

Getting to Zero

Final Report of the Massachusetts Zero Net Energy Buildings Task Force

March 11, 2009

Acknowledgments

There are many extraordinary people who made the development of this report possible. First and foremost, the Massachusetts Zero Net Energy Buildings Task Force wishes to thank Governor Deval Patrick for his vision and leadership in assembling this group and giving us our charge. It is this kind of progressive thinking that will enable us to find creative ways to minimize the impacts of climate change, remake our economy, and build a more secure energy future. We also want to acknowledge Energy and Environmental Affairs Secretary Ian Bowles for chairing our Task Force and his designee, Assistant Secretary David Cash, for his commitment to the project.

While the Task Force was truly a collaborative effort of dozens of individuals working together as one group, there are a number of individuals who truly led the way, spending countless volunteer hours researching and reviewing documents, re-crafting recommendations, and crunching numbers. These people include: Ellen Watts of Architerra, Chair of the Commercial Sector Working Group, Paul Eldrenkamp of Byggmeister, Chair of the Residential Sector Working Group, Carolyn Sarno of the Northeast Energy Efficiency Partnership, Chair of the Public Sector Working Group, Chris Schaffner of The Green Engineer, Chair of the Public Sector Interim Standard Subcommittee, and Ken Fisher of Gensler, Chair of the Public Sector Demonstration Project Subcommittee.

The Task Force would also like to thank the Massachusetts Renewable Energy Trust for providing funds to support this project. Additionally, several organizations provided analysis and technical support to the Task Force including Industrial Economics, Inc. (IEc), Steven Winter Associates, Inc. (SWA), MIT-Fraunhofer Center for Sustainable Energy Systems, Massachusetts Department of Energy Resources, and the U.S. Department of Energy.

We'd also like to recognize the Commonwealth staff members who played a critical role in helping to both push us to be bold while reminding us of the many reality checks the state must face. Specifically, we want to thank Eric Friedman, Janet Curtis, Meg Lusardi, and Larry Masland at the Department of Energy Resources, Marc Breslow and Ian Finlayson at Energy and Environmental Affairs, and Elisabeth Krautscheid at the Massachusetts Renewable Energy Trust. And finally, much gratitude goes to the consulting staff at IEc and SWA, specifically John Weiss, Angela Helman, Sandra Grund, and Mark Price for shepherding the Task Force through months of deliberations.

The extensive voluntary service, commitment, and public/private collaboration of this group has been truly inspiring—we are grateful for having had the opportunity to come together and contribute to our Commonwealth.

Massachusetts Zero Net Energy Buildings Task Force
March 11, 2009

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Deval L. Patrick
GOVERNOR

Timothy P. Murray
LIEUTENANT GOVERNOR

Ian A. Bowles
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1181
http://www.mass.gov/envir

Governor Deval L. Patrick
Massachusetts State House
Boston, MA 02108

Dear Governor Patrick:

I am pleased to submit to you the final report of the Zero Net Energy Buildings Task Force, which you directed me to establish last March in your remarks at the Northeast Sustainable Energy Association annual conference. Your charge to the Task Force was to provide recommendations that would point the way toward universal adoption of zero net energy buildings for new residential and commercial construction by 2030. You also asked for an ambitious new standard for state government buildings and identification of at least one state zero net energy demonstration project. The Task Force report fulfills that charge in all regards.

Over the past year, the Task Force, made up of more than 70 experts in various building and energy related industries, programs, and agencies, has deliberated over hundreds of ideas and proposals. The result is a visionary document that draws on the leading programs around the world, adapting the best ideas to the specific conditions in the Commonwealth. The Task Force has also developed a number of new ideas never before implemented. From the use of specific energy performance targets for each building type, the establishment of building energy report cards, and incentives designed to expand the number of innovative projects being built, the Task Force has given us a large number of creative ideas to consider, now and in the future.

