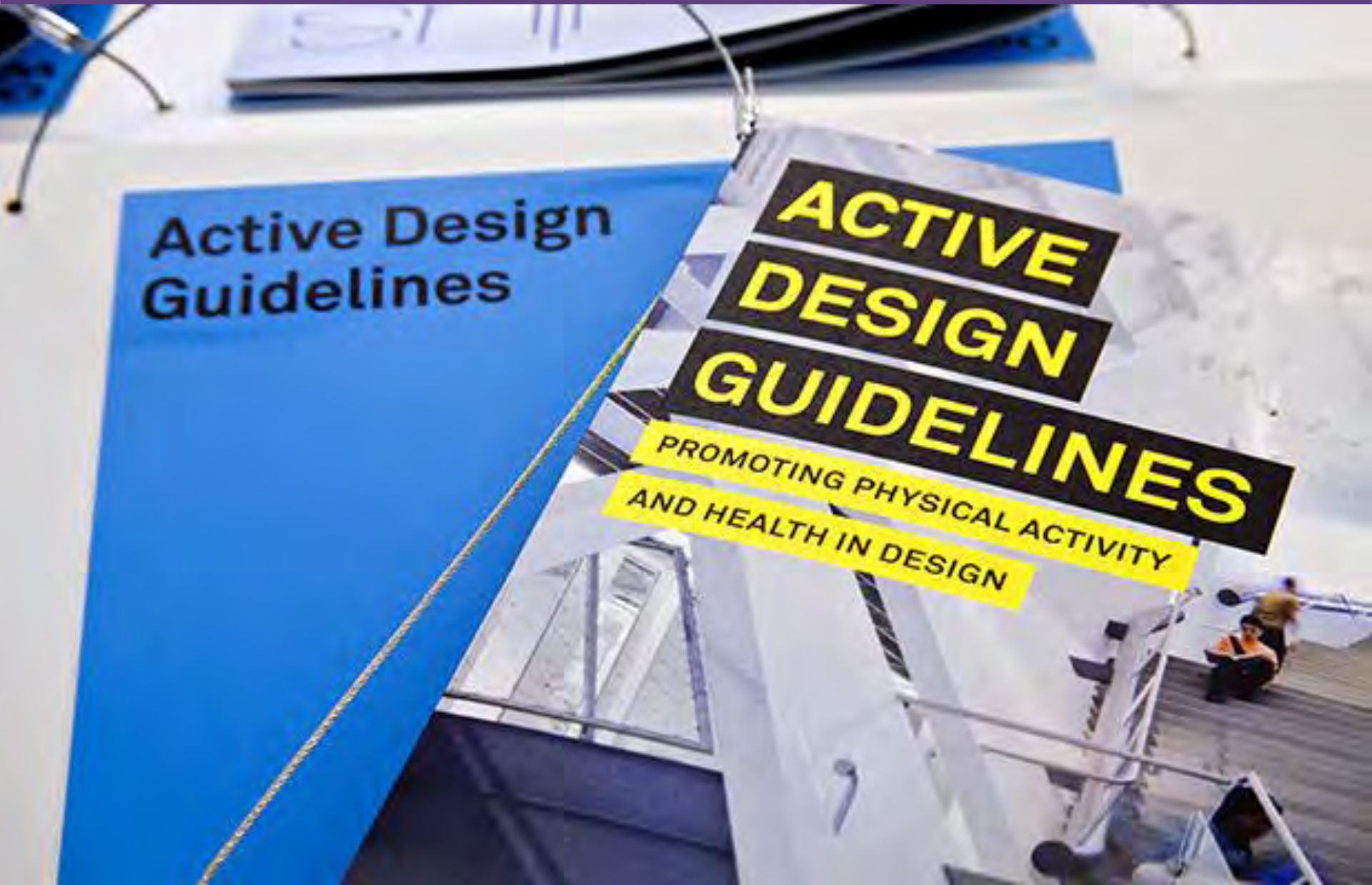
70%

of deaths each year are from **chronic diseases.**

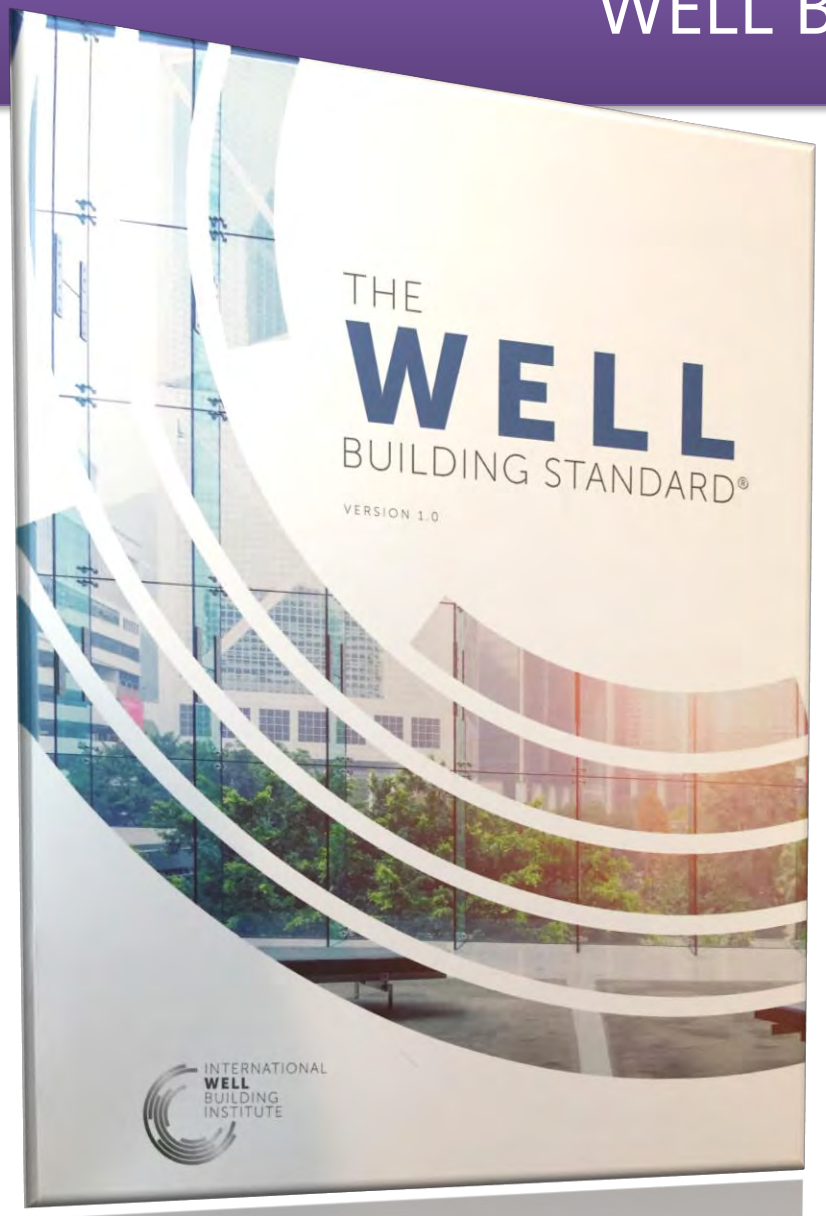


Source: U.S. Centers for Disease Control and Prevention (CDC)

