# COMNET

## Commercial Energy Services Network

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Chair of COMNET Standing Committee

December 6, 2010

# Commercial Building Energy Modeling Guidelines and Procedures

- The Commercial Building Energy Modeling Guidelines and Procedures have detailed procedures for energy modeling of commercial buildings and comparing against multiple baseline standards.
- The current procedures three calculation purposes:
  - federal tax deductions (ASHRAE 90.1-2001),
  - green building ratings (ASHRAE Standard 90.1-2007), and
  - energy labels
- Future purposes could include:
  - code compliance
  - zero energy performance index (zEPI)

# Status of the Modeling Guidelines and Procedures

- Developed in 2009
- First public review in first quarter of 2010
- Second public review in July 2010
- Published August 2010
- Visit www.imt.org/COMNET to download document

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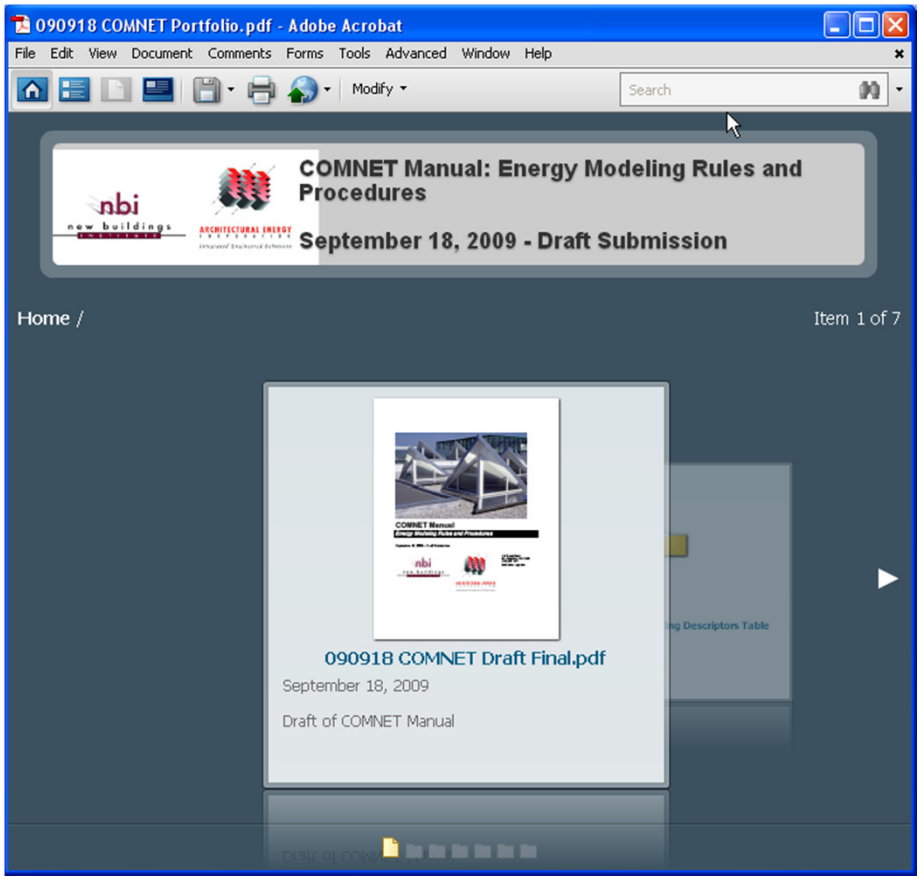
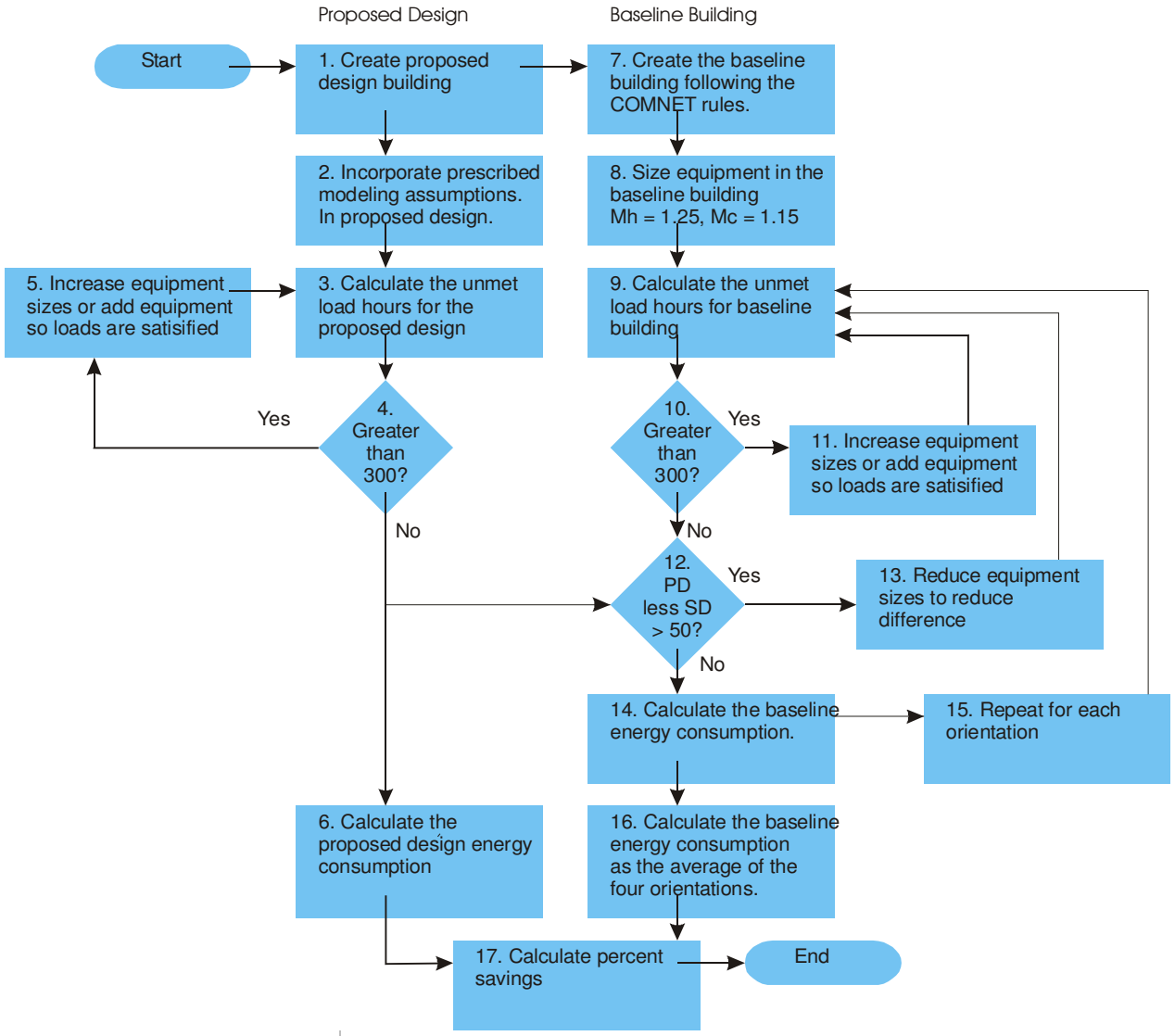


# Chapter 2 – General Modeling Procedures



# Chapter 3 – Software Requirements

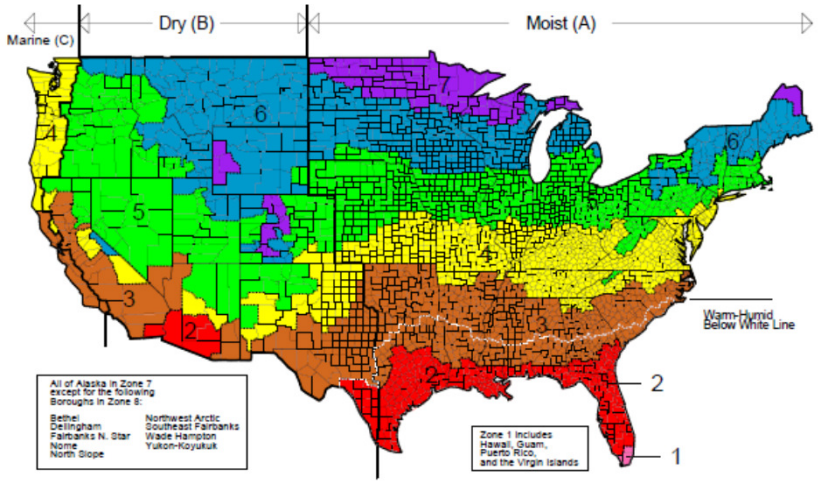
- ASHRAE Standard 140-2007 with acceptance criteria added
- Supplemental tests to verify that prescribed or default modeling assumptions are correctly applied and that the baseline building is correctly created.

