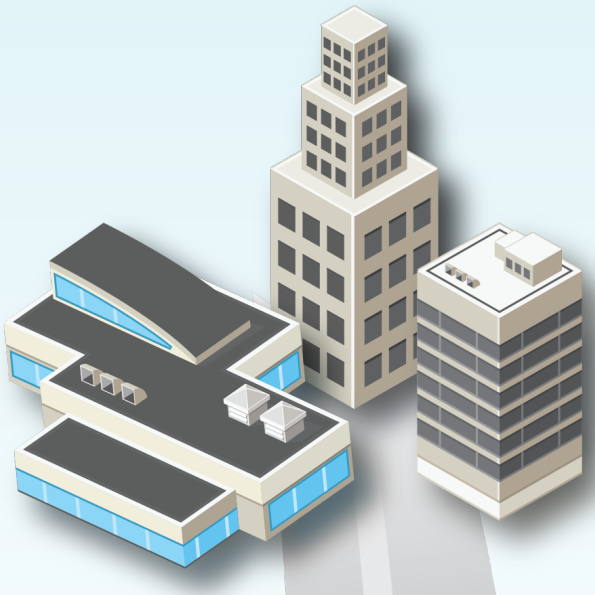

Roadmap to Zero Net Energy Public Buildings

Recommended Steps for the Northeast & Mid-Atlantic

Presented by Northeast Energy Efficiency Partnerships

Roadmap to Zero Net Energy Public Buildings

Recommended Steps for the Northeast and Mid-Atlantic

Presented by Northeast Energy Efficiency Partnerships - May 2012

Northeast Energy Efficiency Partnerships

NEEP transforms the way we use and think about energy. We are a non-profit organization that builds partnerships among the efficiency industry, communities, businesses and policymakers in the North¬east and Mid-Atlantic states. Through advocacy, collaboration and education, we accelerate energy efficiency and make visible its impacts on the region, the economy, the planet, and future generations.

The High Performance Buildings Project was developed to promote operational energy savings in new and retrofitted buildings throughout the region. NEEP's vision is that the work done today on High Performance Buildings will pave the way for the development of zero net energy buildings, buildings that consume no more energy than they produce, on a broader scale throughout the region.

IEc
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Founded in 1981, IEc is a consulting firm with a staff of more than 80 professionals who are well-known for their ability to develop and apply practical, conceptually sound approaches to the challenges posed by a broad array of energy and environmental issues. Local, State, and Federal decision makers call on IEc to help them navigate the trade-offs and barriers associated with reducing overall energy demand, while also increasing the use of clean energy sources, in the built environment. For example, IEc provided comprehensive consulting support for the pathbreaking work of Massachusetts Governor Deval Patrick's Zero Net Energy Buildings Task Force. (www.indecon.com)

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Executive Summary

Buildings represent perhaps the greatest potential reservoir of energy savings available to us as a society, accounting for some 40 percent of our annual energy use. In recent years, a number of dedicated and resourceful practitioners have shown that constructing buildings that use no more energy than they are able to produce on-site – "net zero energy buildings" – is not only possible, but a practical and tangible example of our collective commitment to a clean energy future.

Yet zero net energy buildings remain, in large part, more of an aspiration than a reality. Recognizing the leadership potential of the public sector, Northeast Energy Efficiency Partnerships (NEEP) believes the road to a full-scale deployment of zero net energy buildings starts with the facilities our states and communities construct. This report was developed in collaboration with a group of regional building energy stakeholders and outlines key steps the public sector can take to facilitate the eventual broad adoption of zero net energy building practices throughout the Northeast and Mid-Atlantic states. The focus of this report is on new construction in the public sector because it provides the greatest opportunity for immediate action with the added benefit of substantial long term energy and cost savings.

Included in this report are "intermediate-term steps" that NEEP recommends be taken in the next 10-15 years to make zero net energy public buildings a widespread practice across the region. These are followed by a series of "critical next steps" that we suggest must be taken now to pave the way to a future where all new buildings consume only as much energy as they produce.

Intermediate-term Steps to Facilitate Zero Net Energy Public Sector Buildings

In the next 10-15 years, the region should take steps in the following four areas to facilitate zero net energy buildings (ZNEBs):

- Information and Education
- Building Energy Codes
- Finance
- Utility Regulation

These steps are described in further detail below.

Information and Education

Decision makers will need more and better information that is reliable and readily understood on how buildings perform with respect to energy use. Critical information includes:

- Techniques for achieving substantial energy use reductions and the estimated costs and benefits of those measures;
- Actual energy performance of individual buildings, which could be generated by the implementation of building energy rating and disclosure programs

Key groups of people will need to be trained to advance building efficiency, including design teams, code enforcement officials, contractors, energy raters and commissioners, facilities managers and building operators, and installers of solar photovoltaic and other renewable energy systems.

Building Energy Codes

Building energy codes are a key mechanism for addressing energy use through regulation. Energy codes will need to incorporate the following changes:

- Progressively lower energy use over the next 20 years so that codes are eventually strict enough to facilitate ZNEBs;
- Focus on outcome-based rather than prescriptive requirements to allow for innovative approaches to lowering energy use;
- Require continuous commissioning to ensure that buildings are performing as expected;
- Address all energy used in the building including plug loads, i.e. the energy consumed by devices plugged in to electrical outlets.

To support these regulatory changes, it will also be necessary to get building tenants more actively involved in taking responsibility for their energy use.

Finance

Higher upfront cost is a key barrier to wider adoption of ZNE buildings, particularly for the public sector. Government entities need greater access to financial instruments such as federal and state tax incentives for renewable energy installations and qualifying efficiency investments. It is also noted that a price on carbon pollution would be effective in two ways as a means to create a financial incentive:

- It would provide a direct financial motivation for consumers to use less energy and to demand more efficient buildings;
- The revenues from a carbon assessment could be funneled into programs to subsidize investments in building energy efficiency projects.

Utility Regulation

Ratepayer-funded energy efficiency programs are critical to helping public buildings overcome the financial and informational barriers to zero net energy buildings. Given regulatory commission oversight of such ratepayer funded programs, state regulators and energy offices should work with their program administrators to:

- Create rate mechanisms that fully decouple cost-recovery from volumetric sales;
- Remove barriers to net-metering to promote greater use of on-site renewable energy;
- Provide performance incentives to utilities that effectively help their customers reduce consumption.

Critical Next Steps

In order to achieve the intermediate-term changes, NEEP has identified five critical next steps.

Step 1. Develop a "Path to Highest Performance" Information Campaign

The zero net energy concept exists largely in the province of technical research communities and a relatively small subset of building design and construction professionals. A comprehensive information campaign is needed to convey a consistent message to the broadest possible audience, from building professionals to the public at large.

Step 2. Promote the Continued Development of Exemplary Public Buildings

To overcome initial market resistance and promote greater development of ZNEBs, each state should complete at least two new public sector ZNEB projects within the next three years.

Step 3. Prioritize Measurement and Reporting of Public Building Energy Performance

The region needs to establish a standardized system for measuring and reporting building energy performance. Such a system is necessary to measure progress toward the zero net energy goal. All new public buildings should, therefore, be required to obtain and disclose an asset rating, which provides information on the inherent characteristics that drive building energy consumption.

Step 4. Implement Stretch Building Energy Codes

To lay the groundwork for broader building code changes, states should establish a performance-based stretch energy code for public buildings. Stretch codes promote better building energy performance, help bring energy efficiency into the mainstream design and construction community, and also inform future developments in the base code.

Step 5. Create a Revolving Loan Fund or Similar Mechanism to Provide Capital for Energy Investments

Lack of capital funding is perhaps the single most important financial barrier to greater investment in efficiency and renewables. For public buildings, this lack of funding is caused in part by the split between capital and operating budgets. An appropriate way to address this issue would be to establish state or regional revolving loan funds for efficiency investments. Such a system would align budget incentives so that capital budget managers could reap the benefits of efficiency investments.