The Task Force report also gives us new tools to consider as we move toward zero net energy buildings in the public sector. The Task Force's recommendations for state buildings will help us define a higher energy standard for public construction and renovation. Finally, the Task Force identifies not one but three state projects already in planning that could serve as possible demonstration projects of near-zero net energy construction.

Your leadership and vision has put Massachusetts at the forefront in a wide number of clean energy areas. I look forward to working with you to review these ideas for moving the Commonwealth on a path toward a clean energy future.

Sincerely,

Ian A. Bowles, Secretary
Executive Office of Energy and
Environmental Affairs

Zero Net Energy Buildings – A Vision for Our Future

The Time Is Now

Urgency is growing across the nation as the impacts of global warming on our economy, health, agriculture, and environment become certain. Greenhouse gas emissions from our buildings, transportation, and energy generation are causing our climate to change, and to avoid catastrophic consequences, we must change too. Simultaneously, the advent of peak oil production and the ongoing instability of foreign oil markets threaten our national and economic security, requiring more than ever that the U.S. achieve energy independence.

The imperative is clear: we must find new ways to create clean and local energy, reduce our energy consumption, and remake our society to support a low carbon infrastructure. With buildings contributing close to 40 percent of greenhouse gas emissions and consuming 40 percent of energy in the U.S., energy efficiency and renewable energy technologies must become central to the way we design and build.

Although the current economic and climate challenges before us are great, the opportunities presented by these challenges for technology innovation, job growth, energy savings, and clean energy in the building sector require Massachusetts to act boldly—*the time is now to move toward zero net energy buildings in the Commonwealth.*

Transforming the Way We Build

Imagine a future where buildings and homes produce as much energy as they consume, use minimal if any fossil fuel, and contribute, on balance, no additional carbon to our environment. Imagine a future where the costs of heating, cooling, and operating buildings have been dramatically reduced and where these high- performing buildings are the most sought after properties in the market. And imagine a future where tens of thousands of new, good paying, local, permanent jobs have been created in the emerging new industry of zero net energy buildings.

These collective visions form the basis and inspiration for the work of the Massachusetts Zero Net Energy Buildings Task Force as it developed a framework to transform the way we construct homes and buildings in the Commonwealth. By making our buildings as efficient as possible and harnessing onsite renewable energy, we can curb our dependence on foreign oil, remake our economy, and greatly reduce our carbon footprint.

Over the last year, at the direction and leadership of Governor Deval Patrick and Energy and Environmental Affairs Secretary Ian Bowles, the Zero Net Energy Buildings (ZNEB) Task Force has researched, analyzed, and deliberated a range of recommendations to reduce energy consumption in buildings and increase onsite renewable energy generation, in order to move new residential and commercial construction toward zero net energy and significantly improve energy efficiency in the state's existing building stock. The recommendations outlined in this report attempt to do what no other state has yet done—establish a comprehensive set of policies, mandates, and programs that can dramatically improve building performance, reduce regulatory and financial barriers, unleash the market for technology and design innovation, and provide the necessary education and training to create a pathway that will lead to the universal adoption of zero net energy buildings and deep energy reduction retrofits throughout Massachusetts.

While the Task Force acknowledges that efforts to "green" buildings through smart growth policies, design, materials, and natural resource and water conservation have made substantial progress in recent years, requirements for energy efficiency and renewables have fallen far short of what is needed to meet the challenge of climate change and other environmental, economic, and societal goals. Therefore, while the Task Force focused its work solely on energy use in buildings, its recommendations are not intended to ignore or diminish existing green building activities but rather ensure that our building construction and renovation

sector is incorporating all the strategies necessary to meet the broad energy and economic challenges of the twenty-first century.

There is no doubt that within the following pages the bar has been set high for state government, the commercial and residential building sectors, and citizens throughout the Commonwealth. The ZNEB Task Force's recommendations are visionary and far-reaching, requiring transformational action from a broad range of stakeholders; some surely enthusiastic and some, less so.