# Chapter 4 – Content and Format of Standard Reports

- XML format developed for efficient data exchange
- Standard Reports to be developed from
  - Building Summary
  - Energy Measures
  - Energy Results
  - Representations

# Chapter 5 – Energy Costs and Currency

- Based on California approach to TDV
- Uses DOE/ASHRAE climate zones
- Built from wholesale energy prices
- Default time-of-use energy tariffs for 16 climate zones

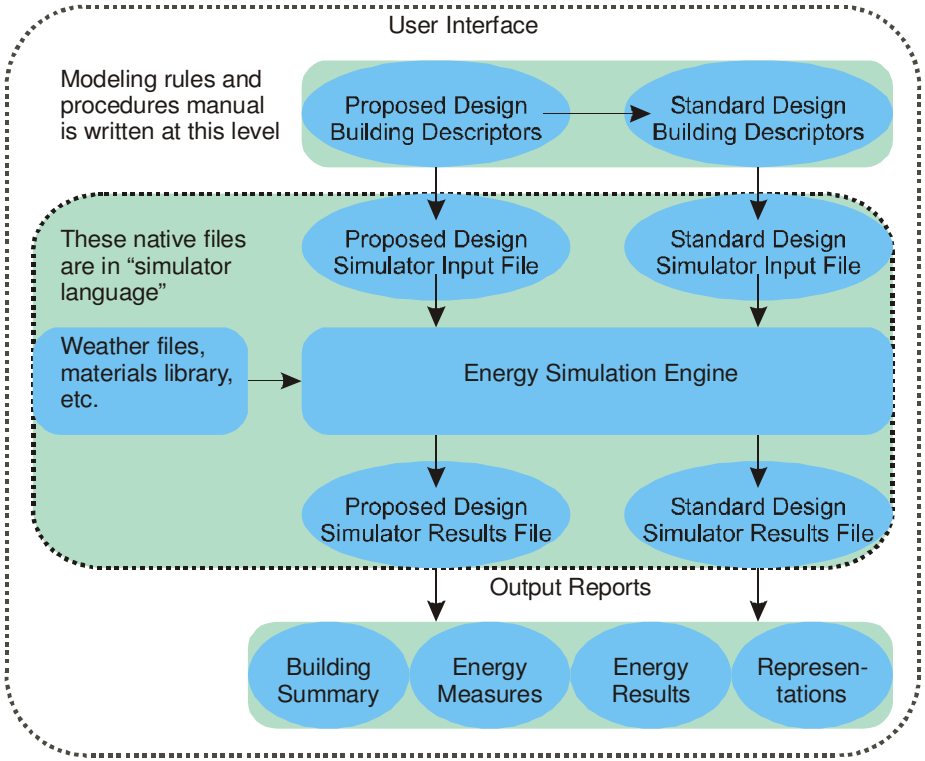



## Example for Zone 4A

| Fuel | Seasons | Day Types | Time Periods | Hours in TOU Period (1-24) | Present Value of Energy Cost |
|---|---|---|---|---|---|
| Electricity ($/kWh) | Summer (June-August) | Weekdays | Peak | 12-20 | $3.41 |
| | | | Mid-Peak | 8-11, 21-23 | $1.02 |
| | | | Off-Peak | 24-7 | $0.83 |
| | | Weekends/Holidays | Off-Peak | 1-24 | $0.83 |
| | Fall (September-November) | Weekdays | Peak | NA | NA |
| | | | Mid-Peak | 7-24 | $0.88 |
| | | | Off-Peak | 1-6 | $0.72 |
| | | Weekends/Holidays | Off-Peak | 1-24 | $0.72 |
| | Winter (December-February) | Weekdays | Peak | NA | NA |
| | | | Mid-Peak | 7-20 | $0.96 |
| | | | Off-Peak | 21-6 | $0.83 |
| | | Weekends/Holidays | Off-Peak | 1-24 | $0.83 |
| | Spring (March-May) | Weekdays | Peak | NA | NA |
| | | | Mid-Peak | 8-22 | $0.95 |
| | | | Off-Peak | 23-7 | $0.77 |
| | | Weekends/Holidays | Off-Peak | 1-24 | $0.77 |
| Gas ($/therm) | Low Demand Season (April-October) | All | All | 1-24 | $9.07 |
| | High Demand Season (November-March) | All | All | 1-24 | $11.99 |
| Steam ($/Mlb) | Low Demand Season (April-October) | All | All | 1-24 | $130.05 |
| | High Demand Season (November-March) | All | All | 1-24 | $171.95 |
| Chilled Water ($/ton-hr) | Low Demand Season (April-October) | All | All | 1-24 | $1.12 |
| | High Demand Season (November-March) | All | All | 1-24 | $1.48 |

# Chapter 6 – Building Descriptors Reference

- In series with the Performance Rating Method (90.1 Appendix G)
- Establishes baseline and credits for:
  - Commercial refrigeration
  - Plug loads
  - Swimming pools
  - On-site power generation
  - Exterior lighting
- Establishes baseline (no credit) for vertical transportation and other components



