Energy Codes *IN ACTION*

Emergng Software for Energy Performance Standards

Charles Eley, FAIA, PE

Learning Objectives

Participants will be able to:

- Judge which types of building projects are best suited for the performance approach.
- Examine software applications to determine if they are suitable for energy code compliance.
- Explain to permit applicants the type of documentation that is expected when the performance approach is used.
- Assess compliance documentation that is submitted using the performance approach.

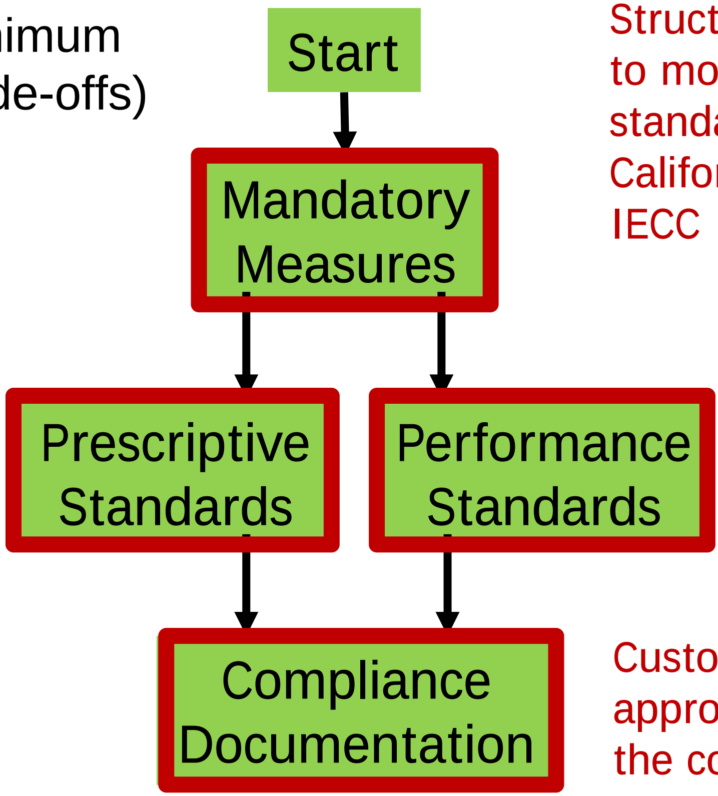
Presentation Outline

- Fundamental compliance approaches
  - Prescriptive
  - Performance
- The performance approach will become more frequent
  - Paucity of prescriptive standards
  - Need for flexibility
  - The California story
- COMNET – A specification for compliance software
- Examples of compliance software
  - CBECC-Com California
  - CBECC-Com 90.1-2010
- zEPI and the movement toward a stable baseline, e.g Addendum 90.1-BM. With this approach, the same modeling work flow may used for:
  - Code compliance
  - LEED points and green building codes
  - Utility incentives, etc.

Performance Standards History and Fundamentals

Basic Code Structure

- **Mandatory measures** (sets minimum level of performance with no trade-offs)
- **Compliance Options**
  - **Prescriptive**
    - Lighting
    - Envelope
      - – Prescriptive
      - – Trade-off procedures
    - HVAC (mechanical)
    - Water Heating
    - Other
  - **Performance**
    - Can make trade-offs between prescriptive standards
    - ASHRAE uses cost
    - California uses time dependent valued energy



Structure is common to most energy standards, including California, ASHRAE and IECC

Custom budget approach has become the common method, as opposed to fixed energy budgets

Calculations and forms are submitted to the building department for a permit

Early Attempts at Performance Standards

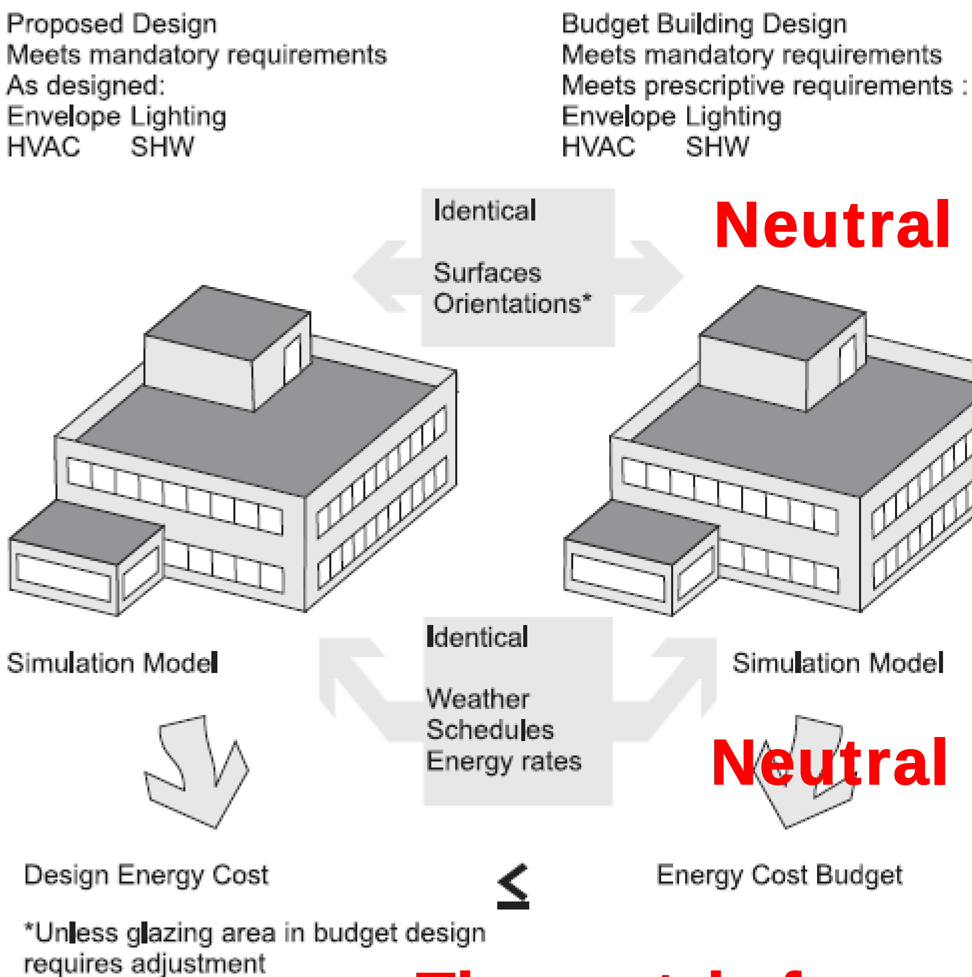
- Based on fixed energy budgets in Btu/ft²-y or kWh/m²-y
- Examples
  - BEPS (Building Energy Performance Standards) at the federal level circa 1980
  - California 1978 nonresidential standards

	Climate 1	Climate 2	Climate 3	Etc.
Offices	xx	xx	xx	xx
Retail	xx	xx	xx	xx
Schools	xx	xx	xx	xx
Hotel	xx	xx	xx	xx
Warehouse	xx	xx	xx	xx
Etc.	xx	xx	xx	xx

Emergence of the Custom Budget Approach

- California 1988 – Software Accredited by the CEC to:
  - Automatically generate the baseline building
  - Enforce the application of neutral independent and neutral dependent building inputs
  - Drastically reduced "gaming" and brought more credibility to the performance approach
- ASHRAE Standard 90.1-1989
  - Followed suit with a slightly modified approach using a prototype building with an aspect ratio of 2.5:1 and the long dimensions facing east and west
- ASHRAE Standard 90.1-1999 (and subsequent additions)
  - Implemented a more "pure" custom budget approach more similar to California. This is called the Energy Cost Budget Method (ECB)
- ASHRAE Standard 90.1-2004 Appendix G (and subsequent additions)
  - Performance rating method used for LEED and other "reach" program
  - Can now be used for code compliance