For those who doubt the possibility of zero net energy buildings, there are inspiring examples of buildings already being developed or undergoing such transformation throughout the region and nation, particularly in the residential sector. These projects are significantly reducing energy costs and cultivating new expertise among architects, engineers, developers, trades people, building inspectors, and the occupants themselves to achieve what was unthinkable even a few years ago—*truly zero net energy buildings*.

At the same time, the Task Force acknowledges that achieving zero net energy will be more difficult for some building types than others and that the concern over the costs of incorporating significant efficiency improvements into buildings is real. However, the Task Force is convinced that the long-term savings in operating costs from deep energy efficiency gains outweigh whatever up-front costs may be required. Additionally, in many instances, innovative design approaches and early decision making can minimize and even lower certain capital costs. By moving down the pathway toward zero net energy construction, there will ultimately be sufficient numbers of successful demonstration projects, technology advances, and overall acceptance of this premise that zero—or near zero—net energy buildings can become a widespread reality over the next twenty years.

Buildings in Massachusetts consume 54 percent of energy in the Commonwealth.

It is understood that the building industry will require new training and an expanded workforce to meet the demand of zero net energy construction targets, particularly retrofits of existing buildings. As a result, the opportunities for economic development and job growth are abundant. Although difficult to predict specifically, the Task Force estimates that tens of thousands of jobs will be created in a variety of fields. To foster the growth of this industry, the Task Force has made several recommendations to address technical training, education, and incentives.

Along with training of industry professionals, the Task Force recognizes the significance of occupant behavior related to energy use. Even the best engineered home with the most advanced building envelope and energy components will not meet the zero net energy target with excessive plug load and disregard for energy use. Clearly, the consumer plays a critical role in realizing energy reduction, which is why energy efficiency education and broad dissemination of exemplar ZNEB case studies are integral to success.

We have reached a turning point in our nation, where the "business as usual" approach to development and dependence on fossil fuel is not only insufficient, but is increasingly detrimental to American prosperity. The Commonwealth of Massachusetts truly has an extraordinary opportunity to lead the nation by establishing new performance standards for our buildings. Implementation won't be easy but the consequence of no action—to our climate and economy—far outweigh the challenges of the Task Force's recommendations. Zero net energy buildings throughout Massachusetts are essential; let us begin.

Table of Contents

Executive Summary

At the direction of Governor Deval Patrick and under the leadership of Energy and Environmental Affairs Secretary Ian Bowles, the Massachusetts Zero Net Energy Buildings Task Force convened for the first time in July 2008 to begin deliberations to transform the building sector, by creating a pathway toward zero net energy buildings in the Commonwealth.
A zero net energy building is one that is optimally efficient and, over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite.

Building on the Commonwealth's leadership to advance energy efficiency and employ cutting-edge design and clean energy technologies, the Task Force was charged with making recommendations that will:

- Allow the state to issue specifications for the first, state-owned zero net energy building by January 1, 2010;
- Lead to the specification of an interim standard for state-owned construction that is significantly more stringent than the Massachusetts LEED Plus benchmark; and
- Put the private sector on a path toward (1) broad marketability of zero net energy commercial and residential buildings by 2020 and (2) universal adoption of zero net energy practices for new commercial and residential construction by 2030.

Upon its formation, the Zero Net Energy Buildings (ZNEB) Task Force reached two initial conclusions. First, recognizing that, even by 2030, achieving the zero net energy performance goal may be infeasible for some buildings, the broader objective should be to reduce energy loads to the minimum practical level, produce onsite as much of the required energy as reasonable from renewable resources, and purchase locally generated renewable energy to satisfy remaining needs. Second, the extended lifetime of a typical building dictates that the absolute magnitude of potential energy reductions associated with the existing building stock will be far greater than those associated with new buildings alone, so developing recommendations that do not address the energy performance of existing buildings would result in a significant missed opportunity for reducing the overall energy needs, and carbon footprint, of the state.