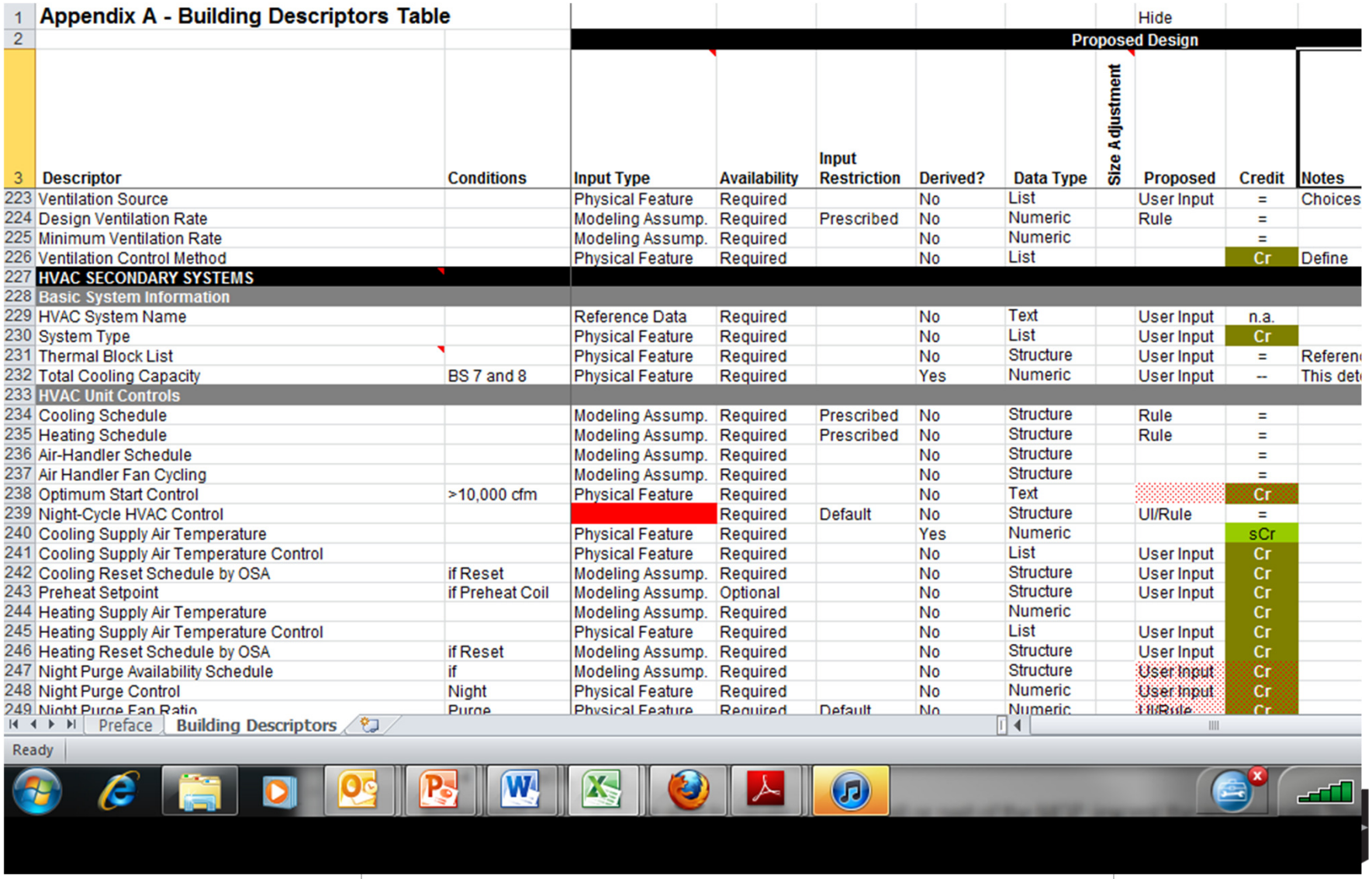
# Anatomy of a "Building Descriptor"

- **Application**. Information on when the building descriptor applies to the proposed design
- **Definition**. A definition for the building descriptor
- **Units**. The units that are used to prescribe the building descriptor
- **Input Restrictions**. Any restrictions on information that may be entered for the proposed design
- **Baseline Rules**. Any restrictions on information that may be entered for the proposed design

# Chapter 7 – Modeling Tips

- Challenging Building Types
  - Laboratories
  - Health Care
  - Data Centers
- Design Features
  - Automatically controlled window shades
  - Chilled Beams
  - Dedicated Outside Air Systems (DOAS)
  - Displacement ventilation
- Design Features (continued)
  - Gas engine driven heat pumps
  - Ground source heat pumps
  - Ice Bear type thermal storage
  - Radiant Heating or Cooling
  - Switchable glazing
  - UFAD
  - Variable flow refrigerant charge

# Appendix A – Building Descriptors Table



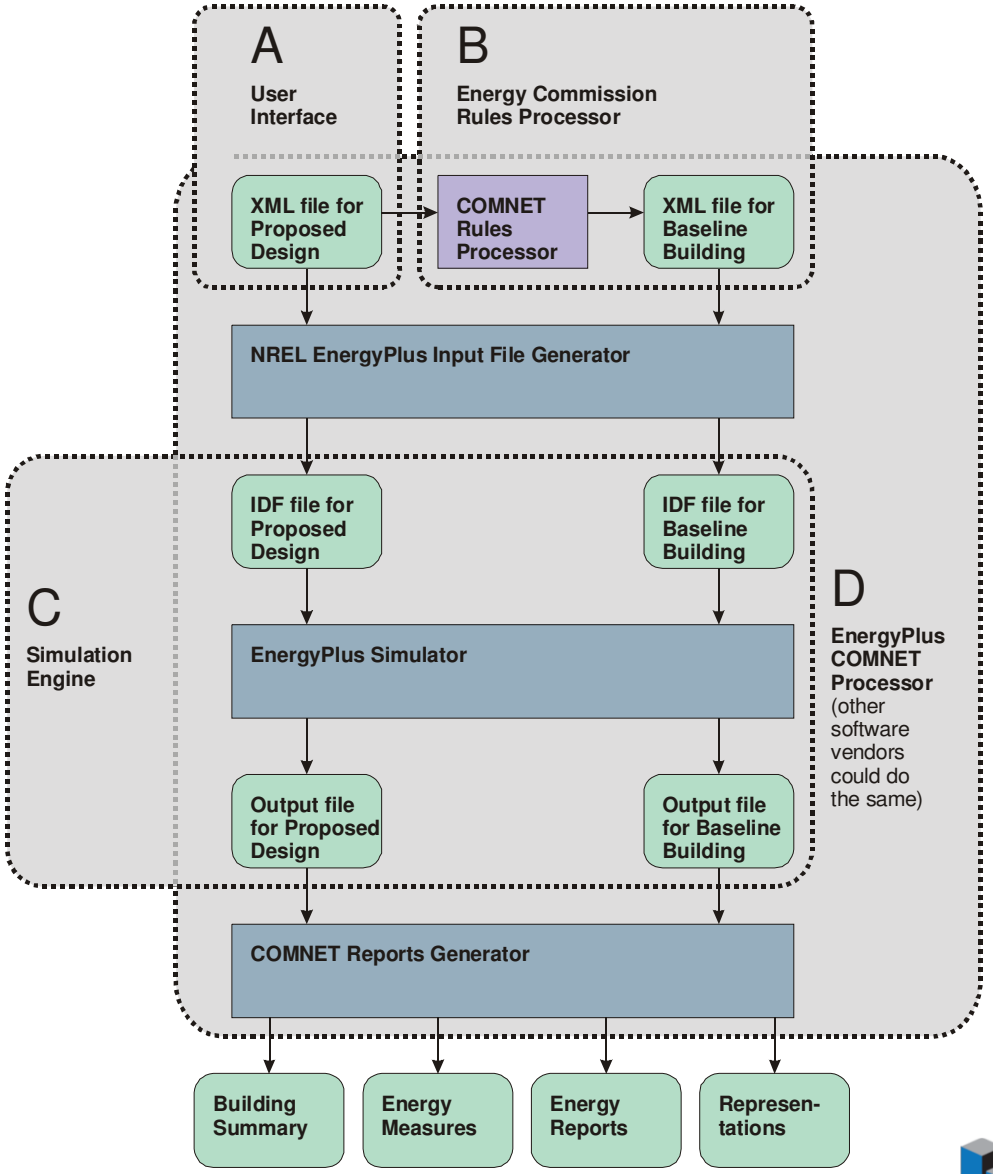
| | Appendix A - Building Descriptors Table | | | | | | | | Hide | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | | Proposed Design | | |
| 3 | Descriptor | Conditions | Input Type | Availability | Input Restriction | Derived? | Data Type | Size Adjustment | Proposed | Credit | Notes |
| 223 | Ventilation Source | | Physical Feature | Required | | No | List | | User Input | = | Choices |
| 224 | Design Ventilation Rate | | Modeling Assump. | Required | Prescribed | No | Numeric | | Rule | = | |
| 225 | Minimum Ventilation Rate | | Modeling Assump. | Required | | No | Numeric | | | = | |
| 226 | Ventilation Control Method | | Physical Feature | Required | | No | List | | | Cr | Define |
| 227 | HVAC SECONDARY SYSTEMS | | | | | | | | | | |
| 228 | Basic System Information | | | | | | | | | | |
| 229 | HVAC System Name | | Reference Data | Required | | No | Text | | User Input | n.a. | |
| 230 | System Type | | Physical Feature | Required | | No | List | | User Input | Cr | |
| 231 | Thermal Block List | | Physical Feature | Required | | No | Structure | | User Input | = | Referen |
| 232 | Total Cooling Capacity | BS 7 and 8 | Physical Feature | Required | | Yes | Numeric | | User Input | -- | This det |
| 233 | HVAC Unit Controls | | | | | | | | | | |
| 234 | Cooling Schedule | | Modeling Assump. | Required | Prescribed | No | Structure | | Rule | = | |
| 235 | Heating Schedule | | Modeling Assump. | Required | Prescribed | No | Structure | | Rule | = | |
| 236 | Air-Handler Schedule | | Modeling Assump. | Required | | No | Structure | | | = | |
| 237 | Air Handler Fan Cycling | | Modeling Assump. | Required | | No | Structure | | | = | |
| 238 | Optimum Start Control | >10,000 cfm | Physical Feature | Required | | No | Text | | | Cr | |
| 239 | Night-Cycle HVAC Control | | | Required | Default | No | Structure | | UI/Rule | = | |
| 240 | Cooling Supply Air Temperature | | Physical Feature | Required | | Yes | Numeric | | | sCr | |
| 241 | Cooling Supply Air Temperature Control | | Physical Feature | Required | | No | List | | User Input | Cr | |
| 242 | Cooling Reset Schedule by OSA | if Reset | Modeling Assump. | Required | | No | Structure | | User Input | Cr | |
| 243 | Preheat Setpoint | if Preheat Coil | Modeling Assump. | Optional | | No | Structure | | User Input | Cr | |
| 244 | Heating Supply Air Temperature | | Modeling Assump. | Required | | No | Numeric | | | Cr | |
| 245 | Heating Supply Air Temperature Control | | Physical Feature | Required | | No | List | | User Input | Cr | |
| 246 | Heating Reset Schedule by OSA | if Reset | Modeling Assump. | Required | | No | Structure | | User Input | Cr | |
| 247 | Night Purge Availability Schedule | if | Modeling Assump. | Required | | No | Structure | | User Input | Cr | |
| 248 | Night Purge Control | Night | Physical Feature | Required | | No | Numeric | | User Input | Cr | |
| 249 | Night Purge Fan Ratio | Purge | Physical Feature | Required | Default | No | Numeric | | UI/Rule | Cr | |