How the Custom Budget Approach Works



Neutral Dependent

Neutral Independent

The metric for comparing energy performance can vary

Energy Metrics

- Site
- Source
- Cost
- TDV

1 kWh =
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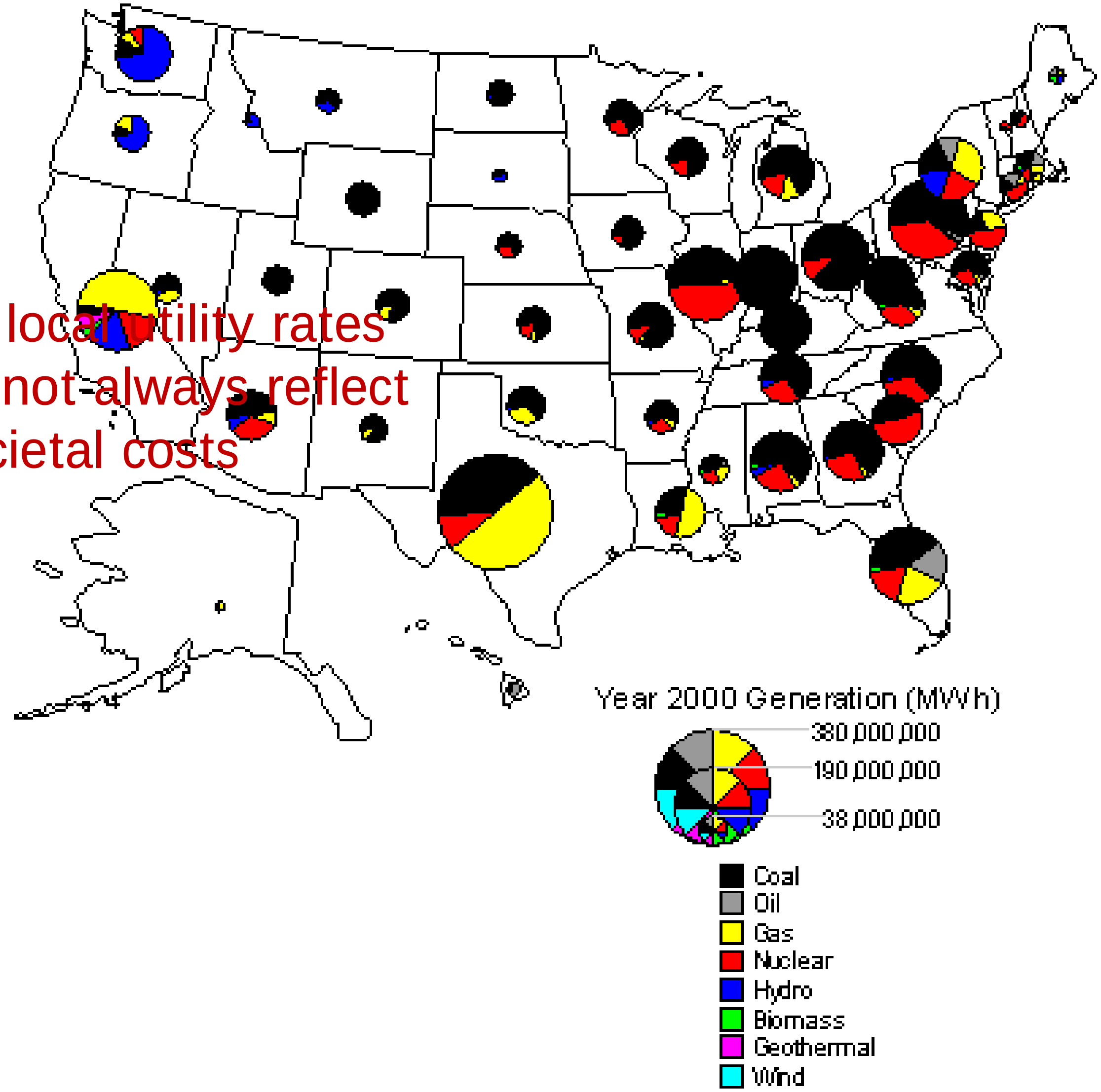
and trans

Based on local utility rates which do not always reflect actual societal costs



Controlling the Energy Calculation Process

	Rated Building	Comparator
Building Assets **These inputs are the only ones that may be different** **The energy modeler only enters this information**	• Insulation • Fenestration • HVAC systems • Lighting • Equipment efficiency	• Values set to code minimum levels • HVAC systems determined through mapping
Neutral Dependent	• Building geometry • Outdoor lighting • Fenestration Area (up to 40%) • Zoning	• Same as the rated building • Data “inherited” from rated building
Neutral Independent **These inputs remain the same with no credit or penalty**	• Plug loads • Occupancy • Schedules • Outside Air • Infiltration	• Same as the rated building

Current Bottoms-up Code Development Process

- Proponents come to the table with their favorite technology
- Each measure is evaluated and the following questions are asked:
  - Is it within the scope of the standard?
  - Is it cost effective?
  - Is it mature and offered by multiple suppliers?
- When the answer to these and other questions is yes, then the "measure" passes the tests and becomes a part of the standard. The "measures" that fail are discarded or postponed until the next code update cycle.
- After everything is sorted out, we take inventory of what passed the test and this becomes the next standard.
- Only then do we evaluate things to see what savings we have achieved.

Precedents for Top-Down Targets

- The Architecture 2030 challenge
- DOE/ASHRAE goal of xx% reduction compared to Standard 90.1-2004
- The California CPUC and CEC have said that new residential buildings will be zero net-energy by 2020.
- The same California policy makers have said that new commercial buildings are to be zero net-energy by 2030.
- California also has the goal that half of existing commercial buildings will be zero net-energy by 2030.

The Paucity of Prescriptive Standards

- Almost all building permits still use a prescriptive approach to compliance.
- Good buildings, including energy efficiency buildings are contextual.
- Prescriptive standards are good at addressing simple things like wall insulation or water heater efficiency, but they can't take advantage of the contextual opportunities presented by the microclimate, the site or the program.
- The aggressive goals for energy efficiency that have been set by California and DOE cannot be achieved through prescriptive standards.

Summary

- Code development will have to move from a bottom-up approach to a top-down approach in order to achieve our goals.
- We need to be smarter when we set the targets
- The use of performance approaches will increase
- We need to invest in the tools in infrastructure to accommodate the greater use of performance approaches
- We will probably have more third-party code verification
- Acceptance testing will be the bridge to more “outcome based” standards

The California Story

1978-1988 Fixed energy budgets were used. Multiple software applications were approved for use with few modeling rules. The Energy Commission and Code Officials had little confidence in the results.

1989-Now Custom budgets were required. Approved compliance software was required to:

- Automatically create the baseline energy model
- Produce standard output reports that are the same for all software
- Restrict modeling inputs

The Result: Virtually all residential permit applications use the performance approach.

70% or more of commercial permit applications use the performance approach.

The Energy Commission and Code Officials have confidence in the results of the calculations and that the buildings are complying.

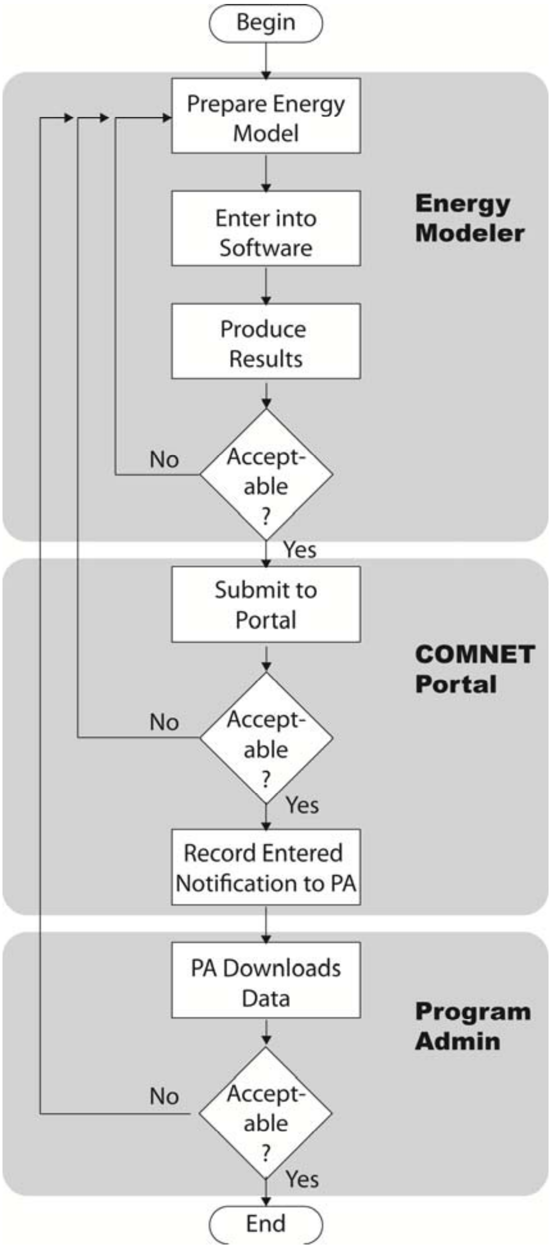
Design professionals have developed special expertise.

COMNET

COMNET
Commercial Energy Services Network

COMNET Goal

Bring the rigor of California performance standards to the national stage . . .