After several months of deliberation and careful consideration of a range of options, the ZNEB Task Force has developed a set of recommendations that, when implemented, would put the state on a clear pathway toward a future in which the amount of energy Massachusetts buildings use, and the carbon emissions they are responsible for, are dramatically reduced. Achieving this critical outcome will require a broad array of interrelated initiatives including: establishing energy performance standards for new construction and eventually to all buildings; measuring and reporting actual energy consumption; designing incentives to lower if not remove financial and regulatory barriers; and developing broad-based education and training programs that reach all parts of the building sector. Together, the Task Force's recommendations are intended to catalyze nothing short of a transformation of the Massachusetts building sector that will serve as a national model for innovative and effective responses to our energy and climate challenges.

The environmental benefits of substantially reducing building energy use are clear. Less intuitive is the "business case" for taking dramatic action, especially during a time of economic instability, but it is just as compelling. The Task Force's recommendations lay the foundation for long-term savings in operating costs from significantly lower energy use. Furthermore, a design process that integrates advanced energy technologies and practices at the planning stage of a project can minimize and even lower certain capital costs (e.g. lower heating and cooling needs can be met by smaller HVAC systems). Even now, utility programs vastly expanded by the Green Communities Act are available to subsidize investments in energy performance strategies, helping to provide a valuable hedge against rising energy costs.

In addition to energy savings, the Commonwealth can benefit on a broader economic basis from the direct creation of new jobs in building professions, attraction of new businesses, and technology research and development. Ultimately, new energy performance standards can unleash the market for innovative practices and technologies that will enhance the state's competitiveness by retaining and expanding the job base, lowering business and residential energy costs, and creating demand for the Commonwealth's growing clean energy sector's products and expertise.

Central to the suite of recommendations for achieving this transformation are the following:

1. ***The Task Force recommends that Massachusetts adopt minimum energy performance standards for buildings that, over time, drive continuous improvement in energy efficiency by using the market to identify the most cost-effective methods of meeting those standards. Massachusetts should systematically raise these standards over the next 20 years until they reach zero net energy for all new construction and major renovation projects in the commercial and residential sector, and move within five years to begin establishing performance standards for existing buildings in the commercial sector.*** The initial standards that the Task Force recommends would guarantee substantial and immediate savings in energy use and costs; more importantly, they are readily achievable using available technologies and design strategies, as demonstrated by exemplary buildings in Massachusetts and across New England.

2. ***The Task Force recommends a series of steps that would lead to the collection and ready availability of energy performance data for each commercial and residential building in the Commonwealth.*** Without accurate data, we cannot see how our buildings are performing relative to their designed performance nor can we track performance over time in order to identify opportunities for continuous improvement. The Task Force's measurement and reporting recommendations would, very simply, create a "labeling" system for buildings comparable to the systems we rely upon to compare the fuel efficiency of the vehicles we drive and the nutritional value of the foods we eat.