Active Design



WELL Buildings



THE SEVEN CONCEPTS OF THE WELL BUILDING STANDARD

- AIR
- WATER
- NOURISHMENT
- LIGHT
- FITNESS
- COMFORT
- MIND

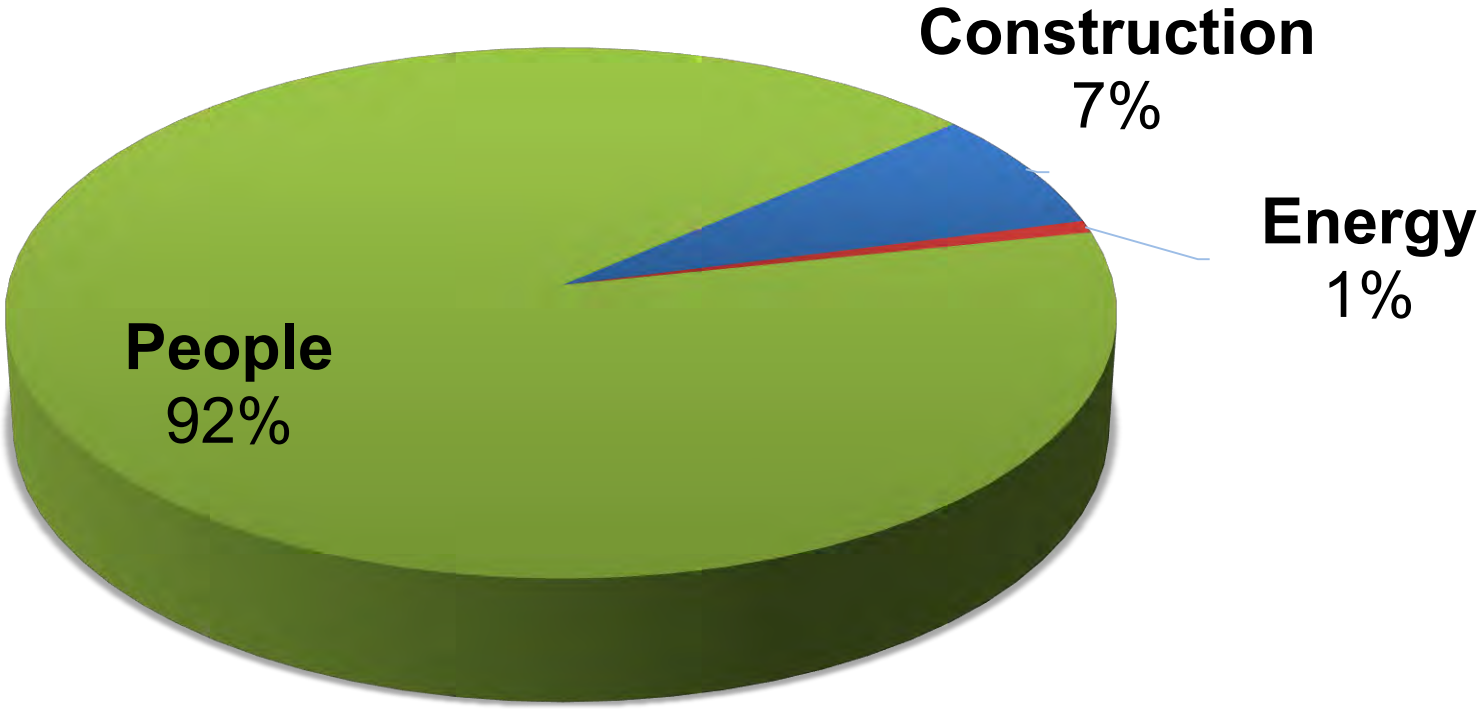
LEVELS OF WELL CERTIFICATION

INTERNATIONAL WELL BUILDING INSTITUTE™ WELL SILVER 2014

INTERNATIONAL WELL BUILDING INSTITUTE™ WELL GOLD 2014

INTERNATIONAL WELL BUILDING INSTITUTE™ WELL PLATINUM 2014

10 year Commercial Building Cost



1% Savings on "People Cost" = **$2.72 / sf/yr savings**

Construction Cost = $20/sf/yr | ($200/sf over 10 years)
Energy Costs = $2/sf/yr | People Costs = $250/sf/yr