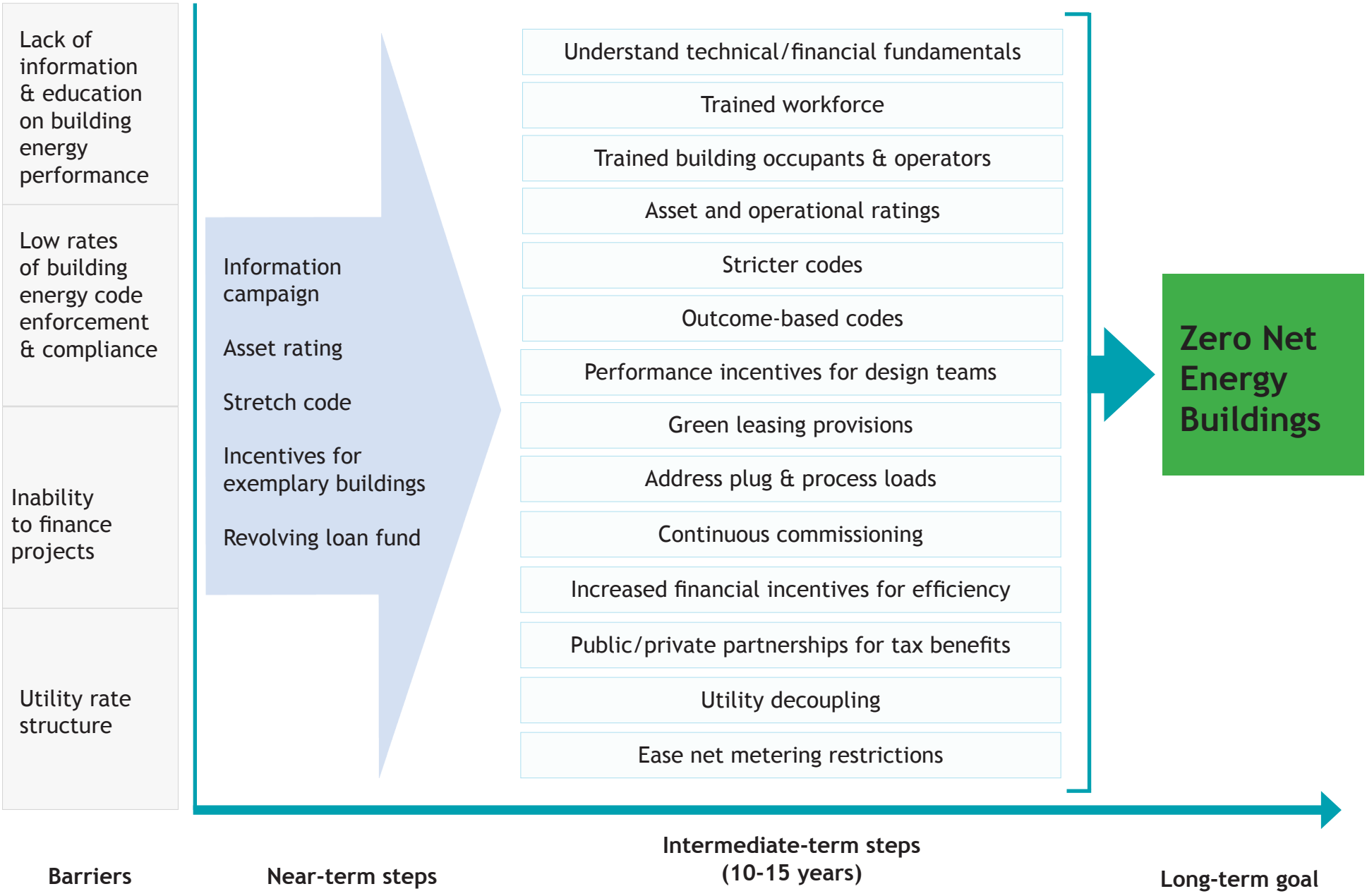
Conclusion

The public sector can and should play a leadership role in pulling the ZNE buildings market forward and creating the foundation for a broader shift across the commercial building sector. The Northeast and Mid-Atlantic states, with their strong existing focus on energy efficiency initiatives, are primed to take on this role. NEEP is committed to advocating for the implementation of the critical next steps described in this report – focused on information and education, additional exemplar demonstration projects, and, most importantly, enhanced systems for the measurement and reporting of increasingly aggressive energy use targets – in order to achieve this objective and to serve as a model for the nation. The need is clear and the tools are available – now is the time for action.

A note regarding the definition of zero net energy

Previous discussions about "zero net energy buildings" have included spirited debate about what that phrase actually means. Points of discussion range from whether the appropriate measure is zero net *site* energy or zero net *source* energy, to the appropriateness of different forms of renewable energy, and whether renewable sources of energy must be building-integrated or at least on the property to "count." Without dismissing the value of these discussions, NEEP adopts a simple definition – a zero net energy building produces as much energy as it consumes over the course of a year – and directs its focus to the simple premise that the path toward zero net energy begins with (1) significant reductions in as-designed building energy consumption, and (2) building operations that ensure as-designed performance. The near-term focus must be on creating conditions and incentives that promote these two goals.

Barriers & Solutions to Zero Net Energy Buildings



Introduction

Building design and construction in the U.S. does not routinely prioritize energy efficiency. As a result, opportunities to create buildings that use substantially less energy—without sacrificing form, function, comfort, or aesthetic appeal—are often missed. And yet, every year new, exemplary buildings are demonstrating what is already possible, up to and including buildings that can be considered "zero net energy"—that is, with annual energy demands low enough to be matched by the output from on-site or local renewable energy systems. With economic, environmental, and national security concerns motivating initiatives to reduce overall energy demand and to meet as much of the demand as possible using cleaner forms of domestically produced energy, it is imperative that we explore opportunities to achieve these objectives in the sector that accounts for 40 percent of the nation's annual energy consumption.

With this report, Northeast Energy Efficiency Partnerships (NEEP) describes specific, near-term, and actionable steps (a "roadmap") for removing or lowering key obstacles to the realization of aggressive building energy performance goals in the Northeast and Mid-Atlantic region, [1] and for making broader adoption of zero net energy buildings, as a standard design objective, more realistic in the medium term.

NEEP has concluded that the "road to zero" should focus in the near term on the public sector. Two considerations lead to this conclusion:

1. **The public sector has a responsibility to lead.** Long-term, transformative initiatives that can deliver broad societal benefits do not readily attract private sector champions, especially when the private sector believes that doing so would be at the expense of near-term financial returns. In these situations, the public sector should "lead by example."
2. **The public sector has a longer investment horizon.** As the market for higher-performance buildings matures, the expected cost savings from improved energy performance may result in a simple payback period that is longer than a private entity would prefer when making a capital investment. The public sector is more likely to be able to accept longer payback periods, and therefore can serve as an incubator for new technologies and alternative design and construction practices.

For this report, NEEP has decided to focus its recommendations on near-term strategies for new building construction, rather than the renovation of existing buildings. While existing buildings offer a far larger opportunity for total energy savings and must eventually be at the center of efforts, the new construction sector is more readily defined and easily tar-

1 The Northeast and Mid-Atlantic region comprises Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New York, New Jersey, Pennsylvania, Rhode Island and Vermont.

geted with clear, implementable strategies. In short, the new construction sector provides the greatest opportunity for immediate actions that can serve to catalyze and accelerate greater transformation across all sectors.

NEEP also recognizes that a future in which *all* buildings are zero net energy is currently not a realistic possibility. Some buildings, due to their locations, structural requirements, or energy use requirements, could never achieve this standard without making infeasible technical or economic sacrifices. But a future in which all buildings exhibit markedly improved energy performance, relative to current benchmarks, is a very realistic possibility. Establishing zero net energy buildings as the goal is a promising way to move the market in the direction of achieving maximum energy performance in all cases. In fact, there is a credible argument to be made that zero net energy, as a concept, becomes a distraction when it is the focal point, and that the immediate objective should be incremental yet aggressive improvements in business as usual energy performance, with zero net energy portrayed only as the logical and *eventua* end state.

As described in this report, initiatives by the U.S. Department of Energy (DOE), and by states such as Massachusetts and California, help to define the opportunity as well as the challenges associated with moving toward the zero net energy building goal in both the residential and non-residential sectors. In the pages that follow, we build on this work by outlining a set of critical, near-term steps that, if successfully implemented, would drive change in the public building sector and in doing so make the necessary intermediate-term changes more likely to occur. We define these steps in four categories: Information and Education; Finance; Regulation; and Utilities.

Our recommendations reflect the collective expertise of leaders in the development and operation of high performance and zero net energy buildings. We convened a group of regional experts specifically for the purpose of discussing the barriers to zero net energy buildings as well as strategies to overcome these barriers. Interviews with a select group of national experts and a review of the relevant literature served to supplement the regional group's conclusions. The Acknowledgements page provides a list of members of the leadership group that participated in the development of this document. In developing these recommendations, the group was aware of the fact that the "public sector" is not monolithic; it includes state executive and other agencies, quasi-public entities, municipalities, school districts, and others, each with different tools at their disposal to promote or mandate change in building practices.

While the intent is to define a roadmap to guide public sector activity in the Northeast and Mid-Atlantic region, the conclusions and recommendations presented here are generally applicable and will hopefully guide similar efforts in other regions of the country. NEEP also recognizes that differences in policy landscapes, as well as climatic conditions, across the Northeast and Mid-Atlantic region will lead the path towards zero net energy to vary across

states; some states may be in a position to move more quickly or aggressively than others. In general, however, the Northeast and Mid-Atlantic states are home to some of the strongest existing energy efficiency policies and programs in the country, and thus offer a strong foundation upon which to demonstrate national leadership in building energy performance.

The Current Zero Net Energy Building Landscape

States have paid considerable attention to the issue of energy efficiency. As one benchmark, the American Council for an Energy-Efficient Economy (ACEEE) produces an annual "State Energy Efficiency Scorecard," which ranks states "based on an array of metrics that capture best practices and recognize leadership in energy efficiency policy and program implementation."[2] Northeast and Mid-Atlantic states dominate the upper end of the spectrum, holding six of the top ten spots. The top states have higher program budgets for efficiency programs, stricter targets, and have realized greater energy savings than others. Clearly, there is a strong foundation in place in many of these states to work toward zero net energy buildings.

Within this context, to understand how to move forward in promoting the goal of zero net energy buildings, it is useful to understand the scope of the efforts currently underway in the building sector to achieve substantial energy use reductions and move toward zero net energy. The best known programs focusing specifically on ZNEB (rather than energy efficiency more generally) are in Massachusetts and California, but several other related initiatives are also worth mentioning.

Massachusetts

Massachusetts has been a clear leader in the ZNEB movement. In 2008, Governor Deval Patrick convened a ZNEB Task Force to identify a path to move the public, commercial, and residential building sectors towards zero net energy use by 2030. Massachusetts took action on several of the Task Force's recommendations, including developing two ZNE pilot building projects and pursuing a building asset labeling initiative. Massachusetts also adopted a "stretch" building energy code for local governments to consider and made it a mandatory requirement of receiving funding and assistance through the state's Green Communities program. Also, through its Leading by Example program, Massachusetts installed several on-site renewable energy projects and installed advanced metering at nearly 20 million square feet of public facilities.