Preface | Building Descriptors

Ready

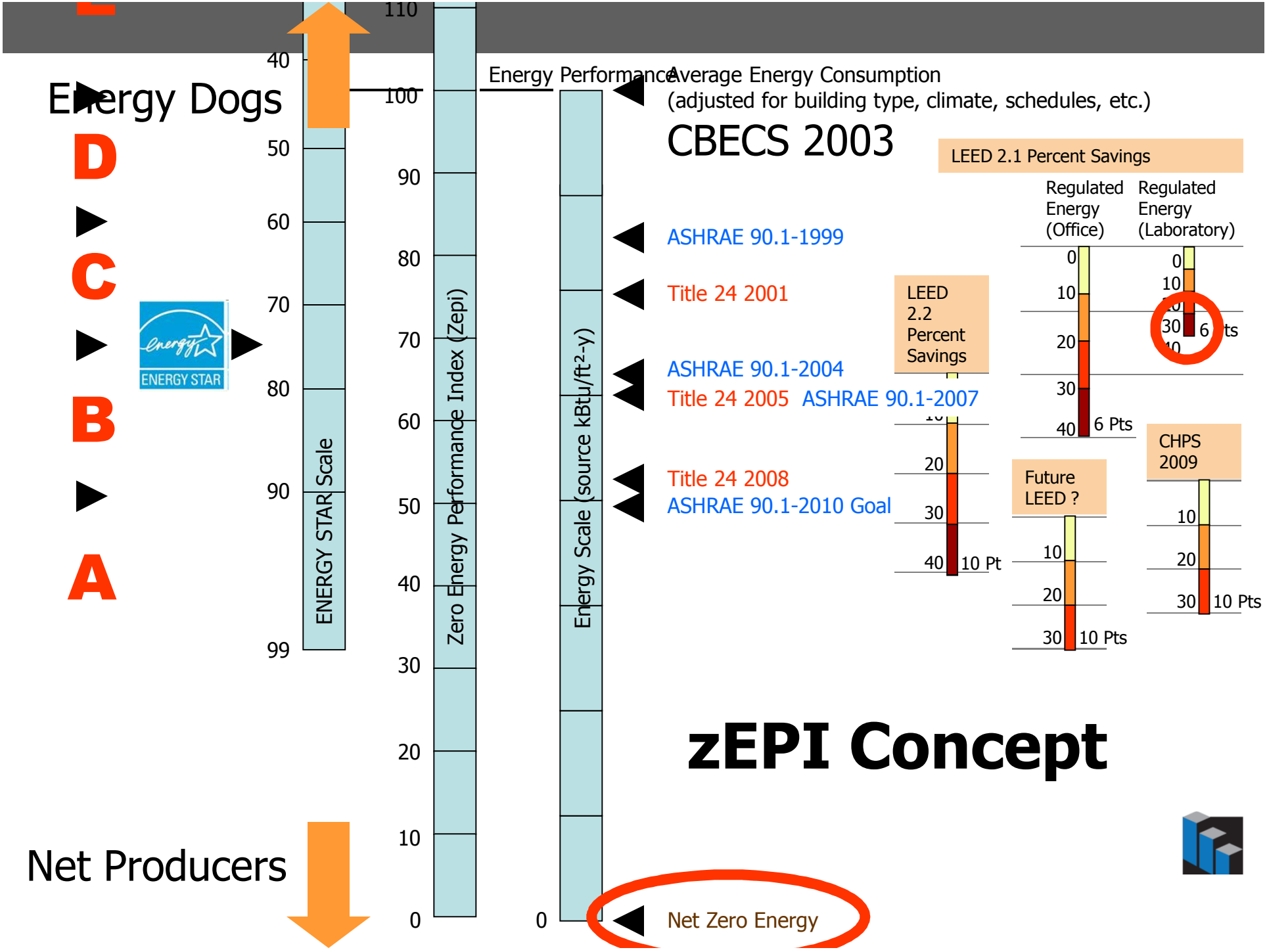
# XML Implementation

- Build on gbXML
- Expand for all building descriptors
- Build rules processor to automatically create baseline building
- Each simulation engine would process the XML files, create native input files, do simulations, and post-process results.



# The Problem with Multiple Baselines

- ASHRAE 90.1
  - 1999
  - 2001 (tax credits)
  - 2004
  - 2007 (green building ratings)
  - 2010
- IECC
  - 2006
  - 2012
- IgCC
- California Title 24
  - 2001
  - 2005
  - 2008
  - 2011
- CalGreen
- Other States
  - Oregon
  - Washington
  - Florida
  - New York
  - Massachusetts


Energy Dogs
D
C
B
A
ENERGY STAR
ENERGY STAR Scale
40
50
60
70
80
90
99
110
100
90
80
70
60
50
40
30
20
10
0
Zero Energy Performance Index (Zepi)
Energy Performance
Energy Scale (source kBtu/ft²-y)
0
Average Energy Consumption
(adjusted for building type, climate, schedules, etc.)
CBECS 2003
ASHRAE 90.1-1999
Title 24 2001
ASHRAE 90.1-2004
Title 24 2005
ASHRAE 90.1-2007
Title 24 2008
ASHRAE 90.1-2010 Goal
Net Zero Energy
LEED 2.1 Percent Savings
Regulated Energy (Office)
Regulated Energy (Laboratory)
6 Pts
LEED 2.2 Percent Savings
10 Pt
Future LEED ?
10 Pts
CHPS 2009
10 Pts
zEPI Concept
Net Producers