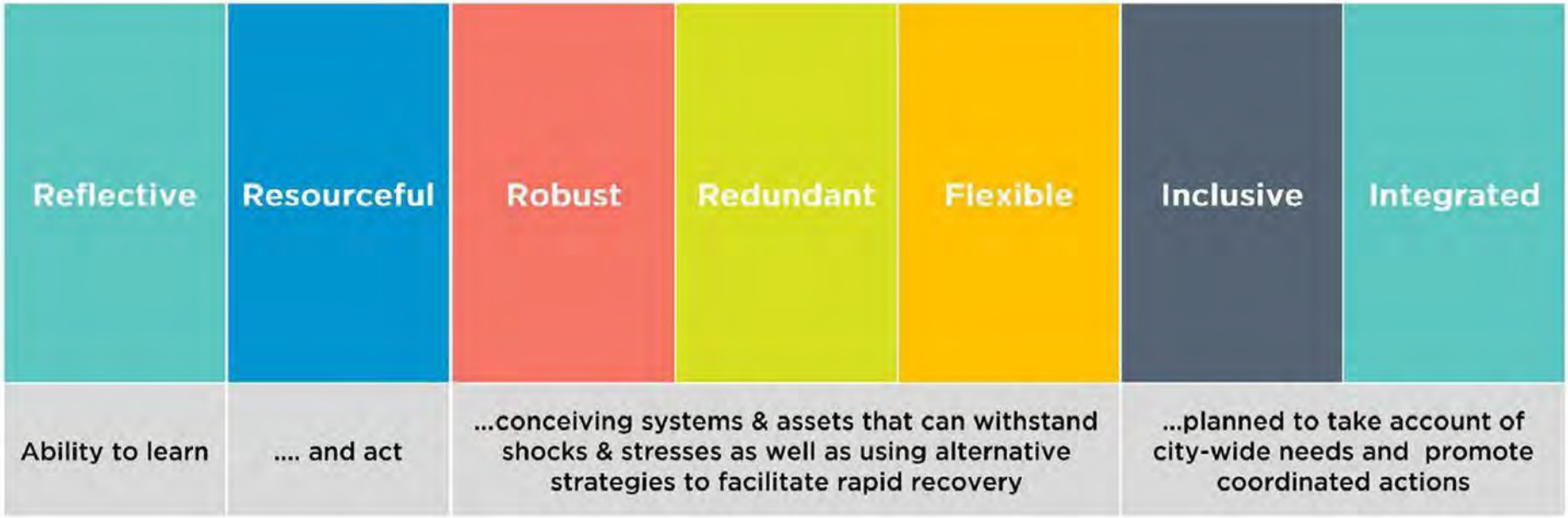
Resiliency

Resiliency

- Withstand, Respond, Adapt
- Distributed Generation
- Role of Solar
- Water Use & Reuse

Resiliency

Resilient systems exhibit certain qualities that enable them to withstand, respond, and adapt more readily to shocks and stresses