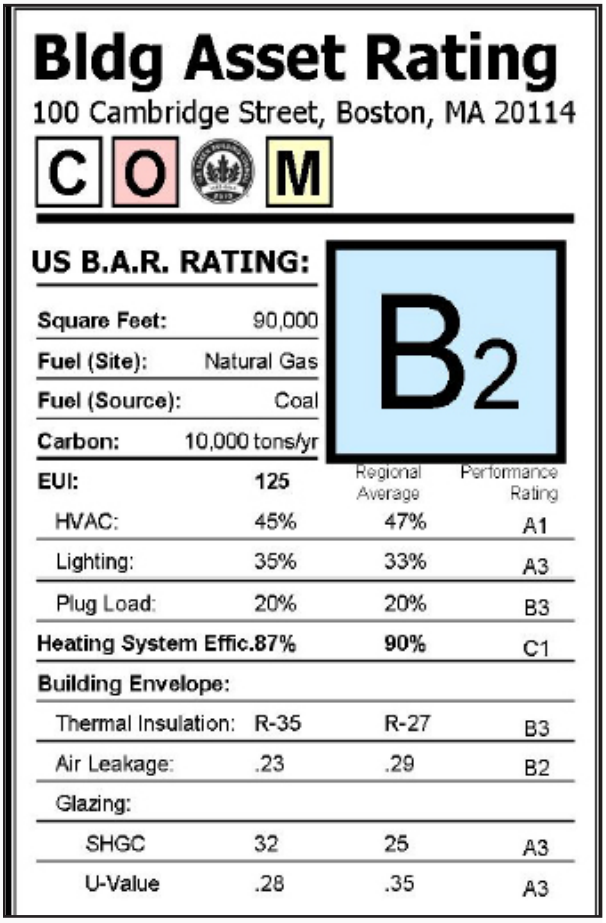
2 Sciortino, Michael et al. "The 2011 State Energy Efficiency Scorecard." American Council for an Energy-Efficient Economy Report #E115, October 2011. Available at http://www.aceee.org/research-report/e115

California

Only California has been as active as Massachusetts in the promotion of zero net energy buildings. In 2008, the state Public Utilities Commission adopted the California Long-Term Energy Efficiency Strategic Plan, which uses a number of different strategies to move towards making all new residential construction zero net energy by 2020 and all commercial buildings by 2030. To implement this long-term plan, the state has also adopted a Zero Net Energy Action Plan for 2010-2012. Efforts to date have focused on raising awareness of ZNEB techniques and benefits through convening stakeholder groups, data-exchange forums, and workshops.

Asset Rating Programs

Several organizations are working to create a dataset on building energy characteristics through asset rating and labeling programs. Asset ratings "evaluate the energy performance of the building based on the thermal envelope (e.g. insulation, windows) and mechanical and electrical systems;" as such, they are "designed to facilitate a direct comparison of energy performance among similar buildings irrespective of tenant behavior."[1] Tenants affect building energy consumption in many ways, such as by determining where to set the thermostat, turning lights on and off, and enabling (or not) efficiency settings on computers. While tenant behavior is a major influence on energy consumption, it is beyond the control of building design and construction teams. For this reason, looking only at a building's actual consumption obscures the impact of those elements that the building team *can* control. Asset ratings have been likened to the miles-per-gallon (MPG) rating for cars, which provide an indication of expected performance but do not directly measure actual consumption. Asset ratings will provide critical information to prospective owners and occupants of the labeled buildings regarding the likely energy costs they will face; they will also help the real estate market to better communicate and capture the value of energy efficiency, which should therefore spur increased energy efficiency investments.



1 Massachusetts Department of Energy Resources. "An MPG Rating for Commercial Buildings: Establishing a Building Energy Asset Labeling Program in Massachusetts." December, 2010.

At present, there are no fully developed and implemented asset rating programs. However, there are multiple efforts underway:

- The U.S. Department of Energy is developing a Commercial Building Asset Rating program to be pilot-tested on a voluntary basis in spring 2012. DOE is currently in the process of figuring out the details of how to measure and communicate expected building energy performance. As currently envisioned, commercial building owners will enter information on the building envelope and mechanical and electrical systems into an online tool, which will translate this information into a score based on pre-established benchmarks. The DOE asset rating is intended to complement ENERGY STAR®'s Portfolio Manager, which benchmarks buildings according to their actual energy consumption. The asset rating is also intended to help identify opportunities for cost-effective efficiency upgrades, although the recommendations will not be as thorough as a comprehensive energy audit.

- The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is currently pilot-testing a building labeling program that includes both asset and operational ratings. The ASHRAE program, known as Building Energy Quotient or bEQ, is a voluntary certification effort for commercial buildings. It has a more significant data-gathering effort, requiring an ASHRAE-certified energy assessor to undertake a comprehensive audit. It also includes information on indoor environmental quality. It is likely to be much more expensive than the DOE approach, but also likely to generate considerably more precise and actionable information on building characteristics.

- Finally, the Massachusetts Department of Energy Resources is undertaking its own pilot effort to develop and implement a building energy labeling program. Massachusetts' program will include both asset and operational ratings and will be integrated with utility-funded efficiency incentive programs. The program is considering making use of ASHRAE's bEQ as the basis for its asset rating, although other options are also being evaluated. The state plans to initiate a two to three-year pilot effort focusing on offices, multi-family apartment buildings, and public buildings. After the pilot phase, the state will consider transitioning to a mandatory statewide program, requiring buildings to renew their ratings periodically.

Other ZNEB Initiatives

While not as aggressive as California or Massachusetts, other states have taken steps toward zero net energy buildings as well. **Delaware** passed a law in July 2009, SB 59, which strengthened the state's building code by basing it on the 2009 version of the International Energy Construction Code (IECC). Most notably, the law also requires all new residential and commercial buildings to be zero net energy *capable* starting in 2026 and 2031, respectively. Zero net energy capable is defined to mean that the building would consume no net energy *if* on-site generation were installed.

In **Washington**, SB 5854, passed in 2009, mandates that the state energy code shall be designed to "construct increasingly energy efficient homes and buildings that help achieve the broader goal of building zero fossil-fuel greenhouse gas emission homes and buildings by the year 2031." It also requires that the state Department of Commerce develop a strategic plan for promoting zero net energy buildings.

There has also been some progress, albeit limited, toward ZNE buildings at the federal level. Executive Order 13514, on Federal Leadership in Environmental, Energy and Economic Performance, mandates that starting in 2020, **all new federal buildings** must be designed to achieve zero net energy by 2030. In the interim, federal agencies are also required to establish goals for greenhouse gas emissions reductions. In addition, the Energy Independence and Security Act of 2007 created the Net-Zero Energy Commercial Building Initiative within the U.S. Department of Energy. While there are no mandatory targets associated with this initiative, it provides coordination between public and private partners to work toward cost-neutral ZNE buildings by 2025.

Outside of government, perhaps the best-known ZNE effort is the **2030 Challenge**, issued by the non-profit group Architecture 2030. The 2030 Challenge is a call to action for the global architecture and building community to embrace an immediate goal of reducing greenhouse gas emissions for new buildings by 60 percent below average, with further reductions down to carbon neutrality in 2030. While the 2030 Challenge allows for off-site renewable energy, which would not qualify as net zero by most definitions, it nonetheless has a great deal of overlap with ZNE efforts in that it seeks dramatic near-term improvements in building efficiency. To date, the 2030 Challenge has been adopted by four states (Illinois, Minnesota, New Mexico, and Washington), and several cities and counties, all of which now require certain building types to meet Architecture 2030's energy use targets. At least one architecture and planning firm, BSA Architects, is in the process of rolling out a training course centered on the 2030 Challenge.

Zero Net Energy Buildings in the Northeast and Mid-Atlantic States

The policy initiatives outlined above play important roles in setting goals, providing incentives, and otherwise promoting more efficient buildings. However, at the most fundamental level, achieving ZNEB depends on the ways in which buildings are physically constructed – i.e., the materials, designs, and construction techniques that determine building energy use. Thus, it is encouraging to see that several zero net energy or otherwise extremely efficient buildings have already been built in the Northeast and Mid-Atlantic states (see Figure 2 for a partial list). Such buildings provide empirical proof that achieving zero net energy is

possible with existing technologies. These buildings also serve as models that can be used by other interested parties going forward. For comparison, DOE's Commercial Reference Buildings for Climate Zone 5a (applicable to southern New England and portions of the Mid-Atlantic states) have energy use intensities of between 64 and 99 kBTU/sq. ft. for office buildings, or 88 to 92 kBTU/sq. ft. for schools.[3]

Figure 2: Sample High Performance Buildings in the Northeast and Mid-Atlantic States

Building	Location	Year Completed	Annual Net Purchased Energy (kBTU/ sq. ft.)
Franklin Regional Transit Center	Greenfield, MA	2012 (projected)	0 (projected)
Hudson Valley Clean Energy Headquarters	Rhinebeck, NY	2009	0
North Shore Community College Health Professions & Student Services Building	Danvers, MA	2011	0 (projected)
Putney School Field House	Putney, VT	2009	0
Woods Hole Research Center	Falmouth, MA	2003 (renovation/ expansion)	10.5
Wind NRG Partners Manufacturing Facility	Hinesburg, VT	2004	15.2
Artists for Humanity EpiCenter	Boston, MA	2004	16.8
31 Tannery project	Branchburg, NJ	2006	24.8
Vermont Law School Oakes Hall	South Royalton, VT	1998	27.2

Sources:

- U.S. Department of Energy High Performance Buildings Database, http://eere.buildinggreen.com/index.cfm;
- Massachusetts Department of Transportation, "Governor Patrick Breaks Ground on First Shovel Ready Recovery Project in Greenfield," http://www.eot.state.ma.us/default.asp?pgid=content/releases/pr041709_greenfield&sid=release;
- Hudson Valley Clean Energy, http://www.hvce.com/zero-net-energy/;
- North Shore Community College, "Sustainability at NSCC," http://www.northshore.edu/sustainability/zneb/;
- Putney School, "Fieldhouse – Green Features," http://www.putneyschool.org/content/fieldhouse-green-features;
- John Grabowski, Case Study – 31 Tannery Project: Back to the Grid," High Performance Buildings Spring 2008, http://www.hpbmagazine.org/images/stories/articles/Back%20to%20the%20Grid.pdf

3 See http://apps1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/refbldgs_eui_tables_1.3_5.0.pdf

Intermediate-term Steps to Facilitate Zero Net Energy Public Sector Buildings (next 10-15 years)

The major question motivating this road map is "how do we get there from here?" In a review of the literature on ZNEB and discussions with leaders in the field (through our one-on-one interviews and the regional leadership meeting convened in November 2011), we identified four themes around which we can describe the necessary evolution of the building landscape if significant progress toward a zero net energy standard is to be achieved. These themes include: Information and Education, Regulation, Finance, and Utilities. While many of these changes are applicable to private as well as public buildings, we believe they are all necessary in order to meet the goal of greater achievement of ZNE performance in the public building sector specifically as defined in this report.

