

# Net Zero by 2030: Where Do We Stand with the Policies, Programs and Projects Necessary to Achieve this Goal?

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## ABSTRACT

The quest to achieve net zero energy buildings by 2030 as a means to curb the impacts of climate change may have lost some of its luster lately as programs and policies focus on efficiency efforts in existing building stock and whatever else that will spur job creation in the near term. But, the development of net zero energy projects, policies and programs has certainly not stopped.

Zero-energy targets for commercial buildings have been widely adopted by groups such as the U.S. Conference of Mayors, National Association of Counties and by hundreds of leading design and engineering firms through the 2030 Challenge and AIA 2030. ASHRAE is also actively tying its work focus and outcomes to the 2030 goal of net zero energy buildings. Massachusetts and California continue to pursue a net zero energy building agenda.

New Buildings Institute (NBI), the Zero Energy Commercial Buildings Consortium (ZECBC) and the National Association of State Energy Officials (NASEO) completed a study in early 2012 examining the number, efficiency features and cost of net zero buildings across the United States. This paper builds on that study and includes: a look at the market, lessons learned from current projects on technologies and strategies applied, descriptions of some of the programs and policies that are supporting forward movement, and recommended next steps.

## Introduction

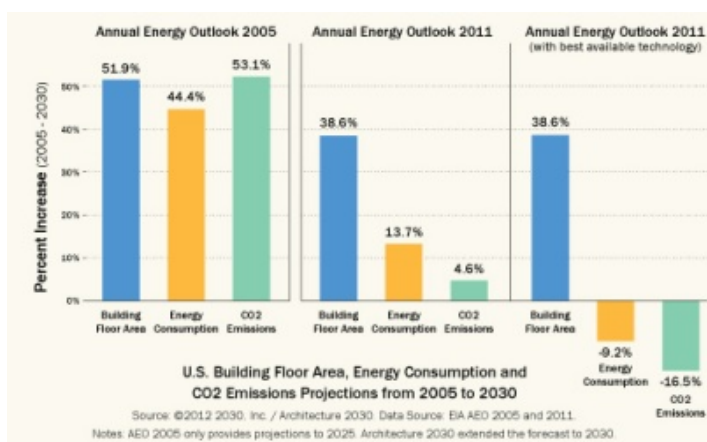
Zero Energy Buildings (ZEBs)—those that are so energy efficient they use no more energy over the course of a year than they produce from onsite renewable sources—are increasingly specified in green building and public policy goals. With buildings accounting for nearly 40% of total domestic energy use<sup>1</sup>, there is clear potential for significant reductions in pollution and increased energy independence from efficiency in this sector. The ZEB concept provides a definitive end focus for a pathway that moves commercial buildings from current design practice to deep energy efficiency, to the final step of adding onsite renewables to supply remaining energy needs.

Documented cases of achieving zero energy, though still rare, are increasing, and more projects are in the planning stages. As the numbers of these extremely low-energy buildings rise, we advance toward the goal of zero energy building as a standard practice by 2030. But, will we achieve it? A recent look by Architecture 2030 at the Annual Energy Outlook indicates things are headed in the right direction.

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<sup>1</sup> DOE *Buildings Energy Data Book*, March 2011. Commercial and residential total share of US primary energy.

“In 2005, the AEO forecast an increase in total U.S. building floor area of 51.9% from 2005 to 2030, with energy consumption and CO2 emissions increasing by 44.4% and 53.1% respectively. While the AEO 2011 projects a slightly lower building floor area increase of 38.6% over this same time period, the projected energy consumption and related CO2 emissions from the Building Sector are dramatically less than what was projected in 2005. The Building Sector is becoming less energy and carbon intensive.” (Architecture 2030)



Policies and programs working to advance highly efficient commercial buildings and zero energy goals are progressing, however these remain limited. Efforts in California and Massachusetts are the most comprehensive and include strategic plans to achieve zero energy buildings by a target date. Continued innovation in public policy will be required, including outcome-based codes and policies that address unregulated loads.