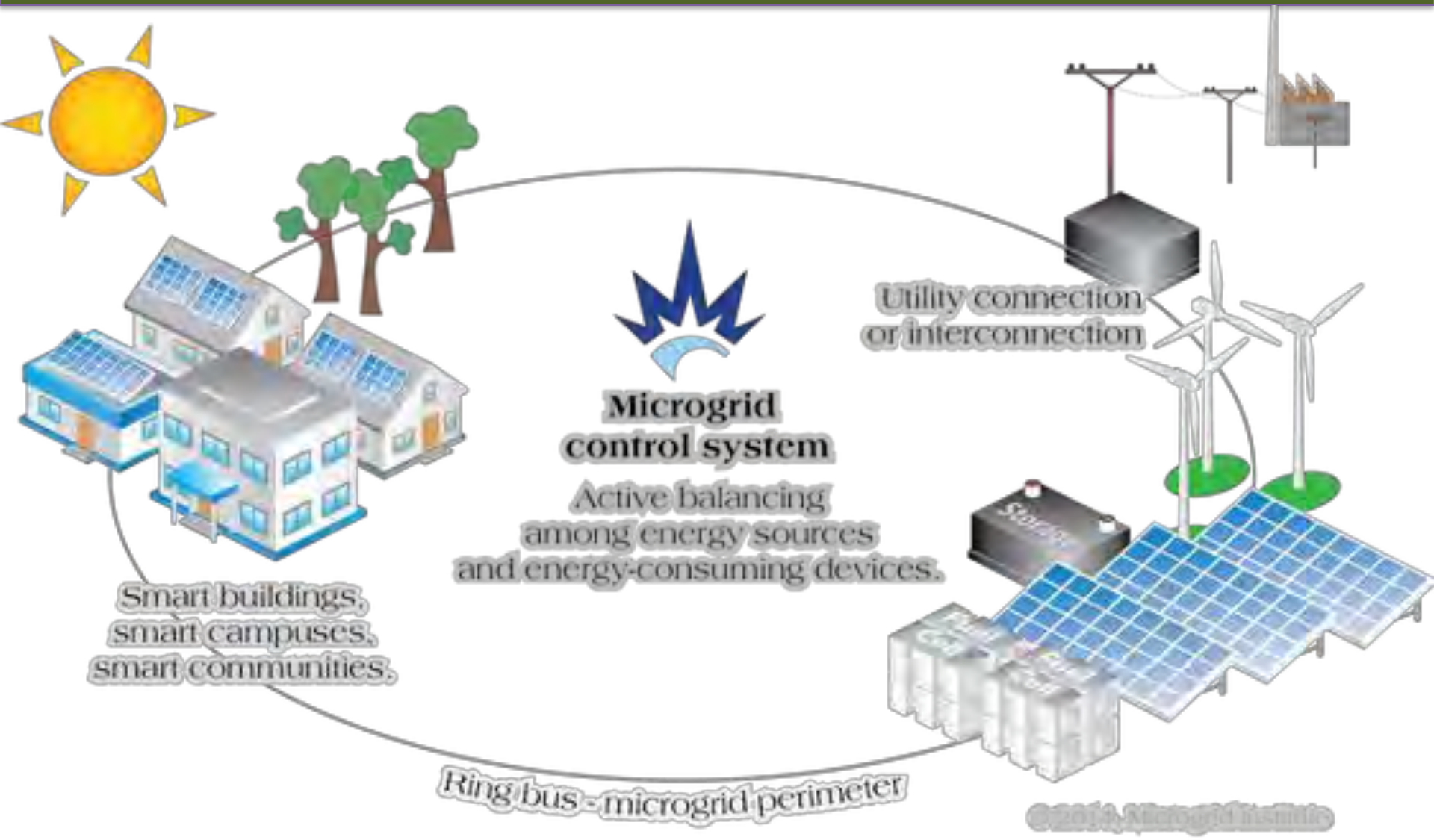
Resiliency

Flooding in New Orleans after Hurricane Katrina

Sudden shocks or accumulating stresses can lead to social breakdown, physical collapse, or economic decline.