In this section (with additional detail in Appendix B), we present an overview of the conditions that will need to emerge in the intermediate-term (i.e., over the next 10-15 years) to facilitate the achievement of ZNE performance on a large scale.

Information and Education

Decision makers need to have reliable, readily understood information on how buildings perform with respect to energy use. These decision makers include the government agencies that commission and subsequently use new buildings, but also policymakers in other government positions, building developers, and architects and engineers. They must understand how different buildings stack up against one another and be able to accurately weigh the financial costs and benefits associated with investments in energy efficiency and renewables. While these different stakeholders are responsible for decisions that affect building energy use at different points in the building life cycle, engagement is needed from everyone involved at all stages of building projects to ensure an efficient design.

There are several forms of information that are needed. Most critically, policymakers need to have access to information that already exists on the techniques needed to achieve substantial energy use reductions, and the estimated costs and benefits of those measures. They also need to understand the ways in which they can help promote efficiency, both through changes to government agencies' own operational procedures and through broader policy efforts. Access to information and the ability to understand and act on this information is a basic, near-term need; it is discussed in more detail in the next section of this report.

Second, aside from access to existing information, decision makers also need more fine-grained information on the actual energy performance of individual buildings. This information is currently not readily available; two separate but related changes are needed to generate it:

- The first is the implementation of a mandatory asset rating system, similar to the pilot efforts currently being explored by the U.S. Department of Energy and Massachusetts' Department of Energy Resources. The proposed development of such a system is discussed in the next section as a near-term, critical step on the path to zero net energy.
- While the focus of this report is on new buildings, i.e., buildings that do not yet exist, it will nonetheless be necessary to look beyond the initial creation of these buildings in order to understand their energy performance characteristics. Thus, in addition to information on the fundamental characteristics of buildings as they are constructed, decision makers also need to have clear information on buildings' actual energy consumption on an ongoing basis. Unlike asset rating systems, which are still in development, existing operational rating systems are already in wide use. These systems show how a building's actual month-to-month energy consumption compares to that of similar buildings, accounting for considerations such as building size, use, occupancy rate, and hours of operation. ENERGY STAR Portfolio Manager is the most well-known operational system, and its use is already being required by several jurisdictions, including California, Washington State, New York City, Washington D.C., and Austin, Texas. By situating an individual building's performance within this wider context, operational ratings provide an indication of when a building is under-performing and where additional efficiency improvements can have the greatest impact.

While generating and providing ready access to key information will be useful, to achieve ZNE performance, key groups of people will also need to be trained and educated in how they can use their positions to advance building efficiency. Design teams need to better understand the methods they can use to improve building efficiency, and particularly, the ways in which an integrated design process can realize efficiencies that may not be possible in a more piecemeal approach. Design teams also need to make better use of building information models and software tools that can facilitate the integrated design process.

Beyond design teams, a better trained workforce is needed in several other areas. These include:

- code enforcement officials, many of whom may have little or no training or expertise in energy issues;
- contractors who install elements of major building systems, such as HVAC and lighting;
- energy raters and commissioners, who inspect such systems;
- facilities managers and building operators; and
- installers of solar photovoltaic and other renewable energy systems - a larger pool of qualified installers will be needed for widespread achievement of ZNE performance.

Building managers and occupants should also be routinely trained on the proper use of key energy-using systems. Efficient HVAC systems have little benefit if temperature set points are not properly established, and malfunctions or deliberate disabling can nullify the potential benefits of motion-activated or automatically timed lighting systems. Building managers in particular should be involved in the design process from the beginning, to ensure buy-in and help them understand the proper operation of various building systems. Occupant training will also be important from an enforcement perspective, especially if there is a shift toward outcome-based building energy codes that could include requirements such as limitations on plug loads.

Building Energy Codes

Building energy codes, which set minimum standards for the energy characteristics of buildings, are a key mechanism for addressing energy use through regulation. Because the focus of this report is on public buildings, stricter energy codes may not be absolutely needed to improve performance if there are other sufficiently strong government initiatives at work. For example, an Executive Order mandating improved energy performance would theoretically remove the need for a tighter code to motivate better performance in public buildings. Nonetheless, energy codes are an important mechanism to achieve better energy efficiency in public buildings, for at least three reasons:

- First, because codes set minimum standards which all buildings (public and private) must meet, they change the baseline against which high performance buildings are evaluated, both in terms of relative energy performance and cost premiums. This means that the *incremental* cost for public buildings to reach a given level of efficiency will decrease as energy codes are ratcheted up, because the baseline will be higher. It also means that governments that wish to "lead by example" will have to build buildings with lower energy use than would be necessary in the absence of stricter codes.
- Second, tightening codes will spur demand in the broader marketplace for efficient buildings and thus for the people, techniques, and materials that create efficient buildings. This should increase the supply of building professionals trained in the development of efficient buildings, making it easier for governments to identify a greater number of professionals with the ability to develop efficient public buildings.
- Finally, whether for political or other reasons, it may not always be feasible to pursue efficiency through executive orders or other directives. In such instances, building codes may be necessary to provide a mandatory performance target for local jurisdictions, as is currently the case in Maine, where communities under 4,000 people have the option to adopt (or reject) the state energy code.

Advocates identify several actions related to building codes that will be necessary to promote zero net energy buildings:

- By definition, to achieve zero net energy, codes need to be sufficiently strict that buildings use only as much energy as they can produce through renewables. This means allowing significantly less energy use than is currently permitted. Energy use through codes could be ratcheted down over time from current levels, for example, with a stricter code taking effect every three years; within about 20 years, codes could be strict enough to facilitate ZNE buildings. To ensure predictability, a stretch code from one cycle could become the base code in the next cycle. As codes get stricter, it will also be important to ensure that code officials have the training and resources needed to ensure compliance.
- To achieve better levels of energy performance, buildings need flexibility to pursue innovative approaches that focus more on outcomes than prescriptive measures. Current building codes have numerous prescriptive provisions that limit such flexibility. For example, codes may prescribe acceptable thermal resistance (R-values) of walls and roofs. Walls with thermal mass, such as concrete, masonry, or logs, may have low R-values but nonetheless perform well with respect to energy performance. Prescriptive provisions in building codes could hinder the use of these energy-efficient materials. Rather than focusing on prescriptive requirements, codes should become 'outcome-based.' That is, codes should specify an acceptable overall level of energy use per square foot of building space, rather than being concerned with minute details of how buildings achieve that level of performance. These outcomes should be based on pre-established benchmarks that vary according to characteristics, such as building type, climate, etc.; the information gathered from rating and disclosure systems could be used to help determine these benchmarks. Measuring and reporting would be straightforward and could be based on consumption data gathered by utilities or other parties and submitted on an ongoing basis over the life of the building. Because the buildings would already have permits issued and be in use, it is unlikely that permit approval could be used as an enforcement mechanism for these ongoing requirements. Instead, new mechanisms for enforcement need to be developed and could take the form of performance bonds or financial penalties, either as utility surcharges, taxes, or fines.
- A shift to outcome-based codes could also help shift the way governments procure new buildings. Specifically, building bids could include provisions linking a portion of the design and construction team's compensation to the building's actual energy use. Insurers may balk at the prospect of design professionals giving a guarantee on energy performance, but structuring these provisions as a bonus for meeting or exceeding an established baseline could overcome this difficulty. This approach would give building design and construction teams much greater accountability for their buildings' per-

formance, and also provide a direct financial incentive to improve energy efficiency. It would also help drive longer-term improvements in building performance by providing a feedback loop to design and construction professionals that is absent currently. Under existing circumstances, it is unusual for building owners or operators to interact with design and construction teams after the initial construction of the building, so the building teams seldom get direct feedback on the actual performance of their buildings.

- Many observers recommend that codes add a requirement for continuous commissioning, i.e. periodic checks of the major building energy systems (HVAC, lighting, etc.) to ensure that they are performing as expected. Such a requirement could be used as a practical means to help buildings achieve code requirements on an ongoing basis. Supporters of this idea recommend that commissioning be required before buildings are sold to new parties, and/or on a regular basis such as every five to ten years. Massachusetts has added a commissioning requirement to its building code, which the Department of Energy Resources is currently working on implementing.
- Ideally, building codes should address all energy used in the building. Right now, most codes do not address plug loads, i.e., the energy consumed by devices plugged in to electrical outlets – computers, televisions, etc. These have been excluded from codes because building design and construction teams have little influence over these sources of consumption. However, plug loads represent a significant proportion of buildings' energy consumption, often around 20 percent and up to 65 percent of the total. Especially as other aspects of buildings get more efficient, codes will need to address plug loads.

The changes outlined above would add a greater emphasis on the building's actual energy use over time than is currently the case. To support these regulatory changes, it will also be necessary to get building tenants more actively involved in taking responsibility for their energy use. While leasing is perhaps more common among private entities, the public sector is nonetheless involved both as a lessee of space owned by other entities, and a lessor of government-owned properties (e.g., vacant schools, excess office space in government buildings, government-owned housing, etc.). New green lease provisions could be developed that clearly lay out who among the building owner, manager, and occupants bears the cost, and who reaps the benefits of efficiency investments and behavioral changes to meet code requirements. Without giving the tenants some responsibilities for energy use, it will be difficult to include energy performance incentives in building design and construction contracts or to enforce plug load provisions in energy codes. Note that dividing responsibility in this way may also require separate metering of plug and process loads and other types of energy use. Regulation requiring or encouraging this level of sub-metering may be necessary to facilitate a move toward greater responsibility and accountability for energy use among building occupants.

Finance

Higher upfront cost is a key barrier to wider adoption of ZNE buildings. This is a particular problem for public buildings. Because government organizations pay no taxes, they typically cannot make use of popular commercial and residential energy efficiency incentives aimed at lowering income or property taxes. Furthermore, depending on the political context, public entities may face budget constraints in which energy efficiency may not be emphasized as much as other budget priorities. This is especially true in the current economic climate. Nonetheless, there are ways to work around these challenges to promote ZNE buildings.

