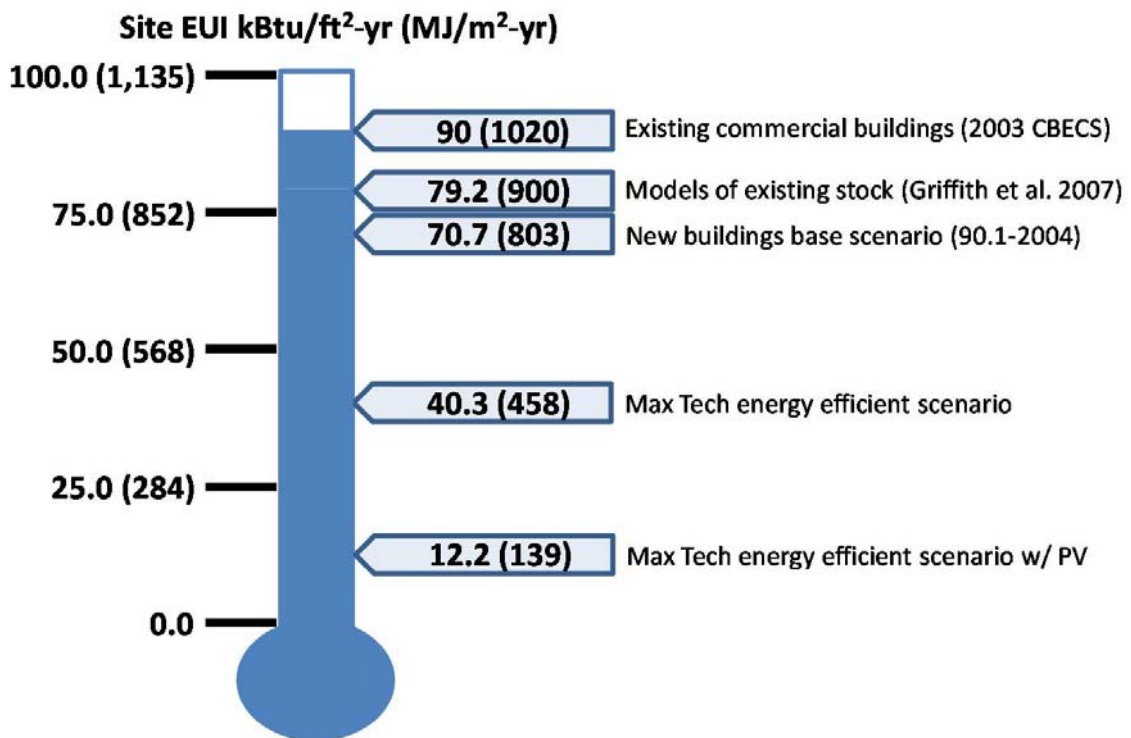




## REPORT OF THE TECHNOLOGY COUNCIL AD HOC COMMITTEE ON ENERGY TARGETS

### Commercial Buildings



**JUNE 2010**

Adapted from Griffith, et. al. 2007 by Lynn Bellenger, PE

## **ACKNOWLEDGEMENT**

Often the work of many, striving for a common cause, can be attributed to a single person whose vision sets the path upon which others travel. In this case, that person is Society President Gordon V.R. Holness, PE. Gordon's passion for improving the performance of the built environment has been an inspiration to many, including especially the authors of this report. We gratefully acknowledge his leadership in focusing on whole building energy use performance through his theme: *Sustaining Our Future By Rebuilding Our Past: Energy Efficiency in Existing Buildings*. It was Gordon's commitment to energy use performance that was the driving force in creating this report.

## **DEDICATION**

This report is dedicated to Lynn Bellenger, PE BEMP, for her dedication and commitment to ASHRAE, her contributions to this report, including the thermometer on the cover, and her election as the first female President of the Society in its one hundred and sixteen year history.

June 2010

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# REPORT OF THE TECHNOLOGY COUNCIL AD HOC COMMITTEE ON ENERGY TARGETS

18 JUNE 2010

The purpose of this Ad Hoc Committee is to meet the requirements in the following ASHRAE Board of Directors motion from the Winter Meeting in Orlando.

**Motion:**

*That the Board of Directors direct Technology Council to develop strategies by June 2010 to address increasing stringency of building energy efficiency with the objective of developing targets and goals.*

Technology Council chair Tom Watson appointed the following individuals to this Ad Hoc Committee on February 17, 2010

Rick Hermans – Chair  
Mick Schwedler – 90.1 Representative  
Ron Burton – 189.1 Representative  
Don Colliver – AEDG Representative  
Doug Reindl – StdC Representative  
Bill Bahnfleth – Vice Chair Technology Council  
Adrienne Thomle – TC 7.6 Representative  
Kent Peterson – Consultant  
Hugh Crowther – Consultant  
Rita Harrold – Consultant  
ASHRAE Staff Liaison – Claire Ramspeck

In addition to these members, the Ad Hoc was pleased to receive input and support from Tom Watson, Lynn Bellenger and Cassandra Craig. Special thanks goes to the Standards staff for production assistance.

The chair wishes to thank these fine individuals for their incredible effort to produce this report in a very short time.

Sincerely,



Chairman

# I. EXECUTIVE SUMMARY

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The purpose of the Ad Hoc Committee recommendations is to define the maximum level of commercial building energy use efficiency and the conservation of primary energy using on-site renewable energy production which is technologically achievable now or in the near future. The specific Energy Use Intensity (EUI) values presented herein were not created by the Ad Hoc but are taken from previous work by NREL published in 2007. The performance levels of EUI in this report are best-estimate projections of what is achievable in the market in 2025 according to the NREL technical paper *NREL/TP-550-41957* “Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector.” (*Assessment*). The Ad Hoc has neither validated nor endorsed the technologies used in the *Assessment* and recommends that this be accomplished by entering into a contract with an appropriate body to reevaluate and update the information in the *Assessment*. Not every new commercial building can be designed for net zero energy use, so the ultimate level of energy use efficiency will not be zero in all building types or climate zones.

The Ad Hoc recommends that:

- 1) *A comprehensive education program be conducted to promote a common understanding of the EUI metric among ASHRAE members and the public.*
- 2) *Energy use targets be defined and developed as follows:*
  - a) *Targets include receptacle and process loads.*
  - b) *Targets are based on the best available technology for energy efficiency and on-site renewable energy production without regard for cost or cost effectiveness.*
  - c) *Two types of targets should be developed: Target Energy Use Intensity (EUI), which includes no on-site renewable energy generation and Net*

*Energy Use Intensity (NEUI), which includes photovoltaic and other on-site renewable energy production.*

- d) *The gross floor area used to define EUI and NEUI is defined as in ASHRAE Standard 105: the sum of the floor areas of the spaces within the building, including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 90 in. (2300 mm) or greater; it is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excludes covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.*
  - e) *EUI and NEUI values are determined by modeling.*
  - f) *One clearly defined set of simulation models consisting of a standardized set of building types should be established in cooperation with the Department of Energy for evaluation of Std 90.1, Std 189.1, and the AEDG.*
- 3) *Buildings subject to the targets be required to comply with ANSI/ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality, and ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy.*
  - 4) *Neither SSPC 90.1 nor SSPC 189.1 be given specific mandatory energy performance targets.*
  - 5) *Neither Std. 90.1 nor Std. 189.1 be the foundational standard that fulfills the Vision 2020 goal which is included in the report entitled “Vision 2020 Producing Net Zero Energy Buildings”.*
  - 6) *The series of Advanced Energy Design Guides, with the concurrence of our partners, be designated as the primary*

*means of fulfilling the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net zero energy buildings by 2030.*

- 7) *ASHRAE enter into a contract with an appropriate body to reevaluate and update the information in NREL/TP-550-41957 “Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector.”*
- 8) *ASHRAE provide research funding and/or seek outside funding to complete the net-zero AEDG series for building types that have the highest probability of achieving net zero-energy and that are not already funded by DOE.*
- 9) *ASHRAE use the values presented in Annex 5 Table 1 as the base values when calculating the “progress toward net zero.”*

To implement the above recommendations, the Ad Hoc offers the following four strategies:

#### Strategy 1

Neither SSPC 90.1 nor SSPC 189.1 will be given mandatory energy use targets. Rather, a target EUI will be suggested to them by Technology Council or their designee for consideration as part of their respective work plans. Analysis of the progress of both standards will continue to be accomplished by computer modeling of benchmark buildings whose input files include receptacle and process loads. ASHRAE will remain committed to developing and promoting technical tools to assist the industry in moving towards NZEBs. ASHRAE will continue to offer itself as an ongoing resource to the federal government by providing

technical tools and by offering a voice of the industry.

#### Strategy 2

ASHRAE will seek approval from our partnering organizations to adopt the series of Advanced Energy Design Guides as the primary means of fulfilling the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net zero energy buildings by 2030. The AEDG Steering Committee will be offered the NEUI targets as goals for the series. ASHRAE will fund and/or seek outside funding for the development of any AEDG building type that have the highest probability of achieving net zero-energy and that are not funded by DOE.

#### Strategy 3

ASHRAE will enter into a contract with an appropriate body to reevaluate and update the information in NREL/TP-550-41957 “Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector.”

#### Strategy 4

In order to promote a common understanding of the energy use efficiency metric EUI and the NEUI renewable energy production metric among ASHRAE members and the public, ASHRAE will conduct a comprehensive education program. This initiative may consist of Journal articles, Position Briefs, Position Papers, Technical Papers, Annual and Winter Meeting seminars, Handbook material, and special targeted publications.

## II. INTRODUCTION

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President Holness has described the goals of this Ad Hoc committee as follows:

“I believe that our objectives on face value are very simple – 1) To provide the design guidance for our members and for the industry to meet legislative requirements and 2) To establish or support a baseline performance data base for the various building types and climate zones against which our Building EQ program, for example, can establish building ratings. Along the way we need to determine basic performance metrics we will work with.

Basic building energy use performance metrics expressed as energy use intensity (EUI) is the most effective means to measure the energy efficiency of a building. It is also the best way to measure the efficiency of an energy standard such as ANSI/ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*; hereafter referred to as ‘Std 90.1.’ Therefore, the main strategy recommended herein is to determine how to set EUI targets for commercial buildings and initial EUI targets for commercial buildings that are constructed or have major retrofits after 2010 (or at the time the target EUIs have been established and published). These targets will lead to the development of the most energy efficient

buildings possible with the goal of net zero energy buildings.”

### DELIVERABLES TO TECHNOLOGY COUNCIL

Our deliverables to the Council are a list of strategies that addresses the following:

- (1) education of ASHRAE members in the definition and use of commercial building Energy Utilization intensity (EUI) targets (Section III),
- (2) identification of the potential obstacles to substantial improvements in building energy efficiency targets (Section IV),
- (3) definition of EUI targets and the basis for their calculation (Section VI) and,
- (4) recommendations regarding appropriate targets and/or goals for increasing stringency of building energy efficiency (Section VII).

### Procedures

This report is a collaborative effort of the Ad Hoc and was passed with a single final vote of the Ad Hoc.

### Process

The Ad Hoc met fifteen times by conference call between February 17, 2010 and June 14, 2010.

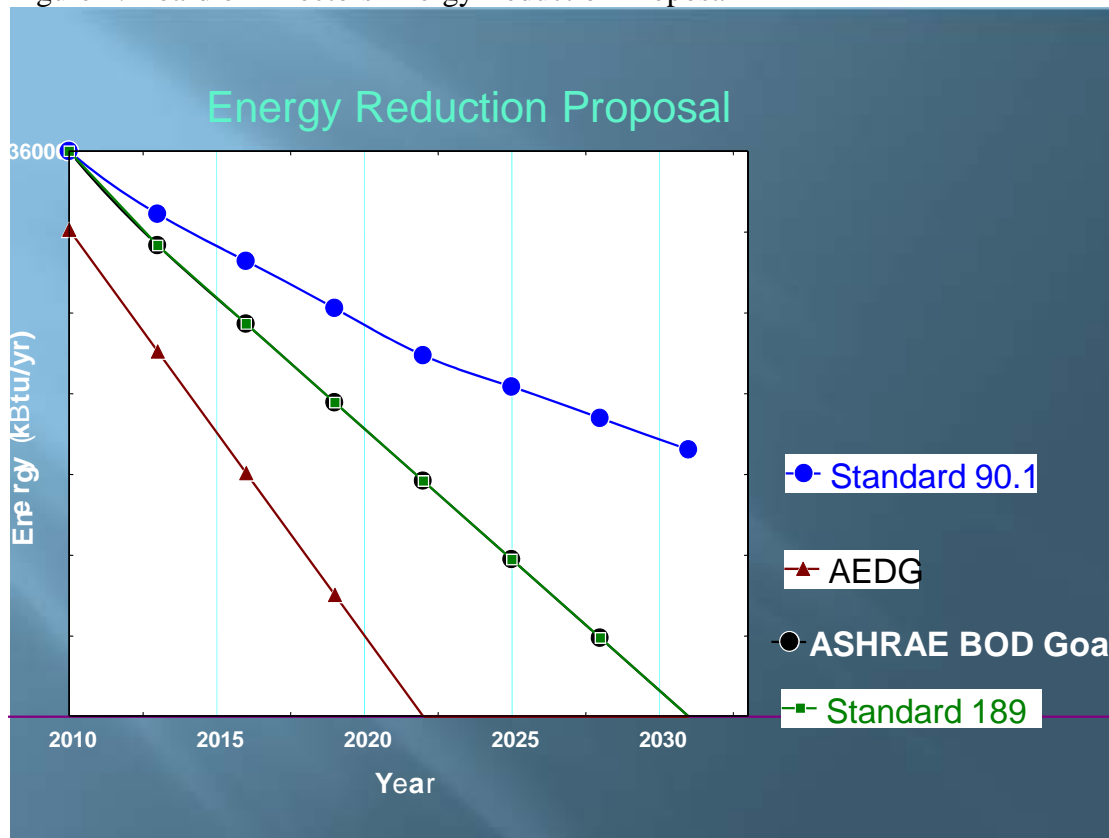
## **BACKGROUND**

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On April 1, 2007, the ASHRAE board of directors voted to approve “Suggested EUI Targets for code-intended standards”. The intention of the targets was to support SSPC 90.1 and SPC 189.1 committee membership with baseline goals as a measurement to monitor their progress towards providing tools by 2020 that would enable the building community to

produce market-viable net zero energy buildings by 2030. The approved motion suggested that Standard 189.1 be the document that achieved the net-zero threshold and that Std 90.1 make steady progress towards an intermediate goal in 2031 roughly half way between zero and the assumed weighted average EUI based on the 2010 edition of the standard (See Figure 1).

Figure 1: Board of Directors Energy Reduction Proposal



In December of 2007, ASHRAE President Terry Townsend drew from the building design research, operations, and manufacturing communities to appoint an ad hoc committee with the charge to “Develop guidance and strategy for the development of energy-related products, the conducting of research in renewable energy systems, and the sequencing of the various identified activities that will produce net zero energy usage for all types of facilities by 2020.”

That Ad Hoc committee produced a report entitled *ASHRAE Vision 2020: Producing Net Zero Energy Buildings*, which was published in January 2008. The Vision 2020 Ad Hoc believed that net zero energy buildings would be market viable by 2030, and they recommended that ASHRAE provide tools by 2020 that would enable the building community to produce market-viable Net Zero Energy Buildings (NZEB) by 2030.

The Vision 2020 Ad Hoc also realized that in order to make such a vision a reality, they would need to define a single meaning for net-zero energy building. The conclusion they reached is supported by this Energy Targets Ad Hoc. Quoting from the Vision 2020 report:

“Ultimately, the only way to measure if a building is a NZEB is to look at the energy crossing the boundary. Other definitions, including source, emissions, and cost, are based on this measured information and include weighting factors and algorithms to get to the metric of interest. Because of the complications involved in making these computations, **site energy measurements** have been chosen through an agreement of understanding between ASHRAE, the American Institute of Architects (AIA), the U.S. Green Building Council (USGBC), and the Illuminating Engineering Society of North America (IESNA).”



In 2007, NREL published *Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector* [Griffith et al., 2007], hereafter referred to as *Assessment*. In this study, NREL researchers developed quantitative predictions to answer the following two questions: How low can you practically go in terms of energy use? And To what extent can rooftop photovoltaics (PV) supply the remaining energy needs of commercial buildings? Each of the CBECS buildings from the 2003 survey was modeled, then modified to represent new construction with energy features and performance complying with ANSI/ASHRAE/IESNA 90.1-2004. The values reported in Table 1 in Annex 5 represent modeled buildings conforming to Std 90.1-2004. These values formed the baseline in the *Assessment*.