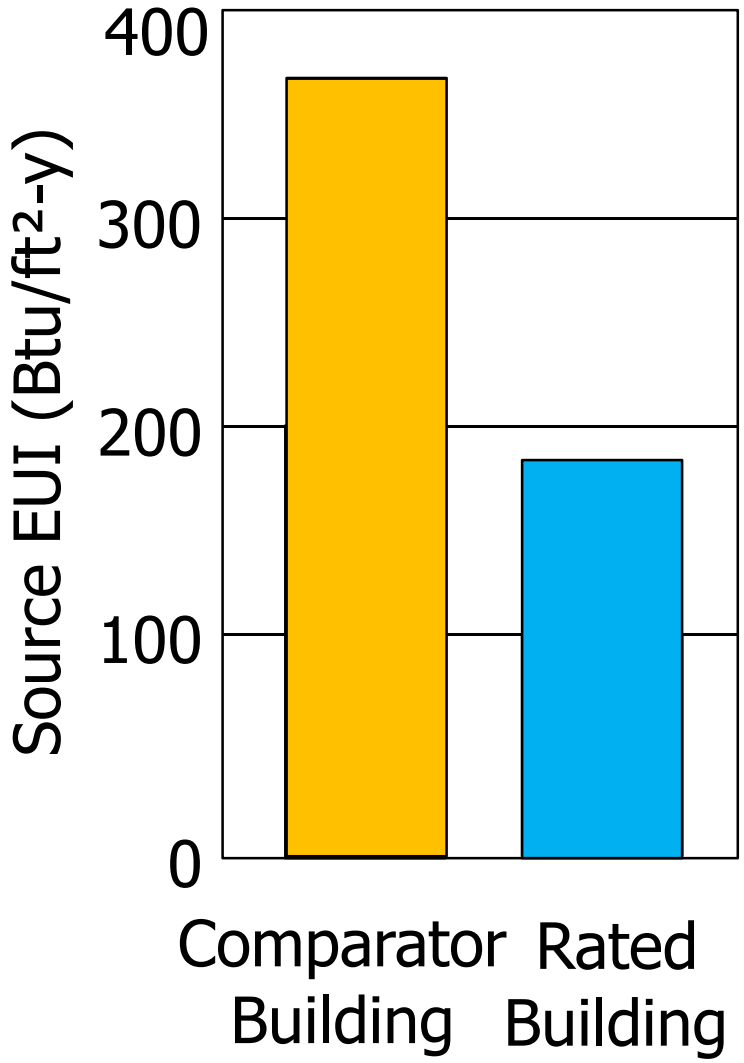
# What is zEPI?

- A unitless ratio . . .

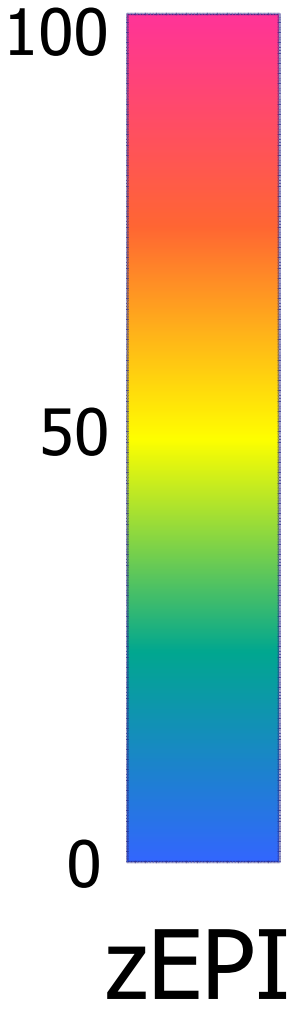
$$\text{zEPI} = \frac{\textbf{Rated Building} \text{ Energy Performance}}{\textbf{Comparator} \text{ Energy Performance}} \times 100$$

- The numerator and denominator should be determined with the same:
  - Climate
  - Building size
  - Operating Conditions
  - Other "**neutral variables**"
- EPA Source Energy is recommended, but other metrics could be used such as cost, site energy, or carbon emissions.
- It is recommended that the denominator represent the energy performance of an average existing building, per CBECS 2003.