Substantial federal and state tax incentives are available for renewable energy installations and qualifying efficiency investments. One way for public entities to make use of these incentives is to create partnerships with for-profit third parties. In such a partnership, the private entity either owns a portion of the energy investment and makes use of the tax credit, or makes a payment to the public entity to be granted the tax break. The state of Oregon, which has generous clean energy subsidies, has a "pass-through" provision in which non-profit or public project owners can transfer tax credits to a private, tax-paying entity in exchange for a lump-sum payment. Essentially, private parties purchase the tax breaks. While the Oregon program encountered difficulties due to the high value of tax breaks granted to large, utility-scale renewable energy projects, a more narrowly targeted approach could help public buildings make use of existing tax incentives. One option would be for contractors to take the tax credit and factor the value of the credit into their construction bids, so that the public entity would receive the benefit of the credit even without claiming it themselves.

We also note that a price on carbon pollution would be effective in two ways as a means to create a financial incentive to spur further development of low and no-energy building projects. First, the higher energy costs resulting from the assessment would provide a direct financial motivation for consumers to use less energy and to demand more efficient buildings. Second, the revenues from a carbon assessment could be funneled into programs to subsidize investments in building energy efficiency projects.

Utility Regulation

Electric and natural gas utilities are uniquely positioned to assist in the promotion of energy efficient construction practices. In order to fully realize this potential, state regulators in the Northeast and Mid-Atlantic should work with key stakeholders to put in place the appropriate financial incentives for utilities to promote energy savings by their customers. The first and most crucial step for states will be to fully implement revenue decoupling in order to sever the link between utility volumetric sales of energy and utility cost recovery. Decoupling is a rate mechanism that detaches a utility's volumetric energy sales from its cost recovery, thus removing disincentives to promote customer energy savings, distributed

generation, and improvements to codes and standards. Moreover, states should also enable utilities to earn shareholder performance incentives for delivering cost-effective savings to customers. Performance incentives allow utilities to earn an investment return on efficiency programs, placing efficiency on a more level playing field with supply side resources. This shift is already underway in many states across the region.[4] With the appropriate incentives in place, utilities could become strong partners in promoting zero net energy buildings throughout the region.

Utility rules also need to change with respect to on-site renewable energy. All of the Northeast and Mid-Atlantic states have adopted legislation enabling net-metering, in which excess electricity produced from on-site energy installation above and beyond a building's own use is fed back to the grid and sold to the utility. However, in some cases, net-metering has been implemented in such a way as to remove much of the financial gain that buildings with renewable energy installations would otherwise accrue; grid interconnection fees for on-site systems can cost tens or even hundreds of thousands of dollars. To promote greater use of on-site renewable energy, states will need to ensure that such barriers are removed.

Finally, states must maintain robust funding for their ratepayer energy efficiency programs. While several Northeast and Mid-Atlantic states have in recent years substantially increased their investments in cost-effective energy efficiency, others have lagged behind, or even diverted large amounts of their energy efficiency funding to other uses, leaving insufficient funding for basic energy efficiency programs, let alone those that would promote ZNEB on a larger scale.[5]

While the utility changes outlined here would be effective in driving improved performance in all buildings (both private and public), they would be particularly important for public buildings. Because public entities cannot easily access many of the tax incentives available to for-profit businesses it will be critical to have utilities actively engaged in overcoming the financial barriers to ZNE performance in order for public buildings to meet this goal. To increase participation in efficiency measures, utilities may want to directly market their programs to public buildings separately from their "small business" or general commercial programs. While strong programs may exist for public buildings, they are not always identifiable or taken advantage of by communities.

4 Craft, Josh and Aslan, Jeff. "Revenue Decoupling in the Northeast." NEEP Policy Brief, Winter 2012. Available at http://neep.org/uploads/policy/Revenue%20Decoupling%20Brief-Final%20Version%201.30.12.pdf.

5 For a comparison of state energy efficiency programs and funding levels, see NEEP, "Northeast Energy Efficiency Snapshot," Fall/Winter 2011. Available at http://neep.org/uploads/policy/EE%20Policy%20Snapshot--10.22.11.pdf.

Critical Next Steps

As noted earlier in this report, the knowledge, skills, and technologies needed to construct and operate much more energy efficient buildings, up to and including those that are truly zero net energy (or even net energy producers), already exist. And yet, maximizing energy performance continues to be the exception, rather than the rule, in building design and operation. NEEP's response to this fact is grounded in pragmatism, coupled with optimism that long-term transformation within the building sector is possible. The previous section of this report described the many changes that will be necessary in the intermediate term to move the market toward zero net energy. This section describes the near-term steps that NEEP believes are critical to prime the public sector market and to make it more likely that the intermediate-term changes will occur.

In general, the keys to unlocking the market's potential are:

- Ensuring that decision makers understand the business case for demanding improved building energy performance;
- Continuing to demonstrate what is already possible, and at what cost, through the design and construction of true zero net energy buildings; and
- Focusing on systems to ensure the measurement, verification, and public reporting of as-designed building energy use.

Step 1: Develop a "Path to Highest Performance" Information Campaign

The zero net energy concept, and even the idea of high performance buildings that might be "near zero" net energy, exists largely in the province of technical research communities and a relatively small subset of building design and construction professionals; as a result, the perception of zero net energy buildings as a luxury, niche market persists. This needs to change. The objectives and the means of creating more efficient buildings need to be reframed for a broader audience, particularly including those who are responsible for creating and managing capital as well as operating budgets for public buildings. A focus of this campaign should be on highlighting the substantial room for improvement between "business as usual" and zero net energy, and the tremendous benefits that can be realized, even without achieving zero net energy, simply by focusing on efficiency improvements.

NEEP also recognizes that the most effective message will be one that begins with fundamental environmental and economic measures, including lifetime operating cost savings and avoided greenhouse gas emissions and associated climate change impacts. Additional benefits include:

- The potential for job creation in the building sector, particularly in response to a growing need for skilled technicians trained to operate energy-related systems, or to measure and report building energy performance post-construction and occupancy.
- The typically overlooked community safety and preparedness benefits of public buildings that may be able to provide shelter, with heat and power, during public emergencies.

To demonstrate these benefits, NEEP can draw from the universe of recently completed projects in the Northeast (e.g., the Health Professions and Student Services building at North Shore Community College in Danvers, Massachusetts), using them as case studies to illustrate anticipated and observed energy performance improvements and the process that led to the design and construction of these facilities.

A comprehensive information campaign would convey a consistent message through multiple modes of delivery to reach the broadest possible audience. While the most important audience members are those responsible for construction and operation of public buildings, the campaign should also seek to educate the public at large to foster awareness and bottom-up demand for higher performing buildings. Modes of delivery could include:

- Bullet-point briefings for one-on-one or small group meetings with higher-level decision makers in the public sector;
- Longer presentations suitable for use in larger group settings (e.g., municipal or state government official conferences);
- Fact sheets for distribution at appropriate venues;
- Educational modules suitable for incorporation into K-12 and post-secondary curricula; and
- A public web site that prominently displays the higher-level information contained in the briefings, fact sheets, etc.; information on existing, exemplary buildings; and a wide range of technical resources.

Net Zero in Emergencies

The region is growing all too familiar with unexpected and extreme weather. Recent months have brought a tornado to Western Massachusetts, hurricane-induced flooding to Vermont, an earthquake to the Mid Atlantic, and snowstorms that have left millions without power. Strong emergency preparedness plans – for states, municipalities, and utility companies – are more critical than ever.

These thoughts were fresh in the minds of the Zero Net Energy Leadership Group as they met to discuss recommendations to include in this report, just days after a freak October snowstorm knocked out power across the region. Stakeholders in the room proposed that energy-independent public buildings, powered by on site renewable energy, have incredible potential to serve as the ultimate storm shelter for residents in these emergency situations.

The group acknowledged that this idea had considerable challenges that needed to be worked out to be feasible, such as the availability of wind and solar during extreme weather and the issue of storing electricity generated on site. Nevertheless, there is agreement that solidly constructed public buildings that are extremely well insulated, energy efficient and have natural ventilation and daylight are going to be better places to be in an emergency event. Exploring the benefits of high performance and net zero design in the context of emergency preparedness and disaster relief plans is a promising area for future consideration.

Step 2: Promote the Continued Development of Exemplary Public Buildings

In the near term, the design and construction of zero net energy public buildings will be the exception rather than the rule. However, it will remain critically important for public officials to not only take advantage of opportunities to make zero net energy a design objective, but also to require that specific building projects achieve zero net energy performance. A reasonable goal would be to complete at least two such public building projects, in addition to any already completed or under construction, in each of the Northeast states within the next three years. In the near term, certain building types may be better suited to this goal than others. Laboratories, for example, often have energy-intensive operations that cannot easily be curtailed. In contrast, schools may be ideal targets for this initial goal: they are not particularly energy-intensive, especially in summer months, and since schools typically have a relatively high ratio of roof area to interior space (because they are not as tall as many commercial buildings), on-site solar installations can provide a larger proportion of energy demand. For demonstration purposes, it may make sense to concentrate on schools and similarly situated buildings first.

These exemplary building projects will serve to demonstrate the viability of zero net energy across different building types and in different climate zones. The projects will also serve as "laboratories" for innovation in collaborative, integrated design and construction processes, and in the use of new technical systems and materials. Equally important will be the opportunity to use these buildings to refine the commercial sector's understanding of the requirements for properly operating a zero net energy building, and ensuring that as-designed performance is realized.

Public authorities should also make it a priority to publicize all facets of the exemplary building projects, from selection, design, and engineering, to financing, construction, and eventual operation. Communicating as much project information as possible, including obstacles and how they were (or were not) addressed, will help to remove any remaining "mystique" that these buildings might have and provide replicable examples of what is possible.

While the public sector is often in the best position to "lead by example," challenging economic circumstances may create an immediate obstacle to the goal of pursuing exemplary projects, especially when there is a clear disconnect between capital and operating budgets (i.e., when the lifetime cost savings provided by a high performance building do not automatically serve as justification for any additional capital expenditure that might be required). Each state should be encouraged to set aside a portion of ratepayer funded energy efficiency program budget funds to develop pilot or demonstration projects resulting in zero net energy public buildings.