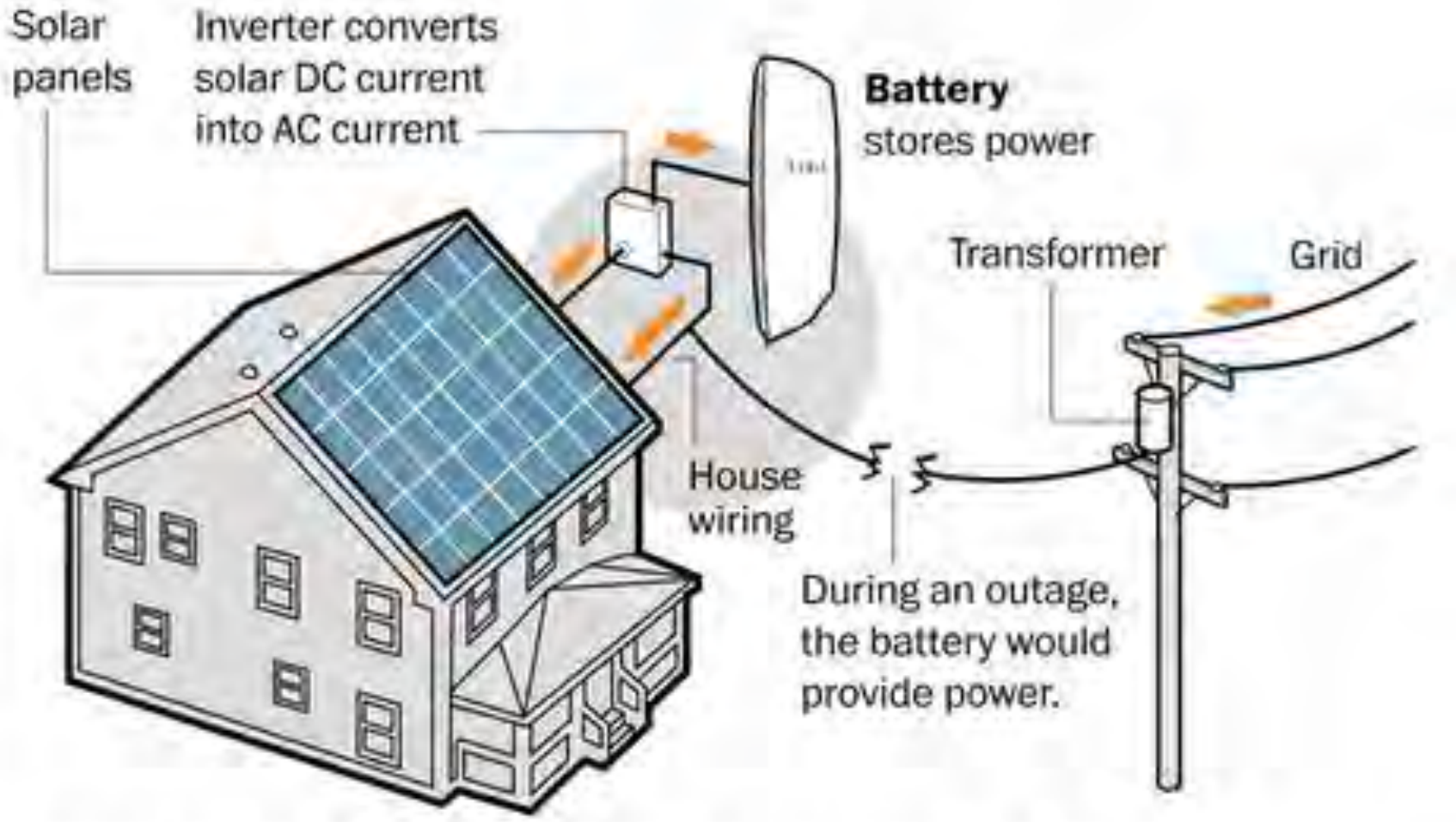
Transporting Power

Distributed Generation & Microgrids



http://www.microgridinstitute.org/

Part of the Solution:
Solar Power & Energy Storage

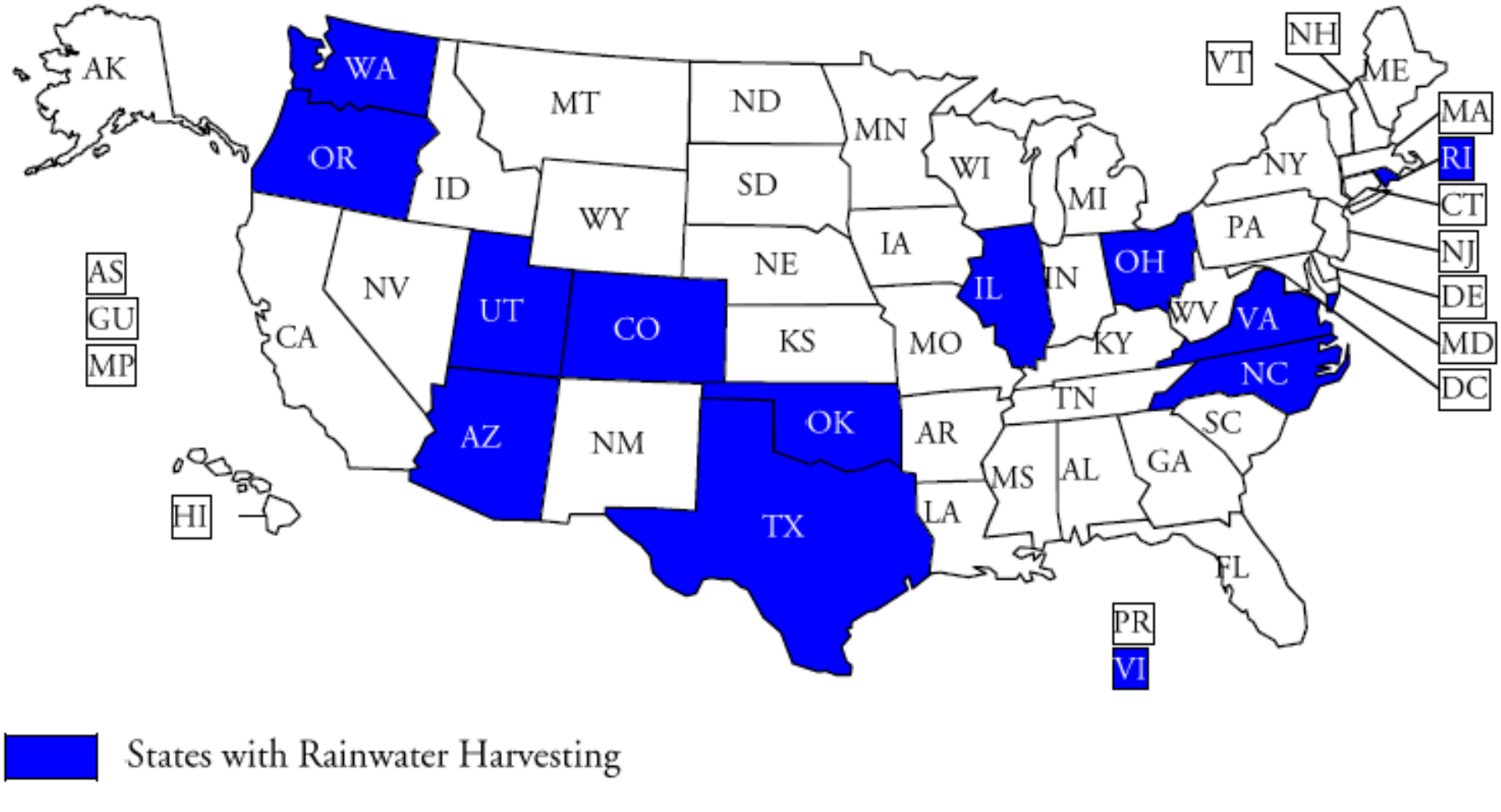


Sources: SolarCity, Tesla, U.S. Energy Information Administration, staff reports
THE WASHINGTON POST