Modeling Guidelines and Procedures (MGP)

1. Overview
2. General Modeling Procedures
3. Software Requirements
4. Content and Format of Standard Reports
5. Energy Costs and Currency
6. Building Descriptors Reference
7. Modeling Tips for Advanced Design Features

Appendices

A – Building Descriptors

B – Modeling Assumptions and Defaults

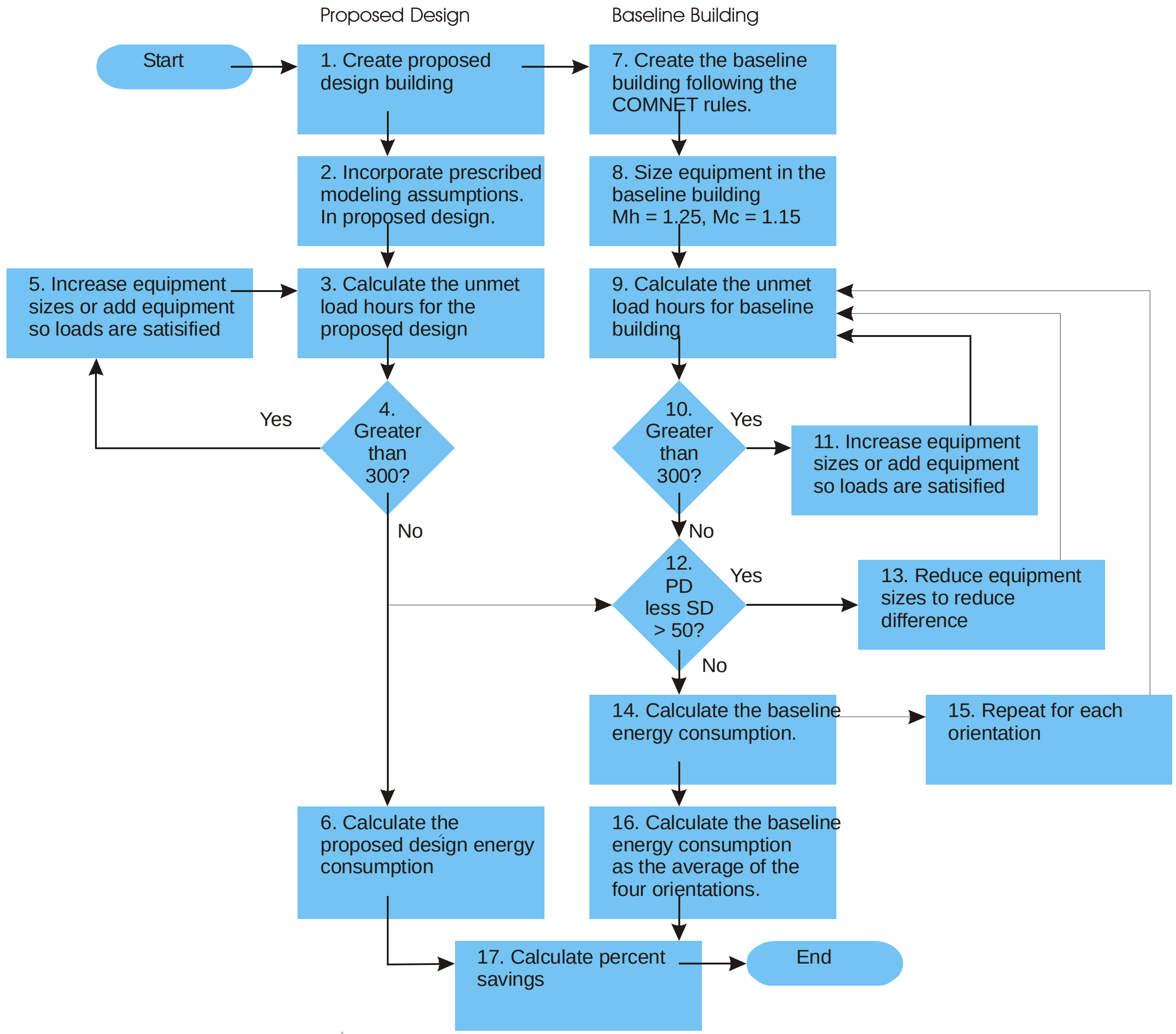
C – Schedules

D – Construction Materials

E – Software Tests

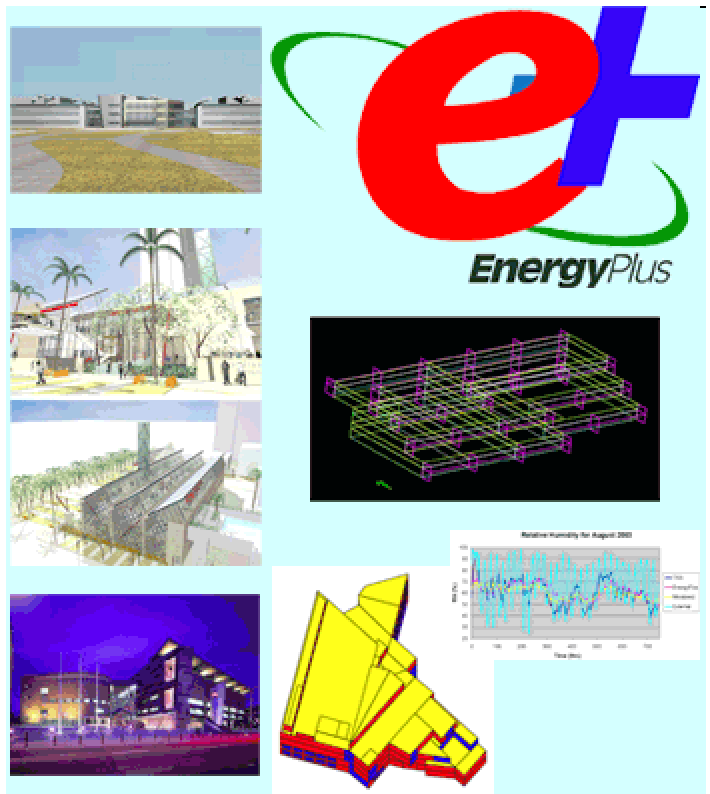
F – TOU Costs Methodology

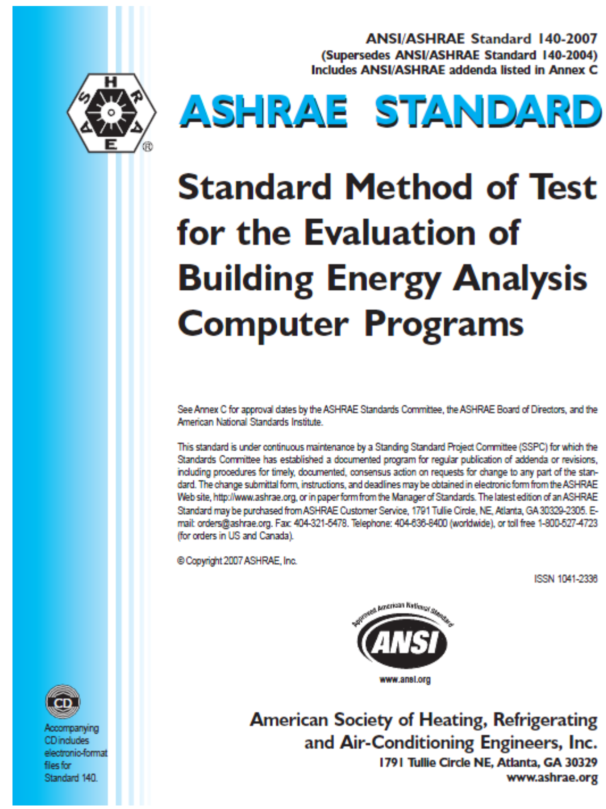
Chapter 2 – General Modeling Procedures



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.




ANSI/ASHRAE Standard 140-2007
(Supersedes ANSI/ASHRAE Standard 140-2004)
Includes ANSI/ASHRAE addenda listed in Annex C

ASHRAE STANDARD

Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs

See Annex C for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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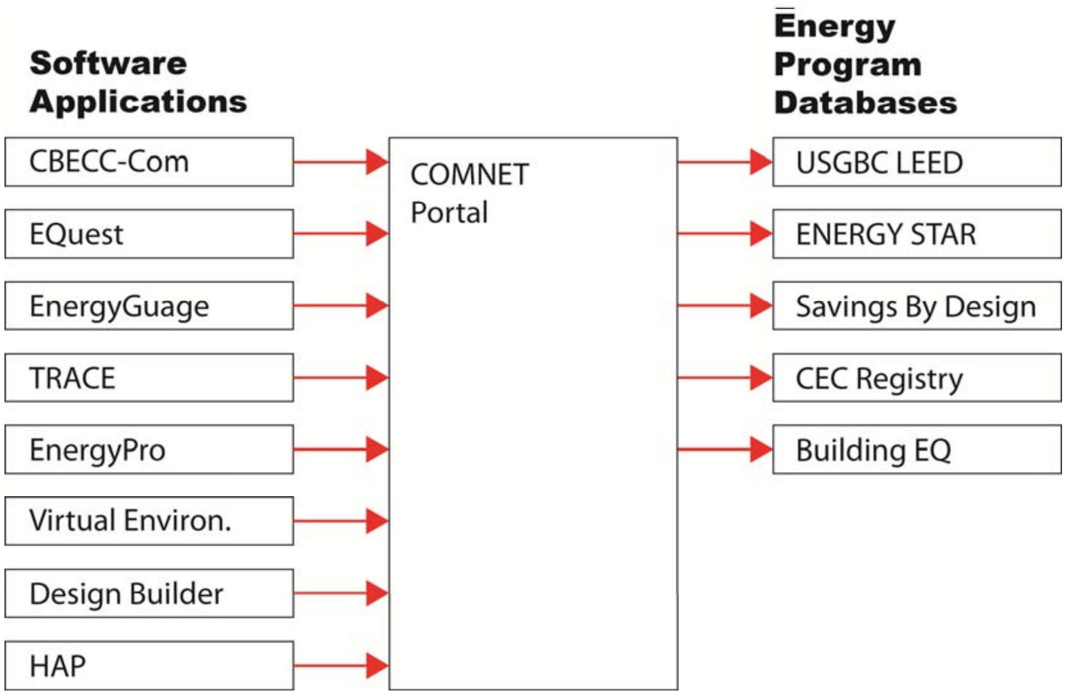
Approved American National Standard
ANSI
www.ansi.org

