<u>Achieving Energy Performance – Going Beyond Codes and Standards</u>

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ABSTRACT

This paper reviews today's challenges in achieving energy performance in buildings and the need to go beyond codes and standards. It takes an historical look back at where we have come from over the past 35 years and the obstacles to achieving our ultimate goal of net zero energy buildings.

Steady progress is being made in the development of energy standards and the movement from purely prescriptive codes and standards towards performance based applications reflective of the total building load. Tools to achieve these ends include new guides and standards for both new and existing buildings.

Ultimately we need to raise public awareness of the impact of building energy use, not only economically but also environmentally. With that there will be a need for greater measurement and verification leading to building energy labeling and the adoption of outcome based codes.

INTRODUCTION

Prior to the Arab oil embargo in 1973 there were really no standards governing the actual energy efficiency of buildings. Most efforts were concentrated on health, safety and comfort of the building occupants. At the request of the National Conference of States on Building Codes the then National Bureau of Standards (Now the National Institute of Standards and Technology) (NIST) developed NBSIR 74-452 Design and "Evaluation Criteria for Energy Conservation in New Buildings". Following issuance of this document ASHRAE was asked to develop the first of its kind building energy efficiency standard.

In August 1975 building upon the work of NBS the ANSI/ASHRAE/IES Standard 90-75 "Energy Conservation in New Buildings" was published. (1) It was enthusiastically received by many state and local jurisdictions around the country. A 1977 Arthur D. Little study of the potential impact of the new standard indicated that it could result in a 27% reduction in building energy use compared to the pre 1973 era.

The standard essentially provided minimum performance prescriptive guidance for new buildings in 38 climate zones around the country. Over the years the stringency of the standard has steadily been increased – see Table No.1. Fourteen years later Standard 90.1 1989, now 14% more energy efficient, addressed 26 climate zones and provided both prescriptive and performance paths for compliance, introducing the Building Energy Cost Budget Method.

Table No.1 Standard 90.1 EUI's

Year	EUI Btu/Sq.Ft.Yr	Change	Rate per Year
Pre 1973	88,000	-	-
1975	65,000	27%	-
1989	55,900	14%	1%/yr
1999	53,300	4%	0.40%/yr
2004	43,250	19%	3.8%/yr
2010	30,600	30%	5.0%/yr
2016	21,625	30%	5.0%/yr
2020	17,300	20%	5.0%/yr

Energy intensity units exclude plug and process loads.

In 1992 under the US Energy Policy Act (EPAct) Standard 90.1 became the baseline standard for energy efficiency and essentially the "law of the land". Unfortunately little was done in terms of real enforcement.

In 1999 the standard was rewritten in full mandatory code enforceable language. In 2004 Standard 90.1 Appendix G "Performance Rating Method", was added providing a means of rating the energy efficiency of design options and at the same time provide an option under the USGBC LEED rating system.

Throughout these revisions and updates, the standard has been developed following the American National Standards Institute (ANSI) consensus process, using a cost justified basis of analysis. While these incremental developments have proven generally effective, the demands for an accelerated increase in energy efficiency for versions of the standard for 2010 and beyond, have proven to be quite challenging. In addition, prior to 2010, the standard only addressed building construction requirements through the certificate of occupancy and did little to address actual operations.

Specifically, through 2010, the standard excluded plug and process loads, food service equipment and other elements under occupant control. Back in 1975 these were considered fairly insignificant (generally only 3 to 5% of building load) and were also thought to be uncontrollable through the codes process. Today plug and process loads can account for 25% to over 50% of total building energy use and have a very significant impact on overall building performance..

In 2009 the US Green Building Council (USGBC) under its Leadership in Energy and Environmental Design program (LEED) version 3.0 adopted ASHRAE Standard 90.1 2007 (less 10%) as the prerequisite for Optimized Energy Performance Credits. Credits escalate to 19 with an energy reduction of 48%.

WHAT HAS BEEN ACHIEVED?