Some utility and public benefits programs, such as that of the Energy Trust of Oregon, are considering or have piloted financial incentives for zero energy commercial buildings. The Living Future Institute offers a Net Zero Energy Building Certification that recently announced its first two approved buildings.

## How Many ZEBs Are There?

In early 2012, NBI, the Zero Energy Commercial Building Consortium and NASEO released a research report summarizing the available literature on the technology and design measures used for ZEBs<sup>2</sup> and incremental costs associated with those strategies.

That study identified a total of 99 buildings, including 21 ZEBs and an additional 39 potential ZEBs that were either still under construction or could not provide enough data to verify zero-energy performance. Just over half of the ZEB projects were completed between 2008 and 2010. (Note: Buildings completed in 2011 were unverified because they lacked a full year of performance data.) Another 39 zero energy-capable buildings were also identified—

<sup>2</sup> Other publications have provided broad overviews of zero energy buildings. See, for example, the 2011 white paper from *Building Design + Construction*, which covers definitions, strategies and some case examples of zero energy construction efforts.

highly efficient buildings that could be zero energy, but didn't take the final step of installing onsite renewable resources.

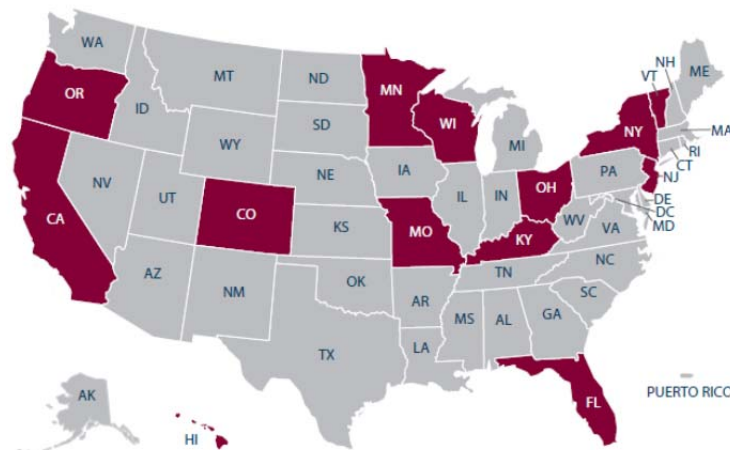
The 2003 national average energy use intensity (EUI) of all U.S. commercial buildings is 93 kBtu/square foot (sf) (CBECS). The least efficient buildings in the study had an EUI of 35 kBtu/sf, while the most efficient used about 10% of the national average or 9 kBtu/sf.

This study focuses on cases in which the zero energy goal is achieved on a single site. Even though location, space constraints, and building activity type won't always accommodate this goal, the single-site lessons also inform the pathway to achieving zero energy goals on a district or regional basis. The policy benefits of ZEBs can be achieved with renewable resources located off-site, either in district systems or through the existing utility grid.

### Current Zero Energy Buildings

Table 1, on the next page, identifies the 21 occupied commercial buildings with either measured net zero energy results (15 cases) or credible modeled<sup>3</sup> expectations for such results (six cases).<sup>4</sup> Those cases without published measured results have been vetted by staff reviewing submissions to the U.S. Department of Energy's (DOE) Zero Energy Buildings Database or other reliable sources.

**Figure 1. Location of the 21 Zero Energy Projects**



The current zero energy buildings are located in a variety of U.S. climates, as shown in Figure 1 above. Both California and Hawaii are well represented, with six and two buildings,

<sup>3</sup> Sophisticated computer modeling of anticipated energy use is common in designing high performance buildings, as a tool for evaluating and choosing among alternative efficiency measures. Modeling reflects the building's performance goals and remains the only quantified estimate of performance until actual energy bills for at least one year of occupancy have been analyzed. The former, measured energy use gives the true indication the performance level achieved, and provides valuable feedback on successful strategies and areas of improvement.