Paul Crowley MET School

Newport, Rhode Island
~16,000 square feet
130 students / 20 staff

The Paul Crowley MET School, currently housed in the Florence Gray Community Center, in Newport, Rhode Island is one of a network of small, public high schools that focus on an individualized learning approach. The RI Department of Education, on behalf of the State of Rhode Island, is planning to build the first net zero state facility and perhaps the first net zero high school facility in the region, giving the school a permanent home.

The project, currently in the early design stages, will maximize renewable energy sources available on site and minimize energy consumption with an air-tight, well-insulated exterior envelope. The building is expected to take advantage of the site's access to solar, wind, and geothermal energies. The staff and students of the Paul Crowley MET School are committed to the efficient use of the facility and to exploring innovative ways of using the building to teach students about sustainability, green technologies, and the environment.

The RI Department of Education's School Construction Program is pursuing a design-build approach with an anticipated completion in 2013. The project will comply with the RIDE School Construction Regulations and with the Northeast Collaborative for High Performance Schools protocol and is intended to provide a model for school construction across the State and the region.

Step 3: Prioritize Measurement and Reporting of Public Building Energy Performance

As important as it is to design and implement a comprehensive and educational information campaign and to build and publicize exemplary projects, perhaps the most important near-term step toward zero net energy is ensuring consistent measurement of building energy performance and developing a system for standardized performance reporting. The path to zero net energy is defined by continuous improvement in the amount of energy consumed in a typical building; absent an objective measure of consumption, it will not be possible to measure progress toward the zero net energy goal. The intent should be to establish a consistent, regional approach to both measurement and reporting. However, in the absence of a consensus approach, individual states should press forward in developing their own programs.

As discussed above, an asset rating provides information on the inherent characteristics that drive building energy consumption, such as the building envelope and major mechanical systems. All new public buildings should be required to obtain such an asset rating, provided by a trained third-party energy rater. The rating should be coupled with a requirement for mandatory disclosure, to provide a large dataset covering numerous buildings. This rating could be communicated via an easy-to-understand, publicly available label located in the building itself and posted in a centralized online database. Public buildings make sense as an initial focus for an asset rating system because the government can use its considerable market power (as a major consumer of real estate) to overcome the initial uncertainty and set-up costs that will come with the roll-out of a new system. In addition, the public sector can lead by example to demonstrate the feasibility and the benefits of an asset rating.

Numerous options are available to define a rating scale, and while it is not the goal of this report to identify a single, preferred approach, it is important to recognize that considerable and ongoing work already exists that can serve as the basis for further regional development of measurement and reporting systems. One such effort is the Commonwealth of Massachusetts' development of an asset rating system for the commercial sector. A white paper prepared by the state's Department of Energy Resources offers recommendations for the creation of a rating scale as well as for the specifications of a reporting "label" that could be displayed at a building location.[6] A second useful resource is a report prepared by Architectural Energy Corporation in July 2009 for Southern California Edison.[7] In this report, the authors make the compelling argument that energy use measurement that focuses on a percentage reduction relative to a building energy code is not a useful approach, given the frequency with which codes change. As an alternative, they propose a stable scale (a "zero energy performance index") which fixes zero net energy performance at zero and average energy consumption at 100 (as initially defined using 2003 federal Commercial Building

6 "An MPG Rating for Commercial Buildings: Establishing a Building Energy Asset Labeling Program in Massachusetts." December 2010. http://www.mass.gov/eea/docs/doer/energy-efficiency/asset-rating-white-paper.pdf

7 "Rethinking Percent Savings: The Problem with Percent Savings and the New Scale for a Zero Net-Energy Future." July 31, 2009. http://www.archenergy.com/assets/files/News/Rethinking_Percent_Savings.pdf

Energy Consumption Survey (CBECS) data, and adjusted for "neutral" variables such as climate, building type, and hours of operation). The energy performance for any new building would then be ranked relative to these two standards. For example, a building that uses half as much energy as the average building would be ranked as a 50 on the scale, while a building that uses twice as much would receiving a ranking of 200. Importantly, this ranking is proposed to include *all* energy use (i.e., HVAC and lighting plus plug loads, refrigeration, and any other process energy requirements).

In addition to the design of the measurement scale and label, a well-designed asset rating system should address several other issues:

- The system must use data that is collected and reported by building managers in a consistent way. This means establishing standardized procedures and calculation methods for estimating energy use. The Commercial Energy Services Network (COMNET) has guidelines for building energy modeling that could be adopted for this purpose.[8]
- Results should be coupled with recommendations for possible improvements. When a particular building system is shown to be substandard, the building owner should be informed of upgrades that could be made to improve performance. To make the process even more effective, asset ratings should be integrated with existing incentive programs from utilities and other energy efficiency program administrators, so that building owners are made aware of potential funding sources to subsidize the suggested efficiency improvements.
- Finally, an asset rating should not simply be acquired at a single point in time and then forgotten. The rating efforts underway in Massachusetts and elsewhere have recommended that asset ratings be paired with operational ratings, such as ENERGY STAR's Portfolio Manager, that benchmark buildings' actual energy use over time. In addition, asset ratings should also be renewed at key points in a building's life cycle, such as when it is renovated, leased or sold, and/or on a periodic basis, such as every 10 years. Buildings could also potentially be evaluated through ongoing random audits of a small proportion of all rated buildings.

By generating reliable, consistent information on the energy characteristics of a significant number of buildings, an asset rating system will help building owners and tenants better understand the likely energy demand of their own buildings, and enable real estate professionals to monetize the energy-saving benefits of efficient buildings in real estate transactions. This, in turn, will allow the financial benefits of energy efficiency to be captured by developers, who expend the costs associated with efficiency investments, ultimately spurring greater investment in efficient buildings by removing a key market failure. Furthermore, by providing concrete information, a rating system will reward design and construction teams whose buildings realize meaningful performance improvements, rather than those whose

8 COMNET. "Commercial Buildings Energy Modeling Guidelines and Procedures." August 16, 2010. http://www.comnet.org/sites/default/files/images/COMNET-MGP-2.pdf

environmental features are potentially more attention-grabbing and 'sexy' but which do not actually perform as well.

Step 4: Implement Stretch Building Energy Codes

As discussed in the previous section to promote zero net energy in the intermediate term, building energy codes should:

- Get gradually stricter over time from their current levels;
- Be outcome-based, i.e., setting maximum consumption levels rather than relying solely on prescriptive requirements;
- Include provisions for continuous commissioning of building systems; and
- Cover all (or nearly all) energy consumed in the building, including plug and process loads as well as major mechanical systems.

MA was the first state in the country to adopt a stretch code. The historic adoption means that buildings designed and built to the Massachusetts stretch code will use approximately 20% less energy than a comparable building designed and built to the standard building code.

The new code has been designed as a local option code, meaning each community has the choice of adopting it or not. This ensures that municipalities have access to a stretch code while preventing the proliferation of different codes statewide.

In the near term, the most important measure to lay the groundwork for these eventual developments is for every state in the Northeast and Mid-Atlantic region to establish, by Executive Order, a performance-based "stretch" code, similar to the code adopted by Massachusetts, which would be mandatory for public buildings. If necessary, similar mandates should be developed by other relevant public authorities to whom an Executive Order would not apply. The Massachusetts stretch code is an appendix to the state building code that individual local governments can choose to adopt; once adopted by a local government, it becomes mandatory for all buildings in the jurisdiction. The state's stretch code requires buildings to meet a performance target of approximately 20 percent lower energy consumption than the base code. Communities that adopt the stretch code are eligible to receive state funds through the state's "Green Communities" grant program. To date, more than 100 cities and towns have adopted the stretch code, covering roughly half of the state's population; the incentive provided by the Green Communities funds has no doubt played a significant role in spurring adoption.

There are multiple ways in which stretch codes will promote better building energy performance and facilitate each of the changes noted above:

- Most directly, for municipalities that adopt the code, buildings will be required to be designed to use less energy than they would have otherwise. However, even in communities that do not adopt the stretch code, a government agency could use the stretch code itself as a goal for public buildings, allowing local governments to lead by example. This could be particularly significant in public organizations (e.g., municipalities, universities) that may have the desire to meet a stricter target than the base code but that may not have the capacity to develop an appropriate target themselves in the absence of an external benchmark such as a stretch code.
- Adopting a stretch code will bring energy efficiency further into the mainstream in the building design and construction community. Presently, there are some leading-edge building teams that are well-versed in energy efficiency techniques, but there are many more building teams that design buildings to satisfy only minimum code requirements. By creating greater demand for efficiency, a stretch code will motivate laggard building teams to catch up with market leaders. By the same token, a stretch code will provide building design and construction teams with greater experience in producing efficient buildings – experience which they will be able to carry over to future building projects.
- Stretch codes would presumably be based on performance, allowing building designers the flexibility to develop innovative solutions, which could in turn produce better outcomes than would be possible otherwise. This experience could help shift the emphasis away from prescriptive measures and towards outcomes in base codes as well. As noted above, the more open and flexible framework of a performance-based code will be important in its own right in promoting more efficient buildings.
- A stretch code can be used to provide signals on likely future developments in the base code. A stretch code in one cycle can become the base code for the next cycle (with modifications as needed). This pattern could form the basis for a cycle of continual, predictable tightening in building codes. Such predictability would help design and construction teams look ahead to understand what will be required of them in the future, providing them more lead time to acquire the skills and knowledge needed to meet the challenges of tightening requirements.
- Finally, stretch codes could provide an opportunity for experimentation, to test out potential new features of energy codes. Making a stretch code based on performance, rather than prescriptive requirements, already constitutes one such form of experimentation. In a similar vein, as noted above, developing such goals is an important near-term step towards promoting zero net energy buildings, as stretch codes would allow for such goals to be tested in the real world. Stretch codes based on performance could easily incorporate targets for plug and process loads; performance

against these targets could then be measured over time through utility bills and/or other actual consumption data. Note that this approach would further allow for pilot-testing of an ongoing enforcement regime, in which code officials check building energy consumption on an ongoing basis long after construction has been completed.