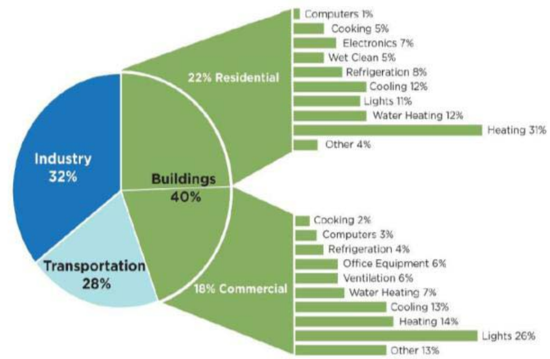
How effective have all of these efforts been in reducing total building energy use? Do we really know? The 1992 Commercial Building Energy Consumption Survey (CBECS) put out by the DOE Energy Information Agency www.eia.doe.gov/CBECS indicated an average annual building consumption intensity of 90.5 kBtu/sf.yr. The 2003 survey showed hardly any change at 90.1 kBtu/sf.yr. despite a 20% improvement in energy efficiency for new building construction. Part of this is can be attributed to 1) the ratio of new buildings against the existing building stock and 2) the significant increases in plug and process loads (computers, printers, cooking equipment, elevators, etc.). However there is a third major element, no small part of the lack of progress relates to actual effectiveness of implementation and enforcement of the building codes.

Typically in the US, new construction only makes up 2% of all construction projects and about 14% of construction costs. Fully 86% of construction dollars go into the retrofit of existing buildings, which have been minimally impacted by energy codes. If we are going to make any real progress on reducing building energy use we must place greater emphasis on improving our existing building stock.

Buildings represent over 40% of our primary energy use. They also represent 72% of our electrical consumption and 55% of our natural gas consumption. Even more importantly they represent nearly 39% of our CO_2 emissions and therefore have a significant impact on our atmosphere.

Figure No.1 shows the typical breakdown of energy use in both residential and commercial buildings.
Obviously these numbers vary depending on building occupancy and climate zone. But they do point out how much energy is used in regulated (building code) and unregulated loads. For residential buildings 30% of the load is not addressed in the building codes, while for commercial buildings that number is 28%.

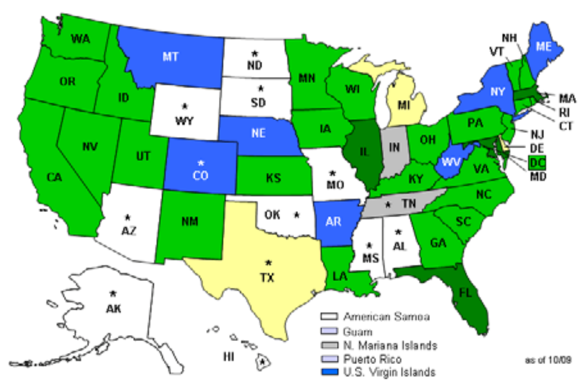
Figure No.1 Energy Consumption in the USA



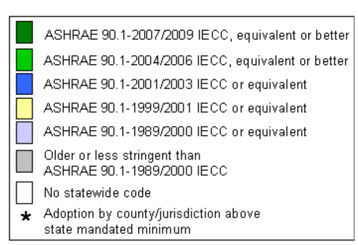
Courtesy of US DOE - Energy Information Agency

Code application and enforcement is another concern. Despite the requirements under EPAct 1992 and 2005 many state energy administrations have still not complied with the mandate.

Figure No. 2 Code Application in the USA



Courtesy of US DOE



This offers substantial opportunities for improvement, From Figure No. 2 (based on October 2009 DOE data) it can be seen that 8 states have no statewide energy code (they may have city codes) while many others are signicantly older than the baseline minimum standard currently being referenced (ASHRAE Std 90.1 2004). particularly as this indicates the codeS adopted only. Actual enforcement and compliance are another key issue that has been reviewed by both DOE and under the Code Assistance Project (2)(3) and needs to be addressed at the jurisdiction level.