<sup>4</sup> Table includes all cases with less than 5 kBtu/sf of reported purchased annual energy. See for example, the 2011 white paper from *Building Design + Construction*, which covers definitions, strategies, and some case examples of zero energy construction efforts. (BD+C)

respectively. The mild climates of these states certainly help make ZEBs achievable. However, projects have also been completed in the harsher climates of Minnesota, Wisconsin, and New York.

With exception of two facilities completed in 2010 — Richardsville Elementary and the NREL facility — all ZEBs are less than 15,000 square feet, and half are less than 5,000 square feet. More large building examples will be helpful in expanding the ZNE impact. However, this relatively small building size is representative of the overall existing commercial building stock.

**Table 1. Verified Zero Energy Buildings**

	Building	Type	Location	Square Feet	Purchased EUI <sup>(1)</sup>	Total EUI <sup>(2)</sup>	Data Source
2000	Oberlin College Lewis Center	Higher ed	Oberlin, OH	13,600	0	32.2	Meas.
2001	Environmental Tech. Center Sonoma State	Higher ed	Rohnert Park, CA	2,200	0	2.3	Meas.
2002	Challengers Tennis Club	Recreation	Los Angeles, CA	3,500	0	9.1	Mod.
	Leslie Shao-Ming Sun Field Station	Higher ed	Woodside, CA	13,200	3.8 <sup>(3)</sup>	9.5 <sup>(3)</sup>	Meas.
2003	Audubon Center at Debs Park	Interp center	Los Angeles, CA	5,000	0	17.1	Mod.
	Science House	Interp Center	St Paul, MN	1,530	0	17.6	Meas.
2005	Hawaii Gateway Energy Center	Office; Interp center	Kailua-Kona, HI	3,600	0	27.7	Meas.
2007	Aldo Leopold Legacy Center	Office; Interp center	Baraboo, WI	11,900	0	15.6	Mod.
	IDeAs Z2	Office	San Jose, CA	6,600	0	24.6	Mod.
2008	Camden Friends Meeting House	Assembly	Camden, DE	3,000	0	na	Meas.
	Environmental Nature Center	Assembly	Newport, CA	8,535	0	17.6	Meas.
	Hudson Valley Clean Energy HQ	Warehouse; Office	Rhinebeck, NY	4,100	0	13	Meas.
2009	Chrisney Library	Library	Chrisney, IN	2,400	0	15.3	Meas.
	Living Learning Center (at Tyson Research Center)	Higher ed	Eureka, MO	2,968	0	24.5	Meas.
	Omega Center for Sustainable Living	Interp Center	Rhinebeck, NY	6,246	0	21	Meas.
	Pringle Creek Painter's Hall	Assembly	Salem, OR	3,600	0	9.5	Meas.
	Putney Field House	Recreation	Putney, VT	16,800	0	9.7	Meas.
2010	Energy Lab at Hawaii Preparatory Academy	Education	Kamuela, HI	5,902	0	11	Meas.
	Magnify Credit Union	Office	Lakeland, FL	4,151	3.5	45	Meas.
	Richardsville Elementary	K-12	Bowling Green, KY	77,000	0	18	Mod.
	NREL Research Support Facility	Office	Golden, CO	222,000	35 <sup>(4)</sup>	35	Mod.

- 1 Purchased EUI is the building's total EUI less any on-site generation. Energy Use Intensity is reported in kBtu/sf/yr. A few sites report small annual totals of renewable generation in excess of the amount used on-site, which may be exported to exterior or adjoining uses. Those excesses are not quantified here.
- 2 Total EUI includes both renewable and purchased energy.
- 3 Leslie Shao-Ming Sun Field Station purchased energy omits propane usage because of metering problems.
- 4 NREL Research Support Facility is modeled to reach net zero upon installation of 1.6 MW PV system.