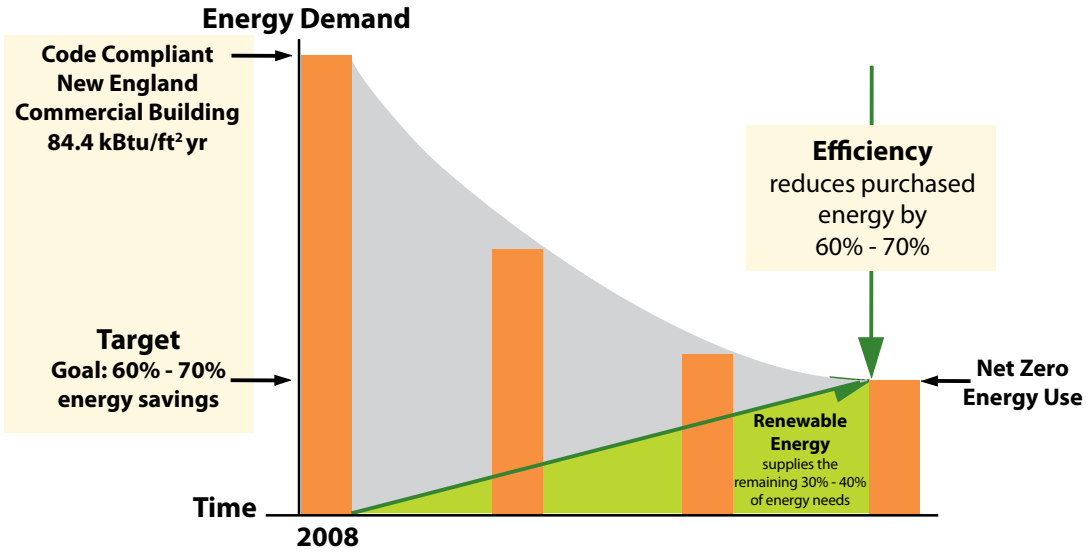
3. ***The Task Force recommends a suite of incentives that would lower, if not remove, existing financial and regulatory barriers to energy efficiency gains, promote the inclusion of onsite renewable energy systems, and help address the "incentive gap" between landlords and tenants.*** Providing incentives to address up-front costs and reduce regulatory barriers can be critical to overcoming obstacles that might prevent the development and construction of high-efficiency buildings and inclusion of innovative technologies.

4. ***The Task Force recommends a workforce development initiative that would rapidly and substantially increase the number of people able to deliver the services that will be critical to the successful implementation of the Task Force's other recommendations.*** Ensuring that all buildings perform at least as well as their design specifications will require a large and highly trained workforce capable not only of assessing energy use and performance but also of identifying opportunities for continuous improvement as technologies and practices evolve. The Commonwealth is fortunate to have the foundation for this initiative in place in the form of existing outreach and training programs provided by public, private, and non-profit institutions.

Many of the Task Force's recommendations align and support aggressive implementation of key state legislation passed in 2008, including the Green Communities Act, the Green Jobs Act, and the Global Warming Solutions Act.

The following tables list the Task Force's recommendations.

Federal Approach for Achieving Net Zero Energy Buildings



Source: Federal R&D Agenda for Net-Zero Energy, High-Performance Green Buildings, National Science & Technology Council, October 2008

Summary of Zero Net Energy Buildings Task Force Recommendations

Commercial Sector

C1. Establish energy performance standards for new buildings and major renovations by building type *(January 1, 2012)*

C2. Improve building code prescriptive energy requirements for new buildings and major renovations *(January 1, 2012)*

C3. Revise energy performance standards for new buildings and major renovations, indexed to exemplars in MA and elsewhere *(January 1, 2018)*

C4. Require "solar-readiness" for new construction and major renovations and actively promote PV installation *(July 1, 2010)*

C5. Require all state-funded public school projects to adopt new state performance standards and comply with the MA-CHPS standard *(July 1, 2009)*

C6. Require publicly displayed Energy Certificates for all buildings *(January 1, 2012)*

C7. Require electricity sub-metering for new buildings and major renovations and move toward sub-metering of all buildings *(January 1, 2012)*

C8. Expedite state permitting for projects that meet "stretch" standards *(July 1, 2009)*

C9. Develop and urge the municipal adoption of model zoning that promotes "stretch" projects *(January 1, 2010)*

C10. Establish energy performance standards for existing buildings by building type *(January 1, 2014)*

C11. Launch a competitive ZNEB grant and loan program *(January 1, 2010)*

C12. Establish an investment tax credit for energy improvements *(January 1, 2012)*

C13. Expand eligibility for renewable energy rebates *(January 1, 2010)*

C14. Allow building owners to sell metered renewable energy to tenants *(January 1, 2012)*

Residential Sector

R1. Establish energy performance standards for new homes and major renovations based on HERS Index *(January 1, 2012)*

R2. Develop a Massachusetts Home Energy Rating System *(January 1, 2011)*

R3. Require home energy ratings in conjunction with specific transactions, inspections, or renovations *(January 1, 2012)*