Step 5: Create a Revolving Loan Fund or Similar Mechanism to Provide Capital for Energy Investments

State government budgets are under severe pressure in today's economic climate. While the combined budget expenditures of the New England and Mid-Atlantic states grew by about 12.5 percent from 2008 to 2010, the vast majority of that increase came from expanded federal funds. The growth in federal funds for states is not likely to persist at this pace. Excluding federal funds, the Northeastern states' budgets grew by just 2.4 percent over two years, or even less after accounting for inflation.[9] Any near-term steps to promote ZNE buildings must be achievable in this context of constrained budgets.

As noted above, allocating money within utility incentive programs to provide funds specifically focused on zero net energy or near-zero net energy demonstration projects will help. However, without a significant influx of additional funding, which we believe is unlikely over the next few years, such programs will only affect a very limited number of buildings. Additional action will be needed to overcome financial barriers on a broader scale.

Lack of capital funding is perhaps the single most important financial barrier to greater investment in efficiency and renewables. In large-scale surveys, facility managers have consistently listed a lack of initial funding as the most significant barrier to energy efficiency, ranked higher than a poor return on investment, lack of technical expertise, or insufficient information.[10] For public buildings, this lack of funding is caused in part by the split between capital and operating budgets; building construction is typically paid for out of the capital budget, whereas operations and maintenance expenses, including energy bills, come from the operating budget. If different government agencies or divisions are responsible for a building's construction and operation, as is common, it means that decision makers overseeing capital budgets will not capture the long-term benefits that come from a one-time efficiency investment. As a result, decision makers commonly do not have sufficient incentive to fund investments in energy efficiency during design and construction, even if these investments would produce net cost savings for the government in the long run.

A key mechanism to overcome this issue is a revolving loan fund that can be tapped to provide funds for efficiency investments. Such a system would align budget incentives, so that capital budget managers (who would presumably manage such loan funds) could reap

9 "Fiscal Year 2009 State Expenditure Report." National Association of State Budget Officers, December 2010. Available at http://nasbo.org/Publications/StateExpenditureReport/tabid/79/Default.aspx

10 See, for example, the Institute for Building Efficiency's annual "Energy Efficiency Indicator" surveys, available at http://www.institutebe.com/Energy-Efficiency-Indicator.aspx?lang=en-US.

the benefits of efficiency investments. From these budget managers' perspective, utilizing a revolving loan fund would eliminate the upfront cost associated with efficiency investments. The loan would then be repaid over time out of the energy cost savings generated. Thus, if a given efficiency measure reduces a building's electricity costs by $100 per month, that $100 is diverted from the operating budget to repay the loan, up to the point where the loan is repaid. Monies paid into the loan fund should be earmarked for further energy investments, rather than used for general budget purposes. If the savings exceeded the financing cost of providing the initial investment, the loan fund would actually grow over time, providing more funding for capital budget managers and more effectively bridging the divide between capital and operating budgets.

The major challenge to creating a revolving loan fund is initial capitalization; if properly designed, the fund should be self-sustaining once it is established. One option to provide initial funds would be to build up the loan fund gradually over time by requiring a modest set-aside as a proportion of utility costs and/or construction costs for new buildings, such as a one percent assessment. Another option would be for states or municipalities to issue revenue bonds that would be repaid through energy savings; some observers have suggested that several states could potentially band together to jointly issue such bonds, an approach that should lower the perceived risk to the investor, and thus reduce financing costs to the states involved. These and many other details would need to be worked out by the relevant agencies; our intent is to provide fairly broad recommendations without delving into all of the details that would be necessary for implementation.

There are alternative methods to address the capital/operating budget divide, which may work similarly to a revolving loan fund. Energy service companies, or ESCOs, often bear the upfront cost of efficiency investments in exchange for payments over time financed by the resulting cost savings. However, such companies are not well-established in all jurisdictions, and many are focused on retrofits rather than on new construction. Nonetheless, where such companies are active, they provide another option for states to explore. Similarly, a number of solar PV companies retain ownership of the systems they install and pay all upfront costs themselves and charge building tenants for the electricity generated. To be feasible, such companies need to be able to take advantage of the generous tax incentives associated with solar PV.

Conclusion

Zero net energy buildings are more than an aspirational goal; they represent the logical evolution of our ability to apply energy efficiency and renewable energy technologies to one of the major energy consuming sectors in the United States and as a result, achieve important environmental, economic, and social objectives. And yet, to get "there" from "here," that is, to transform the building sector such that zero net energy becomes the standard design objective, is a massive undertaking that will not occur quickly. What can occur quickly is a deliberate effort to make buildings increasingly energy efficient so that the achievement of zero net energy performance will be seen as increasingly feasible.

Numerous recently completed buildings, both zero net energy and those that demonstrate performance approaching zero net energy, illustrate what is already possible when existing practices and readily available technologies are applied in a new way. Too often, however, these buildings are perceived as "experimental," or expensive showpieces, when in fact the only thing distinguishing a zero net energy building from others of similar use or shape or size is its (considerably smaller) annual energy bill. The challenge is to move decision makers, when presented with design possibilities, from asking "Why maximize energy performance?" to asking "Why not?"

The public sector can and should play a leadership role in pulling the market forward and creating a foundation for a broader shift across the commercial building sector. The Northeast and Mid-Atlantic states, with their strong existing focus on energy efficiency initiatives, are primed to take on this role. NEEP is committed to advocating for the implementation of the critical next steps described in this report – focused on information and education, additional exemplar demonstration projects, and, most importantly, enhanced systems for the measurement and reporting of increasingly aggressive energy use targets – in order to achieve this objective and to serve as a model for the nation. The need is clear and the tools are available – now is the time for action.

Appendix A

Compendium of Recommendations for the Promotion of Zero Net Energy Buildings

Below is a more comprehensive list of recommendations drawn from literature, interviews with stakeholders, and the November 2011 meeting of the Zero Net Energy Leadership Group, which informed the development of this report.

Information

- Building owners and their agents are "generally unaware of the attributes of energy-efficient buildings, how those attributes align with their business interests, or how to obtain a higher performance building" (Commercial Buildings Consortium 2011, p. 16). They must be provided with existing information to inform them on these factors.
- Communications should not dwell unnecessarily on zero net energy buildings, but should focus on deep energy efficiency improvements below current levels.
- Make the business case for zero net energy buildings through:
    - Savings in energy costs (factoring in likely changes in energy costs, not just current prices);
    - Increase in net asset value;
    - Non-energy benefits that increase market value, e.g., view and comfort; and
    - Disaster-readiness during extreme weather events.
- "A widely accepted standard for integrated design and methods for energy efficiency must be established by a nationally accepted authority and endorsed by key entities" (Commercial Buildings Consortium 2011, p. 17).
- Create a clearinghouse for information on high performance buildings. While DOE has a high-performance building database, it is not extensively used and there appears to be little quality control in the data input.
- Gather information on integrated design and enter it into high performance building databases.
- Create and implement an asset rating system to evaluate and communicate building energy performance.
    - Establish a minimum size threshold above which all buildings would be required to be rated;
    - Develop tools to aid performance assessment and benchmarking;
    - Require disclosure through public displays of labels;
    - To ensure consistency, standardize procedures for measurement, calibration, and publishing of performance data;

        - Use guidelines such as Commercial Energy Services Network (COMNET) to standardize inputs into energy modeling tools;
    - Use a technical rather than a statistical scale. Translate technical results into a letter grade or something similar, using DOE's commercial benchmarks by building type;
        - Use site energy use intensity, with a complementary greenhouse gas metric;
    - Integrate recommendations from the initial assessment of the building with utility incentive and financing programs;
    - If ratings are left voluntary, states and utilities should collaborate to build market demand for building ratings, and should consider reaching out to industry associations as well; and
    - Create a database of building energy performance and provide it to key stakeholders, to allow them to compare multiple buildings.
- Require periodic operational ratings to complement the asset rating.
    - The UK, Germany, and Austria have Energy Certificates that can be used as models. Operational ratings can be self-reported based on utility data, with random audits.
- The financial implications of building energy performance should be routinely included in real-estate valuation.

Codes

- Implement stretch codes that set a stricter performance target than the base codes.
- Gradually increase the stringency of mandatory building codes, with the goal of driving toward zero net energy buildings over 20 years.
    - To provide predictability, reach codes in one cycle should become the base code in the next cycle.
- Codes should be "outcome-based," assessing compliance based on actual performance rather than design.
    - Codes should establish a metric normalized for neutral variables such as occupancy, climate, and building type, in order to overcome the problem of higher performance baselines being built into codes for projects considering higher-performing options. Targets should be expressed in terms of actual and modeled energy use per square foot.
    - Energy use limits should be indexed to the actual average energy performance of exemplary buildings in within the climate zone. For example, new building standards could be 133 percent of the average annual energy use per square foot for the 20 best exemplars of each building type, as annually reported.

- Consumption data from utilities can be used to verify code compliance.
- Owners should be held accountable for meeting performance targets. However, they may be able to pass on this accountability to design and operations teams through performance provisions in contracts. Ultimately, owners, operators, and occupants/tenants must all have defined responsibilities for meeting energy use targets.
- Utility surcharges or fines could be assessed for non-compliance.
- Even if codes are predominantly outcome-based, they should maintain some prescriptive provisions to penalize the use of low-performing systems. The New Building Institute's Core Performance Standards could be used as prescriptive guidelines.