THE OPPORTUNITIES AHEAD

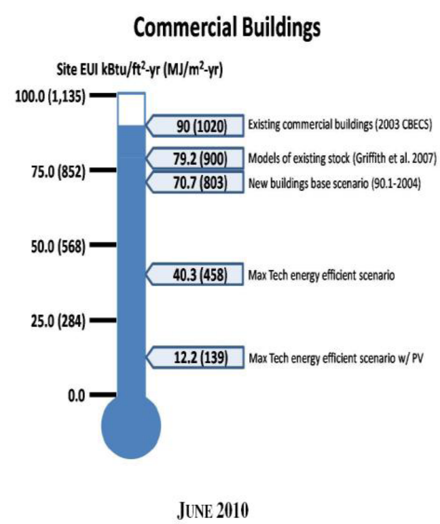
All of this of course relates to minimum energy efficiency codes and standards. There is clearly far greater public awareness and interest today than even five years ago in green and sustainable buildings, much of it thanks to the work of USGBC and their LEED rating system. But there is also growing interest in high performance buildings that exceed minimum code requirements.

The federal government has set extremely aggressive goals for all federal buildings. EPAct 2005 requires all new federal buildings to be designed to use 30% les energy than requirements under Standard 90.1 2004. The Energy Independence and Security Act of 2007 (EISA) Section 431 requires a 30% reduction in actual fossil fuel use for the entire existing federal building inventory by 2015 (relative to the energy use in 2003) on an agency by agency basis. While EISA 2007 Section 433 requires all new federal buildings to follow a schedule for reduction in fossil fuel use below CBECS 2003 (91,000 Btu/sf.yr) including plug and process loads to the point of net zero by 2030.

There is much anticipation of new legislation under consideration in the House and Senate. House Bill HR. 2454 and Senate Bill S.1462 (4) would both essentially require a 30% reduction in new building energy use by 2010 (against ASHRAE Standard 90.1 2004 – for which the last DOE performance determnination numbers are available), and 50% reduction by 2016. The House Bill also sets a target of a 75% reduction by 2021. Are these reductions realistic? From a technical standpoint - possibly. Analysis by Griffin et.al. indicate that reduction in energy intensities from 70.7 kBtu/sf.yr. to 40.3 kBtu/sf.yr., or 43% , are achievable under maximum energy efficiency scenarios today. See Figure No.3. Further significant reductions can be made through the use of on-site renewable energy sources, such as solar photo voltaics.

Studies by the National Renewable Energy Laboratory (NREL) also indicate that 50% to 55% reductions are achievable on a cost effecive basis on new building construction. What about existing buildings?
Studies by the Mckinsey Global Institute indicate that there are significant opportunities for building energy savings, but it would take considerable financial incentives to effectively move the marketplace. The study indicates that at current energy prices it would take incentives in the order of $170 billion per year for the next ten years to really have an impact. But the results are impressive.

Figure No. 3 Building Energy Use



Courtesy Griffin, et. al. 2007

Such programs could reduce total building energy use in the US by 23% (or over 9.3 quads) by 2020 while offering a 17% annualized return on that investment. The study has stimulated considerable interest with programs like Home Star and Building Star being proposed. One such program would target the retrofit of 50 million existing residential and commercial buildings at a cost of $500 billion over ten years, saving $685 million in energy costs per year while creating over 625,000 new jobs. Importantly these programs could reduce electrical energy use by 20% and gas energy use by 15%.

Table 4. Indicates the potential energy use levels by different building types and climate zones, under the maximum available technology scenario, by the year 2020 (without the use of renewable).

We are making progress on many fronts but there are still significant challenges ahead, not the least of which is our energy costs. Despite the dramatic increases in fuel oil costs from around $3 per barrel in 1973 to over $30 per barrel following the oil embargo, and the steady run up in costs to around $80 per barrel today, the US still enjoys relatively low energy prices at 1/3 to 1/4 of those in other parts of the globe. Higher energy costs would certainly provide greater incentive towards energy efficiency. We also can expect future emphasis on demand control and peak load shaving, along with real time pricing from utility companies.

Table 4 Target EUI (kBtu/ft^2-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	86.0	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

ACTIONS ASHRAE IS TAKING

In addition to our research programs and support for technology development, ASHRAE is on an aggressive path forward to improve both new and existing buildings following our Roadmap to Sustainability and Vision 2020. The path is centered on six key elements:

1. The *Advanced Energy Design Guide* series (AEDG);
2. Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*;
3. Standard 189.1, *Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings*;
4. Standard 100, *Energy Efficiency in Existing Buildings*;
5.Commissioning and retro-commissioning guidance; and
6. Operations and maintenance guidance.