Accompanying CD includes electronic-format files for Standard 140.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

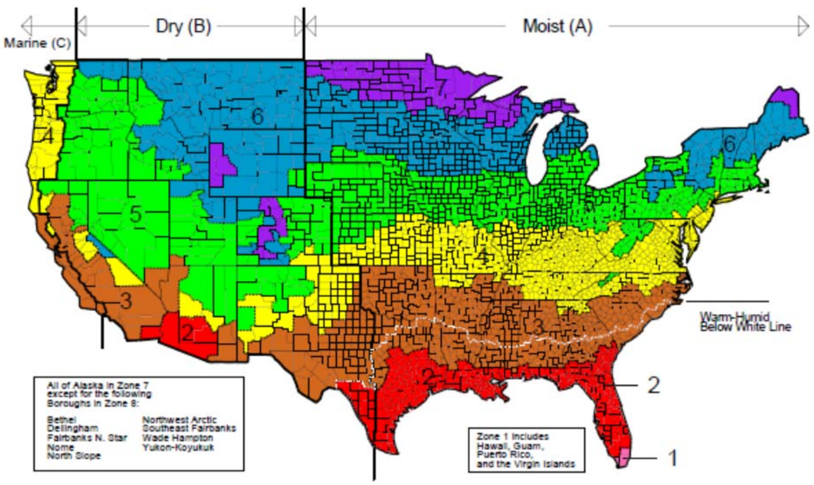
Chapter 4 – Content and Format of Standard Reports

- XML format developed for efficient data exchange
- Standard Reports
  - 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

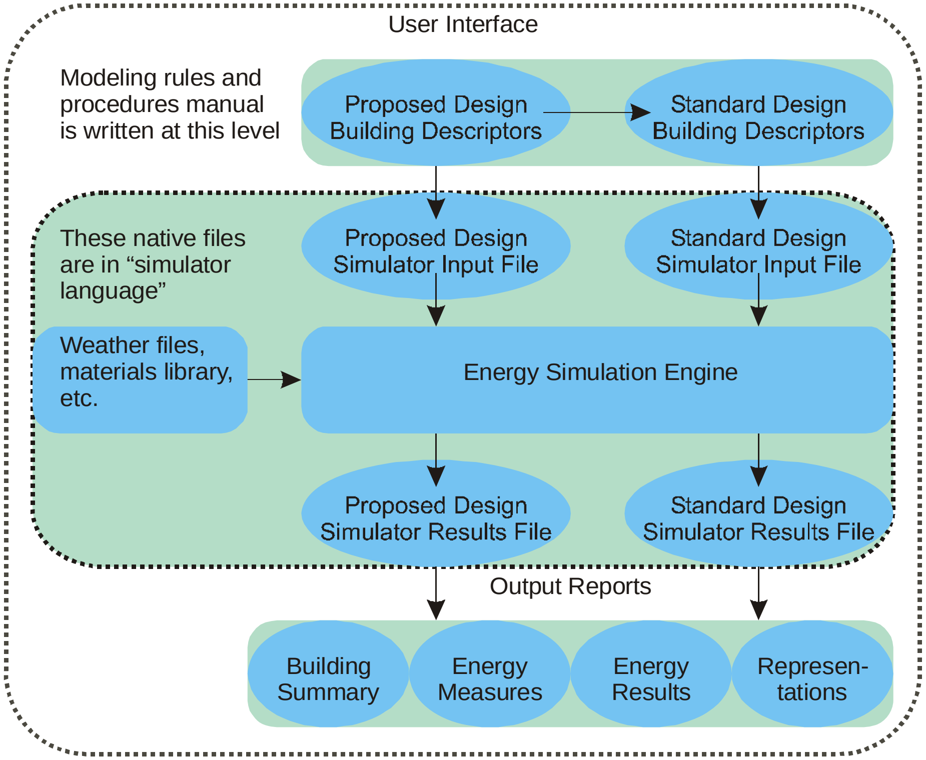


Example for Zone 4A

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

- Consistent 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



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
  - Natural Ventilation
  - Hybrid or Mixed Mode
  - No AC
  - Radiant Heating or Cooling
  - Switchable glazing
  - UFAD
  - Variable flow refrigerant charge

COMNET Appendices

Appendix A – Building Descriptors Table	Tabular summary and classification of building descriptors
Appendix B – Modeling Data	Modeling data and assumptions by building type and space use. For technical documentation on plug loads, click here.
Appendix C – Schedules	Default and prescribed schedules of operation.
Appendix D – Construction Materials	Default construction materials library.
Appendix E – Software Tests	Spreadsheets and specifications for software tests.
Appendix F – Energy Costs	Documentation of the methodology used to develop the Chapter 5 energy costs.
Appendix G – XML Schema	The COMNET compliant XML schema specified in Chapter 4 and supported by the COMNET Portal.
Appendix H – Equipment Curves	Spreadsheet that summarizes and graphs the default equipment performance curves referenced in the Modeling Guidelines and Procedures.

COMNET Stakeholders

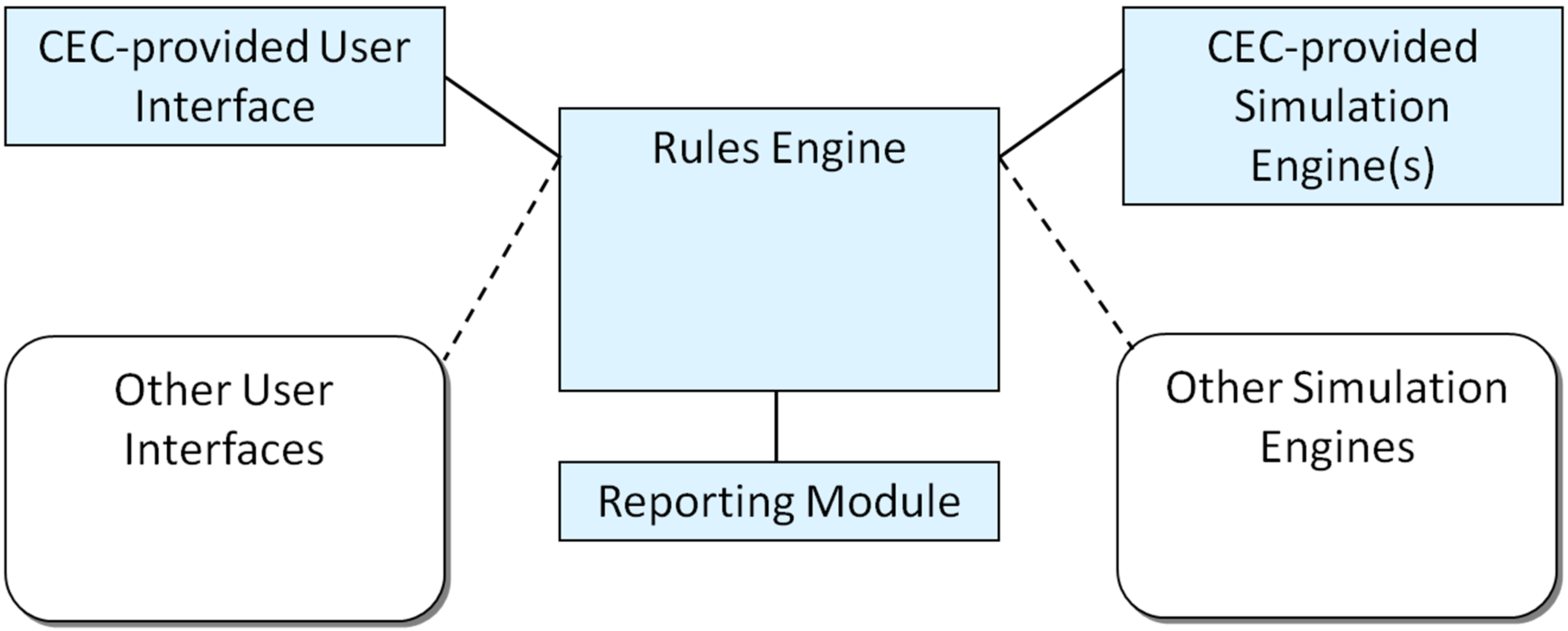
General Partners	Software Developers	Program Administrators	Energy Modelers	Credentialing Authorities
		Commonality		
Have an interest in an energy efficient future	Develop, market and support energy analysis software	Operate programs or enforce codes that depend on accurate and reliable energy modeling	Perform energy analysis on specific projects to comply with codes and recognition programs	Train and or offer credentials for qualified energy modelers
		COMNET Benefits		
More energy efficient buildings A world that is closer to being sustainable	More stable procedures for creating baseline buildings Less time required for software development, maintenance and support More profit	More confidence in modeling results and energy savings Less time reviewing energy modeling submissions Smooth and efficient data flow from energy models to the program database	No need to create baseline building Can focus more time on making buildings more energy efficiency	Increased demand for qualified energy models and related credentials