R4. Measure and provide annual energy use data in all homes *(January 1, 2012)*

R5. Launch a deep energy retrofit pilot demonstration program *(January 1, 2010)*

R6. Develop a ZNEB performance monitoring protocol *(January 1, 2011)*

R7. Develop and urge municipal adoption of model zoning that addresses existing regulatory barriers *(January 1, 2010)*

R8. Expand home energy weatherization rebate program to incentivize incremental super-insulation retrofits *(July 1, 2009)*

R9. Co-sponsor a mortgage write-down program for deep energy retrofit projects *(January 1, 2010)*

R10. Establish a ZNEB revolving loan fund; investigate a zero net energy bond *(January 1, 2012)*

Summary of Zero Net Energy Buildings Task Force Recommendations

State-Owned Buildings

S1. Adopt a prescriptive standard for new buildings and major renovations that requires:

a. Adherence to the requirements of the NBI Core Performance Standard

b. Optimized building orientation

c. Adherence to DCAM/DOER requirements for solar ready roofs

d. Minimum onsite renewable energy generation, where feasible, or comparable generation at an alternate location

S2. Adopt a performance standard by building type based on DOE Commercial Benchmark Models for all new construction and major renovation

S3. Install advanced metering in new buildings or in buildings that undergo major renovation

S4. Verify and publicly report energy performance

S5. Require third-party building commissioning and re-commissioning

S6. Provide building operator and occupant training

S7. Conduct regular review of state standard implementation

S8. Recommend a new standard for state-funded projects *(January 2012)*

(State recommendations implementation: July 1, 2009, unless otherwise noted)

Specifications to be developed for the first state-owned zero net energy building. Three prospective zero net energy state demonstration projects identified *(January 2010)*:

- Division of Fisheries and Wildlife Headquarters, Westborough, MA
- North Shore Community College, Health and Student Services Building, Danvers, MA
- Lowell Trial Court, Lowell, MA

Workforce Development, Technology Development, and Education

W1. Support Home Energy Rating System (HERS) Rater training *(January 1, 2010)*

W2. Enable the training and licensing of sufficient numbers of energy assessment and auditing professionals *(January 1, 2011)*

W3. Enable the training and licensing of sufficient numbers of renewable energy installation professionals *(January 1, 2011)*

W4. Develop training programs to increase the number of energy efficiency service providers and weatherization specialists *(January 1, 2010)*

W5. Develop a comprehensive continuing education and training program for the building industry, including architects, engineers, and builders, and regulator communities *(January 1, 2011)*

T1. Emphasize building energy technology in the mission of the Clean Energy Technology Center *(January 1, 2010)*

T2. Support the growth of the state's energy measurement and control technology industry *(January 1, 2010)*

T3. Promulgate state-specific energy efficiency standards for appliances, as appropriate *(January 1, 2011)*

E1. Develop and disseminate zero net energy/ retrofit consumer guidance *(January 1, 2010)*

E2. Develop a statewide ZNE marketing campaign *(January 1, 2011)*

E3. Require elementary and secondary schools to teach students about building performance *(September 1, 2010)*

E4. Identify, validate, and publicize project exemplars *(January 1, 2011)*

Note: All dates listed indicate *target* implementation of respective recommendation.

Introduction

"Less energy usage isn't enough. We have to set our sights not higher, but lower—all the way to zero."

– Governor Deval Patrick

The Governor's Charge

In March 2008, during an address to attendees at the Northeast Sustainable Energy Association's Building Energy conference, Governor Deval Patrick issued a challenge to members of the Commonwealth's building industry professions: help us to reduce the energy demand, and the carbon footprint, of buildings in dramatic fashion—specifically, to put Massachusetts on a path toward zero net energy buildings.