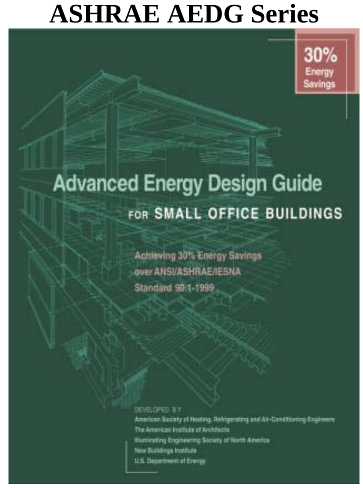
We have a great opportunity with these six key vehicles to provide sequential guidance over the life cycle of buildings if we plan this right and provide the tools to keep our green buildings green.

Advanced Energy Design Guides

The AEDG series (6) has been a hugely successful tool in providing fundamental guidance for a 30% energy efficiency improvement over Standard 90.1 that is practical, cost effective and uses off-the-shelf technologies. More importantly, the guides target a segment of the market, small buildings, which are not normally reached by design engineers. According to the 2003 CBECS survey, 89% of all commercial buildings are 25,000 sf. or less. Fifty-three percent of them are under 5,000 sf.

These are not projects that utilize large amounts of design engineering; in fact most will never be seen by a design engineer. But that does not mean we cannot provide the tools for greater efficiency and sustainability. The intent is that the AEDGs, as non-consensus guide documents, lead the way in providing design guidance for energy-efficient buildings. To date, we have six of the guides already published offering guidance to achieve 30% energy efficiency improvements.

ASHRAE AEDG Series



In addition ASHRAE is developing a three-part *Advanced Energy Efficiency Guides*: *Existing Building Guide* series. The first in this series is now available and shows the business case for why owners should improve the energy efficiency of their buildings, the technical guide will show what those improvements should be, and the operation and maintenance guide will show how to keep those buildings operating efficiently. These *Advanced Energy Efficiency Guides* (AEEG) identify the potential energy savings measures for existing buildings based on a number of renovation scenarios. They also identify specific energy conservation measures and show how to determine the economic viability based on life-cycle cost analysis.

ASHRAE intends to initiate an AEDG series to achieve 50% savings targeted for completion 2010 through 12; and plans are underway an AEDG series to achieve net zero energy buildings, targeted for completion between 2013 and 2015.

ASHRAE's Board of Directors decided that these guides were of such importance that they should be made available for free download in pdf format. To date, more than 275,000 copies have been distributed in some 180 countries around the globe.

Standard 90.1

Standard 90.1 is ASHRAE's critical baseline energy-efficiency standard intended for code adoption as a *minimum* compliance standard. It is the cornerstone driving our efforts towards energy-efficient buildings. It is the basis of national and, increasingly, international energy-efficient building codes. The 2010 updates are targeting a 30% improvement in energy efficiency as compared to the 2004 standard, .although this is proving to be difficult to achieve on a cost effective basis. The real challenge, however, will be the next milestone, looking ahead to 2015 and the target of average aggregate energy usages of 21,600 Btu/sf.yr and to the 2020 target of 17,300 Btu/sf.yr based upon building types and climate zones. These levels of performance cannot be achieved by incremental changes to the building envelope or system components. Such targets will dictate things like building orientation, use of day lighting and natural ventilation. They will almost assuredly dictate system selection such as ground source heat pumps (GSHP), dedicated outdoor air systems (DOAS) and radiant heating/cooling.The standard is being revised to include some measure of plug and process loads for consistency with CBECS and other benchmarks.

Standard 189.1

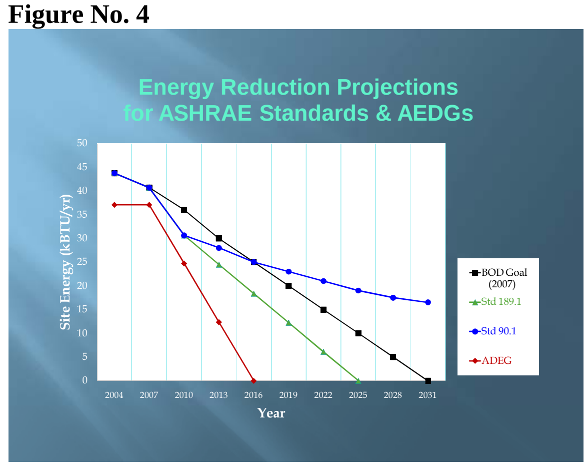
While Standard 90.1 remains the preeminent baseline tool for achieving minimum energy efficiency, the big emphasis today is on high performance buildings. ASHRAE has developed *Standard 189.1 for high performance sustainable building design and construction*, for that purpose.