Next, they modified these baseline building models with a set of technologies and practices that represent projections for improvements out to 2025. These annual simulations provide estimates for the energy performance levels that might be achievable in 2025. (See Table 2 in Annex 5)

The report concluded that energy efficiency improvements that use projections of the best available technologies and practices and integrated, whole-building design approaches can, on average, reduce consumption by 43%. These improvements did not include the use of site-generated electricity with photovoltaics or wind or the use of ground-source heat pumps. Another conclusion was that, on average, reductions of 59% compared to ASHRAE 90.1-2004 are needed for PV power systems to provide enough energy to achieve ZEBs (offices need 67% savings, warehouses 6%, educational facilities 43%, and retail 44%). A major limitation to the ZEB analysis in the NREL report is the assumption that site-generated electricity in excess of the instantaneous building demand can be freely put back into the utility grid. Should utilities embargo site-generated electricity during periods where distributed generation would encroach on their

baseload generation, achieving a net zero site energy will potentially be compromised. The NREL results were all based on site energy use and the assumption that 50% of the building roof area was available for PV that was installed flat on the roof. The average commercial building EUI (including receptacle and process loads) could be 70.7 kBtu/ft<sup>2</sup>·yr (803 MJ/m<sup>2</sup>·yr) if all buildings were rebuilt to current standards. By applying a comprehensive package of technologies and practices, termed “Max Tech” in the report, the EUI could be further reduced to as little as 40.3 kBtu/ft<sup>2</sup>·yr (458 MJ/m<sup>2</sup>·yr). However, if PV was added and the excess generated electricity could be freely put into the grid, the EUI could be reduced to 12.2 kBtu/ft<sup>2</sup>·yr (139 MJ/m<sup>2</sup>·yr).

Since this study was completed, the DOE Benchmark building models have been published, new technologies have become market viable, and the interest in performance-based energy efficiency goals has increased. Due to the practical limitations imposed by using a generic set of rules for generating the models and the challenges of modeling advanced technologies and practices in the version of EnergyPlus available at the time, the study produced conservative results and somewhat underestimated the maximum technical potential.

Another important part of our charge was the need to educate the industry and the public on energy performance metrics, including definitions, and how the EUI targets are established, measured, and used in policy making.

One important aspect of that education is to clearly define the difference between building energy use “efficiency” and building energy “conservation” where source fuels for electric generation are conserved by the use of site based renewable energy. This difference will become clear in the section on definitions where the Efficiency Only EUI (EUI) and the Net EUI (NEUI) are defined.

## GOALS

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The goals of establishing targets are to:

- 1) move ASHRAE toward establishing needed design guidance to reduce energy consumption,
- 2) lead the drive toward the design, construction, and operation of net-zero-energy buildings;
- 3) advance the goals of ASHRAE's Vision 2020;
- 4) provide direction to ASHRAE for the future development of its research, education, policy, publications and programs (e.g. BEQ); and
- 5) provide assistance to governments and non-governmental organizations to develop their energy related programs.

## III. EDUCATION OF ASHRAE MEMBERS

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Building energy performance metrics have been extensively used by numerous bodies to set policy for commercial building energy use reduction goals. Yet there is no single generally accepted definition of the metric. This section of the report describes many of the various definitions and their use. The Ad Hoc therefore

recommends one clear, logical definition that will be used by ASHRAE for setting policy and for measuring progress towards the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net-zero energy buildings by 2030.

## DIFFERENT EUI DEFINITIONS

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Building Energy Use Intensity (EUI) is a tool that can be used to describe the amount of energy used in a building. It is often given in "kBtu/ft<sup>2</sup>-yr". The following EUI equations

are from the ASHRAE *Performance Measurement Protocols for Commercial Buildings* and ANSI/ASHRAE Standard 105.

$$\text{Total Energy Use Intensity (EUI)} = \frac{\text{TotalAnnualEnergyUse}}{\text{GrossFloorArea}} \quad \text{kBtu/ft}^2 \text{ yr (kWh/m}^2 \text{ yr)}$$

$$\text{Net Energy Use Intensity (NEUI)} = \frac{\text{NetAnnualEnergyUse}}{\text{GrossFloorArea}} \quad \text{kBtu/ft}^2 \text{ yr (kWh/m}^2 \text{ yr)}$$

$$\text{Energy Cost Intensity (ECI)} = \frac{\text{NetAnnualCost}}{\text{GrossFloorArea}} \quad \text{\$/ft}^2 \text{ yr (\$/m}^2 \text{ yr)}$$

EUIs are very helpful for setting performance based goals. For example, a hypothetical policy goal could be described in this way, “*we would like to move the USA building stock from an annual site energy usage of 100 kBTU/ft<sup>2</sup> to 50 kBTU/ft<sup>2</sup> by the year 2020.*” Such a policy need not describe the means and methods to accomplish the goal.

The current focus on reduction of energy use in building stock has made the use of EUIs very popular by governmental organizations, non-

government organizations, and building industry groups, including ASHRAE. Unfortunately, there is no clear single definition for EUIs, so comparing one organization’s EUI goals to another organization’s EUI goals is confusing, particularly since everyone tends to use the same units, kBTU/ft<sup>2</sup>-yr.

The following table was put together to assist in understanding some of the variances for building energy use intensities.

**Table 1 – EUI Definitions**

Document	Term	Distinctions	Energy Considered	Area
ASHRAE Std 105-2007	Energy intensity: an expression of the annual energy used or calculated to be used by a building or building space per unit of gross floor area	Gross floor area: the sum of the floor areas of the spaces within the building, including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 7.5 ft or greater.	Measured site energy use for all types of energy	Gross
ASHRAE Std 90.1-2007, Chapter 11 ECB	Modeled annual energy cost	Although this is site energy, the addition of cost reflects the source variances between fuel types.	Site	Gross
California Title 24, Part 6, Performance Method	Modeled annual energy costs using time-dependent valued (TDV) energy.	The TDV values reflect both the cost of the energy and the infrastructure to get it to the site.	Time-dependent valued site energy	Conditioned Floor area
Arch 2030	Annual fossil fuel based energy in kBtu/ ft <sup>2</sup> -yr	Only accounts for fossil fuels (coal, oil and gas)	Site fossil fuel	Same as CBECS and Energy Star
ASHRAE Std 100-2006	Annual total energy for all fuels	All sources of site energy and conditioned space for floor area	Site implied by electrical conversion @ 3600 kJ/kWh) All fuels	Conditioned Floor area

<b>Document</b>	<b>Term</b>	<b>Distinctions</b>	<b>Energy Considered</b>	<b>Area</b>
Energy Star	Annual energy in kBtu/ft <sup>2</sup> -yr	Currently limited to the following building types: <ul style="list-style-type: none"> <li>• Bank / Financial Institution</li> <li>• Courthouse</li> <li>• Dormitory</li> <li>• Hospital (acute and children's)</li> <li>• Hotel</li> <li>• House of Worship</li> <li>• K-12 School</li> <li>• Medical Office</li> <li>• Office</li> <li>• Retail Store</li> <li>• Supermarket / Grocery Store</li> <li>• Warehouse (refrigerated and unrefrigerated)</li> </ul>	Site and Primary (Source)	Gross Building Floor Area
CBECS (Commercial Buildings Energy Consumption Survey)	Annual energy in kBtu/ft <sup>2</sup> -yr (U.S. national sample survey conducted every 4 years that collects information on the stock of selected commercial buildings types, their energy-related building characteristics, and the energy consumption and expenditures. It is based on a sample of 5,215 buildings across the country that were statistically sampled and then weighted to represent the entire stock of commercial buildings in the US.)	Actual building areas are used for EUI calculation. The EIA then purposefully rounds off the reported area to mask the identity of the respondent	Site and Primary (Source)	Gross Building Floor Area
EISA 433	Annual fossil fuel generated energy in kBtu/ft <sup>2</sup> -yr. Step reduction targets are set relative to the 2003 CBECS with a 100% reduction by 2030.	Law only applies to federal buildings	Site fossil fuel	Gross Building Floor Area

Table 1 shows that direct comparisons of EUI values presented by different organizations are not possible without standardizing the following:

- Definition of building area

- Choosing site or source energy and defining exactly what is included in the energy measure
- Units of measure

## **EUI DEFINITIONS AND THEIR ROLE IN INFLUENCING BEHAVIOR**

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Setting EUI goals is one approach to encouraging reductions in building energy use. Attempts to define EUI, however, can lead to some unintended results. Consider, for example, the following different ways to define EUI:

- Choosing site energy is attractive because it is easily measured and understood by the building owner (Look at your energy bills). However, this option could promote using electric heat (COP=1) over hot water heat (boiler COP <1) and that may not be the desired outcome.
- Choosing source energy takes into consideration the total primary energy including all the losses in delivering the energy to the point of use. Using source energy may seem more realistic in terms of quantifying how much impact a building has on the environment; however, understanding all factors in the processes—from the point where fuel is extracted through to the delivery of energy to a building—is highly time-dependent and complex. Approaches

aimed at converting site energy use to source energy use with a “weighting factor” are oversimplified and can misrepresent actual benefits or costs associated with time-dependent site energy use.

- Using site fossil fuel solves the issue of attempting to understand where source energy came from (coal, nuclear, hydro, etc). However, it too introduces a conversion factor for electricity to source fossil fuel. Further, it creates a situation where instead of introducing energy efficiency measures, the building owner could simply purchase alternative energy electricity (wind). While this is an improvement over carbon based power, it still circumvents energy efficiency.
- Introducing site generated energy (photovoltaic or wind power) as means of reaching a EUI goal may reduce carbon emissions. However, it can likewise promote on-site generation over energy use efficiency.

## **EUI USE OVER TIME**

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Improving energy performance targets is a desirable goal. New goals typically take the form of “ASHRAE Standard 90.1 -2010 will be 30% more efficient than ASHRAE Standard 90.1–2007.” Unfortunately, if a definition in the standard is changed or if the methodology of calculating the energy performance is changed, it becomes confusing or even misleading as to whether or not the target was met. For example, consider how DOE performs the Determination for ASHRAE Standard 90.1.

With each new edition of ANSI/ASHRAE/IESNA Standard 90.1, DOE issues a Determination about whether the new edition will improve energy efficiency in commercial buildings. The Determination is based on analysis by the Building Energy Codes Program and is required by Section 304 of the Energy Policy and Conservation Act (EPCA, Public Law 94-163), as modified by the Energy Policy Act of 1992 (EPAAct 1992). DOE has one year to

publish the Determination after the newest edition of the code is approved, after which then results are published in the Federal Register. If DOE finds that the newest version of Standard 90.1 is more energy efficient than the previous version, states are required by the Energy Policy Act to certify that their building energy codes meet the requirements of the new Standard within two years.

The DOE Determination calculation process has continued to evolve since the original goal was set in 2007, making it difficult to understand exactly what is being modeled for the final Determination calculations. This updated methodology is described in *Draft Methodology for a Comparative Analysis of ANSI/ASHRAE/IESNA Standard 90.1–2007 and Standard 90.1–2004*<sup>1</sup>, dated January 20, 2008—although it is believed that even this document does not reflect the current state of the evolving building types and weighting factors of those building types

being used in the analysis. In other words, the Determination for one version of the standard may consider different building types and use a different classification of building types than the Determination for a subsequent version of the standard. The DOE Determination, however, is simply a process to perform a quantitative and qualitative analysis of the new version compared to the old version. It is not intended to provide building EUI or average EUI data that can be compared over time. We must also recognize that some energy-efficiency measures are difficult if not impossible to model in these energy simulations.

The same challenge is occurring with the Advanced Energy Design Guides (AEDGs). The first set of guides was targeted at being 30% more efficient than ASHRAE Standard 90.1 - 1999. The next set is targeting 50% more efficient than ASHRAE Standard 90.1 -2004. A moving target makes comparisons difficult.

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## OUTREACH TO ASHRAE MEMBERSHIP

The Ad Hoc committee prepared an article for the ASHRAE High Performance Building Journal Summer 2010 issue titled “*Building EUI*” to help educate our membership on both the power of EUIs and the opportunity for their

use but also the issues that need to be considered. A copy of the article is provided in Annex 4. Further recommendations for educating the membership and public are listed in the Recommendations section of this report.

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## EUI AND GOVERNMENT POLICIES

There are many current and pending legislation impacting energy goals. Annex 2 contains a short summary of government activity in the US at the time this report was prepared.

The current trend in government policy making is to focus on relative reductions of energy use in buildings that are assumed to be compliant with the model energy code. Such policy making

may not have had a rigorous thought process to consider the ultimate consequences of such reductions upon the natural gas and electric utility grid and the business of electric generation and transmission or natural gas distribution. The possible consequences of the success of a broad net zero energy future are described in Annex 3.

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<sup>1</sup> [http://www.energycodes.gov/implement/pdfs/determinations\\_com\\_07draftmethodology.pdf](http://www.energycodes.gov/implement/pdfs/determinations_com_07draftmethodology.pdf)

## **IV. IDENTIFICATION OF POTENTIAL OBSTACLES TO SUBSTANTIAL IMPROVEMENT**

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The members of ASHRAE Standing Standards Project Committees 90.1 and 189.1 have worked hard to increase the energy efficiency of compliant buildings, but progress has been slow.

The following is a list of obstacles which

explains why establishing energy targets for code-intended standards is difficult to accomplish. Although many of these arguments apply to any energy code, they are especially true for performance-based codes.

### **STANDARDS DEVELOPMENT**

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Achieving specific targets within the standards development process and within the desired timeframe has proved to be difficult. The 30% improvement goal was hard for the SSPC to refuse because of the number of public proclamations about the desirability of meeting it. The short time line for compliance with the goal was especially challenging for the SSPC.

When making such large changes, the consensus process becomes very difficult due to the large number of resulting public review comments. Another obstacle is the difficulty of making changes to a code-intended standard. While it is a standard, it is also used as a code in the marketplace. ASHRAE properly uses a financial metric to see if a change proposal meets a cost effectiveness test. At this time, however, none of the SSPCs have been able to make a 50% reduction work within the cost effectiveness model. During the last revision

cycle of 90.1, both the baseline and the analysis method of evaluation were being developed and a meaningful measurement of the progress of the standard wasn't available until the later stages of the cycle. This resulted in a more recent version of the standard going backwards in effectiveness because the baseline modeling and weightings changed compared to the previous version. It is this lack of a clear feedback mechanism that has hampered the SSPC in their efforts to reach specific goals.

While it is the timeframe, consensus process, and lack of feedback that create difficulty for the SSPC, it is also recognized that our practitioners desire to have a fixed target for their designs. So just as the changing nature of the baseline causes problems for the SSPC, a moving energy use target is confusing and problematic for the design community as well.

### **CODE ENFORCEMENT**

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State and local regulatory authorities have difficulty addressing targets, specifically in adopting and enforcing codes to accomplish the goals. The Ad Hoc wonders how a code official would enforce an energy use target if it were a code minimum requirement. Real energy savings cannot easily be verified to provide a comparison against predicted energy savings. In those jurisdictions where energy performance is currently required, code officials simply require

the design professional to verify that the building meets the designed (modeled) energy use target. This approach is the only logical one available to local jurisdictions that do not have the expertise or the resources needed to enforce performance-based energy codes. The effect of this is that oversight is being relegated from building code officials to the designers. In general, we believe that energy codes are always secondary to fire and life safety codes.

It is true that this verification problem is not just for performance-based energy targets but for any energy standard or code. But where a prescriptive code is enforceable by current code officials if they chose to, a performance code has no meaningful enforcement mechanism. In addition, code officials view the energy code as changing much more rapidly (and would change even more rapidly with targets) than other parts of the code. The enforcement community—

which consists primarily of building officials-- has a real problem focusing on energy efficiency targets, and in fact even focusing on current energy codes. They do not have the resources to hire and train additional personnel to enforce these measures, and existing personnel and resources are used to ensure building safety (structural, fire, plumbing, etc.), leaving little opportunity to also deal with energy issues.

## **MARKET RESISTANCE**

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Most building decision makers will not embrace the targets without a clear economic incentive to do so. Those managing the facilities must show positive return on investment before they can positively impact decisions to strive for the goals. Even building owners who are non-profit need to know there is a sufficient ROI over some reasonable period of time.

More importantly, lenders are more interested in making sure they have a relatively short payback period (a 7-10 year payback is more than many lenders will accept). Some building owners will justify energy efficiency improvements by saying they are mandatory, but this may not work long term and will eventually result in a negative backlash.

There has been some market movement towards energy efficiency in leased space caused by tenants who are interested in greener space and are willing to pay premium lease rates. However, the general resistance to energy

efficiency improvements points to the fact that they need some type of incentive that changes the cost-effectiveness equation. For example, the incentive for a developer who has no long term interest in the facility will be much different than the incentive for an owner/manager who will occupy the facility for a long time and will benefit from reduced energy costs. This raises the question of identification of target “customers”: specifically, who will use energy targets and what are the needs of these users? It seems to be an important question to consider when crafting targets because the intended use may determine the venue in which they are implemented.

The Ad Hoc committee members considered the issue of which type of EUI would be subject to compliance with a target: a measured EUI or the results of modeling. This unanswered question also has consequences for enforcement by code officials.

## **CONSEQUENCES OF UNMET EXPECTATIONS**

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An unusual obstacle occurs by considering what happens to ASHRAE if we set a target that is unachievable. How does ASHRAE continue to earn the right to set targets? If our consensus

documents do not attain an aggressive goal, policy makers may decide that ASHRAE should no longer be the basis for the national model energy code.



## UTILITY WARS

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Fuel switching together with utility industry wars is another obstacle. Any EUI target that is set with a fuel type that is either specified or implied will cause extreme difficulty in obtaining consensus. Utilities and their representatives have a material interest in the specifics of how energy codes, and energy targets, are created. As these targets become more aggressive, some technologies and some fuel types may not appear viable. Therefore the

affected parties may object to any energy target proposed as a consensus document at all levels (ASHRAE, ANSI, codes), using whatever means they have to thwart the process. There is a general school of thought that when a site based energy target is set with a mixture of fossil fuels and electricity, there will be a temptation to meet the target by switching away from fossil fuels towards electricity by, for example, using direct electric resistance heating.