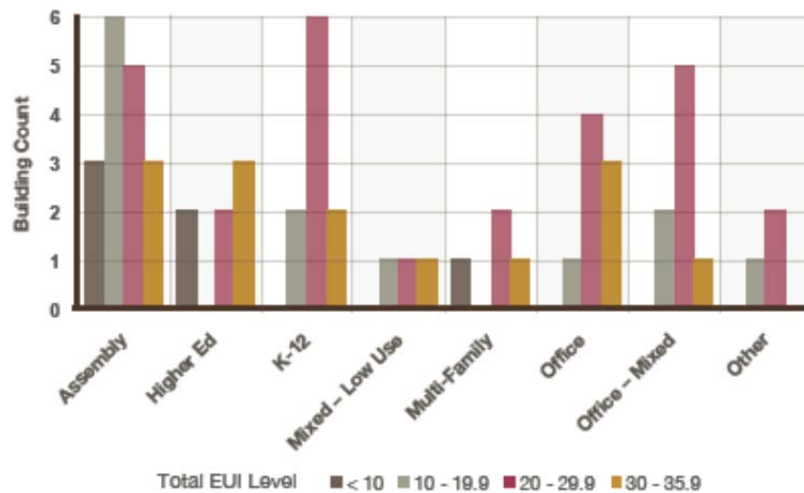
## Zero Energy-Capable Buildings

Expanding the search from the same primary sources to zero energy capable buildings increases the data set to 60, including the 21 already described and the 39 zero energy-capable buildings. “Zero energy-capable” (ZEC) is based here on total energy used, including both purchased and onsite renewable sources. A fairly generous eligibility cut-off was used in identifying these cases, taking all buildings with total energy use of 35 kBtu/sf or less.

Whether or not they are currently using renewables, these ZEC buildings have total EUIs low enough that many would have the potential for achieving net zero through onsite renewables. The ability to take that final step would depend on the assessment of available space for installing PV panels, the abundance of solar radiation for the building location, and financial considerations.

Figure 2 summarizes 60 cases by EUI level and activity type. As with the smaller group of current ZEBs, activity types in the ZEC cases tend to be in lower-use categories.

**Figure 2. Zero Energy and Zero Energy Capable Building**



This larger set of cases is still weighted toward small and very small buildings, which is representative of the total commercial building stock. However, this group also includes examples in the important mid-to-large office building categories, as shown in Table 2.

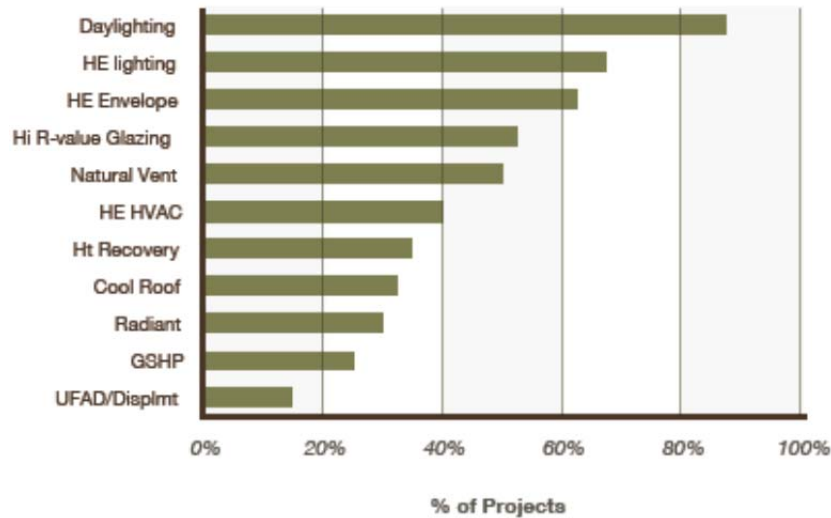
**Table 2. Zero Energy and Zero Energy-Capable Counts by Type and Size**