Standard 189.1 was targeted to be 30% higher efficiency in 2009 than Standard 90.1 2004 and achieving a further 10% or so by 2010 with similar reductions in energy use for 2015 and 2020. The standard is based on total energy use, including plug and process loads.

What is unique about this standard is that it was developed in partnership with USGBC and the Illuminating Engineering Association (IES). It addresses all of the elements under the USGBC LEED rating system. Agreement has been reached with the International Code Council (ICC) to incorporate Standard 189.1 as an appendix to and alternative path of compliance for the International Green Construction Code (IgCC).

Putting together these goals for the AEDGs, Standard 90.1 and Standard 189.1 into graphical form you get a clear picture of the path forward.

Figure No. 4



Standard 100

While Standards 90.1 and 189.1 address components of major renovations for existing buildings, only Standard 100 provides the overall guidance, processes and procedures necessary for developing major retrofit programs

Standard 100 establishes the basics of energy auditing and then the process and procedures to move through any energy retrofit program. More critically Standard 100 is a comprehensive code intended standard that provides detailed processes and procedures for the retrofit of existing residential and commercial buildings in order to achieve greater energy efficiency.

The standard addresses major and minor modifications for both residential and commercial buildings. It addresses single and multiple activity buildings with variable occupancy periods (one shift, two shift, three shift). It identifies 53 building types (Per CBECS and RECS) in 16 climate zones/sub-zones. It identifies requirements for buildings with energy targets undergoing major retrofit and for buildings without energy targets (mostly industrial, agricultural and special laboratories).

The standard describe the requirements for compliance including the need for energy use surveys, energy assessments, establishment of energy targets, evaluation of energy efficiency measures (both individually and collectively) on a life cycle cost basis and establishment of energy management, operation and maintenance programs. It also covers implementation and verification, while identifying the need for ongoing commissioning..

Commissioning and Retro-Commissioning

Unfortunately, while we can seemingly design and build the most efficient buildings, the real challenge is to keep them operating efficiently. It is not unusual for building performance to deteriorate as much as 30% in the first three to four years of operation. Commissioning and retro-commissioning can play a key role in reducing that performance decay. Commissioning is a quality focused process that if implemented early in the design process can save time and money while improving the quality of the end product: a healthy and productive building.

According to studies, retro-commissioning of existing buildings can result in energy savings of 10% to 40% simply by improving operational strategies. The $0.20 to $0.50 per square foot cost can be returned in less than one year through energy savings of at least 15%, according to the Building Commissioning Association (www.bcxa.org).
Regardless of the quality of design and construction, even with commissioning, building performance cannot be sustained without operator training.

Operation and Maintenance

We must continue to develop the technology, tools and educational programs to support the operation and maintenance of the buildings we design. That includes determining the right building performance metrics to help consumers understand and support these efforts and the training required for building operators.

NET ZERO ENERGY BUILDINGS

The concept of net zero energy buildings represents an exciting opportunity and is a great marketing tool. Certainly a number of pilot programs have demonstrated that NZEBs can indeed be achieved, technically, but not yet on a cost effective basis. ASHRAE generally defines NZEB as buildings which, on an annual basis, use no more energy than is provided by on-site renewable energy sources. But exactly how do we define net-zero? Zero Cost, Zero Energy or Zero Carbon?

What is clear is that net-zero-energy buildings cannot be achieved by energy efficiency alone _ renewable energy components must be applied. Then the challenge becomes _how to do that in dense urban and high rise environments?