Reaching Consensus through a Web-Based Content Management System

- Anonymous users or guests can view the material
- Registered users can make comments on the guidelines and procedures
- Technical committee can make edits directly on the website, but these are not published until a approval process is completed
- Public review drafts would be reviewed on the site

CBECC-Com

Collaborate with other publicly-funded entities to develop and update "rule-based" building energy analysis software

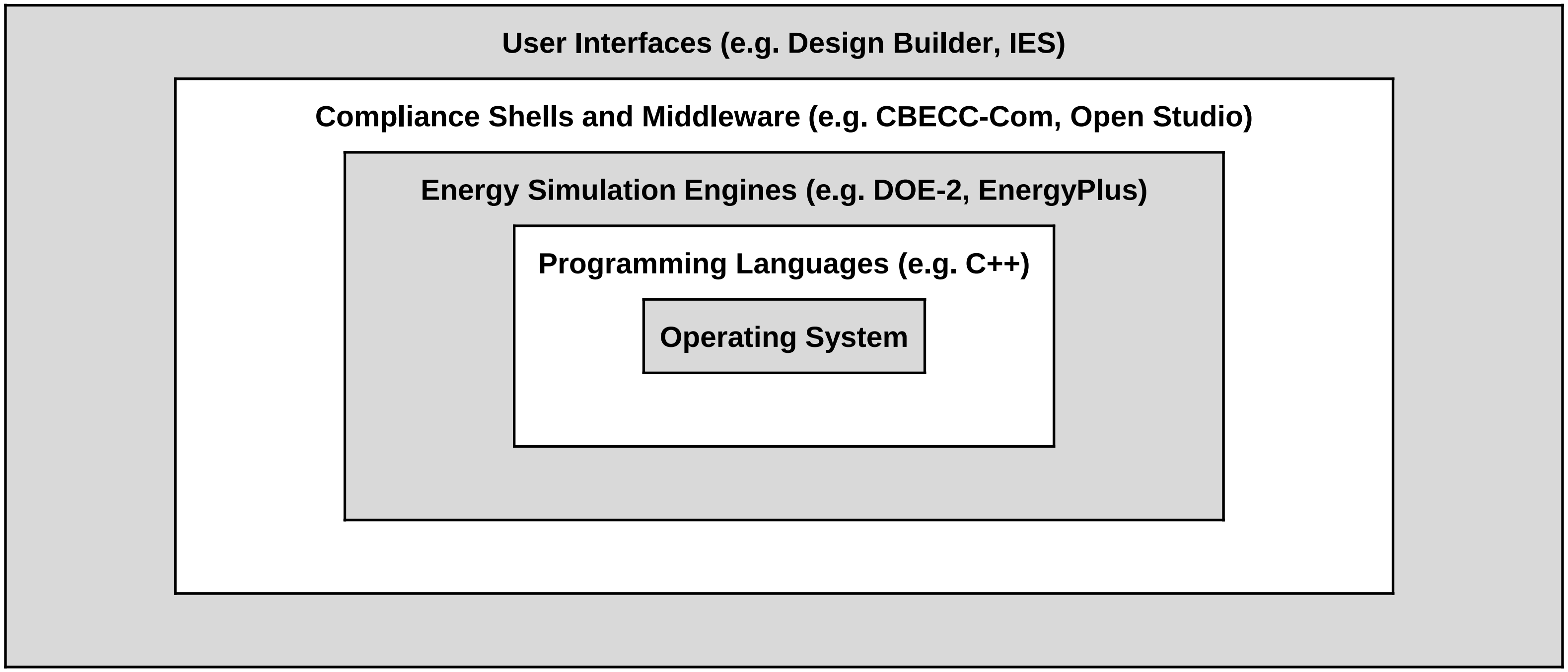


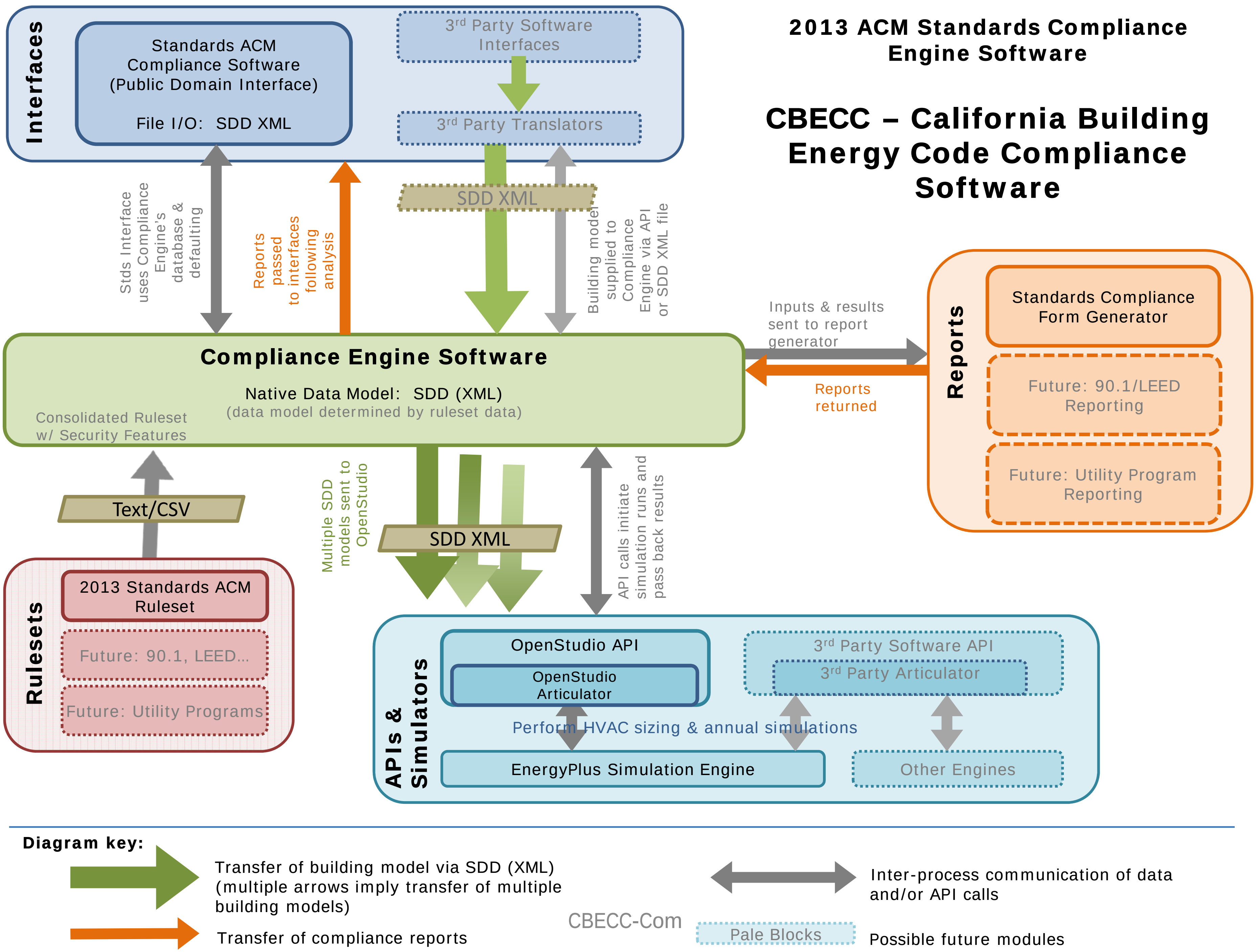
Potential collaborators: Investor Owned Utilities, Regional Energy Networks, U.S. DOE, Building Code Authorities

Distribute Software under an Open Source license

- No obligation for derivative works to contribute back to public domain software code base – facilitates market innovation
- No costs for access to and use of CEC funded software tools - publicly funded software has already been paid for