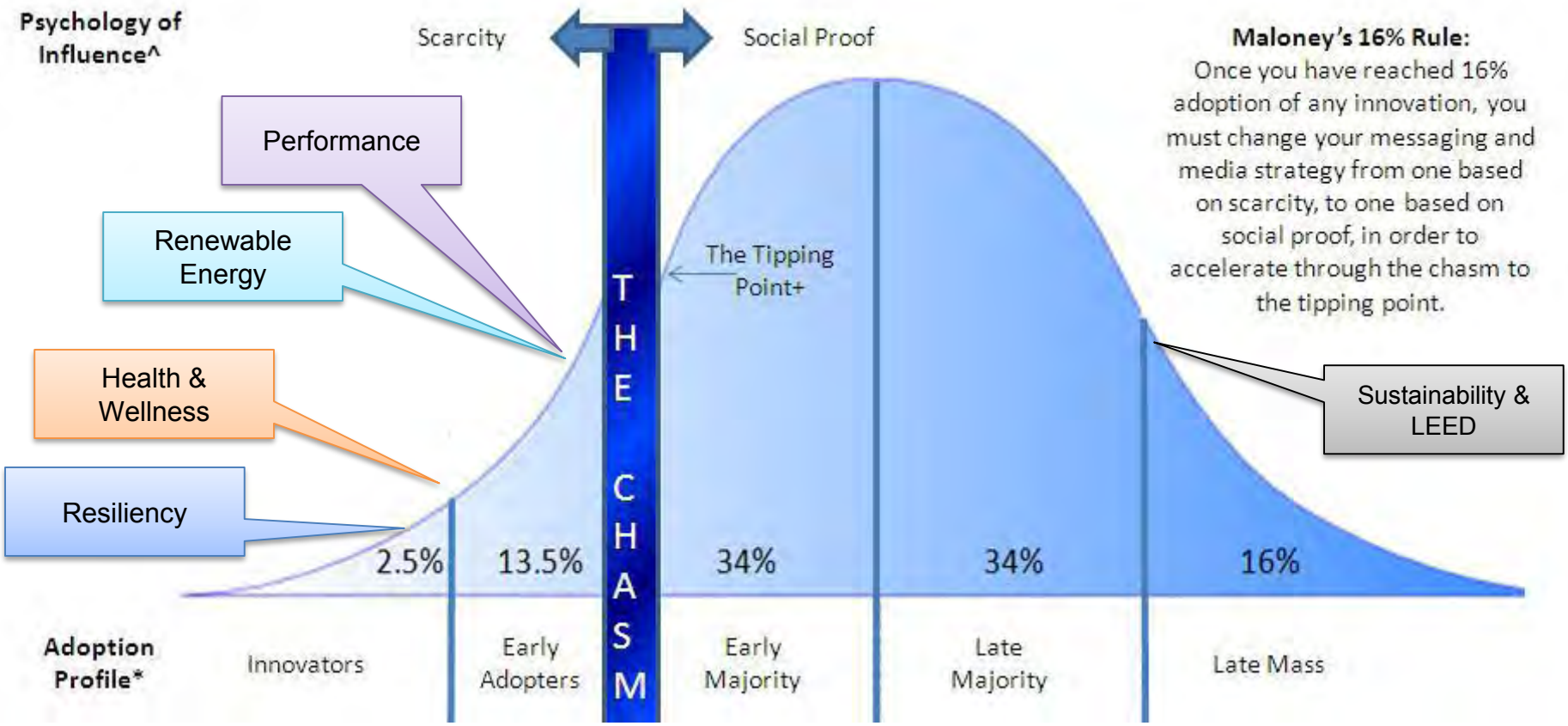
Part of the Solution:
Free Water from the Sky

Blue is the New Green: Rainwater Regulations

State Rainwater | Graywater Harvesting Laws and Legislation



Accelerating Innovation



Questions & Discussion

www.tlc-engineers.com
mark.gelfo@tlc-eng.com