How do we get there from a technology standpoint? Only by a fully integrated design and construction approach, addressing

- Building orientation to suit climate zone
- Coordinated siting, landscaping and building location
- Highly insulated building envelope
- Optimized high performance fenestration
- Optimized use of day-lighting
- Low density ambient lighting - electronic dimmable
- High efficiency task lighting – occupancy control
- Control of plug and process loads
- Dedicated outdoor air systems with enthalpy recovery and demand control
- Super efficient HVAC systems
- Expanded use of heat pumps
- Radiant heating and cooling systems
- High performance packaged systems – including variable refrigerant flow (VRF) systems.
- On going commissioning, operation and maintenance

AIA’s California Council 5) has identified the major factors FOR Integrated Project Delivery and developed a Manual of Practice as a tool for the industry.

BUILDING CODES - WHERE ARE WE HEADED

We have operated for years with prescriptive standards as the basis of our building codes and they have served us well. However as we look for even greater energy efficiency it is apparent that it could only be achieved by addressing building operations as a whole, rather than as a series of parts. In addition, our current buildings codes only address design and construction issues and their impact typically ends with certificate of occupancy.

Performance standards and their resulting code applications do allow a more holistic and sophisticated systems approach to building design and construction. They allow analysis of building orientation and its impact on solar heat loads and on the use of day lighting. More importantly performance standards allow closer analysis of the interaction of all the buildings systems, especially if plug and process loads are included. However, even this approach comes up short as we seek out higher and higher performance, because it fails to take into account the impact of the building owners and occupants. This is where building modeling and performance simulation can provide significant benefit in accounting for these load interactions.

Building occupants have control over three critical building functions - plug and process loads, lighting and thermal comfort. Collectively these can account for 30% to 60% of the total building load. The occupants actions in turning off computers and task lights when not in use can have a major impact. Much of that can only be achieved by raising occupant awareness and by changing mindsets and culture. Thermal comfort is a classic example. ASHRAE Standard 55 clearly defines a range of temperature, humidity and air movement acceptable to 80% of building occupants. Simplistically put, most occupants are comfortable in a range of temperatures between 68^{o}F and 78^{o}F, yet we insist on setting space temperatures at (say) 72^{o}F and expecting control at +/- 1^{o}F. In Europe, for example, the comfort temperature band is treated as a dead zone, requiring neither heating nor cooling in that range.

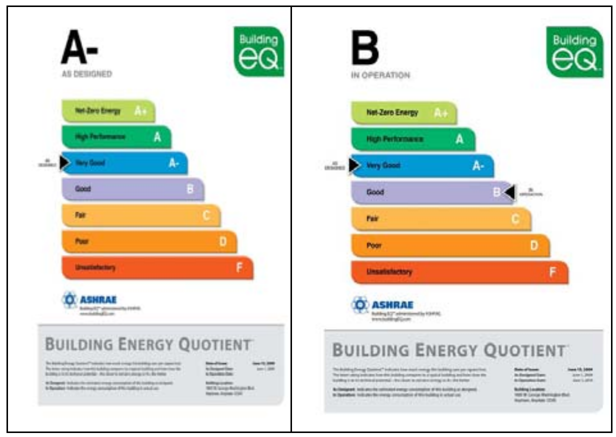
How do we change that? First by raising public awareness of energy and the environment and second by developing a culture of sustainability. It will also a take a different approach in buildings standards and code application that takes us beyond building design and construction and into actual operations. Outcome based codes and standards can regulate actual building energy use in real life operation, but would require a wholesale change in the way we currently do business, including periodic auditing.

MEASUREMENT AND VERIFICATION

Part of raising public awareness can be attained by increased measurement and verification so that we fully understand how and where energy is being used. Information is a key to success and additional metering and sub metering of systems will be essential. Graphical displays have also proven helpful in raising occupant awareness of the impact of their actions.

Experience in Europe, Japan and Australia has shown that ultimately we need to accurately monitor and display the actual building energy use on a building by building basis. Building energy labeling can address many of the issues raised. ASHRAE has developed a two part building energy labeling program (called the ASHRAE Building Energy Quotient or bEQ)(7) designed to identify A) The building potential energy performance at the design stage and B) Actual building energy use in full operation – see Figure 5.

Figure No. 5 Building Energy Labeling



The scale of the label ranges from A+ demonstrating net zero energy performance, down to F, which would be unsatisfactory performance.