Software Layers

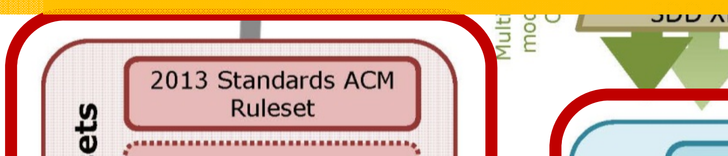



2013 ACM Standards Compliance Engine Software
CBECC – California Building Energy Code Compliance Software
Interfaces
Standards ACM Compliance Software (Public Domain Interface)
File I/O: SDD XML
3rd Party Software Interfaces
3rd Party Translators
SDD XML
Stds Interface uses Compliance Engine's database & defaulting
Reports passed to interfaces following analysis
Building model supplied to Compliance Engine via API or SDD XML file
Compliance Engine Software
Native Data Model: SDD (XML)
(data model determined by ruleset data)
Consolidated Ruleset w/ Security Features
Inputs & results sent to report generator
Reports returned
Reports
Standards Compliance Form Generator
Future: 90.1/LEED Reporting
Future: Utility Program Reporting
Text/CSV
Rulesets
2013 Standards ACM Ruleset
Future: 90.1, LEED...
Future: Utility Programs
Multiple SDD models sent to OpenStudio
SDD XML
API calls initiate simulation runs and pass back results
APIs & Simulators
OpenStudio API
OpenStudio Articulator
3rd Party Software API
3rd Party Articulator
Perform HVAC sizing & annual simulations
EnergyPlus Simulation Engine
Other Engines
Diagram key:
Transfer of building model via SDD (XML) (multiple arrows imply transfer of multiple building models)
Transfer of compliance reports
Inter-process communication of data and/or API calls
Pale Blocks
Possible future modules
CBECC-Com

- EnergyPlus – energy analysis engine focused on commercial buildings
  - Supported by U.S. DOE over last 15 years
    - Prioritization of work to facilitate CEC adoption for 2013 Standards
  - Contributions from PIER-funded R&D to model several technologies applicable to CA climates
    - Natural ventilation, displacement ventilation, under floor air distribution systems, evaporative cooling
- OpenStudio – building energy analysis software platform using EnergyPlus
  - Supported by U.S. DOE via National Renewable Energy Laboratory
  - Use to complete building energy model translation from Rules Engine to EnergyPlus, run EnergyPlus simulations and retrieve results
    - Distributed under an open source license

- Web-based Report Generator separate from analysis software
  - Can be used for both Res and Nonres compliance reporting
  - Better, more secure connections with HERS and Nonres Registries
  - Ability to generate 3rd party reports for other purposes (e.g. utility incentive programs)

- Ability to modify compliance rules with standards update cycles
- Allows multiple rule sets to be established for ... compliance
  - National and International Standards (e.g. ...)
  - ... incentive programs
  - Existing building asset rating programs
- Encourage integration of performance compliance calculations in architectural and mechanical design tools
- Data exchange accomplished using XML standards



- Leverage all appropriate public investments in building energy software tools
  - Using rule-based software architecture originally developed in 1997 for ASHRAE 90.1 code compliance, funded by U.S. DOE via Pacific Northwest National Laboratory
  - Same software architecture to be used for Residential and Nonresidential compliance software programs

Transfer of building model via SDD (XML) (multiple arrows imply transfer of multiple building models)

Inter-process communication of data and/or API calls

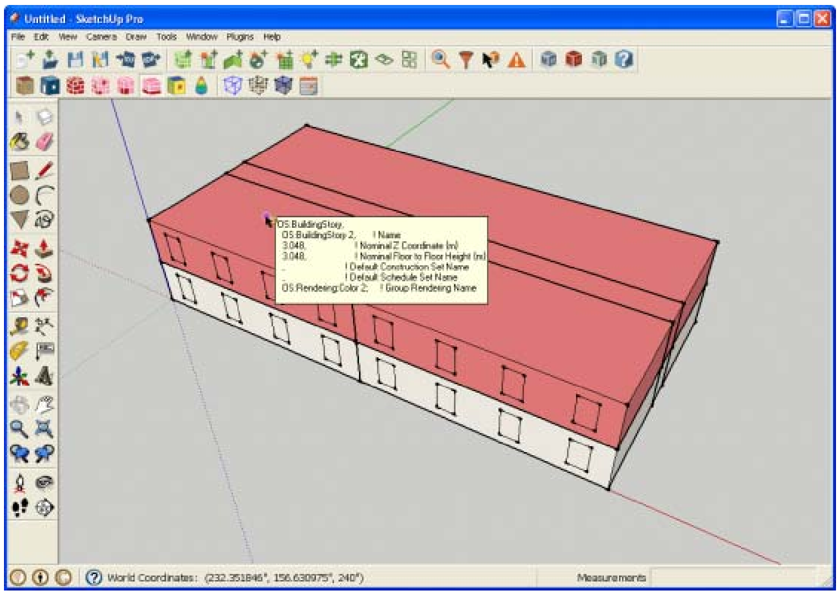
CBECC-Com

Transfer of compliance reports

Pale Blocks – Possible future modules

Compatible with Building Information Modeling (BIM)

1. Create geometry in Sketchup or Other BIM tool

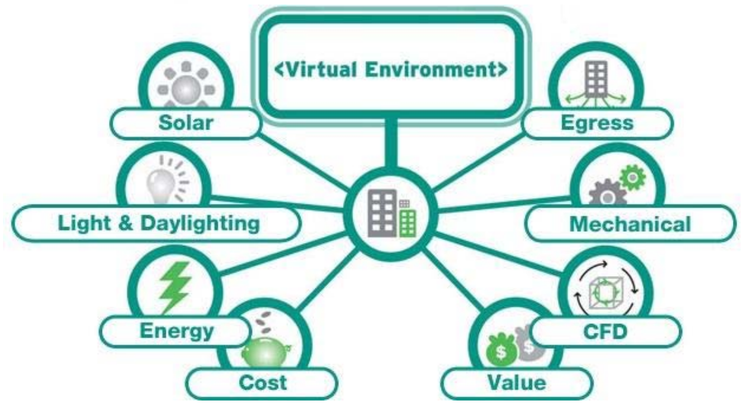


2. Import building geometry

CBECC-Com

3. Define remaining properties in CBECC-Com (e.g. Lighting, HVAC, DHW)

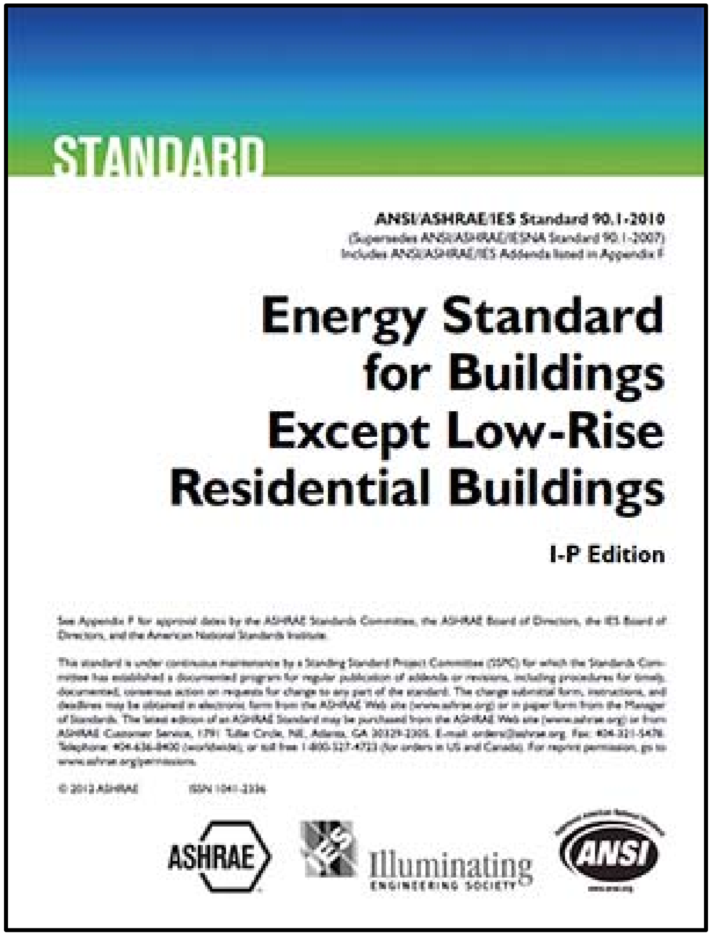
Other Software Interfaces to CBECC-Com



Others?