## POTENTIAL CONFLICT WITH OTHER ORGANIZATIONS

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ASHRAE does not work alone but in cooperation with other organizations that may choose different methods for setting energy targets. These other organizations have their own procedures and policies which may or may not harmonize with ASHRAE's. ASHRAE has gained its reputation by being objective and

thoughtful in its policy making, taking into consideration all sides of an issue before publishing consensus documents. On the other hand, if ASHRAE does not set the targets, others may set them using other means and leave our members struggling to find ways to meet these targets in their designs.

## MISSING RESEARCH

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We currently lack research on some building types such as datacenters and supermarkets. We also lack research on all types of receptacle and process loads that would allow us to devise

methodologies for reducing the growing influence of these loads on the total EUI as the HVAC and lighting use decline.

## V. DEFINITION OF EUI TARGETS AND THE BASIS FOR THEIR CALCULATION

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**Efficiency Only Energy Use Intensity (EUI):** the *Target Energy Use* divided by the *Gross Floor Area* measured in kBtu/ft<sup>2</sup>-yr.

**Net Energy Use Intensity (NEUI):** the *Net Energy Use* divided by the *Gross Floor Area* measured in kBtu/ft<sup>2</sup>-yr. Those building types which are capable of a high level of efficiency and on-site generation will have a NEUI of zero; while those that have limited ability for on-site generation or that have large receptacle and process loads will reach some non-zero level of net energy use intensity.

**Target Energy Use:** the total energy consumed by the modeled building in one year without the use of photovoltaics or wind generators (Referred to in Std 105 as Total Energy Use).

**Net Energy Use:** for a building is the energy consumed by the modeled building in one year minus the energy produced on the site such as from photovoltaics (taken from Std 105 definition of Net Energy Use).

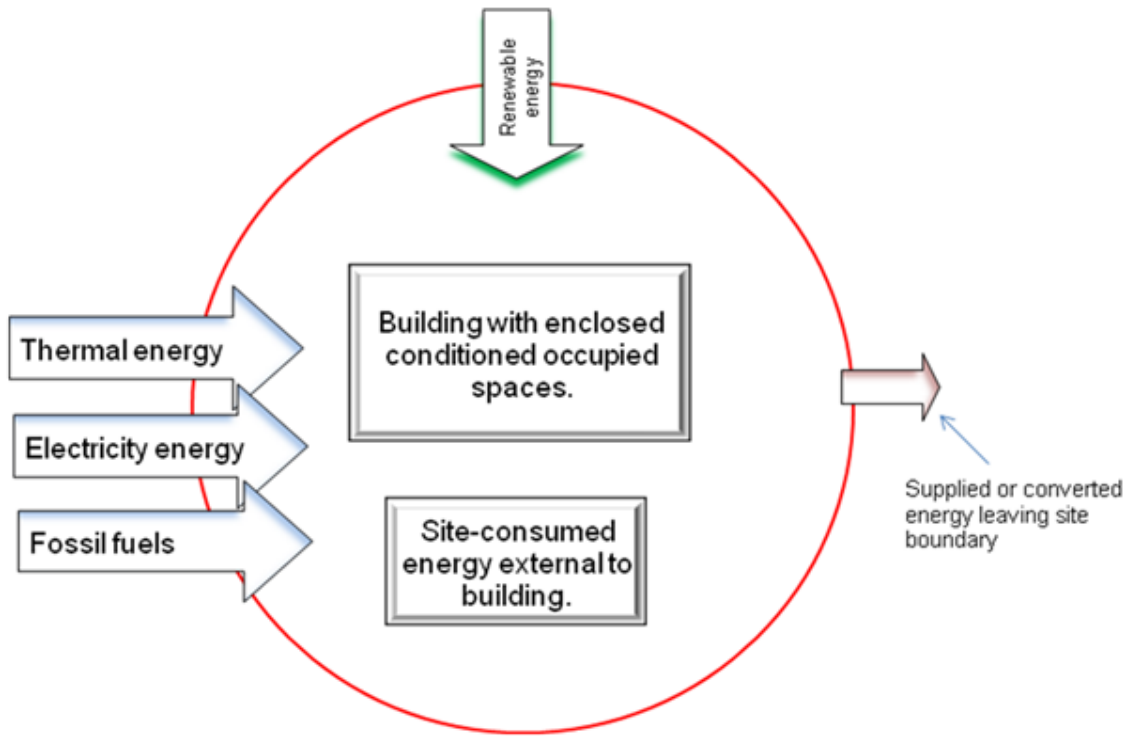
**Gross Floor Area:** the sum of the floor areas of all the spaces within the building, including halls and other circulation areas, any common areas, basements, interior shafts (by floor), mezzanine and intermediate-floored tiers, and penthouses with headroom height of 90 in. (2300 mm) or greater; it is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but it excludes covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, parking garages, surface parking, and similar features (taken from Std 105 definition of gross floor area).

The following table represents the results of a ballot on various questions of definition. Refer to the “*Energy Target Ad Hoc Ballot – All*” spreadsheet for a detailed discussion on each question. Look also at the comments by Ad Hoc members on the survey questions.

**Table 2 Ad Hoc Committee Ballot**

	<b>Question</b>	<b>Y/N/Abstain</b>	
Question 1	<i>Should EUI include plug loads?</i>	6-0-0 CNV	PASSED
Question 2	<i>Should ASHRAE's target EUI goals require compliance with Std 62.1 and Std 55?</i>	6-0-0 CNV	PASSED
Question 3	<i>Should our Target EUI use the Std 105 definition of Gross floor area which is also used in Std 90.1, Std 189.1, and the benchmark buildings?</i>	5-1-0 CNV	PASSED
Question 4	<i>Should our energy targets report Net Site energy as shown in Group 1(See Boundaries Below)?</i>	4-2-0 CNV	PASSED
Question 5	<i>Should the Energy Targets be generated from Energy Models?</i>	5-0-1 CNV	FAILED
Question 6	<i>Should Energy Targets be set for Std 90.1 and Std 189.1 via negotiation with each SSPC?</i>	3-4-0 CV	FAILED
Question 7	<i>Should Standard 90.1 be the document to comply with the Board goal of Net zero energy by 2020?</i>	1-6-0 CNV	FAILED
Question 8	<i>Should Standard 189.1 be the document to comply with the Board goal of Net zero energy by 2020?</i>	3-4-0 CV	PASSED
Question 9	<i>Should the AEDGs be the documents to comply with the Board goal of Net zero energy by 2020?</i>	4-0-2 CNV	

**Figure 2: NEUI: the sum of all energy flows crossing the boundary on an annual basis**



**EFFICIENCY AND RENEWABLE ENERGY PRODUCTION**

**Figure 4-4 Max Tech and BASE with and without PV**

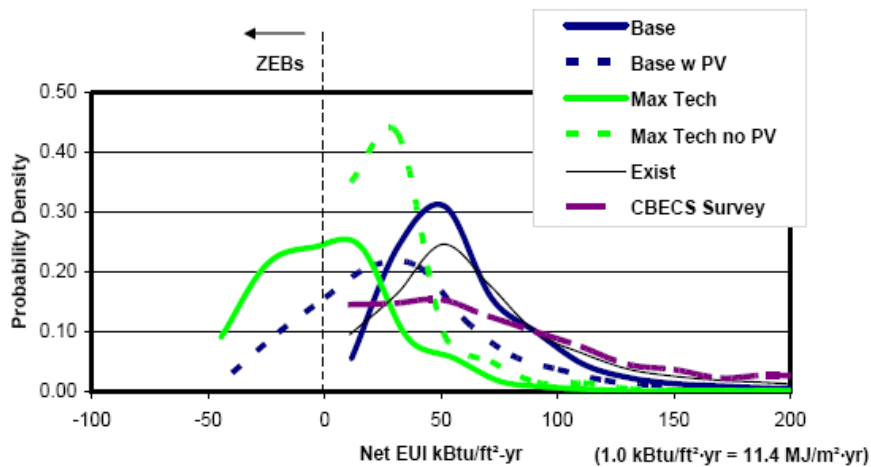


Figure 4-4 PDFs for net EUI for three scenarios

## EFFICIENCY

One of the major recommendations of the Ad Hoc Committee Members to Technology Council is adopting a clear and consistent definition of the Base and Efficiency EUI. In this report, the Ad Hoc presents several tables of EUI. The first is the EUI for buildings built according to 90.1-2004 (Annex 5 Table 1). This becomes the base value for the “percentage savings” calculations or the baseline from which to measure a building’s energy use efficiency. Another is the Efficiency-Only EUI (Table 4 Target EUI) which is intended to become the goal for energy efficient buildings. In the

*Assessment*, NREL defined a metric called *Max Tech with no PV* where building models were created with a set of technologies and practices that represent projections for improvements out to 2025. It is the *Target Energy Use* divided by the *Gross Floor Area* of a building using all of the available best practices and best available efficiency technology without the use of on-site generation such as PV or Wind. This number represents the maximum efficiency available by building type. In the *Assessment*, the national average Max Tech w/o PV EUI was calculated to be 40.3 kbtu/sf-yr. (See Figure ES-1).

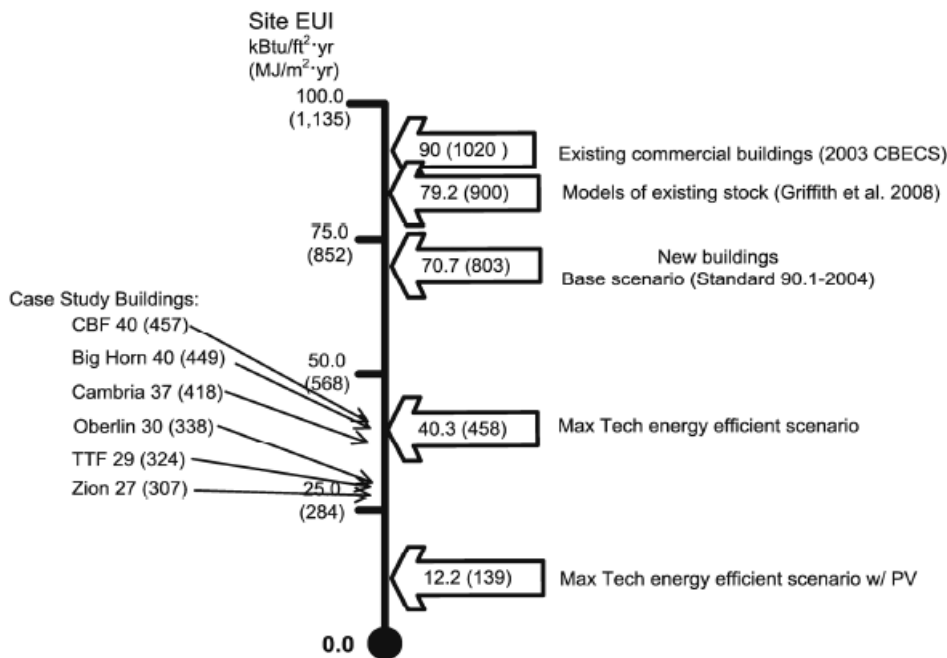


Figure ES-1 Average results for EUI for current stock, minimum standard, and Max Tech scenarios

## RENEWABLE ENERGY PRODUCTION

Another table of EUI in this report shows the values of annual NEUI (See Table 5) when PV is included. These values show the EUI that could be expected if these building types had on-site PV which offset some of the annual electrical needs. Some building types show

NEUI of NZ which indicates that these buildings can be expected to reach net zero energy use on an annual basis assuming the electric grid will accept any exported electric generation. In the *Assessment* some of the building types were reported as net energy producers on annual basis

as seen in Annex 5 Table 3 *Max Tech with PV*. This means that the assumption on amount of PV installed was excessive. In reality, based on today's prices, the value should not go below zero since the owner would not put an excessive amount of PV on the roof. By reporting these values in Tables 4 & 5, one for maximum

efficiency and one for renewable energy production, the Ad Hoc is placing importance upon the need to first aim for implementing building energy reduction measures and achieve maximum efficiency before the application of on-site generation from PV or wind.

## REGULATED VS UNREGULATED LOADS

As the efficiency levels of the regulated loads (i.e., those loads which are under the control of a code or regulation) in commercial buildings improve, the relative effect of the unregulated loads increases. See Table 3.1 from the Energy Information Agencies Building Energy Data Book for the end-use split of energy consumption in commercial buildings. Table 3 below shows a scenario of what happens when unregulated loads are ignored. An Energy Target needs to pay attention to these unregulated loads

and make assumptions regarding their improved efficiency over time. The Max Tech scenario from the *Assessment* has an assumption of a 25% improvement in unregulated loads over the analysis time period. The average unregulated receptacle and process load assumptions in the base case is estimated at 10.1 kbtu/ft<sup>2</sup>-yr and drops to 7.6 kbtu/ft<sup>2</sup>-yr in the Max Tech scenario. This number must continue to be evaluated and reduced in the refreshed study that is recommended later in this report.

**Table 3 Impact of Unregulated Loads as Regulated Loads are Reduced**

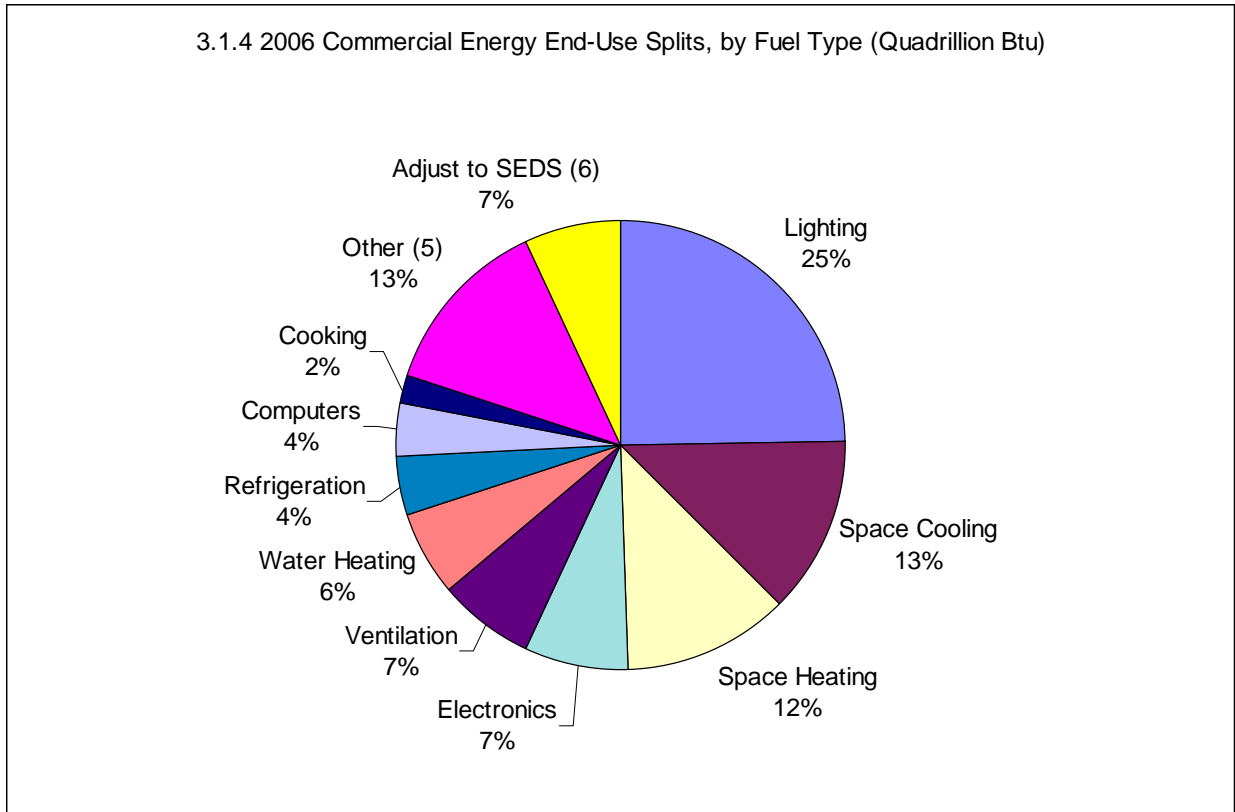
PRIMARY ENERGY					
	Today <sup>1</sup> kBtu/ft <sup>2</sup> -yr	30% Reduction kBtu/ft <sup>2</sup> -yr		50% Reduction kBtu/ft <sup>2</sup> -yr	
Regulated	67	37	53%	17	34%
Unregulated	33	33	47%	33	66%
	100	70		50	
Regulated Load Reduction		45%		75%	
SITE ENERGY					
	Today <sup>1</sup>	30% Reduction		50% Reduction	
Regulated	64	34	49%	14	28%
Unregulated	36	36	51%	36	72%
	100	70		50	
Regulated Load Reduction		47%		78%	

3.1.4	2006 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)											
	Natural	Fuel	Other		Renw.	Site	Site		Primary	Primary		
	Gas	Oil (1)	LPG	Fuel(2)	En.(3)	Electric	Total	Percent	Electric (4)	Total	Percent	
Lighting						1.40	1.40	16.9%		4.45	4.45	24.8%
Space Cooling	0.02					0.71	0.73	8.8%		2.25	2.27	12.6%
Space Heating	1.18	0.24		0.10		0.21	1.73	20.9%		0.65	2.17	12.1%
Electronics						0.42	0.42	5.1%		1.34	1.34	7.5%
Ventilation						0.38	0.38	4.6%		1.21	1.21	6.7%
Water Heating	0.55	0.05			0.02	0.16	0.78	9.4%		0.50	1.13	6.3%
Refrigeration						0.23	0.23	2.8%		0.73	0.73	4.1%
Computers						0.21	0.21	2.6%		0.68	0.68	3.8%
Cooking	0.23					0.04	0.27	3.3%		0.12	0.35	2.0%
Other (5)	0.27	0.03	0.08	0.05	0.13	0.57	1.12	13.6%		1.81	2.36	13.2%
Adjust to SEDS (6)	0.67	0.22				0.11	1.00	12.1%		0.34	1.23	6.9%
<b>Total</b>	<b>2.92</b>	<b>0.53</b>	<b>0.08</b>	<b>0.15</b>	<b>0.16</b>	<b>4.43</b>	<b>8.27</b>	<b>100%</b>	<b> </b>	<b>14.09</b>	<b>17.93</b>	<b>100%</b>

Note(s): 1) Includes (0.42 quad) distillate fuel oil and (0.11 quad) residual fuel oil. 2) Kerosene (0.02 quad) and coal (0.08 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of (0.13 quad) biomass, (0.03 quad) solar water heating, and (less than 0.01 quad) solar PV. 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.18. 5) Includes service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 6) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2008, Mar. 2008, Tables A2, p. 117-119, Table A5, p. 124-125, and Table A17, p. 143-144; EIA, National Energy Modeling System for AEO 2008, Mar. 2008; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2 and 5-25 - 5-26; EIA, AEO 1998, Dec. 1997, Table A5, p. 108-109 for 1995 ventilation; and BTP/Navigant Consulting, U.S. Lighting Market Characterization, Volume I, Sept. 2002, Table 8-2, p. 63; EIA, Supplement to the AEO 2008, April 2008, Table 22.