Type	Size (total square feet)						Total
	1k - 5k	5k - 10k	10k - 25k	25k - 50k	50k - 100k	> 100k	
Assembly	6	4	5	2			17
Higher Ed	2		4	1			7
K-12		1	1		6	2	10
Mixed-Low Use	2		1				3
Multi-Family		2	1			1	4
Office	1	2	3		1	1	8
Office-Mixed	1	2	3	2			8
Other	1		1		1		3
<b>Total</b>	<b>13</b>	<b>11</b>	<b>19</b>	<b>5</b>	<b>8</b>	<b>4</b>	<b>60</b>

### Design Strategies Utilized

Figure 3 presents the technology penetration of 11 design strategy categories reported in the buildings studied. A couple caveats are needed when looking at this data. First, the typical case study does not necessarily mention every efficiency measure used, nor does it clearly define the details of measures that are mentioned. This summary is therefore primarily an indication of the types of strategies that have been considered noteworthy. In addition, these summaries represent the entire set of documented cases, across a wide range of climates. Climate-responsive design is a necessary part of optimized design, but the current data set is not large enough to show differences by region in strategies used. As more documented examples are consolidated, important breakdowns such as analysis by climate will become possible.<sup>5</sup>

**Figure 3. Technologies Used in ZEB and Zero Energy-Capable Buildings**



<sup>5</sup> Note that it is possible to search NBI's Getting to 50 Buildings Database by state or climate zone to find specific case studies in a particular area.

More than 85% of the studied cases report designs incorporating daylighting. Most reports, however, do not provide sufficient detail to know whether effective automated controls were installed to maximize potential energy savings, nor how well the daylighting was balanced with an appropriately managed ratio of window to wall area. Approximately two-thirds reported high efficiency lighting, including occupancy-based controls and/or high efficiency lamps (68%). More than 50% of the buildings also report using a high performance envelope with increased insulation and well-insulated glazing. Half of the buildings use natural ventilation. These strategies align well with the proven design approach of starting with a good building envelope, access to natural light and ventilation, and an integrated design of building systems.

The most noteworthy characteristic of the reported strategies is that nearly all refer to measures and equipment that are commercially available today.

The common theme across these ZEBs is their focus on the goal: to build a building that puts at least as much energy into the grid than it uses. The clear statement of objectives at the beginning of the design process, as a guide to decisions and prioritizations throughout the project, is essential to optimized results. In terms of features, each building has taken an integrated, location-specific approach to achieving that goal of net zero energy use. These buildings demonstrate that net zero is feasible, with examples in many different U.S. climates. With this intent, a skilled design team and off-the-shelf building technology, these projects have demonstrated the feasibility of meeting that goal.

## **Incremental Costs Are Within Range**

The design and construction process includes many iterations of changes and trade-offs to balance owner wishes with budget limitations. Within this framework, quantifying the incremental cost of energy-saving features can be problematic. Incremental costs of efficiency measures in zero energy buildings were assessed from two perspectives. A number of modeling studies were reviewed (Cascadia 2009, Hendricks 2011, HOK 2011, Leach 2010, Matthiessen 2007, Packard 2002, Thornton 2009, Thornton 2010).

These studies indicate incremental costs for efficiency features of between 3% and 18% of baseline costs (not including renewable). Costs for achieving the levels of efficiency needed to support ZEB buildings appear to require only limited additional costs for some building types. In larger buildings, the costs of moving to advanced types of HVAC increased costs more significantly.

Deriving incremental costs from the few ZEBs that had data was difficult because of the limited information. However, the few reported ZEBs appear to show lower overall incremental costs than the modeled estimates. Those costs are between 0% and 10%. Payback periods, where mentioned, are 11 years or less, except for one case where the PV system extended the period. Recurring themes in the actual cases include the use of creative trade-offs in the design and construction process to manage total project costs within budget.

## Program and Policy Pathways for Moving to ZEBs

Emerging programs that support and recognize ZEBs in the market have already had noticeable impact but remain extremely limited. Programs so far include: Net Zero Energy Building Certification by the Living Future Institute, which recently approved its first two buildings; a deeper savings version of the Savings by Design program of the California utilities; and a Path to Zero pilot for new construction conducted by the Energy Trust of Oregon.