CBECC-Com Standard 90.1-2010 Version

- Under development by PNNL and AEC (now NORESCO)
- First phase complete, but limited to unitary HVAC equipment.
- Second phase expected in third quarter 2015 and will address central plants



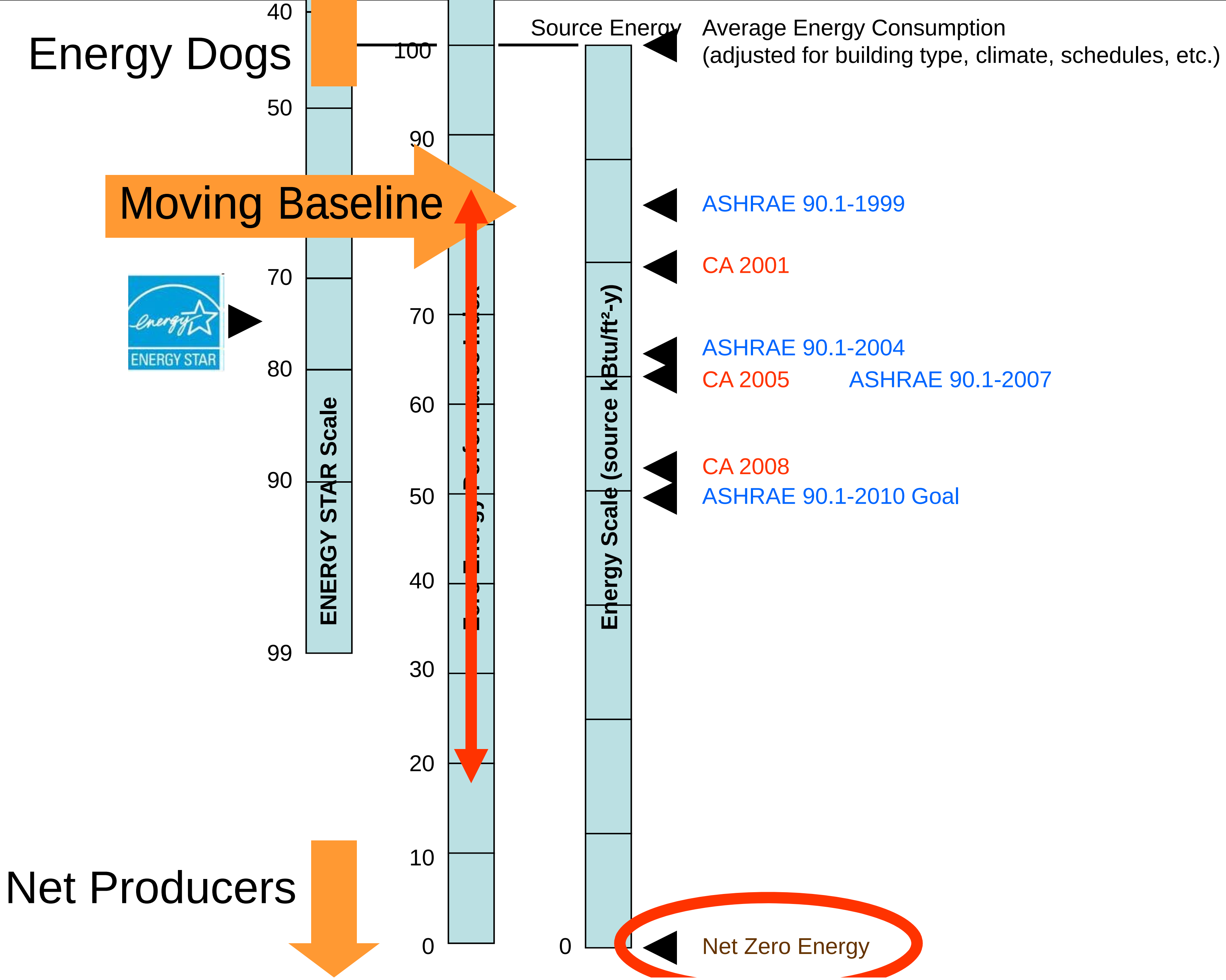
Zero Energy Performance Index

What can we learn from water heaters and air-conditioners?

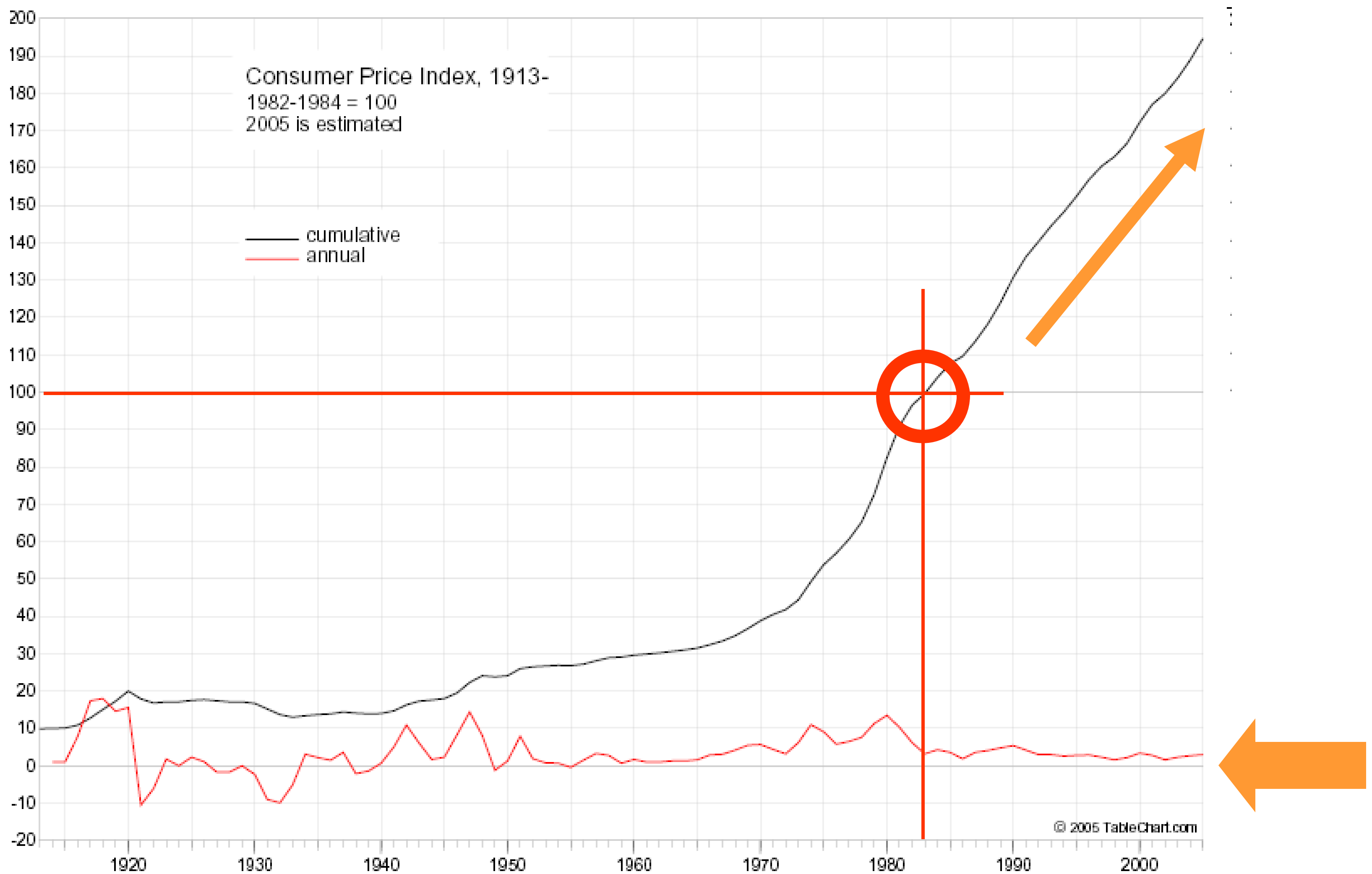
You don't need to change the test procedure everytime standards require a more efficient product.

We need a meaningful scale and performance procedures for whole building performance that is stable over time.