- Energy use targets should vary according to building type. DOE's 16 commercial building types should be used to define building types, with adjustments for different climate zones.
- Commercial codes should set a minimum size threshold of 10,000 square feet; the size should include all conditioned space in the building.
- The scope of codes should be expanded to account for all energy use. Plug and process loads are often greater than 20 percent of total building energy use, and can be greater than 65 percent.
  - If no national standard emerges, states should develop their own maximum plug load standard, subject to technical feasibility.
  - Occupants should be held accountable for plug-load targets.
- Enforcement agencies need to have adequate funding, capacity, understanding, technology, and training to effectively enforce compliance with building codes.
  - The State of Washington privatized its code enforcement and has had positive results; other states could consider following its lead.
- Enforcement must go beyond the traditional plan review and inspection process.
- Energy codes should be written in language that is readily useable in energy modeling software programs.
- Require submetering for all tenants in commercial buildings.
- Require self-diagnostic energy management systems (EMSs) for new buildings.
- Schools should be built to comply with the Collaborative for High Performance Schools (CHPS) building standard.
- Require solar-readiness for new buildings by considering building orientation, roof configuration, and electrical systems.
- Require 3rd-party commissioning when buildings are constructed. In addition, build-

ings over a certain size threshold should be required to undergo recommissioning on a periodic basis, such as every five or 10 years.

- Take care to avoid encouraging sprawl by recognizing the environmental benefits of density and urban development.

Finance

- Develop and expand utility incentive programs for energy efficiency. Public benefits charges can be used to provide funding for incentive programs.
    - Utility programs should provide funding specifically for demonstration projects of zero net energy or otherwise very high-performing buildings.
- Develop other new incentive programs as well, including:
    - Capital subsidies, grants, and loans, including competitive awards for high-performing buildings
    - Expedited permitting
    - Density bonuses
- The gap between capital and operating budgets must be bridged. Most energy efficiency improvements are paid for out of operating budgets, with finance term of two to three years. These improvements should be shifted to the capital budget, which typically has a 15-20 year finance term.
    - Establish revolving loan funds for public sector financing. Savings in energy costs should be earmarked for future energy projects, rather than being diverted to other budget areas.
- Develop and promote alternative leasing provisions that address split incentives between owners and tenants. On a related note, include information in real estate contracts that clarifies who pays the costs and receives incentives and energy benefits of efficiency.
    - Accelerate the deployment of life-cycle cost analysis tools to facilitate these alternative leasing provisions by helping all parties understand the costs and benefits involved in different energy-related investment decisions.
    - Use property assessed clean energy (PACE) programs to help building owners finance energy saving retrofits or new equipment through publicly-organized bond programs. The cost would be paid back over time through supplemental assessments on property taxes. The Northeast states could work together to implement a PACE program on a regional scale, to lower costs and increase access to capital.
- Public entities should partner with private companies to access available tax benefits for investments in efficiency or renewables. The Oregon pass-through program may provide a useful template.

- Decouple electricity and revenues and/or profits for utilities. Implement a system of "decoupling-plus," in which utilities have a financial incentive to actively promote efficiency.
    - Note, however, that even in California, which has such a system, "utility programs in CA have naturally tended towards measures which produce readily-quantified, low-cost, near-term savings which offer the opportunity to "buy" load reduction in easy, well-packaged measures with limited market impacts. There has been little incentive for utilities to engage in measures with a longer-term orientation" (California Energy Efficiency Plan January 2011 update, p. 4). Thus, utility regulations should be written in a way to promote longer-term energy-saving strategies.
- Consider a 'feebate' system for building permits, where more efficient buildings pay lower rates than less efficient ones.
- Tax incentives often have a time-consuming application processes that does not coincide with the real estate commercial development cycle. The process should be expedited to the extent possible to allow greater use of existing incentive programs.
- Regulations should make it easier to buy and sell renewable energy.
- While all Northeastern states have adopted net-metering rules, implementation in some areas still allows for very high charges that can discourage on-site renewables.
- Explore bulk purchasing of small PV systems to be installed at several different sites.

Education

- Convene stakeholder groups to build clarity and consensus on specific workforce needs.
- Implement a broad-based workforce development initiative to train people for jobs associated with building design, construction, and maintenance.
- Provide targeted training for the following groups:
    - Existing design professionals, contractors, and commissioning agents
    - Building operators and occupants
    - Installers of solar PV systems
    - Code officials
- Encourage training for multi-functional teams adept at the integrated design and construction process.
    - Facility managers, in particular, should be brought into the integrated design process.
- Government agencies responsible for professional licensing should develop a licensing and quality assurance program for energy raters.

- Create a building energy assessment curriculum within the public college and university system. In addition, bring building sciences into the curriculum for K-12 education.

Other

- To maximize impact, target the largest buildings first. The largest 5 percent of buildings make up about 50 percent of total building area and energy use.
- Use an integrated approach to design, construction and operation of buildings. "Many of the failures in modern buildings are system integration failures. Better system platform design, plug and play configuring systems, feedback sensors as part of self-commissioning systems, and auto-diagnostic software and hardware all are examples where R&D to redesign and/or improve technology could have a major impact" (Selkowitz et al., p. 5).
- While the focus is on new buildings, efficiency advocates should also promote continuous improvement of existing buildings.
- Leverage the ongoing industry information toward greater adoption and use of Building Information Models (BIM).
- Provide increased support for research and development into energy efficiency and renewables.
- Take an expansive definition of 'net zero' to allow climate benefit districts (CBD) – geographic areas larger than a single building that must be net zero on a combined basis. This will encourage district-wide green infrastructure, such as district heating and cooling, that may not be promoted under stricter definitions of net zero.
- Governors and others in prominent positions should use the "bully pulpit" to actively promote zero net energy and indicate a commitment to the zero net energy goal.

Bibliography

Architectural Energy Corporation. "Rethinking Percent Savings: The Problem with Percent Savings and the New Scale for a Zero Net-Energy Future." July 31, 2009. Available at http://www.archenergy.com/assets/files/News/Rethinking_Percent_Savings.pdf

Brown, Ramsey K. "Challenges and Potential Solutions in Achieving Net-Zero Commercial Buildings through Current Building Codes and Standards Processes." Washington Internships for Students of Engineering, August 4, 2010.

COMNET. "Commercial Buildings Energy Modeling Guidelines and Procedures." August 16, 2010. Available at http://www.comnet.org/sites/default/files/images/COMNET-MGP-2.pdf

Dunsky, P. et al. "A Roadmap for the Northeast U.S.: Valuing Building Energy Efficiency through Disclosure and Upgrade Policies." Northeast Energy Efficiency Partnerships, November 1, 2009. Available at http://www.neep.org/uploads/policy/NEEP_BER_Report_12.14.09.pdf

Institute for Market Transformation. "Building Energy Transparency: A Framework for Implementing U.S. Commercial Energy Rating & Disclosure Policy." July 2011.

Kandel, Adrienne et al. "A Comparison of Per Capita Electricity Consumption in the United States and California." Presented at the 2008 ACEEE Summer Study on Energy Efficiency in Buildings. California Energy Commission Publication CEC-200-2009-015, August 2008. Available at http://www.energy.ca.gov/2009publications/CEC-200-2009-015/CEC-200-2009-015.PDF

Massachusetts Department of Energy Resources. "An MPG Rating for Commercial Buildings: Establishing a Building Energy Asset Labeling Program in Massachusetts." December 2010.

Massachusetts Zero Net Energy Buildings Task Force. "Getting to Zero: Final Report of the Massachusetts Zero Net Energy Buildings Task Force." March 11, 2009.

McCarey, Maggie and Mark Walsh-Cooke. "The ZNE Early Design Process & The Cx and Re-Cx Process: The Necessary Bookends of Any Great Building Project." 2010.

Mills, Evan. "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions." Lawrence Berkeley National Laboratory. Report prepared for California Energy Commission and Public Interest Energy Research, July 21, 2009. Available at http://cx.lbl.gov/2009-assessment.html

National Association of State Budget Officers. "Fiscal Year 2009 State Expenditure Report." December 2010. Available at http://nasbo.org/Publications/StateExpenditureReport/tabid/79/Default.aspx

National Science and Technology Council Committee on Technology. "Federal Research and Development Agenda for Net-Zero Energy, High-Performance Green Buildings." Report of the Subcommittee on Buildings Technology Research and Development, October 2008.

New Buildings Institute. "Summary and Recommendations of the Getting to Fifty Summit." April 10, 2007.

Next 10. "Untapped Potential of Commercial Buildings Energy Use and Emissions: Capturing Wasted Energy: Efficiency, Retrofits, Barriers." 2010. Available at http://www.next10.org

Sciortino, Michael et al. "The 2011 State Energy Efficiency Scorecard." American Council for an Energy-Efficient Economy Report #E115, October 2011. Available at http://www.aceee.org/research-report/e115

Selkowitz, Stephen. "Scale Matters: An Action Plan for Realizing Sector-Wide "Zero-Energy" Performance Goals in Commercial Buildings." Lawrence Berkeley National Laboratory, August 22, 2008. Available at http://escholarship.org/uc/item/1kf4t1nh

Sherlock, Cynthia Hansel et al. "The Massachusetts Green Affordable Housing Initiative Early Results and Indications of Market Transformation." ICF International and Tohn Environmental. Published in 2010 ACEEE Summer Study on Energy Efficiency in Buildings.

State Energy Efficiency Action Network. "Existing Commercial Buildings Working Group Blueprint." May 5, 2011. Available at http://www1.eere.energy.gov/seeaction/pdfs/commercial_blueprint_final_05-05-2011.pdf

U.S. Department of Energy. "High Performance Buildings Database." Available at http://eere.buildinggreen.com/index.cfm

U.S. Department of Energy. Notice of Request for Information: Commercial Building Asset Rating Program. EERE-2011-BT-NOA-0049. Federal Register Vol. 76, No. 152, August 8, 2011. Available at http://www.gpo.gov/fdsys/pkg/FR-2011-08-08/pdf/2011-20014.pdf

Zero Energy Commercial Buildings Consortium. "Analysis of Cost & Non-Cost Barriers and Policy Solutions for Commercial Buildings." Final Report, February 2011.

Zero Energy Commercial Buildings Consortium. Draft Report of the Codes and Standards Working Group. August 24, 2010.

Zero Energy Commercial Buildings Consortium. "Next Generation Technologies, Barriers & Industry Recommendations for Commercial Buildings." February 2011.

"Zero Net Energy Action Plan: Commercial Building Sector 2010-2012." California Energy Efficiency Strategic Plan. August 2010; updated January 2011 and June 2011.