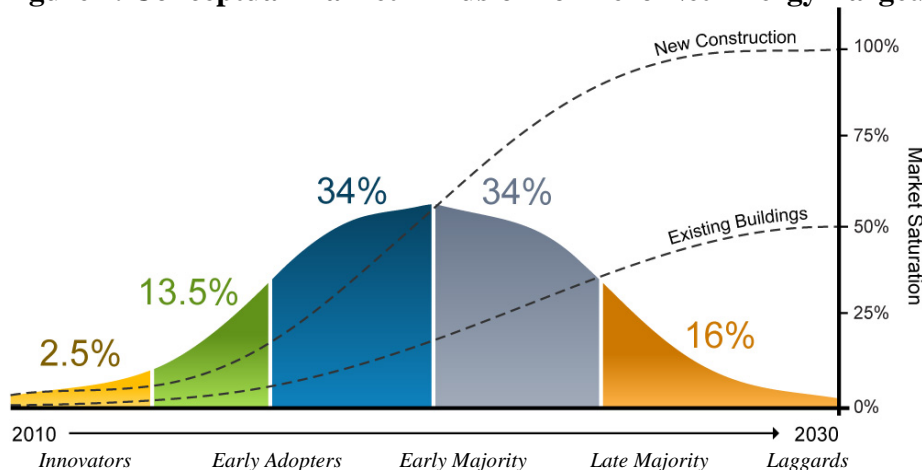
Nationally, the Zero Energy Commercial Buildings Consortium works to coordinate a broad-based industry/ government collaborative of about 500 organizations to move the commercial sector to net zero levels of energy performance. On the policy front, California and Massachusetts lead.

When considering the locations of identified ZEB or zero-energy capable buildings, the program and policy support of California and Oregon appears to be making a difference. Of the 99 buildings identified to date that are either ZEBs or approaching ZEB status, 23 projects are located in California and 9 are in Oregon.

In California, state agencies have adopted BBES (Big, Bold, Energy Efficiency Strategies) and goals of making all new commercial buildings zero net energy by 2030. This also includes making all new residential construction zero energy by 2020, and 50% of existing commercial buildings by 2030.

As part of this planning approach, the California Public Utilities Commission has used the diagram depicted in Figure 4 which represents the diffusion of the zero net energy concept across the market.

**Figure 4. Conceptual Market Diffusion for Zero Net Energy Targets**



As major building owners and managers of public building portfolios, state and local governments can lead by example by becoming early adopters of advanced technologies and energy management practices. Indeed, the relatively high number of public ZEBs indicates the level of public sector commitment and market-leading capacity. Demonstration projects, public procurement policies and public facility management practices can prove performance, generate a body of data, enhance industry capacity, and provide education and awareness-raising opportunities.

Policies such as building energy codes, renewable portfolio standards, energy efficiency resource standards, and statewide energy efficiency or greenhouse gas reduction targets define a



floor for minimum performance. Additionally, states can push the envelope through voluntary initiatives such as building energy reach codes and building energy rating and disclosure. These voluntary policies establish expectation in the marketplace and in the industry for continuous energy efficiency improvements in the future—charting a predictable path toward net zero energy goals.

The Commonwealth of Massachusetts is a prime example of how stretch codes can significantly advance market practice. The state set its stretch code in 2009 and within two years, over 100 “green” communities had adopted it. Utility programs in the state were aligned with the stretch code and offered incentives for buildings that followed it. The stretch code, which is based on NBI’s *Core Performance Guide*, ultimately served as the basis for the 2012 International Energy Conservation Code (IECC) approved in October 2010.

By the time the 2012 IECC becomes the base code for Massachusetts in early 2013, the next iteration of the state’s stretch code will be in place and the utility efficiency programs operating there will likely be incenting it. The alignment of utility program and stretch code specifications allows for greater impact of both efforts to accelerate the market acceptance and adoption of more stringent energy efficiency codes in the future.