The impetus for the Governor's challenge is clear: residential and commercial buildings nationally consume nearly 40 percent of total annual energy production, while emitting 40 percent of national carbon emissions. Additionally, in Massachusetts, where all fossil fuel energy is imported and energy costs are among the highest in the nation, energy costs for the public and private sectors are a drain on the economy and continue to hurt our competitiveness. Finally, because of its history of cutting edge technology development, Massachusetts is particularly well-suited to seize enormous economic development opportunities in clean energy.

Recognizing the opportunity to make building energy performance a central element of the state's broad energy and environment strategy, the Governor specifically called for the creation of a Task Force charged with making recommendations that will:

- Allow the state to issue specifications for the first, state-owned zero net energy building by January 1, 2010;
- Lead to the specification of an interim standard for state-owned construction that is significantly more stringent than the Massachusetts "LEED Plus" benchmark; and
- Put the private sector on a path toward (1) broad marketability of zero net energy commercial and residential buildings by 2020 and (2) universal adoption of zero net energy practices for new commercial and residential construction by 2030.

The Task Force

The Zero Net Energy Buildings (ZNEB) Task Force was comprised of more than 70 leaders (see Appendix A for members list) from the local building-related industries and government agencies. Task Force membership included representatives from the fields of:

- Architecture and Engineering
- Real estate development and Construction
- Energy utilities and Building management
- Renewable energy technology firms and Academia
- Law and Environmental advocacy
- Federal, state, and municipal government

To accomplish its objectives, the Task Force created three working groups: public sector, commercial sector, and residential sector. The public sector working group subsequently formed two sub-groups, one focused on the demonstration project goal and the other focused on developing an interim standard for state construction projects. The Task Force met as a whole on four occasions between July 2008 and January 2009, while the working groups each met several additional times. The working groups were responsible for developing draft recommendations for consideration by the full Task Force.

Zero Net Energy Building Definition

At its first meeting, the Task Force deliberated over how to create an easily understood definition of a zero net energy building, concluding that it should recommend adoption of both an "aspirational" definition and a practical alternative, as follows:

A zero net energy building is one that is optimally efficient and, over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite. The Task Force recognizes, however, that currently, and even by 2030, certain buildings will not be able to meet the definition of zero net energy for technological or economic reasons (or both). Therefore, the Task Force strongly recommends that where zero net energy is truly not feasible, buildings in Massachusetts should reduce energy loads to the minimum practical level, produce onsite as much of the required energy as reasonable from renewable resources, and purchase locally generated renewable energy to satisfy remaining needs.

For additional information about the Task Force's consideration of this issue, see Appendix B.

Barriers

Although not the focus of its deliberations, the Task Force identified a series of existing barriers that are preventing widespread adoption of significantly more efficient and zero net energy buildings. The recommendations that follow are designed to address these and other roadblocks.

Barrier #1 – Up-front Cost: Despite long-term savings, the up-front cost necessary to significantly reduce energy consumption and add renewables can be a significant barrier to adoption of new technologies or strategies, especially when capital budgets and operating budgets are set and managed independently, with little if any opportunity to use savings from the latter to defray the former, as is the case with public construction and certain development projects.

Barrier #2 – Trained Workforce: The absence of a sufficiently large cadre of local and highly skilled professionals, from architects and engineers to developers and builders, who are able to guide a building project toward optimal energy performance, can make it difficult to design and construct buildings that meet zero net energy targets.

Barrier #3 – Building Energy Information: The lack of specific information regarding a building's energy use and how that building ranks in comparison with other similar structures can make it difficult to identify where and how to develop plans to achieve the maximum energy savings opportunities.

Barrier #4 – Building Operator and Occupant Behavior: Even when buildings are designed and constructed to meet stringent energy standards, occupant or operator behavior can have a significant impact on the building's energy use.

Barrier #5 – Regulations: Building-related regulations, particularly those established at the local level, can sometimes get in the way of energy efficient construction.