# What happens if the building is operated 24x7?

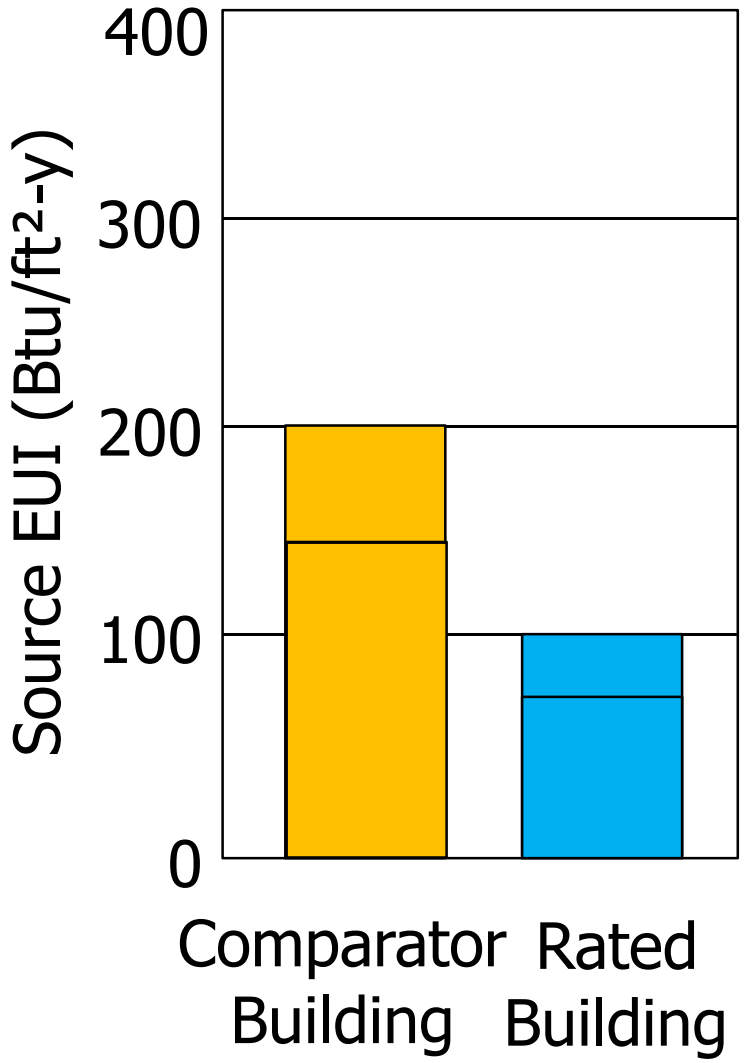



The EUI of both the comparator and rated buildings go up a lot

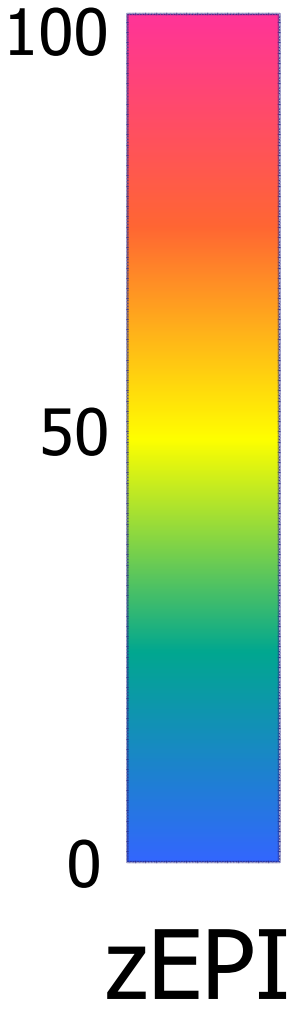



But zEPI is relatively unchanged

# If plug loads and operation hours are reduced ?

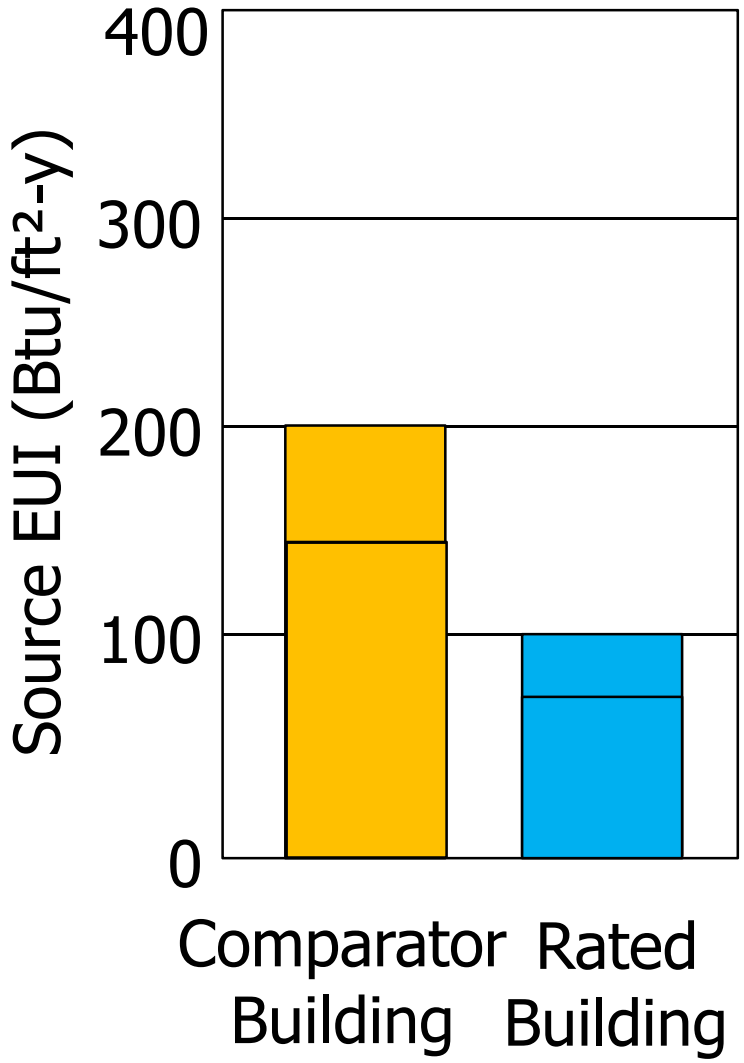



The EUI of both the comparator and rated buildings goes down

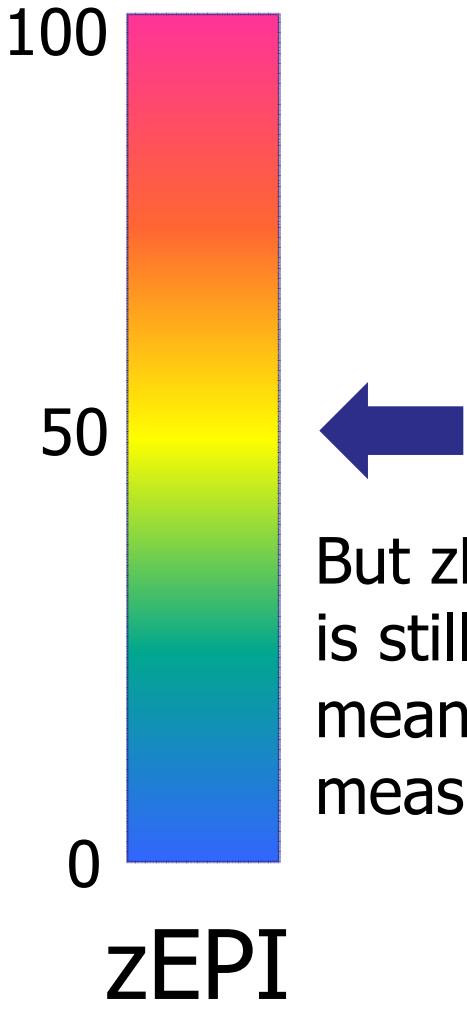



But zEPI is relatively unchanged

If we use utililty bills instead of models?

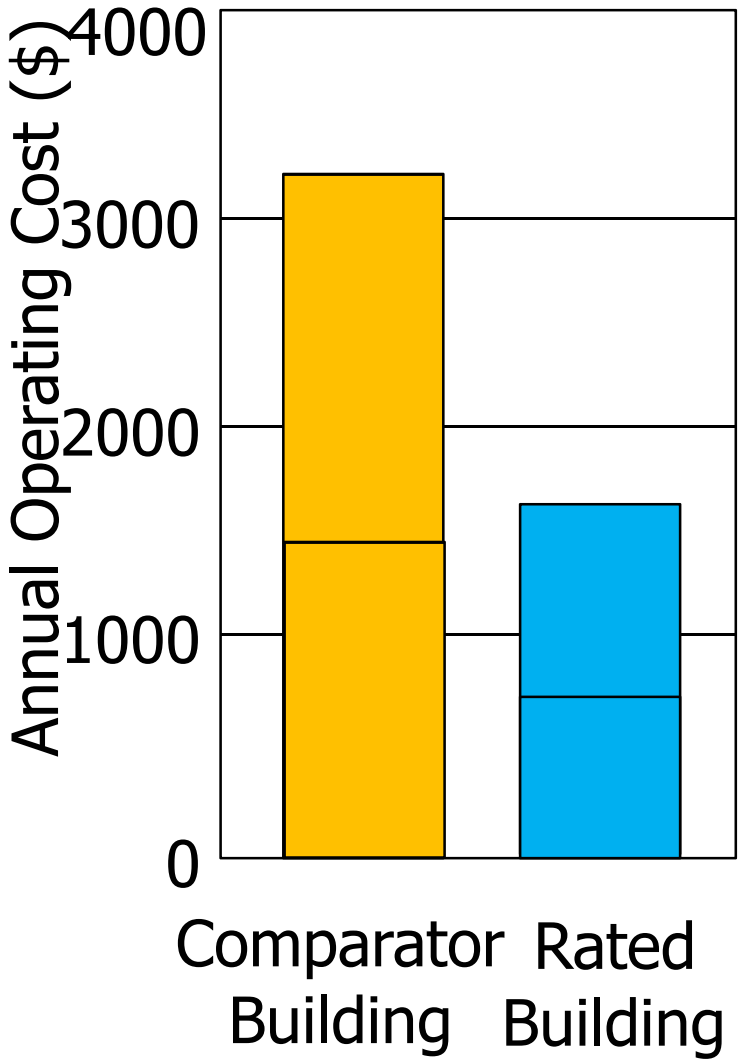



The EUI of both the comparator and rated buildings may not match the modeling results

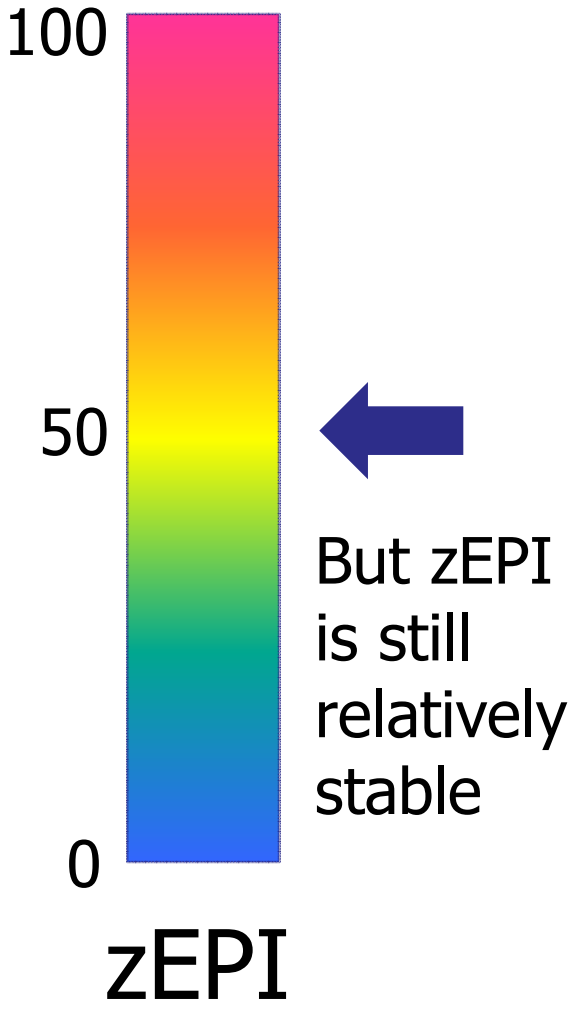



But zEPI is still a meaningful measure

If we substitute another metric like cost?