States can also play a key role in facilitating commercialization of new and emerging technologies through program investment. Through demonstration grant programs, revolving loan funds, credit enhancement mechanisms such as loan loss reserves or interest rate buy-downs, and state equity investments, the public sector has demonstrated the ability to successfully bridge the commercialization “valley of death” from applied research and development to deployment. This focus by states on policies and programs that can support and incent sustained market demand and supply for emerging clean energy technologies is a fertile area for more exploration in the transition to ZEBs.

## Needs & Next Steps

Despite the limitations of the data, ZEBs are becoming a realistic option for smaller buildings especially in moderate climates. For larger or more complex buildings in more challenging climates, modeling studies are showing positive paybacks that, while outside the financial parameters of the general development community, might appeal to a class of owner-occupiers. When looking at actual building projects, for which cases are limited, it is notable that ZEB efficiency levels were achievable within established budget parameters.

Soft costs related to the design and construction on these innovative buildings are not well documented; they would likely be higher than for conventional construction, though not to the degree that is often perceived. There is still much groundbreaking work to be done. Continued innovation and dedicated pursuit of ZEBs will create cost reductions over the long term, result in more ZEB and ZEC buildings entering the market, and move advanced practices more swiftly to standard practice, improving the energy efficiency of the entire building stock over time.

Extending the goal of ZEBs to a broader range of building types, climates and use patterns will likely prove challenging. In dense urban areas, it may not be possible to locate sufficient PVs (or other renewables) on each site, but the ZEC pathway still enables deep energy efficiency, making district and equivalent renewable strategies feasible.

To continue to accelerate development of ZEBs and begin to integrate lessons from these buildings into general design and construction activities as well as policies and program efforts, the following actions are recommended:

- **Practical guidance to help identify opportunities:** The marketplace needs clear summaries of the conditions where ZEBs are most feasible (anticipated loads, climate), and the path to move toward those goals.

Ongoing communication can be fostered by continually updating a set of case studies showing clear definition of the processes and techniques used as well as results and lessons learned with varying climates, building types and settings. Clear *studies of avoided costs* (both initial design and construction savings and ongoing energy savings) from energy efficiency-focused integrated design can help explain the potential and support needed financing of first costs.

- **Encourage measurement and communication of results:** ZEBs are already entering a “second generation” of more typical building types and ownership patterns; lessons learned from these examples could accelerate interest at both the market and policy levels towards zero energy and zero energy-capable buildings. For the most useful lessons, ZEB owners must measure total energy use in a way that gives insight into successful strategies and areas for further improvement.

Knowing the annual totals for onsite energy use and purchased energy is the essential first step. Submetering or other analysis to identify areas for further improvement is also required to put that information to good use. Communication of these results should extend beyond the owner/operator, going back to the design team for incorporation into future efforts and to program sponsors for evaluating overall results.

- **Develop a better basis for benchmarking performance:** As more successful zero energy-capable buildings emerge, we can shift the benchmarking focus from a broad peer group based on past commercial building national average EUIs to a forward-looking target based on demonstrated results of industry leaders. Two things are needed to improve the relevance of the latter basis. Clearly, a larger pool of documented very high performance results will help demonstrate achievable levels for a greater portion of building situations. Meaningful benchmarking also requires being able to identify true efficiency across buildings with a wide range of occupancy schedules and plug load requirements. (Eley, 2009)

- **Promote outcome-based codes and policies that address unregulated loads.** The move to a zero-energy building stock will likely require a series of major shifts in the structure of codes, both in the presentation of code requirements and in ensuring compliance. Current codes and standards do not take into account elevators and escalators (vertical transportation) or plug and process loads. Plug and process loads encompass energy used by equipment not included in the building during construction (such as computers, appliances and refrigeration). To control this expanding use, future codes must include them (ZECBC). Outcome-based codes and policies based on the actual energy performance of buildings rather than predictions will be required.

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