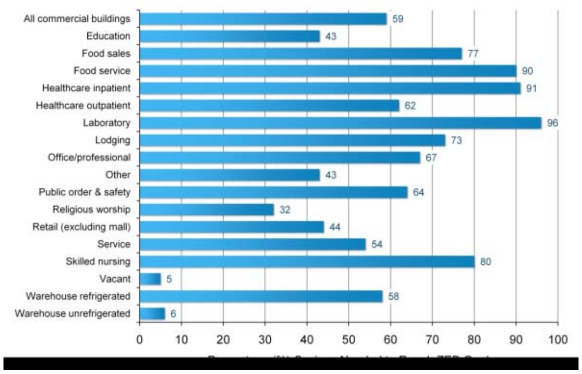
The scale is based on CBECS and other building performance data for reflecting different building types in different climate zones. This allows for peer to peer building performance comparison. The real benefit of the program lies in the supporting documentation which gives owners the tools and understanding to control and improve energy use.

The program has recently completed a robust pilot phase, measuring 23 buildings in a range from 25,000 s.f to 750,000 s.f in different climate zones. The full program is expected to be rolled out, for public use, shortly. Initially this will be a voluntary program and the pilot has had an enthusiastic reception. Ultimately it is expected that many jurisdictions will make building energy labeling mandatory. ASHRAE has developed new certification programs for Energy Assessors and for Building Energy Modeling to support the bEQ program.

The goal of 50 percent of existing buildings achieving net zero energy by 2030 is significantly more challenging than achieving 100 percent net zero energy in new construction.

A study conducted for the U.S. Department of Energy (Figure 6) indicates the depth of energy savings required by building type to achieve net zero within the footprint of the building (assuming the application of solar energy to create the required renewable component. The study indicates that achieving net zero in warehouses should be simple; however doing so in hospitals and labs would be extremely difficult.

Figure No. 6 US Department of Energy Building Energy Reductions Needed



On average, a two–thirds reduction in energy use is required to approach these goals. In many respects, California leads the way in addressing these issues. Their track record over the past 35 years is quite impressive and the California Energy Efficiency Strategic Plan offers a broad range of solutions to achieve Zero Net Energy.

CONCLUSIONS

Reaching high performance buildings goals and significantly reducing energy use in both new and existing buildings does present very significant challenges and goes far beyond codes and standards as we know them today. With net zero energy buildings as the ultimate goal it will take a comprehensive and aggressive approach that addresses all the major elements, including:

- Further advancements in code intended standards
- Improvements to building energy codes
- More rigorous application and enforcement of building codes
- An integrated building design approach
- Federal, state and utility rebates and incentives
- Benchmarking, measurement and verification
- Auditing and sub metering
- Addressing all significant end users including all currently unregulated loads
- Commissioning and retro-commissioning
- Operator training
- Consumer awareness and behavioral changes

There are no “easy” solutions. The answers are not simply technical since we largely know the technology needed to achieve net zero energy. And no one issue is going to provide the kind of results that we need, though elements like code application and enforcement can go a long way. This country has always been driven by economic sticks and carrots and much can be done to stimulate change through the combination of energy taxes and parallel incentive programs, if we have the political will to implements these. Whether driven by economic or environmental concerns changes to current codes and standards practices will be needed if we are to achieve our high performance building goals. The movement from prescriptive standards, to performance standards and eventually to outcome based standards will be just one essential step on the path to success.

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1. ASHRAE Standards 55, 90.1 189.1 and 100 www.ashrae.org/technology/page/548
2. Building Codes Assistance Project, *Roundtable Discussion on Energy Code Compliance and Evaluation*, Washington, DC, 2009.
3. Department of Energy, *Measuring State Energy Code Compliance*, Washington, DC, March 2010.
4. American Clean Energy and Security Act of 2009, H.R. 2454; American Clean Energy Leadership Act of 2009, S. 1462; and Practical Energy and Climate Plan Act of 2010, S. 3464.
5. AIA California Council, *Integrated Project Delivery—A Working Definition*, Version 2, Sacramento, CA, 2007.
6. ASHRAE, *Advanced Energy Design Guides*, Atlanta, GA. Various titles available at http://www.ashrae.org/publications/page/1604.
7. ASHRAE Building Energy Quotient, http://www.buildingEQ.com.