Zero Energy Performance Index

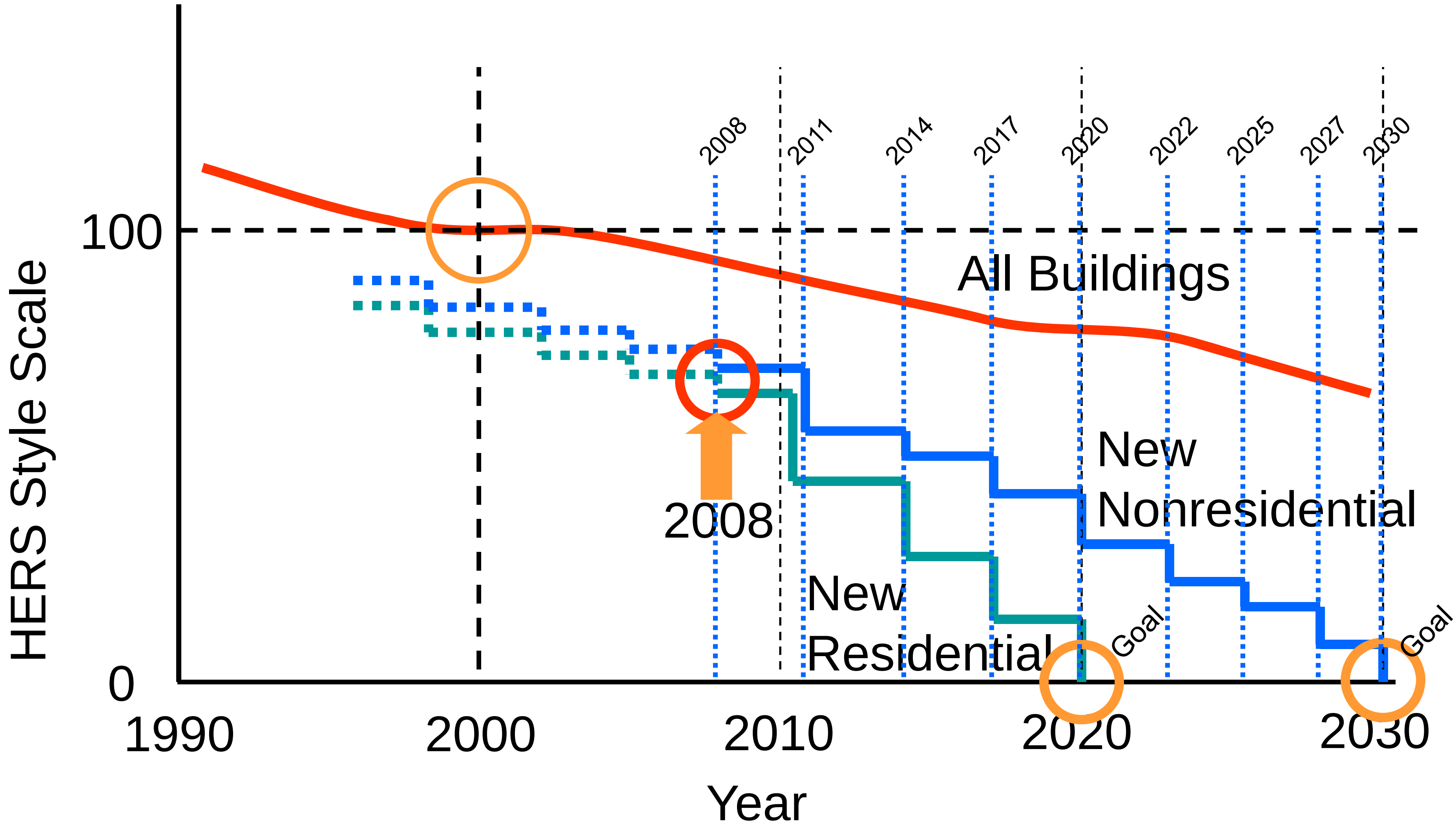


Consumer Price Index



Case-Shiller Home Price Index

The Zero Energy Performance Index as a Policy Framework



ASHRAE Standard 90.1 Addendum BM

TECHNICAL FEATURE

A Stable Whole Building Performance Method For Standard 90.1

By **Michael Rosenberg,** Member ASHRAE, and **Charles Eley, P.E., FAIA,** Member ASHRAE

Wouldn't it be great if a single energy model could be used to demonstrate minimum code compliance, green code compliance, establish a LEED rating, and determine eligibility for federal tax and utility incentives? Even better, what if the basic rules for creating those models did not change every few years?

A recently proposed addendum to ANSI/ASHRAE/IES Standard 90.1-2010 aims to meet those goals. Addendum *bm* establishes the Performance Rating Method found in Appendix G of Standard 90.1 as a new method of compliance while maintaining its traditional use in gauging the efficiency of "beyond code" buildings. Furthermore, the addendum sets a common baseline building that would stay the same for 2013 and future versions of Standard 90.1, while only the improvement target will change with each new edition.

Background

Standard 90.1-2010 has two whole building performance approaches: the Energy Cost Budget (ECB) method used for code compliance and the Performance Rating Method (PRM) used for LEED calculations and other beyond-code programs. The performance methods are similar in that the design or proposed building is compared to a baseline building that is in compliance with the prescriptive standards. The differences are in the details of how the baseline is defined and the scope of design elements that can be credited.

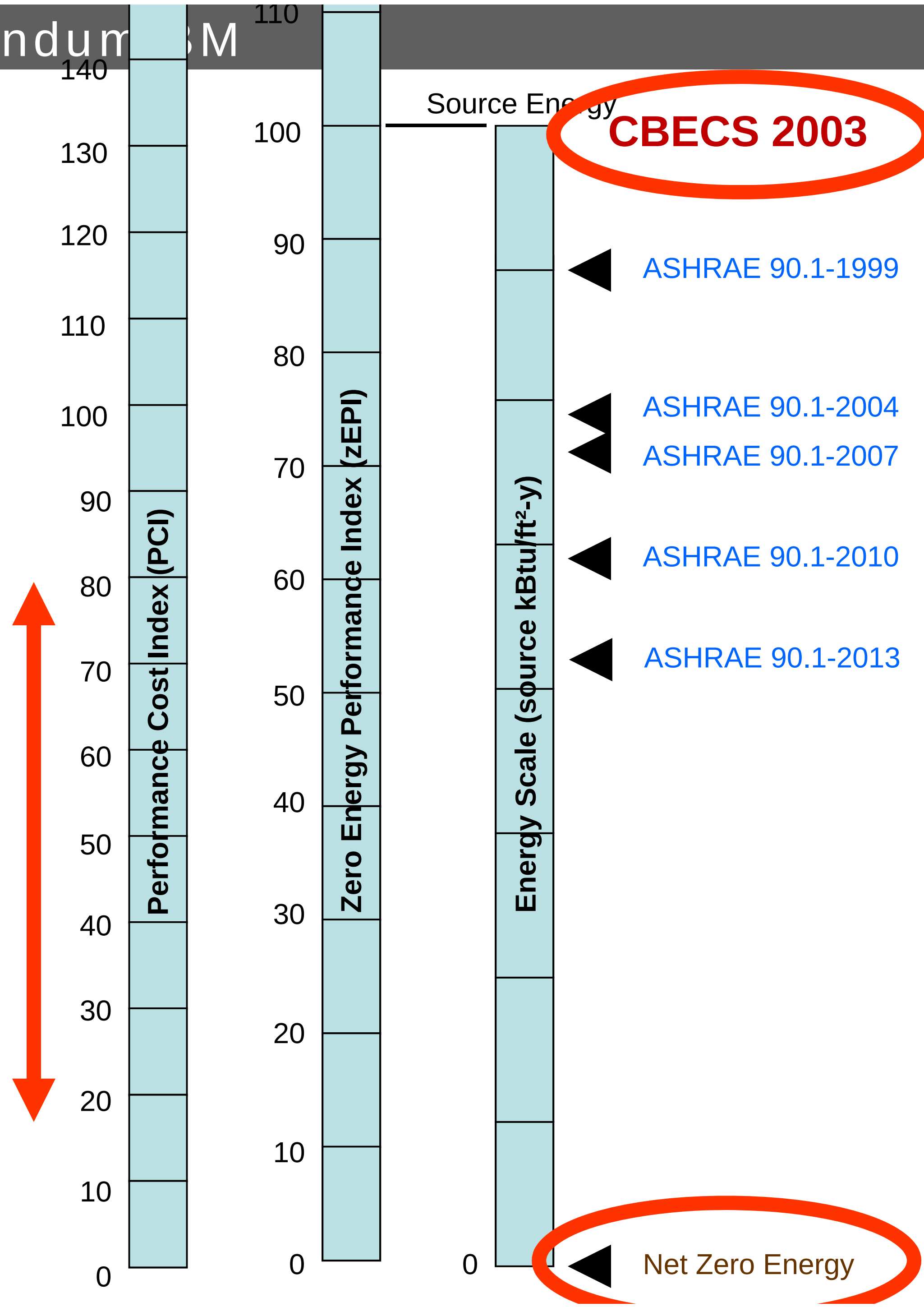
The ECB method is intended to be used for code compliance, and as result, the baseline building tracks the proposed design in many respects. For example, if the proposed building design has wood-framed walls, a 20% window-to-wall ratio, all windows facing south, and is served by a water-source heat pump system, the comparison is to a baseline building with wood-framed walls, a 20% window-to-wall ratio, all windows facing south, served by a water-source heat pump system, with all components just meeting prescriptive requirements. If the same building had mass walls, a 40% window-to-wall ratio, all windows facing west, and an air-source heat pump system, the comparison would be to a baseline building with mass walls, a 40% window-to-wall ratio, all windows facing west, and an air source heat pump system, with all components just meeting prescriptive requirements.

About the Authors

Michael Rosenberg is a senior research scientist at Pacific Northwest National Laboratory, Eugene, Ore. He is a member of the SSPC 90.1 Energy Cost Budget Subcommittee and the LEED Energy and Atmosphere Technical Advisory Group. **Charles Eley, P.E., FAIA,** is a consulting architect and mechanical engineer in San Francisco. He is a past member of SSPC 90.1 and is currently a member of SSPC 189.1. He is an ASHRAE certified building energy modeling professional.

Performance Cost Index

- Similar to zEPI (zero energy performance index)
- Baseline is 90.1-2004 instead of CBECS 2003
- Metric is energy cost instead of source energy
- The scale is stable and does not change each time an addendum is approved for Standard 90.1
- Deterministic – Many of the more complicated prescriptive requirements have been introduced since 2004.
- Same modeling workflow can be used for multiple purposes:
  - Code compliance
  - Green building ratings (LEED)
  - Utility incentive programs
  - Energy ratings



More Information

www.comnet.org/mgp

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The End