**Figure 3.1 Commercial Building Energy End Use Split: (2006 EIA Building Energy Data Book)**



## VI. EUI TARGETS AND NET TARGETS

From NREL/TP-550-41957 December 2007 *Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector*

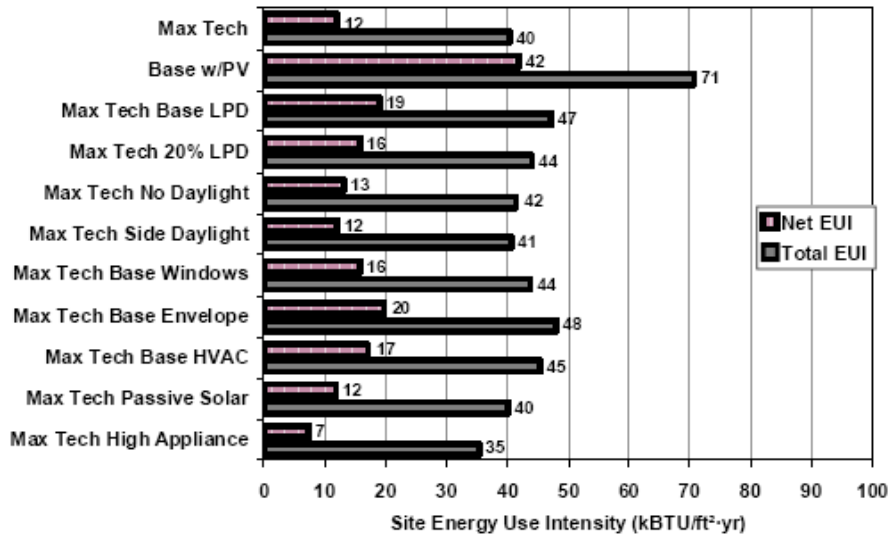


Figure 4-2 Mean site EUIs for entire sector under various scenarios: IP Units (kBTU/ft²-yr)

30

The performance levels in Tables 4 and 5 are best-estimate projections for what could be available in the market in 2025 according to the *Assessment*. The Ad Hoc has neither validated nor endorsed the technologies and performance assumptions used in the *Assessment* and recommends that this be done through ASHRAE's research program.

With some limitations on modifying the building geometry and the HVAC system topology, the *Assessment* determined that the national average EUI achievable using the best available efficiency technologies without PV or wind site electricity generation was 40.3 kbtu/ft²-yr across all building types and climate zones (See Table 4 Target EUI). This represents a 43% reduction from the Standard 90.1-2004 benchmark. This value can be further reduced by refreshing the *Assessment* with new information on

technologies made available since 2007 and by including new building geometries, optimized and additional HVAC systems and types and operational practices that will improve the annual energy use efficiency.

Table 5 Max Tech scenarios NEUI w/ PV is modified from the Max Tech scenario in the *Assessment* document. No buildings in Table 5 NEUI Targets are net positive energy producers (which would be shown in the table by negative numbers).

The *Assessment* provides a description of the assumptions made to achieve these EUI. The assumptions, by their nature, provide suggestions for means and methods to accomplish the efficiency levels indicated in Tables 4 & 5.



**EFFICIENCY ONLY ENERGY USE INTENSITY TARGETS (EUI)**

**Table 4 Target EUI (kBtu/ft<sup>2</sup>-yr) 2025 Efficiency Only Max Tech Scenario EUI without PV**

Climate Zone															
	All	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
All	40.3	55.2	41.8	44.4	48.1	37.1	44.6	38.8	28.0	32.7	41.9	36.2	37.6	35.2	35.5
Office/professional	32.7	33.8	35.9	31.7	30.3	30.3	29.0	34.2	37.6	30.5	33.1	28.5	31.0	29.0	34.7
Nonrefrigerated warehouse	17.4	14.3	13.4	a	14.9	14.5	12.0	17.0	21.8	13.8	19.4	21.9	20.6	18.5	20.8
Education	23.0	74.5	26.6	30.9	19.9	21.6	27.1	25.6	17.4	18.8	21.6	18.6	22.4	23.8	27.0
Retail (excluding mall)	28.6	22.5	33.3	38.7	26.1	25.6	24.8	27.7	24.7	a	29.3	29.7	30.9	33.5	35.0
Public assembly	30.4	53.1	36.3	a	38.4	31.8	25.6	26.7	21.1	39.2	29.4	26.4	29.9	27.0	26.8
Service	37.1	72.6	41.7	a	28.7	31.5	22.2	38.4	26.6	a	40.0	34.2	34.4	34.6	41.6
Religious worship	16.4	a	17.2	a	11.9	12.8	a	16.0	21.4	a	18.6	13.1	19.1	13.7	a
Lodging	28.8	36.3	30.7	a	29.5	25.7	a	29.4	30.2	29.0	28.0	26.7	27.4	28.1	27.7
Food services	311.3	482.1	298.1	a	316.6	334.4	304.3	304.6	a	401.1	316.3	293.1	306.1	198.3	291.7
Health care (inpatient)	71.3	78.2	74.9	79.8	68.8	72.0	68.5	67.9	60.9	a	77.2	70.3	65.3	64.0	95.4
Public order and safety	43.7	a	38.7	a	35.9	51.5	a	37.8	a	a	49.0	59.2	44.1	60.8	a
Food sales	107.1	a	112.3	a	118.5	94.0	98.6	112.7	a	a	101.7	109.9	106.2	a	100.6
Health care (outpatient)	40.4	36.8	52.8	a	39.0	59.5	a	33.5	34.3	a	42.4	33.2	34.1	34.1	46.0
Vacant	11.6	a	6.0	28.3	13.3	10.1	8.3	16.3	16.6	6.3	7.3	7.7	14.2	a	28.2
Other	30.9	a	45.4	a	23.6	29.7	a	32.0	12.5	a	31.8	22.8	30.0	34.0	21.8
Skilled nursing	86.8	a	93.5	a	85.4	77.3	a	95.0	a	a	93.4	68.8	75.3	74.0	a
Laboratory	286.3	a	A	a	296.9	318.7	a	227.3	a	a	285.6	a	243.1	274.8	a
Refrigerated warehouse	51.1	a	a	a	a	a	a	52.5	a	a	51.4	43.3	52.5	a	a

a = Category has less than 5 samples in 2003 CBECS

## NET ENERGY USE INTENSITY TARGETS (NEUI)

**Table 5 2025 Max Tech Scenario NEUI with PV (kBtu/ft<sup>2</sup> - yr)**

Climate Zone	All	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
All	12.2	19.8	7.4	9.4	13.4	2.9	27.3	13.6	NZ	15.5	18.5	1.5	13.9	NZ	12.7
Office/professional	14.2	17.9	12.3	NZ	8.0	7.0	23.0	18.9	20.6	19.5	17.1	4.4	12.0	NZ	15.0
Nonrefrigerated warehouse	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	2.9
Education	NZ	36.5	NZ	NZ	NZ	NZ	1.8	0.0	NZ	NZ	2.1	NZ	0.3	NZ	NZ
Retail (excluding mall)	NZ	NZ	NZ	NZ	NZ	NZ	4.3	NZ	NZ	NZ	NZ	NZ	1.0	NZ	2.1
Public assembly	1.7	NZ	NZ	a	8.6	NZ	NZ	3.8	NZ	19.2	2.5	0	8.2	10.7	NZ
Service	NZ	19.7	NZ	a	NZ	NZ	NZ	5.6	NZ	a	6.6	NZ	0.1	NZ	6.8
Religious worship	NZ	a	NZ	a	NZ	NZ	a	NZ	NZ	a	NZ	NZ	NZ	NZ	a
Lodging	14.1	25.7	18.1	a	10.9	3.8	a	17.4	23.5	7.9	16.9	0.4	14.6	NZ	9.7
Food services	276.2	425.0	255.7	a	277.0	288.6	287.5	272.8	a	356.7	288.3	254.4	278.2	151.2	253.0
Health care (inpatient)	61.1	68.5	64.1	71.9	54.7	61.5	50.5	58.3	54.1	a	70.9	51.9	56.1	52.5	88.7
Public order and safety	20.1	a	18.4	a	1.1	20.9	a	18.0	a	a	27.5	20.0	18.7	48.7	a
Food sales	66.7	a	66.0	a	71.8	45.6	58.8	72.1	a	a	64.7	74.9	68.1	a	77.2
Health care (outpatient)	11.7	10.4	13.1	a	1.0	19.9	a	8.7	NZ	a	21.3	NZ	11.5	8.1	26.6
Vacant	NZ	a	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	a	14.8
Other	NZ	a	2.9	a	NZ	NZ	a	NZ	NZ	a	4.4	NZ	7.9	NZ	NZ
Skilled nursing	61.5	a	65.4	a	54.4	30.9	a	75.7	a	a	73.9	21.9	55.6	34.7	a
Laboratory	272.9	a	a	a	290.0	286.4	a	205.9	a	a	274.2	a	234.4	261.0	a
Refrigerated warehouse	15.6	a	a	a	a	a	a	11.2	a	a	31.9	1.1	16.8	a	a

a = Category has less than 5 samples in 2003 CBECS

NZ = Net Zero NEUI building

## VII. RECOMMENDATIONS

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The Ad Hoc Committee recommendations attempt to define the maximum level of commercial building energy use efficiency which is technologically achievable now or in the near future. The specific numbers presented in Tables 4 and 5 were not created by the Ad Hoc but are derived from the *Assessment*. It is the opinion of the Ad Hoc that not every new commercial building can be designed for net zero energy use, so the ultimate level of energy use efficiency will not be zero in all cases.

### **The Ad Hoc recommends that:**

- 1) *A comprehensive education program be conducted in order to promote a common understanding of the EUI metric among ASHRAE members and the public.*

Building energy performance metrics have been extensively used by numerous bodies to set policy for commercial-building energy-use reduction goals. Yet there is no one generally accepted definition of the metric. The Ad Hoc Committee report recommends one clear, logical definition that will be used by ASHRAE for setting policy and for measuring progress towards the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net-zero energy buildings by 2030.

The committee prepared an article for the ASHRAE High Performance Building Journal Summer 2010 issue titled “*Building EUI*” to help educate our membership on both the power and opportunity of EUIs and also the issues that need to be considered. A copy of the article is in Annex 4. A follow-up article will be prepared to report on the results of the Ad Hoc. Other opportunities exist for education and outreach to the membership, including policy briefs, position papers, annual and winter meeting presentations and special publications.

- 2) *Energy use targets be defined and developed as follows:*

- a) *Targets include receptacle and process loads.*

Energy Targets recommended herein include assumptions about the reduction of receptacle and process energy use even though these loads are unregulated. The impact of unregulated loads increases as the regulated load energy use is reduced. Without addressing the unregulated loads, true net zero energy buildings will not be possible. Refer to the section in this report on Regulated vs Unregulated Loads.

- b) *Targets are based on the best available technology for energy efficiency and on-site renewable energy production without regard for cost or cost effectiveness.*

- c) *Two types of targets are developed: Target Energy Use Intensity (EUI), which includes no on-site renewable energy generation, and Net Energy Use Intensity (NEUI), which includes photovoltaic and other on-site renewable energy production.*

The definitions of *Target Energy Use* and *Net Energy Use* are shown in Section V. The target EUIs are based on site energy use simulated from models by building type and climate zone using the Efficiency Only Energy Use Intensity definition from this report. The EUI Targets proposed here represent the lowest possible energy consumption on an annual basis using the best available efficiency technology without the use of photovoltaics. The NEUI Targets recommended in this report indicate those building types which, due to their ability to achieve the Efficiency Only EUI coupled with their available on-site generation capacity, can achieve true net zero energy use intensity. For those

building types which are unable to achieve true net zero EUI either due to their low on-site electric generation capability or due to their large receptacle and process loads, we have recommended low non-zero NEUI.

- d) *The gross floor area used to define EUI and NEUI is defined as in ASHRAE Standard 105:*

**Gross Floor Area:** *the sum of the floor areas of all the spaces within the building, including halls and other circulation areas, any common areas, basements, interior shafts (by floor), mezzanine and intermediate-floored tiers, and penthouses with headroom height of 90 in. (2300 mm) or greater; it is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but it excludes covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, parking garages, surface parking, and similar features.*

The Ad Hoc conducted a vote on the various definitions. The results of that vote are reported in Section V.

- e) *EUI and NEUI values are determined by modeling.*
- f) *One clearly defined set of simulation models consisting of a standardized set of building types should be established in cooperation with the Department of Energy for evaluation of Std 90.1, Std 189.1, and the AEDGs.*

These models should be compliant with Std 62.1 and Std 55. They should be based upon a standardized set of building types (not necessarily the building types shown in Tables 4 & 5) with standardized assumptions and operational parameters. They should be mutually agreeable to all of the partners of the AEDG Steering Committee as well as to SSPC 90.1 and SSPC 189.1.

Since there are several different sets of models being used more or less independently for evaluation of these three documents, a deliberate coordination effort will be required of Technology Council to bring them together in a wayfashion which is acceptable to the Department of Energy and the various national laboratories who are under contract from DOE for their creation and use. The Ad Hoc recommends that Technology Council or its designee perform this coordination.

- 3) *Buildings subject to the targets be required to comply with ANSI/ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality, and ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy.*

When building energy use performance metrics are presented with the expectation of compliance, it is natural to assume that there will be a certain amount of “gaming” that occurs which seeks to comply in the most expedient fashion. On occasion, this expedience includes some shortcuts to energy use reductions that may be detrimental to the well being and comfort of the building occupants. This actually occurred frequently during the energy crisis of the 1970s. This recommendation seeks to close the loophole that would allow building operators to reach compliance in this fashion.

- 4) *Neither SSPC 90.1 nor SSPC 189.1 should be given specific mandatory energy performance targets.*

Much has been said about the difficulty of using a prescriptive, incremental, consensus based process to make dramatic improvements to code-intended ANSI standards. (See Section VI in this report) The ASHRAE consensus process is slow and sometimes contentious because it seeks compromise and agreement among numerous materially affected parties. In this

arena of defining the maximum allowed energy use intensity among new commercial buildings, improvements to the standards tend to reach a point of diminishing returns and, in time, appear to asymptotically approach some level of energy use efficiency.

SSPC 90.1 should be aware that their current work plan includes an energy efficiency improvement goal. The Ad Hoc interprets this goal to be equivalent to approximately 50 kbtu/ft<sup>2</sup>-yr. The Ad Hoc interprets the goal for SSPC 189.1 as approximately 40 kBtu/sf-yr which represents the national average as shown in Table 4.

- 5) *Neither Std. 90.1 nor Std. 189.1 should be adopted as the primary means of fulfilling the Vision 2020 goal.*

The Ad Hoc recommends the following policy proposal for the role of Std 90.1 and Std 189.1. These proposals could be incorporated into the respective work plans of the SSPCs at their discretion.