The scale on this graph changes

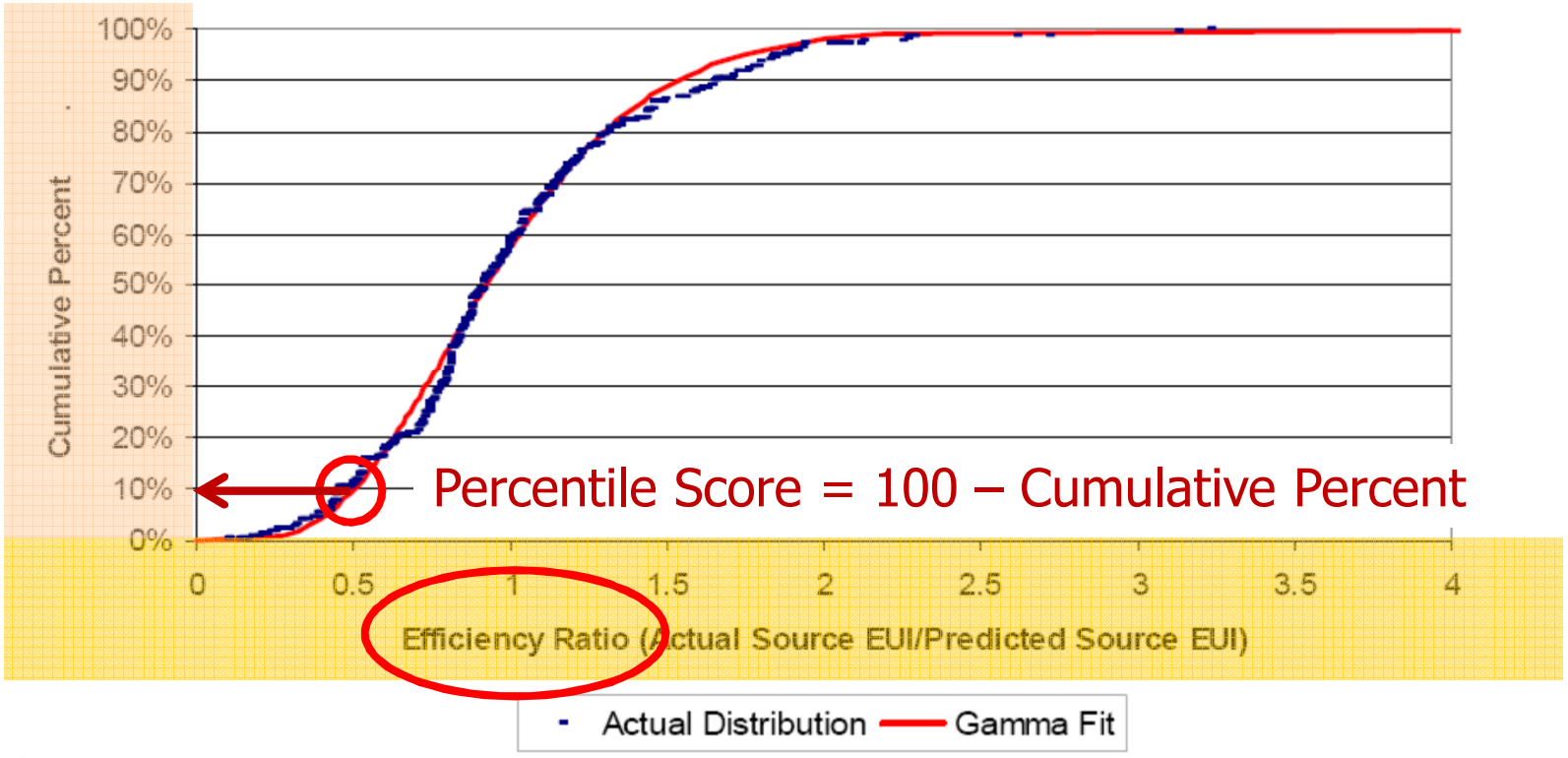



But zEPI is still relatively stable

# zEPI is already used as part of ENERGY STAR

The ENERGY STAR percentile scale is a direct transformation from zEPI (or what EPA calls the Efficiency Ratio)

The gamma curve has a different shape for other building types, but it makes the statistical transformation from zEPI to the EPA percentile.



# zEPI applies to both the performance and outcome approach

- **Performance Approach**
  (New Buildings)
  - No energy bills exist so performance must be determined through models
  - Average energy use (the denominator) should also be determined through models
    - Provides consistency
    - Models are good for comparisons
    - Inherently neutralizes for climate, operating conditions, etc.

- **Outcome Approach**
  (Existing Buildings)
  - Compare utility bills of the rated building to average utility bills determined from CBECS
  - Same process as ENERGY STAR Portfolio Manager
  - EPA regression equations neutralize for climate, operating conditions, etc.

# Options for the Performance Approach (New Buildings)

- Directly calculate the energy performance of the comparator building
  - A modeling approach for doing this is being developed as part of the ASHRAE Building EQ Asset Rating (As Designed) process.

$$zEPI = 100 \times \left( \frac{sEUI_{Rated}}{sEUI_{BldgEQ}} \right)$$

- Ultimately this is what we want to do
- A foundation for this is being developed as part of the ASHRAE Building EQ Asset Rating program

- Calculate the energy performance of a known (or assumed) reference point on the scale
  - This approach is currently in the IgCC
  - Minimum compliance with IECC 2006 results in a zEPI of 73
  - Goal is a 30% reduction from this base, which results in a target of 51