ANSI/ASHRAE/IESNA Standard 90.1: This document should describe the highest permissible EUI for a mandatory code regulated building. The SSPC must use scalar economics to justify the prescriptive measures and continue to use the ASHRAE code-intended standards development process. The ultimate goal for the energy use intensity of a minimally compliant building is recommended to be somewhere roughly half way between the NEUI shown in Table 5 and the 90.1-2010 EUI as determined by DOE.

ANSI/ASHRAE/USGBC/IES Standard 189.1: This document will describe the lowest possible EUI for a mandatory code regulated building without using scalar economics while giving the building design the greatest possible flexibility by allowing room for the designer to trade off prescriptive requirements with photovoltaics and wind generation. This document should allow the use of purchased green power

credits to reach the goal if the SSPC agrees with this approach<sup>1</sup>. Moreover, this document should not restrict the design to a single technology but should use at least two technologies as long as there are at least two manufacturers of those technologies. It should not require net zero building design but should reach the target NEUI by 2020 with PV and/or wind and possibly purchased PV and/or wind.<sup>1</sup>

- 6) *The series of Advanced Energy Design Guides, with the concurrence of our partnering organizations, be designated as the primary means of fulfilling the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net zero energy buildings by 2030.*

We recommend that ASHRAE seek approval from our partner organizations to develop the AEDG series to become the tool that designers will use to design buildings with the lowest technologically feasible NEUI as shown in Table 5. The NEUI should be modified as necessary by the Steering Committee to fulfill the joint mission of the partner organizations. The documents should assume that some electric generation will be provided by on-site PV and/or on-site wind on an annual basis. The documents should allow the purchase of some off-site electric generation produced by PV and/or wind to count towards the NEUI.

The design could be restricted to a single technology as long as more than one manufacturer is available. The AEDGs may even suggest single technologies by listing some successful examples. Economics for the technologies need not be based upon any scalar but upon the experience of the professionals developing the guides.

Currently, there is no consensus process other than the approval of the steering committee to develop the AEDG series; however the documents do undergo an extensive public peer review.

Since the AEDG series are educational documents to show how energy savings in buildings can be accomplished, they do not follow the ASHRAE Standards development process. Instead, the Steering Committee has instituted a form of consensus building that seeks input from interested parties in order to produce an effective and well respected document. This process is ideal for creating the aggressive building energy use efficiency improvements necessary to achieve net zero energy design guidance.

- 7) *ASHRAE should enter into a contract with an appropriate body to reevaluate and update the information in NREL/TP-550-41957 “Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector.”*

The *Assessment* is an excellent document which, although developed for a different purpose more than three years ago, is ideal for ASHRAE to reconfigure in order to establish EUI targets using the latest efficiency technology and using optimized geometry of the benchmark buildings along with optimized topology of the HVAC systems.

The performance levels in Tables 4 and 5 are best-estimate projections for what could be available in the market in 2025 according to the *Assessment*. The Ad Hoc has not validated nor endorsed the technologies used in the *Assessment* and recommends that this be accomplished using ASHRAE research.

In addition, the refreshed assessment should make aggressive efficiency improvement assumptions, determined in conjunction with the Technology Council, about receptacle and process load levels in the future. The Ad Hoc recommends that ASHRAE go beyond the work of the NREL *Assessment* and increase the “Max Tech” options to include technologies from several sources not available or not considered by the 2007

study’s authors. These should include, for example, the High Performing Building Magazine, the DOE High Performance data base, the USGBC, the DOE Commercial Buildings Energy Alliance, and others. The only restriction on the use of any technology for Max Tech is that a technology must be available from more than one manufacturer.

To accomplish this, the Ad Hoc recommends to Technology Council that ASHRAE conduct research to determine the minimum technically feasible EUI and NEUI in 16 building types for 16 climate zones with the accompanying weighting factors and to complete this work by the end of the Society year 2010-2011 by revising the *Assessment* under the direction of Technology Council. ASHRAE should also conduct research and analysis with appropriate organizations and partners to determine the specific building types to target for achieving net zero energy and the extent to which net zero energy buildings affect the grid as discussed in Annex 3 “Market Penetration of Net Zero Energy Buildings.”

- 8) *ASHRAE should provide research funding to complete the net-zero AEDG series for building types that have the highest probability of achieving net zero-energy and that are not already funded by DOE.*

Not all building types shown in Table 5 are currently planned to receive a net zero AEDG. Therefore, the Ad Hoc recommends ASHRAE provide funding and/or seek outside funding to complete the 50% and net zero AEDGs for those building types to fulfill the Vision 2020 goal. The Steering Committee should determine which building types are needed.

- 9) *ASHRAE use the values presented in Annex 5 Table 1 as the base values when calculating the “progress toward net zero.”*

## POSSIBLE STRATEGIES TO IMPLEMENT THE ABOVE RECOMMENDATIONS

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### Strategy 1:

Neither SSPC 90.1 nor SSPC 189.1 will be given mandatory energy use targets. Rather, a target EUI will be suggested to them by Technology Council or their designee for consideration as part of their respective work plans. Analysis of the progress of both standards will continue to be accomplished by computer modeling of benchmark buildings whose input files include receptacle and process loads. ASHRAE will remain committed to developing and promoting technical tools to assist the industry in moving towards NZEBs. ASHRAE will continue to offer itself as an ongoing resource to the federal government by providing technical tools and by offering a voice of the industry.

### Strategy 2:

ASHRAE will seek approval from our partnering organizations to adopt the series of Advanced Energy Design Guides as the primary means of fulfilling the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net zero energy buildings by 2030. The AEDG Steering Committee will be offered the NEUI targets as goals for the series. ASHRAE will fund and/or seek outside funding for the development of any AEDG building type that is not currently funded by DOE.

### Strategy 3:

ASHRAE will enter into a contract with an appropriate body to reevaluate and update the information in NREL/TP-550-41957 “Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector.”

### Strategy 4:

In order to promote a common understanding of the energy use efficiency metric EUI and the NEUI on-site renewable energy production metric among ASHRAE members and the public, ASHRAE will conduct a comprehensive education program. This initiative may consist of Journal articles, Position Briefs, Position Papers, Technical Papers, Annual and Winter Meeting seminars, Handbook material, and special publications.

<sup>1</sup> The purchase of renewable energy such as PV and wind may be a necessary part of any low energy use policy due to the impossibility of such on-site generation caused by the lack of physical space to accommodate the technology as may be the case, for example, in a dense urban environment. The purchase could possibly be limited to the difference between the potential PV and/or Wind available within the site limitations and the amount needed to reach net zero on an annualized basis.

## **VIII. ENERGY TARGETS BRIEF**

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**This is a potential Position Brief with the definitions and strategies. It probably needs some more text to explain all this but there is no room.**





**ASHRAE**  
Washington, D.C.

ASHRAE, founded in 1894, is an international organization of 55,000 persons. ASHRAE fulfills its mission of advancing heating, ventilation, air conditioning and refrigeration to serve humanity and promote a sustainable world through research, standards writing, publishing and continuing education.

ASHRAE is headquartered in Atlanta, Ga. The Washington, D.C., office works with federal government leaders as well as other scientific and engineering societies, trade associations and public interest groups. For more information, visit [www.ashrae.org](http://www.ashrae.org) or contact Doug Read in the Washington office.

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## **ENERGY TARGETS FOR COMMERCIAL BUILDINGS**

*Efficiency Only Energy Use Intensity (EUI) is the Target Energy Use divided by the Gross Floor Area measured in kbtu/sf-yr.*

*Net Energy Use Intensity (NEUI): is the Net Energy Use divided by the Gross Floor Area measured in kbtu/sf-yr.*

*Target Energy Use: for a building is the total energy consumed by the modeled building in one year without the use of photovoltaics or wind generators. (Ref: ANSI/ASHRAE Std 105 definition for "Total Energy Use")*

*Net Energy Use: for a building is the energy consumed by the modeled building in one year minus the energy produced on the site such as from photovoltaics. (Ref: ANSI/ASHRAE Std 105 definition for "Net Energy Use")*

*Gross Floor Area: the sum of the floor areas of all the spaces within the building, including halls and other circulation areas, any common areas, basements, interior shafts (by floor), mezzanine and intermediate-floored tiers, and penthouses with headroom height of 90 in. (2300 mm) or greater; it is measured from the exterior faces of exterior walls or, or from the centerline of walls separating buildings, but it excludes covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, parking garages, surface parking, and similar features (Ref: ANSI/ASHRAE Std 105 definition of gross floor area).*

### **ASHRAE VIEW**

**Strategy 1:** *Neither SSPC 90.1 nor SSPC 189.1 will be given mandatory energy use targets. Rather, a target EUI will be suggested to them by Technology Council or their designee for consideration as part of their respective work plans. Analysis of the progress of both standards will continue to be accomplished by computer modeling of benchmark buildings whose input files include receptacle and process loads. ASHRAE will remain committed to developing and promoting technical tools to assist the industry in moving towards NZEBs. ASHRAE will continue to offer itself as an ongoing resource to the federal government by providing technical tools and by offering a voice of the industry.*

**Strategy 2:** *Seek approval from our partnering organizations, to make the series of Advanced Energy Design Guides become the documents to fulfill the Vision 2020 goal of providing tools by 2020 that enable the building community to produce market-viable net zero energy buildings by 2030. The AEDG Steering Committee will be offered the NEUI targets as goals for the series. ASHRAE will fund and/or seek outside funding for the development of any AEDG building type that is not currently funded by DOE.*

**Strategy 3:** *ASHRAE enters into a contract with an appropriate body to reevaluate and update the information in NREL/TP-550-41957 "Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector."*

**Strategy 4:** *In order to promote a common understanding of the energy use efficiency metric EUI and the NEUI on-site renewable energy production metric among ASHRAE members and the public, ASHRAE will conduct a comprehensive education program. This initiative may consist of Journal articles, Position Briefs, Position Papers, Technical Papers, Annual and Winter Meeting seminars, Handbook material, and special publications.*

*Conclusion: Not all building types are capable of reaching annual net zero energy use. Current understanding suggests that the minimum technologically achievable EUI on average for all building types is 40.3 kbtu/sf-yr and 12.2 kbtu/sf-yr for NEUI.*

## IX. ANNEX 1 ROLE OF ASHRAE IN ENERGY PERFORMANCE MEASUREMENT

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ASHRAE has many existing standards, guidelines, certification and training programs and tools to assist federal and state agencies in their efforts to reduce energy usage in the US. Some of the standards and guidelines are:

1. Standard 105 -2007: Standard Methods of Measuring, Expressing and Comparing Building Energy Performance. Committee being formed to review for update.
2. Standard 100- 2006: Energy Conservation in Existing Buildings. Active committee is working on major revision
3. Standard 90.1 continuous: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
4. Standard 90.2 continuous: Energy Efficient Design of New Low-Rise Residential Buildings. New committee formed to address status of standard
5. Standard 189: Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings.
6. Guideline 14: Measurement of Energy and Demand Savings. Active committee working on major revisions
7. Procedures for Commercial Building Energy Audits: Active committee working on major revisions
8. Building Energy Quotient labeling: current pilot program exists
9. Advanced Energy Design guides: 30% guides exist for all except existing buildings

Generally the scope for energy performance measurement may be confused by a failure to distinguish among:

- expected energy performance of a new building during design phase (STDs 90 and many ISO standards),
- “asset” performance of existing buildings based on how the building should (or could) perform (various combinations of calculation and actual measurement, e.g.,

Building EQ asset rating and many European ratings or STD 189.1),

- actual measurement of “as-operated, as-occupied” energy performance (STD 105, some ISO standards, Building EQ proposed operational rating, the forthcoming ASHRAE book on performance measurement protocols, and proposed for STD 100R).

ASHRAE has the opportunity to write a paper explaining the differences that exist and why these publications and programs should not be expected to align.

Note that the International Performance Measurement and Verification Protocols and ASHRAE Guideline 14 are not directly about energy performance measurement, but about measurement and verification of energy (and other) savings (performance of savings measures).

ASHRAE scope differences are further confused by variations in sectoral coverage. Definition of sectoral coverage can be important.

1. STD 105-2007 does not place a limit on the types of buildings covered, but does limit the scope to buildings, both existing and proposed:  
“This standard: a. covers the measurement of energy use for existing buildings and the prediction of energy use for proposed buildings, b. specifies techniques for measuring, expressing, and comparing the energy performance of buildings . . .” STD 105 distinguishes between measurement of energy use and measuring energy performance.
2. STD 100R is currently moving in the direction of no limit on type of building covered.
3. STDs 90 covers proposed new buildings. Setting energy efficiency targets for a standard like 90.1 has a major difference in

scope from defining the method for measuring an operational energy performance for the proposed Building EQ label.

4. Some ISO and European national standards focus on specific building types.

A major conceptual issue is distinguishing among the matrix of potential scope “cells,” including other standards entities like ISO also. The major differences between real-world occupied buildings and proposed designs of buildings are not often understood, but these differences may lead to confused “scoping” of ASHRAE work. Similarly, STD 90.1 methods might be used in meeting the requirements of STD 105, but they are small subset of possible good methods, and they are only appropriate for the “prediction of energy use” side of STD 105.

Many conceptual and policy issues flow from understanding these scope issues. One example would be development of priorities for ASHRAE on setting targets for 90.1 vs. many other types of performance methods or targets,

such as for STD 100 or Building EQ. A clear delineation of how ISO and other standards fit in the picture is also needed and important.

An ASHRAE role should be to continue to work with all global standards and building code agencies and councils to coordinate the content of the existing standards, recognize the on going efforts in keeping these standards up to date with the current economic and environmental issues and provide guidance on adherence to the existing standards.

In addition ASHRAE should work with the federal and local agencies to simplify and educate building owners, operators and managers in why it is important to:

- determine actual building energy use
- conduct level 1, 2 or 3 energy audits
- establish energy targets for buildings
- continuous energy improvements through operations and maintenance of buildings

## **X. ANNEX 2 BUILDING ENERGY EFFICIENCY REQUIREMENTS AND PENDING LEGISLATION**

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### **Building Energy Efficiency Requirements and Pending Legislation**

Reference	Summary	Notes	Status	Location
<b>Current Requirements for State Adoption of Commercial Energy Codes</b>				
Energy Conservation and Production Act Section 304 (b) (Updating State building energy efficiency codes)	Within 2 years of October 24, 1992, each state must certify that a state's commercial building code regarding energy meets or exceeds the requirements of Standard 90.1-1989. When 90.1-1989 or any successor standard is revised, DOE shall within 12 months determine whether the revised version will improve energy efficiency in commercial buildings. If the Determination is affirmative, then within 2 years each state must certify that it has reviewed and updated the provisions of its commercial building code provisions regarding energy efficiency in accordance with the revised standard. The certification is to include demonstration that the provisions of the State's commercial building code regarding energy efficiency meet or exceed the revised standard.	<p>*Incentive funding is provided to states for adoption of such codes, but there is no mechanism for enforcement of these provisions if states do not comply.</p> <p>*No targets are established for improvement in code revisions (however backsliding is not allowed).</p> <p>*No requirement to demonstrate cost effectiveness of the recognized code or standard.</p>	Currently law applying to states	42 USC 6833 (b)
American Recovery and Reinvestment Act Section 410	As a condition of receiving some State Energy Program funds under the recovery act, states and local governments are required to implement a building energy code for commercial buildings that meets or exceeds 90.1-2007 and develop a plan to achieve compliance with the code within 8 years in at least 90% of new and renovated space.	*All 50 states have provided certification that they will comply with these requirements.	Current law	H.R.1, Public Law 111-5

Reference	Summary	Notes	Status	Location
<b>Pending Legislation to Establish Targets for Future Commercial Energy Codes</b>				
<p>American Clean Energy and Security Act of 2009 (Waxman/Markey) Section 201 (Greater Energy Efficiency in Building Codes)</p>	<p>Establishes energy efficiency targets for "National Building Code" with target at date of enactment 30% reduction in energy use relative to current baseline, in 2015 at 50%, and in 2018 and every 3 years thereafter 5% additional reductions. DOE may move targets up or down if they can be achieved with a code that is life-cycle cost-justified and technically feasible. For commercial buildings the baseline code is Standard 90.1-2004. A "National Energy Efficiency Building Code" shall be established that is sufficient to meet the targets set within 1 year of establishment of the target. If during the 1 year period a code published by a recognized developer of national energy codes and standards meet or exceed the target then DOE shall select the code with the highest efficiency in the most cost-effective manner. If no code by a recognized developer of energy codes and standards meets the target then DOE shall establish the "National Energy Efficiency Building Code" by rule. DOE shall consider ASHRAE standards, ICC codes, NBI Core Performance Criteria, Energy Star Program, DOE Commercial Buildings Program, NBI and RESNET data and information. DOE to provide technical assistance to recognized developers to support development. If code by recognized developer meets target then DOE to provide support for dissemination for free and providing training. If national code is based on prior code by recognized developer then DOE to negotiate and provide appropriate compensation. Within 1 year of</p>	<p>*Targets can be shifted up or down by DOE based on cost-effectiveness and technical feasibility.            * No requirement that Standard 90.1 serve as the basis for the "National Energy Efficiency Building Code."            *States required to demonstrate 90% compliance with the code.            *DOE to enforce code if states fail to enforce. *States will lose funding or allowances if they are out of compliance</p>	<p>Passed the House of Representatives</p>	<p>H.R. 2454</p>

Reference	Summary	Notes	Status	Location
<b>Pending Legislation to Establish Targets for Future Commercial Energy Codes</b>				
	<p>new National Energy Efficiency Building Code states shall update their codes and certify they meet or exceed targets met by the National Energy Efficiency Building Code. If states do not certify meeting or exceeding the targets then the National Energy Efficiency Building Code shall become the applicable code in that jurisdiction. If states or localities fail to enforce the code, it shall be enforced by DOE.</p>			

Reference	Summary	Notes	Status	Location
<b>Pending Legislation to Establish Targets for Future Commercial Energy Codes</b>				
American Clean Energy Leadership Act of 2009 (Senate Energy Bill) Section 241	DOE shall support updating national model building energy codes and standards at least every 3 years to achieve overall energy savings compared to 90.1-2004 of 30% during or after 2010 and 50% during or after 2016. Targets shall be set by DOE at least 3 years in advance at the maximum level of energy efficiency that is technologically feasible and life-cycle cost effective. DOE to provide technical assistance to model code-setting and standard development organizations. DOE shall submit amendment proposals sufficient to meet the targets. If a revised version of 90.1 does not meet the targets then DOE shall provide proposed changes that will meet the target and ASHRAE has 180 days to incorporate the proposed changes. If proposed changes are not incorporated then DOE shall establish a modified code meeting the targets. Modifications shall achieve the maximum level of savings technologically feasible and life-cycle cost effective and be based on the latest addition of IECC or 90.1. Within 2 years of enactment states must demonstrate that the state's code provisions meet or exceed 90.1-2007. States shall demonstrate 90% compliance with the code. DOE shall support development of voluntary advanced codes achieving energy savings of at least 30% compared to national model building codes--preference given to ICC and ASHRAE. Incentive funding to states to implement requirements.	*DOE required to provide amendments to meet targets. *ASHRAE has second chance if 90.1 does not meet the target. *Any modifications made by DOE are to be based on 90.1. *Supports development of advanced codes (e.g., 189.1).	Passed Senate Energy and Natural Resources Committee	S.1462

Reference	Summary	Notes	Status	Location
<b>Pending Legislation to Establish Targets for Future Commercial Energy Codes</b>				
Clean Energy Jobs and American Power Act (Kerry/Boxer Bill) Section 163	EPA (or other agency designated by the President) shall engage in rulemaking to establish building code energy efficiency targets by 2014. EPA (or other agency designated by the President) shall engage in rulemaking to establish national energy efficient building codes that meet the targets.	*No recognition for existing codes and standards. *Essentially a placeholder for language to be developed later in the process. *Provides climate related funds and allowances to states for code implementation and enforcement.	Passed Senate Environment and Public Works Committee	S.1733



Reference	Summary	Notes	Status	Location
<b>Energy Efficiency Requirements for U.S. Federal Buildings</b>				
Energy Policy Act of 2005 (EPAAct 2005) Section 109	Within 1 year of enactment, DOE shall establish revised federal building energy efficiency performance standards that require if life-cycle cost effective that buildings be designed to achieve energy consumption levels at least 30% below Standard 90.1-2004. DOE to determine if updates to federal standards are appropriate based on cost-effectiveness within 1 year of revisions to the baseline standard.	*FEMP has developed the necessary rules and requirements (72 FR 72565).	Still part of the requirements for federal buildings	Public Law 109-58
Energy Independence and Security Act of 2007 (EISA) Section 433	DOE to issue revised federal building energy efficiency performance standards specifying that buildings be designed to reduce fossil fuel use compared to CEBECS 2003 of 55% in 2010, 65% in 2015, 80% in 2020, 90% in 2025, and 100% in 2030.	*This is in addition to the requirements already provided by EPAAct 2005 as indicated above.	Current requirement for federal building energy use	Public Law 110-140
Executive Order 13514	Each agency to establish reduction targets for GHG emissions relative to 2008 baseline considering reductions in agency building energy intensity. All new federal buildings in design phase in 2020 or later are designed to achieve net-zero energy by 2030. All new construction and major renovations or repair and alterations to meet the Guiding Principles (see below). Pursue cost-effective innovative strategies to minimize consumption of energy, water and materials.	* Expands on provision in E.O.13423 and the Guiding Principles	Issued by President Obama on October 5, 2009	E.O.13514 / 74 FR 52117

Reference	Summary	Notes	Status	Location
<b>Energy Efficiency Requirements for U.S. Federal Buildings</b>				
Executive Order 13423	Federal agencies to assure that new construction and major renovations comply with the 2006 Federal Leadership in High Performance and Sustainable Buildings MOU. Requires 15% of the existing federal capital asset building inventory of each agency to incorporate the Guiding Principles by 2015.	*Builds on the Guiding Principles established by the MOU discussed below.	Signed by President Bush on January 24, 2007	E.O.13423 / 72 FR 3919
2006 Federal Leadership in High Performance and Sustainable Buildings MOU	Agencies will strive to incorporate and adopt Guiding Principles into agency policy and guidance. 1. Employ Integrated Design Principles. 2. Optimize Energy Performance (for new construction reduce energy cost budget by 30 percent compared to 90.1-2004, 20% for major renovations). 3. Protect and Conserve Water. 4. Enhance Indoor Air Quality. 5. Reduce Environmental Impact of Materials.	*Guiding Principles were extended to all agencies with adoption of E.O 13423.	Incorporated into E.O.13423	

## XI. ANNEX 3 MARKET PENETRATION OF NET ZERO ENERGY BUILDINGS

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The Energy Independence and Security Act of 2007 established a net zero commercial buildings initiative. As stated in the legislation,

The goal of the initiative shall be to develop and disseminate technologies, practices, and policies for the development and establishment of zero net energy commercial buildings for—

- (1) any commercial building newly constructed in the United States by 2030;
- (2) 50 percent of the commercial building stock of the United States by 2040; and
- (3) all commercial buildings in the United States by 2050.

These goals, if fully realized, may have unintended consequences that limit their intended benefits. An example of an unintended consequence is the inability of the present utility grid to accept large amounts of exported PV generated electricity.

Net zero energy buildings<sup>1</sup> are conjoined with renewable energy. The renewable energy technologies most relevant to building applications include photovoltaics, wind energy, and solar thermal. By their very nature, the electricity or thermal energy produced by renewable energy sources is not only time- and weather-dependent but inherently intermittent on short and intermediate time scales, nor is it necessarily coincident with electric and thermal demands of buildings these technologies serve. Nearly all constructs for net-zero energy buildings assume the building is grid-connected. As such, the utility grid becomes a critical component of the building's energy infrastructure, bridging the mismatch between

the site electric demand and the on-site renewable energy supply.

Given these considerations, the goal of achieving an increasing percentage of commercial buildings reaching net zero seems highly desirable; however, the potential capital and operating conflicts with the electric utility grid and the generation infrastructure must be taken into account.

In a recently completed study, Myers (2010) considered high penetrations of photovoltaics (typical of what would accompany a substantial penetration of net zero buildings). Myers considered the:

- Coincidence of PV generation and utility demand
- Contribution limit of PV into existing electricity grid (using the summer-peaking state of Wisconsin utilities)
- Economics of varying penetration rates
- Emissions reductions from displaced generation

Although PV was the primary focus of the study, Myers also considered the deployment of wind energy electric generation and he assessed whether there might be synergy with PV.

Figure A below shows a load duration curves for six different Wisconsin utilities. Points on each curve represent the number of hours in the year the utility experienced a given utility aggregate load (where the load is normalized to each utility's respective peak load). Although this data happens to be for utilities in Wisconsin for a single year, load duration curves for other utilities exhibit similar character. A key characteristic to note is that the aggregate electric load never goes to zero. In fact, for most utilities, their aggregate demand does not drop below ~40% of their peak. Utilities often refer to the production units that generate electricity for this block as their "base load" capacity. Base load plants generally run "flat

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<sup>1</sup> A building that annually uses no more energy from the utility grid than is provided by on-site renewable energy sources.

out” for significant periods of time and are not easily ramped up or down to follow fluctuations in end-use electric demands. This infrastructure also tends to be characterized by high capital

costs but lower fuel costs compared to mid-peak and peak generating capacity. It is generation capacity that utilities and their customers rely upon for the reliable delivery of electricity.

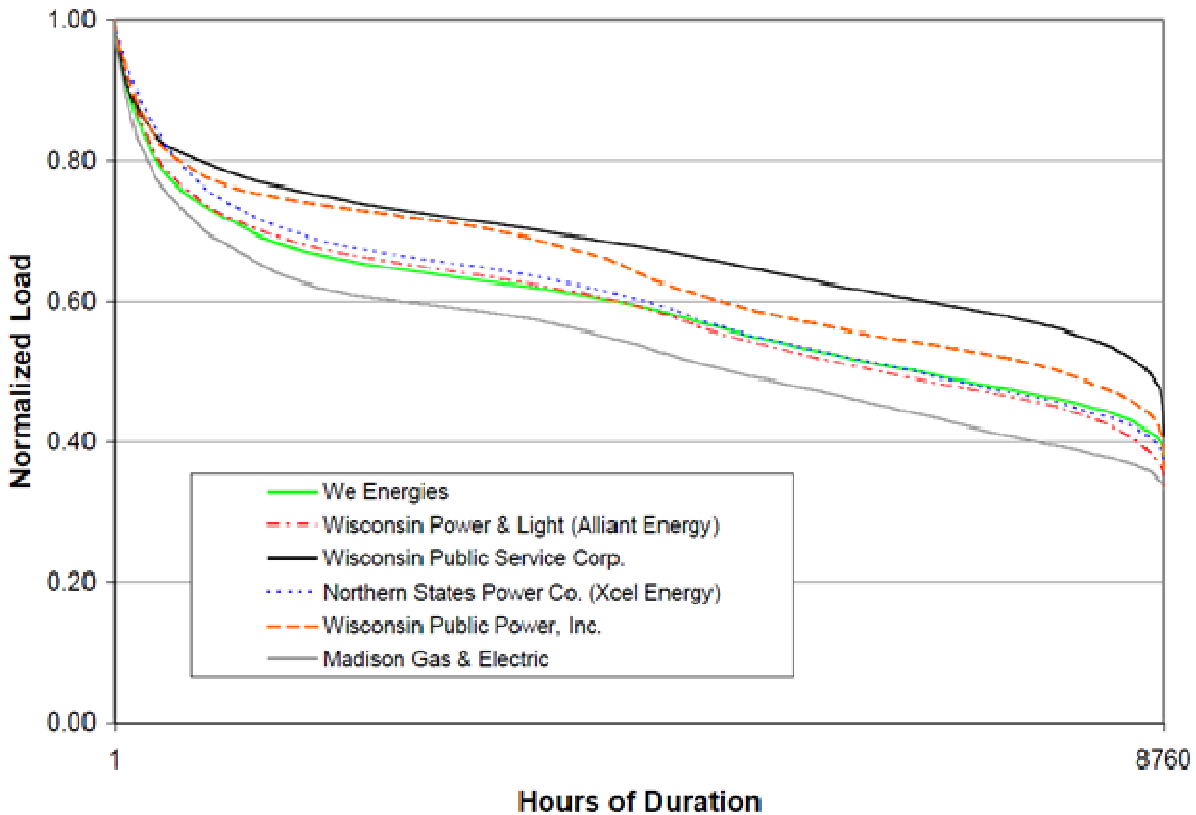


Figure A: Utility load duration curve (Myers, 2010).

As the penetration of net zero energy buildings increases, electricity generated by buildings will begin to encroach on base load generation. Beyond this point, how will further penetration of net zero buildings impact the grid? Will buildings be able to “export” the excess site-generated electricity during these periods or will utilities block the export of site-generated electricity to avoid reducing the capacity of their baseload generation? Can storage technologies be used during these periods of apparent excess electricity production? These and other related questions need to be considered. Figure B shows the fraction of total utility electric demand that can be met by distributed PV in “net zero buildings” as a function of the installed

PV capacity with flex factor as a parameter. The flex factor represents the fraction of the aggregate utility peak demand below which the utility power generation equipment can accommodate load following with varying PV output. A flex factor of 60% means that installed renewables would not be allowed to decrease base load generation below 40% of the utility peak (consistent with the load duration curves shown in Figure A). Under this scenario, Myers found that approximately 20% of the annual electric energy demanded by end-users could be met with PV. This level of electric energy delivery required that the rated capacity of installed PV be four times the utility peak demand.

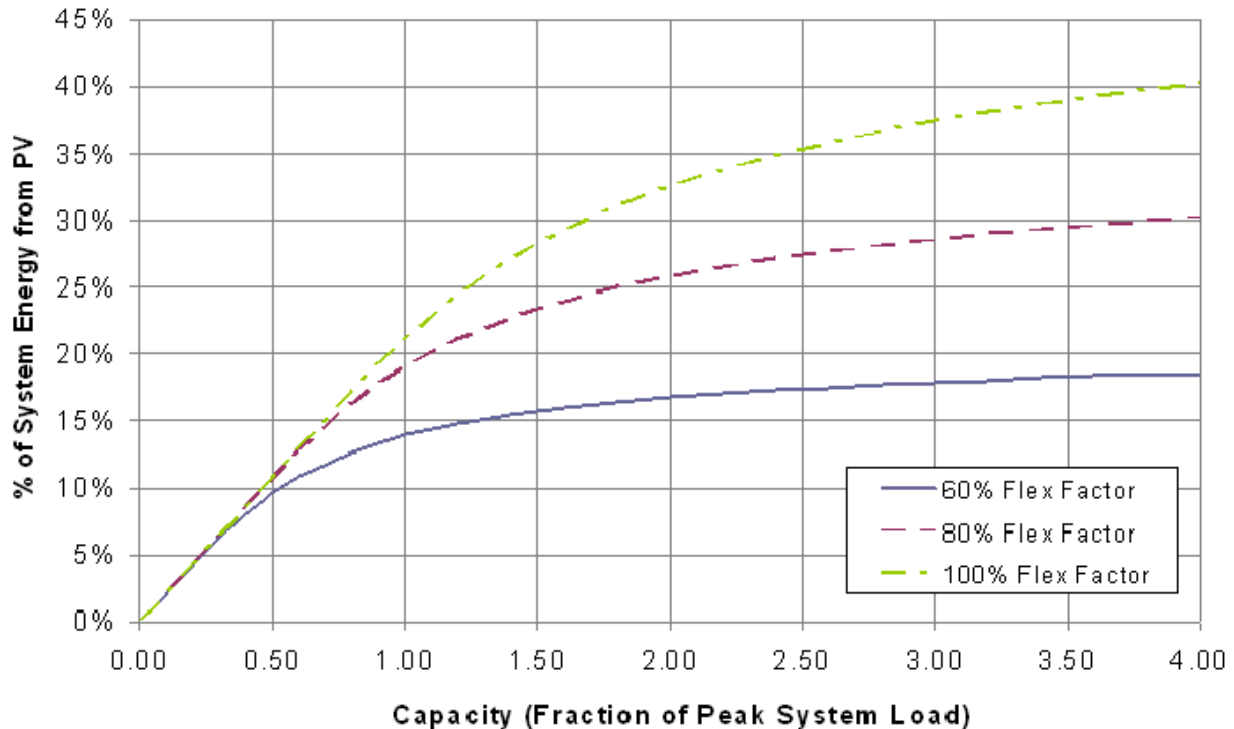


Figure B: PV Contribution to total system energy with various system flexibility factors (Myers, 2010).

In essence, a potential conflict exists with facilities that rely on the supply of firm electric power and time-variability of site-produced renewable energy to achieve net zero. These two goals are in conflict as the penetration of net zero buildings begins to encroach on base load generation. At the present time, the production of PV generation is approximately two orders of magnitude below a level where such conflicts may arise. Possible future solutions to address these potential conflicts include:

- a) Off grid operation where each net-zero building is electrically independent of the utility grid.
- b) Addition of energy storage in some form to decouple the renewable production of electricity from the demand. Battery storage

or thermal energy storage are possible solutions.

Research is needed to better understand the broader impacts of high penetration of net zero buildings. It will also be important for ASHRAE to be involved with or lead this research in cooperation with other industry stakeholders (IEEE, EPRI, and others associated with the power industry).

**Reference:**

Myers, K., "Assessment of High Penetration of Photovoltaics in Wisconsin", M.S. Thesis, University of Wisconsin-Madison, Solar Energy Laboratory, <http://sel.me.wisc.edu/publications-theses.shtml> , (2010).

## XII. ANNEX 4 “BUILDING EUI” AN ARTICLE IN HIGH PERFORMANCE BUILDINGS SUMMER 2010

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### Understanding Building Energy Use Intensities (EUI)

Anyone involved in the energy efficient design of buildings will eventually come in contact with building Energy Use Intensities or EUIs. The typical definition of EUI is:

*Annual Building Energy Use (thousands of Btus or MJ) divided by Building Area (ft<sup>2</sup> or m<sup>2</sup>)*

EUI designations are used throughout the building industry. They are employed as targets for codes, standards and incentive programs, and as benchmarks for building operation. However, as developed in this article, the means by which the EUIs are calculated can have a great impact both on their accuracy for comparisons between buildings and in the credit that they provide alternative building technologies. These issues will be clarified as we examine the details of the EUI numerator and denominator. In addition to the formulation of the EUI, there are issues of how to address the internal and external factors that impact building energy use including: weather, occupant schedules, maintenance, occupancy rates, receptacle loads and a host of others. The same building used differently or placed in a different climate or containing different tenants can have drastically different EUIs regardless of the EUI formulation.