$$zEPI = 73 \times \left( \frac{sEUI_{Rated}}{sEUI_{IECC2006}} \right)$$

- The “73” may change for different buildings and climates

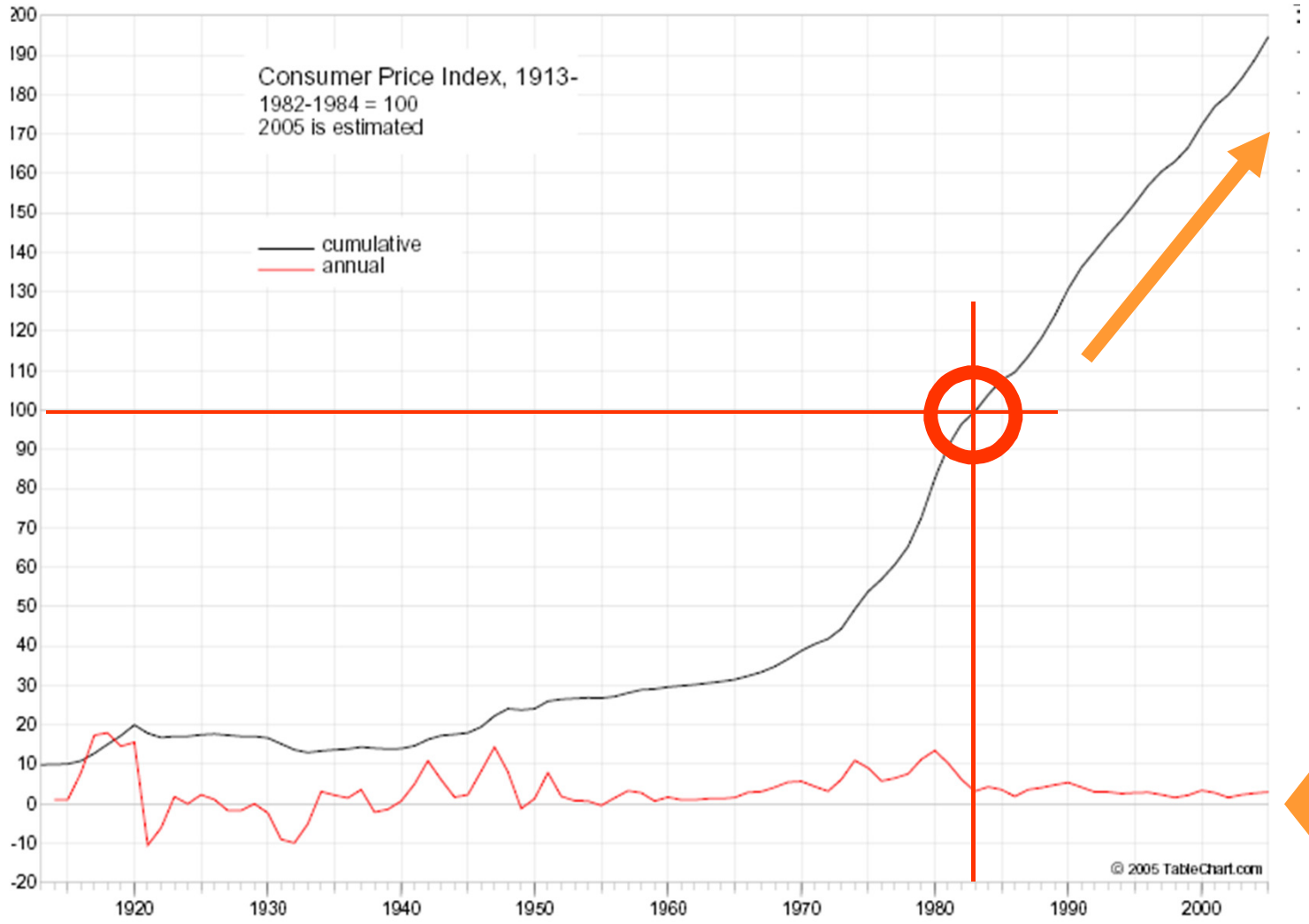
## More is Better

- US EPA mileage ratings
- Examination grades
- Gross domestic product

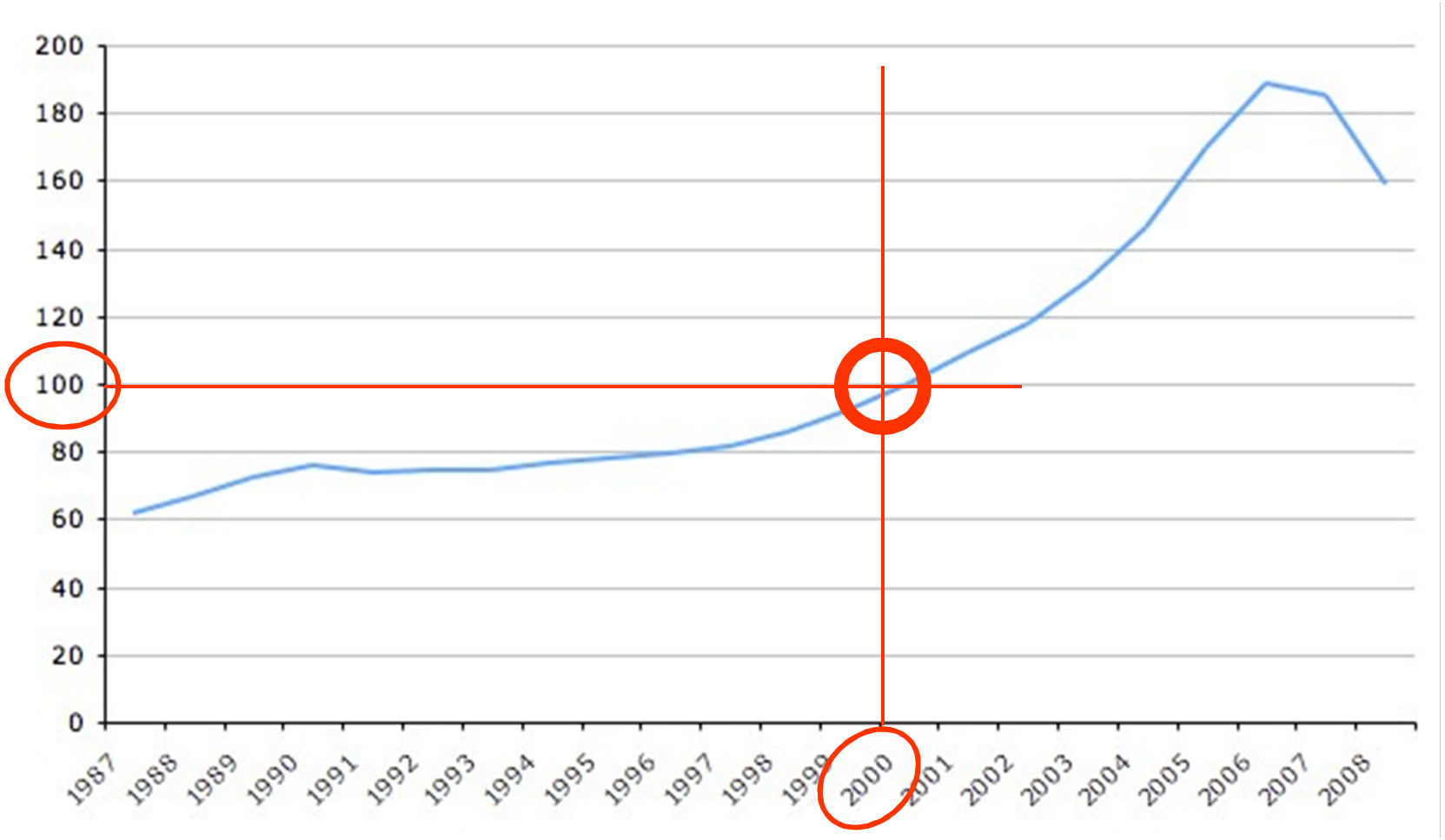
## Less is Better

- European mileage ratings (liters/100 km)
- Weight watcher points
- HERS Ratings
- Regional cost adjustments

# A parallel concept, the Consumer Price Index



# A parallel concept, the Case-Shiller Home Price Index



# Benefits of a zEPI Style Scale

- Stable over time
- Reduces the confusion associated with moving baselines
- Is technically consistent with the EPA ENERGY STAR scale
- Related to real-life energy consumption
- It works as we set goals that get us closer to net zero energy
- Works for both asset ratings and operational ratings
- Works for both new and existing buildings

# Future Potential

- Presents the opportunity to have a standard test procedure for all buildings based on  and a uniform and stable scale.
  - We don't redefine the way we test windows, wall assemblies or air conditioners each time we change the standard for these items.
  - Yet for the whole building, this is exactly what we do. Each time we make changes to the standard, the way we evaluate performance changes.
- With a stable procedure that does not change over time, software developers will be able to automate the process, which will bring more replicability, reliability and confidence.
- Energy code updates will be as simple as referencing a new point on the zEPI scale.

# The End

Visit www.COMNET.org

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