Let's begin with the denominator in the equation. What is included in the definition of building area –is it total gross building area, conditioned building area or occupied building area? Should enclosed parking garage area be included if it is part of the building? The definition of the building area varies by who is doing the measuring and for what purpose.

The first obvious outcome is that comparing a building EUI calculated with one definition of floor area CANNOT be directly compared to another with a different definition. The second outcome is subtler. Setting targets using EUIs is

meant to drive behavior. In this case, reduce energy use in buildings. The definition of gross area can have unplanned consequences. For example, consider two identical buildings in the same city. One is located at a subway station and the other has an attached parking garage on the property. If the EUI area definition includes parking garages, the building that promotes the use of automobiles over public transportation will show a lower EUI due to additional low energy building area in the parking garage.

It may be more meaningful to use a different denominator other than building area for certain building types. Why not annual energy per person in the building? Consider the energy required to provide a built environment for a student. Why not annual energy used per volume of data flow through a data center or per unit manufactured in a factory? These may be much better EUIs for these specific building types. They may drive better behavior in reaching a desired building energy efficiency goal.

If manipulating the denominator was interesting, consider the industry variations of the numerator! Defining the energy use to calculate a EUI is even more challenging. The choices include where you measure the energy (at the site or at the source), and how you compare different energy sources (by energy content or energy cost). In all cases, these are typically evaluated over an annual period.

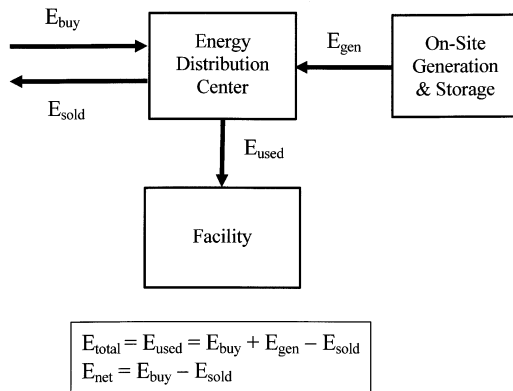
It is first important to define where the building energy will be measured. If measured at the building site. Annual site energy usage is generally understood to mean the amount of energy that crosses the building property line during the course of a year. It is the sum of the building electric meter, gas meter and energy meter if the building is connected to a central heating and/or chilled water plant. Site energy is easily measured by building owners and makes this definition of energy very attractive. Different sources can be compared by their

energy content (btuhs or kW) or energy cost.

Here is another example of how goals can drive undesirable behavior. Using site energy and energy content in the definition of a EUI for a building in Minneapolis, Minnesota could promote the usage of electric baseboard heat ( $COP_{site}=1$ ) over hot water heat ( $COP_{site} < 1$ ).

If the intent is to understand the total energy use including generation, then source energy will be utilized. Annual source energy is generally understood to mean the total annual energy used to generate the energy used at the building site. This would include energy used to create the electricity at the generating station and distribute it to the building site.

**Figure 1 – Total and net energy flows.**



From a practical point of view, establishing source energy usage is much more difficult on a per building basis. Source energy multipliers for electric generation can vary by region, time-of-day, and generation types. Even this definition can drive some peculiar behavior. It would allow a building owner to make a significant improvement in their EUI value by simply buying and using “green” electricity. This could be done in lieu of making any energy efficiency improvements in the building.

Energy cost is a proxy for source energy. Unfortunately the retail cost of energy does not always reflect the true cost of the energy. The largest energy users typically get the lowest rates and there are subsidies inconsistently applied to different sources.

Table 1 below shows different characteristics and variances for Building Energy Use Intensities referenced in the U.S. building industry today. Many of these EUIs have slightly different definitions and metrics. We need to be careful when comparing since the actual measured energy units, fuel sources, measurement location (site versus source), and/or floor area could be different.

**Table 1 – Abbreviated Comparison of Energy Use Intensities**

Document	Term	Distinctions	Energy Considered	Area
ASHRAE Std 105-2007	Energy intensity: an expression of the annual energy used or calculated to be used by a building or building space per unit of gross floor area	Gross floor area: the sum of the floor areas of the spaces within the building, including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 7.5 ft or greater.	Measured site energy use for all types of energy	Gross
ASHRAE Std 90.1-2007, Chapter 11 ECB	Modeled annual energy cost	Although this is site energy, the addition of cost reflect the source variances between fuel types.	Site	Gross
California Title 24, Part 6, Performance Method	Modeled annual energy costs using time-dependent valued (TDV) energy.	The TDV values reflect both the cost of the energy and the infrastructure to get it to the site.	Time dependent valued site energy	Conditioned Floor area
Arch 2030	Annual fossil fuel based energy in kBtu/ft <sup>2</sup> -yr	Only accounts for fossil fuels (coal, oil and gas)	Site fossil fuel	Same as CBECS and Energy Star
ASHRAE Std 100-2006	Annual total energy for all fuels	All sources of site energy and conditioned space for floor area	Site implied by electrical conversion @ 3600 kJ/kWh All fuels (par 5.5.4 & Table 1)	Conditioned Floor area



Document	Term	Distinctions	Energy Considered	Area
Energy Star	Annual energy in kBtu/ ft <sup>2</sup> -yr	Currently limited to the following building types: <ul style="list-style-type: none"> <li>• Bank / Financial Institution</li> <li>• Courthouse</li> <li>• Dormitory</li> <li>• Hospital (acute and children's)</li> <li>• Hotel</li> <li>• House of Worship</li> <li>• K-12 School</li> <li>• Medical Office</li> <li>• Office</li> <li>• Retail Store</li> <li>• Supermarket / Grocery Store</li> <li>• Warehouse (refrigerated and unrefrigerated)</li> </ul>	Site and Primary (Source)	Gross Building Floor Area
CBECS (Commercial Buildings Energy Consumption Survey)	Annual energy in kBtu/ ft <sup>2</sup> -yr (U.S. national sample survey conducted every 4 years that collects information on the stock of selected commercial buildings types, their energy-related building characteristics, and the energy consumption and expenditures. It is based on a sample of 5,215 buildings across the country that were statistically sampled and then weighted to represent the entire stock of commercial buildings in the US.)	Actual building areas are used for EUI calculation. The EIA then purposefully rounds off the reported area to mask the identity of the respondent	Site and Primary (Source)	Gross Building Floor Area
EISA 433	Annual fossil fuel generated energy in kBtu/ft <sup>2</sup> -yr. Step reduction targets are set relative to the 2003 CBECS with a 100% reduction by 2030.	Law only applies to federal buildings	Site fossil fuel	Gross Building Floor Area

If one definition of EUI is based on site energy use and another is based on source energy use, no comparisons can be made between the two values. The U.S. government enacted EISA legislation for high performance federal buildings based on “site fossil fuel”.

California’s Title 24 Energy Standards are based on site time-dependent valued energy. Most ASHRAE documents utilize annual site energy and annual energy cost (Standards 90.1, 90.2, 189.1, Advanced Energy Design Guides, etc.).

Let’s assume a standardized definition for building EUI is established. What would the EUIs be used for? For policy setting, governments around the world would like to improve the energy efficiency of buildings in their countries. EUIs can be a great tool to set such goals.

Building owners and operators will want to know how their buildings perform and set goals to improve their performance. Some will do it because they must (legislated), but most will do it because it is good business (market forces). Building energy performance metrics will vary by the type of building and climate. The future use of EUI to measure a building’s energy performance suggest there is a need for a matrix of EUI goals by building type and climate zone for local usage along with a methodology to create a regional or national weighted average for policymaking.

Many other factors influence the selection and application of EUIs. Do the EUIs apply to new construction or existing buildings? Are they for comparing building simulations or actual building performance data against a database? Are they for setting targets for what is best available technology (life cycle cost not

considered) or are they for setting targets for minimum compliance?

EUIs are generally applied to existing buildings as they are measurable. Computer based modeling is typically applied to new construction. With computer modeling you can compare a proposed building and a minimally compliant building in the same climate with the same internal loads and schedules. The results generally won’t reflect the buildings actual energy use (or cost) due to variations in climate, occupancy, schedules and internal loads.

One could get discouraged and say there is too many variables.. Goals are good – they drive behavior, focus our attention and help us move forward with improvement. Consider EPA fuel efficiency ratings for automobiles. No one expects to get exactly the fuel efficiency listed for his or her model of car, but you do know how one model compares to another. Further, you know the higher the miles per gallon, the better. This in turn drives market forces on improvement.

In January 2010, the ASHRAE Board of Directors asked ASHRAE’s Technology Council to address the issue of setting energy performance targets and EUIs. ASHRAE has a leadership role to play advising policymakers on how to define and establish what is possible with the various building types and to help support future policy. When the policymakers have set their vision, ASHRAE will need to help designers, building owners and operators achieve these targets. To provide the technical guidance, ASHRAE will need to challenge itself to continually raise the bar on the arts and sciences of energy conscious design in the built environment.

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ANSI/ASHRAE/USGBC/IES Standard 189.1-Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings

ASHRAE Vision 2020, Producing Net Zero Energy Buildings. Published January 2008

U.S. Energy Information Administration  
CBECs Trends in Energy Consumption and Energy Sources,

[http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/cbecs\\_trends/siteintdetail.html](http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/cbecs_trends/siteintdetail.html)

[http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed\\_tables\\_2003/detailed\\_tables\\_2003.html#consumexpen03](http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html#consumexpen03)

Energy Independence and Security Act of 2007, Section 433.

## SIDEBAR ON MODEL ENERGY CODE DETERMINATION

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### U.S. Model Energy Code Determination

With each new edition of ANSI/ASHRAE/IESNA Standard 90.1, DOE issues an official Determination about whether the new edition of the standard will improve energy efficiency in U.S. commercial buildings. The Determination is based on analysis by the Building Energy Codes Program and is required by Section 304 of the Energy Policy and Conservation Act (EPCA, Public Law 94-163), as modified by the Energy Policy Act of 1992 (EPAct 1992). DOE has one year to publish the Determination after the newest edition of the code is approved. Determination results are published in the Federal Register.

If DOE finds that the newest version of Standard 90.1 is more energy efficient than the previous version, states are required by the Energy Policy Act to certify that their building energy codes meet the requirements of the new Standard within two years.

For example, DOE recently issued a Determination that Standard 90.1-2004 is more energy efficient than Standard 90.1-1999. States have two years from the time DOE officially notifies them to certify that their energy codes are at least as stringent as 90.1-2004, or justify why they cannot comply.

Once DOE issues a positive Determination, DOE must provide technical assistance and incentive funding to states to:

- Review and update state energy codes
- Implement, enforce, and evaluate compliance with state energy codes
- Permit certification extensions if the state demonstrates good faith to comply

and the state has made significant progress toward compliance

DOE must also send a letter to the governor of each state, notifying them of the Determination and outlining the state's responsibilities. The letter also advises the governor of the availability for technical assistance and incentive funding from DOE, and provisions for time extensions if needed. Each state's energy offices and the responsible state code office receive letters with same information, but in more detail than the governor's letter.

The DOE Determination calculation process has continued to evolve since the original goal was set in 2007, making it difficult to understand what exactly is being modeled for the final Determination calculations. This updated methodology is described in *Draft Methodology for a Comparative Analysis of ANSI/ASHRAE/IESNA Standard 90.1-2007 and Standard 90.1-2004*<sup>2</sup>, dated January 20, 2008 –although it is believed that even this document does not reflect the current state of the evolving building types and weightings of those building types being used in the analysis. In other words, the determination of one version of the standard may consider different building types and allocation of building types than the determination of a subsequent version of the standard. The Determination is simply a process to perform a quantitative and qualitative analysis of the new version compared to the old version. It is not intended to provide building EUI or average EUI data that can be compared over time. Some energy efficiency measures are difficult to model in these energy simulations.

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<sup>2</sup>[http://www.energycodes.gov/implement/pdfs/determinations\\_com\\_07draftmethodology.pdf](http://www.energycodes.gov/implement/pdfs/determinations_com_07draftmethodology.pdf)

## ASHRAE/IESNA Standard 90.1 and CBECS

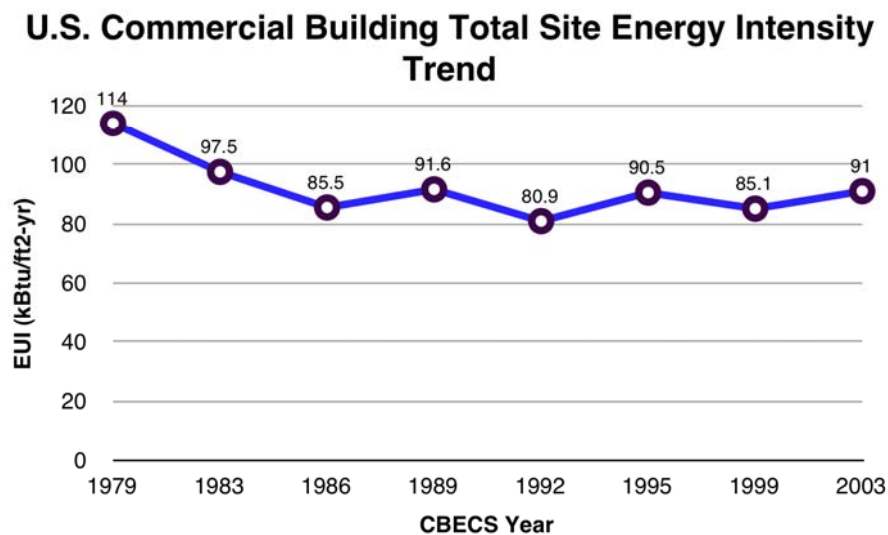
Standard 90.1 is intended to set the minimum efficiency requirements for new buildings and renovations and covers building envelope, mechanical, service water heating and electrical systems. Appendix G of Standard 90.1 provides a method to model performance to evaluate alternatives to the prescriptive measures using annual energy cost. It is important to note that Standard 90.1 Appendix G and other energy code simulations are not intended to provide a means of accurately estimating energy consumption in a building since they do not reflect the actual occupancy, operating schedules or receptacle/process loads anticipated in the building.

The Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their

energy consumption and expenditures. It is based on a sample of 5,215 buildings across the country that were statistically sampled and then weighted to represent the entire stock of commercial buildings in the U.S. Commercial buildings include all buildings in which at least half of the floor space is used for a purpose that is not residential, industrial, or agricultural, so they include building types that might not traditionally be considered "commercial," such as schools, correctional institutions, and buildings used for religious worship. CBECS represents a mix of both old and new buildings.

While it may seem on a cursory review, that both Standard 90.1 and CBECS can provide Energy Use Intensity (EUI) in kBtu/ft<sup>2</sup>-yr, the two EUIs are not related and should not be compared. CBECS historical data can be compared to previous CBECS data to see commercial building energy usage trends on the complete building stock as shown in Figure 1.

**Figure 1 US Commercial Building Total Site Energy Intensity Trend**



Energy Information Administration  
Commercial Buildings Energy Consumption Survey

### **XIII. ANNEX 5 MAX TECH FROM THE ASSESSMENT**

Table 1. BASE Energy Use Intensities based upon ANSI/ASHRAE/IESNA Standard 90.1-2004 by Subsector and Climate Zone, in kBtu/ft2-yr

Subsector	Climate Zone															
	All	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8
All	71	82	68	73	78	58	62	70	55	56	75	64	76	74	74	74
Office/professional	57	55	61	65	52	46	44	60	58	53	60	48	62	61	68	68
Nonrefrigerated warehouse	41	27	31	31	37	30	30	42	49	30	47	51	50	47	45	45
Education	52	52	49	57	42	41	54	60	34	43	53	44	60	64	64	64
Retail (excluding mall)	68	68	66	66	63	54	54	68	58	58	73	71	76	91	100	100
Public assembly	62	66	66	66	72	52	52	54	48	77	68	50	66	51	70	70
Service	83	83	78	78	60	63	63	79	52	52	92	76	102	86	108	108
Religious worship	44	40	40	40	29	29	29	44	59	59	51	35	57	39	44	44
Lodging	55	65	51	51	52	40	40	57	61	61	55	51	60	64	63	63
Food Services	354	354	354	354	380	375	375	368	368	368	336	283	341	341	354	354
Health care (inpatient)	111	108	108	108	118	98	97	106	106	106	115	106	113	116	116	116
Public order and safety	67	54	54	54	67	67	67	60	60	60	78	78	73	87	87	87
Food sales	181	200	200	200	190	151	151	188	188	188	173	182	208	208	181	181
Health care (outpatient)	76	76	80	80	64	79	79	66	66	66	90	76	82	78	107	107
Vacant	30	30	23	23	30	20	20	41	41	41	21	21	40	40	40	40
Other	58	73	73	73	58	58	58	57	57	57	61	61	63	63	63	63
Skilled nursing	131	132	132	132	113	102	103	145	145	145	142	106	132	132	132	132
Laboratory	323	323	323	323	323	369	369	272	272	272	313	313	323	323	323	323
Refrigerated warehouse	86	86	86	86	86	86	86	88	86	86	85	86	86	86	86	86

Table 2 Max Efficiency Tech Scenario EUI (without PV) by Subsectors and Climate Zones, IP Units (filled using similar technique as in Order 430.2B)

Subsector	Climate Zone														
	All	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
All	40.3	55.2	41.8	44.4	48.1	37.7	44.6	38.8	28.0	32.7	41.9	36.2	37.6	35.2	35.5
Office/professional Warehouse	32.7	33.8	35.9	31.7	30.3	30.3	29.0	34.2	37.6	30.5	33.1	28.5	31.0	29.0	34.7
Nonrefrigerated warehouse	17.4	14.3	13.4	13.4 a	14.9	14.5	12.0	17.0	21.8	13.8	19.4	21.9	20.6	18.5	20.8
Education	23.0	74.5	26.6	30.9	19.9	21.6	27.1	25.6	17.4	18.8	21.6	18.6	22.4	23.8	27.0
Retail (excluding mall)	28.6	22.5	33.3	38.7	26.1	25.6	24.8	27.7	24.7	24.7 e	29.3	29.7	30.9	33.5	35.0
Public assembly	30.4	53.1	36.3	36.3 a	38.4	31.8	25.6	26.7	21.1	39.2	29.4	26.4	29.9	27.0	26.8
Service	37.1	72.6	41.7	41.7 a	28.7	31.5	22.2	38.4	26.6	26.6e	40.0	34.2	34.4	34.6	41.6
Religious worship	16.4	17.2 a	17.2	17.2 a	11.9	12.8	12.8 c	16.0	21.4	21.4 e	18.6	13.1	19.1	13.7	16.4 b
Lodging	28.8	36.3	30.7	30.7 a	29.5	25.7	25.7 c	29.4	30.2	29.0	28.0	26.7	27.4	28.1	27.7
Food Services	311.3	482.1	298.1	298.1	316.6	334.4	304.3	304.6	304.6 d	401.1	316.3	293.1	306.1	198.3	291.7
Health care (inpatient)	71.3	78.2	74.9	79.8	68.8	72.0	68.5	67.9	60.9	60.9 e	77.2	70.3	65.3	64.0	95.4
Public order and safety	43.7	38.7 a	38.7	38.7 a	35.9	51.5	43.7 b	37.8	37.8 d	37.8 d	49.0	59.2	44.1	60.8	60.8 h
Food sales	107.1	112.3 a	112.3	112.3 a	118.5	94.0	98.6	112.7	112.7 d	112.7 d	101.7	109.9	106.2	106.2 g	100.6
Health care (outpatient)	40.4	36.8	52.8	52.8 a	39.0	59.5	59.5 c	33.5	34.3	34.3 e	42.4	33.2	34.1	34.1	46.0
Vacant	11.6	6.0 a	6.0	28.3	13.3	10.1	8.3	16.3	16.6	6.3	7.3	7.7	14.2	14.2 g	28.2
Other	30.9	45.4 a	45.4	45.4 a	23.6	29.7	30.9 b	32.0	12.5	12.5 e	31.8	22.8	30.0	34.0	21.8
Skilled nursing	86.8	93.5 a	93.5	93.5 a	85.4	77.3	77.3 c	95.0	95.0 d	95.0 d	93.4	68.8	75.3	74.0	74.0 h
Laboratory	286.3	286.3 b	286.3 b	286.3 b	296.9	318.7	318.7 c	227.3	227.3 d	227.3 d	285.6	285.6 f	243.1	274.8	286.3 b
Refrigerated warehouse	51.1	51.1 b	51.1 b	51.1 b	51.1 b	51.1 b	51.1 b	52.5	51.1 b	51.1 b	51.4	43.3	52.5	51.1 b	51.1 b

Notes - Category has less than five samples in 2003 CBECs. Values for this category filled from:

- a - Climate Zone 2A
- b - All Climate Zone
- c - Climate Zone 3B
- d - Climate Zone 4A
- e - Climate Zone 4B
- f - Climate Zone 5A
- g - Climate Zone 6A
- h - Climate Zone 6B

Source: [http://www.eere.energy.gov/buildings/highperformance/pdfs/energy\\_use\\_intensity\\_targets.pdf](http://www.eere.energy.gov/buildings/highperformance/pdfs/energy_use_intensity_targets.pdf)

Table 3. Max Tech with PV Scenario EUI by Subsectors and Climate Zones, IP Units [filled using similar technique as in Order 430.2B

Subsector	Climate Zone														
	All	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
All	12.2	19.8	7.4	9.4	13.4	2.9	27.3	13.6	-8.0	15.5	18.5	1.5	13.9	-2.0	12.7
Office/professional	14.2	17.9	12.3	-7.6	8.0	7.0	23.0	18.9	20.6	19.5	17.1	4.4	12.0	-8.6	15.0
Nonrefrigerated warehouse	-20.7	-40.9	-28.8	-28.8 a	-32.0	-27.6	-33.9	-22.4	-26.5	-12.7	-16.3	-13.6	-8.9	-25.4	2.9
Education	-6.0	36.5	-10.2	-25.5	-16.7	-15.2	1.8	0.0	-31.5	-4.7	2.1	-18.2	-0.3	-11.9	-5.4
Retail (excluding mall)	-8.5	-31.3	-2.6	-23.3	-19.0	-16.8	4.3	-7.6	-23.0	-23.0 e	-0.7	-10.0	1.0	-7.7	2.1
Public assembly	1.7	-2.4	-4.4	-4.4 a	8.6	-10.2	-10.5	3.8	-30.5	19.2	2.5	-11.1	8.2	10.7	-2.6
Service	-0.3	19.7	-2.4	-2.4 a	-19.4	-18.9	-29.5	5.6	-8.7	-8.7 e	6.6	-2.5	0.1	-9.5	6.8
Religious worship	-13.1	-23.2 a	-23.3	-23.3 a	-22.5	-22.9	-22.9 c	-11.5	-23.4	-23.4 e	-4.5	-23.7	-3.2	-26.1	-13.1 b
Lodging	14.1	25.7	18.1	18.1 a	10.9	3.8	3.8 c	17.4	23.5	7.9	16.9	0.4	14.6	-16.7	9.7
Food Services	276.2	425.0	255.7	255.7 a	277.0	288.6	287.5	272.8	272.8 d	356.7	288.3	254.4	278.2	151.2	253.0
Health care (inpatient)	61.1	68.5	64.1	71.9	54.7	61.5	50.5	58.3	54.1	54.1 e	70.9	51.9	56.1	52.5	88.7
Public order and safety	20.1	18.4 a	18.4	18.4 a	1.1	20.9	20.1 b	18.0	18.0 d	18.0 d	27.5	20.0	18.7	48.7	-48.7 h
Food sales	66.7	66.0 a	66.0	66.0 a	71.8	45.6	58.8	72.1	72.1 d	72.1 d	64.7	74.9	68.1	68.1 g	77.2
Health care (outpatient)	11.7	10.4	13.1	13.1 a	1.0	19.9	19.9 c	8.7	-5.0	-5.0 e	21.3	-1.8	11.5	8.1	26.6
Vacant	-17.0	-17.0 a	-42.2	-4.5	-31.4	-24.6	-19.3	-2.6	-22.1	-11.0	-17.1	-34.1	-8.6	-8.6 g	14.8
Other	-1.3	2.9 a	2.9	2.9 a	-18.2	-11.8	-1.3 b	-2.7	-42.4	-42.4 e	4.4	-25.6	7.9	-9.3	-10.7
Skilled nursing	61.5	65.4 a	65.4	65.4 a	54.4	30.9	30.9 c	75.7	75.7 d	72.7 d	73.9	21.9	55.6	34.7	34.7 h
Laboratory	272.9	272.9 b	272.9 b	272.9 b	290.0	286.4	286.4 c	205.9	205.9 d	205.9 d	274.2	274.2 f	234.4	261.0	272.9 b
Refrigerated warehouse	15.6	15.6 b	15.6 b	15.6 b	15.6 b	15.6 b	15.6 b	11.2	15.6 b	15.6 b	31.9	1.1	16.8	15.6 b	15.6 b

Notes - Category has less than five samples in 2003 CBECS. Values for this category filled from:

a - Climate Zone 2A

b - All Climate Zone

c - Climate Zone 3B

d - Climate Zone 4A

e - Climate Zone 4B

f - Climate Zone 5A

g - Climate Zone 6A

h - Climate Zone 6B



## XIV. REFERENCES

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1. B. Griffith, N. Long, P. Torcellini, R. Judkoff, D. Crawley, J. Ryan *Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector* National Renewable energy Laboratory Technical Report NREL/TP-550-41957 December 2007.
2. **6834 Federal building energy efficiency standards**  
 (3)(A) *Not later than 1 year after August 8, 2005, the Secretary shall establish, by rule, revised Federal building energy efficiency performance standards that*  
  
*(1) if life cycle cost effective for new Federal buildings...*
3. **Waxman-Markey Bill, aka the American Clean Energy and Security Act (ACES), H.R. 2454, Title II, Subtitle A, Building Energy Efficiency Programs, Section 304**  
  
*(ii) COST-EFFECTIVENESS CALCULATIONS.—Calculations of life cycle cost-effectiveness shall be based on life cycle cost methods and procedures under section 544 of the National Energy Conservation Policy Act (42 U.S.C. 8254), but shall incorporate to the extent feasible externalities such as impacts on climate change and on peak energy demand that are not already incorporated in assumed energy costs.*
4. **Federal Law Regarding Energy Code Determinations (EPA Act 1992 Section 304) Commercial buildings**  
 (2)(A) *Whenever the provisions of ASHRAE Standard 90.1-1989 (or any successor standard) regarding energy efficiency in commercial buildings are revised, the Secretary shall, not later than 12 months after the date of such revision, determine whether such revision will improve energy efficiency in commercial buildings. The Secretary shall publish a notice of such determination in the Federal Register.*  
  
*(B)(i) If the Secretary makes an affirmative*

*determination under subparagraph (A), each State shall, not later than 2 years after the date of the publication of such determination, certify that it has reviewed and updated the provisions of its commercial building code regarding energy efficiency in accordance with the revised standard for which such determination was made. Such certification shall include a demonstration that the provisions of such State's commercial building code regarding energy efficiency meet or exceed such revised standard.*

*(ii) If the Secretary makes a determination under subparagraph (A) that such revised standard will not improve energy efficiency in commercial buildings, State commercial building code provisions regarding energy efficiency shall meet or exceed ASHRAE Standard 90.1-1989, or if such standard has been revised, the last revised standard for which the Secretary has made an affirmative determination under subparagraph (A).*

### 5. **Energy Independence and Security Act (EISA) of 2007**

#### **SEC. 431. ENERGY REDUCTION GOALS FOR FEDERAL BUILDINGS.**

*Section 543(a)(1) of the National Energy Conservation Policy Act (42 U.S.C. 8253(a)(1)) is amended by striking the table and inserting the following:*

<i>Fiscal Year Percentage Reduction</i>	
<i>2006.....</i>	<i>2</i>
<i>2007.....</i>	<i>4</i>
<i>2008.....</i>	<i>9</i>
<i>2009.....</i>	<i>12</i>
<i>2010.....</i>	<i>15</i>
<i>2011.....</i>	<i>18</i>
<i>2012.....</i>	<i>21</i>
<i>2013.....</i>	<i>24</i>
<i>2014 .....</i>	<i>27</i>
<i>2015 .....</i>	<i>30</i>

**SEC. 433. FEDERAL BUILDING ENERGY EFFICIENCY PERFORMANCE STANDARDS.**

(a) *STANDARDS.*—Section 305(a)(3) of the Energy Conservation and Production Act (42 U.S.C. 6834(a)(3)) is amended by adding at the end the following new subparagraph:

(D) *Not later than 1 year after the date of enactment of the Energy Independence and Security Act of 2007, the Secretary shall establish, by rule, revised Federal building energy efficiency performance standards that require that:*

(i) *For new Federal buildings and Federal buildings undergoing major renovations, with respect to which the Administrator of General Services is required to transmit a prospectus to Congress under section 3307 of title 40, United States Code, in the case of public buildings (as defined in section 3301 of title 40, United States Code), or of at least \$2,500,000 in costs adjusted annually for inflation for other buildings:*

(I) *The buildings shall be designed so that the fossil fuel-generated energy consumption of the buildings is reduced, as compared with such energy consumption by a similar building in fiscal year 2003 (as measured by Commercial Buildings Energy Consumption Survey or Residential Energy Consumption Survey data from the Energy Information Agency), by the percentage specified in the following table:*

<b>Fiscal Year Percentage Reduction</b>	
2010 .....	55
2015 .....	65
2020 .....	80
2025 .....	90
2030 .....	100

**6. Waxman-Markey Bill, aka the American Clean Energy and Security Act (ACES), H.R. 2454, Title II, Subtitle A, Building Energy Efficiency Programs, Section 304.**

(a) *ENERGY EFFICIENCY TARGETS.*—  
(1) *IN GENERAL.*—*Except as provided in*

*paragraph (2) or (3), the national building code energy efficiency target for the national average percentage improvement of a building’s energy performance when built to a code meeting the target shall be—*

(A) *effective on the date of enactment of the American Clean Energy and Security Act of 8 2009, 30 percent reduction in energy use relative to a comparable building constructed in compliance with the baseline code;*

(B) *effective January 1, 2014, for residential buildings, and January 1, 2015, for commercial buildings, 50 percent reduction in energy use relative to the baseline code; and*

(C) *effective January 1, 2017, for residential buildings, and January 1, 2018, for commercial buildings, and every 3 years thereafter, respectively, through January 1, 2029, and January 1, 2030, 5 percent additional reduction in energy use relative to the baseline code.*

(2) *CONSENSUS-BASED CODES.*—*If on any effective date specified in paragraph (1)(A), (B), or (C) a successor code to the baseline codes provides for greater reduction in energy use than is required.*

**7. American Clean Energy Leadership Act of 2009 (Senate Energy Bill S1462) Section 241.**

As passed by Senate Committee on Energy and Natural Resources establishing future model code

**Subtitle C—Building Efficiency**

**PART I—BUILDING CODES**

**SEC. 241. GREATER ENERGY EFFICIENCY IN BUILDING CODES.**

(a) *IN GENERAL.*—Section 304 of the Energy Conservation and Production Act (42 U.S.C. 6833) is amended to read as follows:

**SEC. 304. UPDATING STATE BUILDING ENERGY EFFICIENCY CODES.**

*(a) UPDATING NATIONAL MODEL BUILDING ENERGY CODES.—*

*(1) TARGETS.—*

*(A) IN GENERAL.—The Secretary shall support updating the national model building energy codes and standards at least every 3 years to achieve overall energy savings, compared to the 2006 IECC for residential buildings and ASHRAE Standard 90.1–2004 for commercial buildings, of at least—*

*(i) 30 percent in editions of each model code or standard released during or after 2010; and*

*(ii) 50 percent in editions of each model code or standard released during or after 2016.*

*(B) SPECIFIC YEARS.—*

*(i) IN GENERAL.—Targets for specific years shall be set by the Secretary at least 3 years in advance of each target year, coordinated with the IECC and ASHRAE Standard 90.1 cycles, at the maximum level of energy efficiency that is technologically feasible and life-cycle cost effective and on a path to achieving net zero-energy buildings.*

*(ii) DIFFERENT TARGET YEARS.—*

*Subject to paragraph (2)(D), prior to 2013, the Secretary may set a different target year for 1 or both model codes described in subparagraph (A) if the Secretary determines that a 50 percent target cannot be met in 2016.*

**8. Clean Energy Jobs and American Power Act (Kerry/Boxer Bill; Senate Bill S1733) Section 163**

As passed by the Senate Environment and Public Works Committee with targets and codes to be established by the EPA.

**SEC. 163. ENERGY EFFICIENCY IN BUILDING CODES.**

*(a) ENERGY EFFICIENCY TARGETS.—*

*(1) RULEMAKING TO ESTABLISH TARGETS.—*

*The Administrator, or such other agency head or heads as may be designated by the*

*President, in consultation with the Director of the National Institute of Standards and Technology, shall promulgate regulations establishing building code energy efficiency targets for the national average percentage improvement of buildings' energy performance. Such regulations shall establish a national building code energy efficiency target for residential buildings and commercial buildings when built to a code meeting the target, beginning not later than January 1, 2014 and applicable each calendar year through December 31, 2030.*

*(b) NATIONAL ENERGY EFFICIENCY BUILDING CODES.—*

*(1) RULEMAKING TO ESTABLISH NATIONAL CODES.—The Administrator, or such other agency head or heads as may be designated by the President, shall promulgate regulations establishing national energy efficiency building codes for residential and commercial buildings. Such regulations shall be sufficient to meet the national building code energy efficiency targets established under subsection (a) in the most cost-effective manner, and may include provisions for State adoption of the national building code standards and certification of State programs*

*(c) ANNUAL REPORTS.—The Administrator, or such other agency head or heads as may be designated by the President, shall annually submit to Congress, and publish in the Federal Register, a report on—*

*(1) the status of national energy efficiency building codes;*

*(2) the status of energy efficiency building code adoption and compliance in the States;*

*(3) the implementation of and compliance with regulations promulgated under this section;*

*(4) the status of Federal and State enforcement of building codes; and*

*(5) impacts of action under this section, and potential impacts of further action, on lifetime energy use by buildings, including resulting energy and cost saving.*