Concern about Higher Up-front Costs

Despite the general perception that incorporating significant energy performance improvements into current construction projects is not economically justifiable, the consensus of the Task Force is that:

- energy savings over the building's life more than pay for any additional up-front costs that might be necessary;
- an integrated design process that considers energy from the start can minimize and even lower certain capital costs (e.g. lower heating and cooling demand results in smaller HVAC systems);
- funding is available from many utilities to subsidize energy-related improvements and such funding will only increase as recent legislative and regulatory changes take effect; and
- incorporating efficiency measures now provide a hedge against rising energy costs.

Recommendations Overview

In the most general terms, the pathway to zero net energy begins with steps to reduce building energy demand to the lowest practicable levels, usually the most cost-effective way of reducing use of fossil fuels. Achieving this objective also minimizes the scale of the renewable energy systems that would be required to satisfy building energy need, and thus increases the technical and economic feasibility of their installation. The Task Force has based its recommendations on what it views as the four critical elements of a broad strategy to address existing barriers and move Massachusetts buildings along a transformational path toward zero net energy. These elements include:

1. The establishment and enforcement of clearly described and measured ***performance standards, based on modeled and actual energy use per square foot, along with augmented prescriptive standards*** that go well beyond current codes and requirements;

2. Integrated efforts to ***measure and report*** energy performance, thereby ensuring energy benchmarking, the ability to compare and rank performance, and the availability of an unambiguous record of progress toward the performance goals;

3. A suite of ***incentives*** intended to lower if not remove existing financial and regulatory barriers to energy efficiency improvements and the incorporation of renewable energy systems, and to address the "incentive gap" between landlords and tenants; and

4. A range of initiatives focused on ***education and workforce development*** that would help to create a building sector characterized by consumers who understand and seek out greater energy performance, an industry that is better able to deliver what the consumer wants, and a well-trained workforce capable of meeting what will be a growing need for technical skills.

As it has in the past, the state would lead by example through its adoption of a more aggressive performance standard and its commitment to design and construct one or more zero net energy buildings within the next several years.

In developing its specific recommendations, the Task Force collected and reviewed a wide range of information and carefully considered alternative strategies before arriving at what it believes are the most appropriate steps for the Commonwealth to take as it moves carefully yet aggressively toward its goals.

The Task Force notes that the Governor's charge focuses on the long-term transformation of new building design and construction. However, the lifetime of a typical building dictates that the potential energy reductions associated with the existing building stock will be far greater than those associated with new buildings alone, especially in the Northeast where growth is slower and energy costs are higher. To develop recommendations that do not address the energy performance of existing buildings would result in a significant missed opportunity for reducing the Commonwealth's overall energy needs and carbon footprint, despite the greater complexity of moving all existing buildings toward maximum energy performance. Therefore, the recommendations include specific additional measures to achieve ***continuous improvement in the energy performance of existing buildings.***

The Task Force also notes the existence of critical electricity generation, transmission, and distribution issues that extend beyond the scope of its work (and are therefore not addressed in its recommendations), which must be addressed if the Governor's zero net energy goals are to be fully realized. In particular, the widespread installation of distributed, renewable energy systems, capable of bridging the gap between building energy demand reductions and zero net energy, will depend on continued progress toward the development of a more robust, and smarter, grid and the establishment of regulations and policies that make it easier, not harder, to buy and sell renewable energy. Finally, the Task Force recognizes that its work is part of Governor Patrick's larger agenda to address energy and environmental challenges. As such, the Task Force supports aggressive implementation of the Green Communities Act, the Green Jobs Act, and the Global Warming Solutions Act as further catalysts for the Task Force's recommended actions.

Commercial Building Sector Recommendations

Historically, energy efficiency requirements for commercial buildings have been prescriptive, meaning that they mandate very specific installation of particular measures, such as levels of insulation in walls and roofs, quality of windows, etc. These prescriptive standards improve energy performance by specifying various building technologies and products. This prescriptive approach has resulted in widely varying energy performance for similar buildings, based on a variety of factors, including, but not limited to, design features, orientation, site design, etc. In other words, the same two buildings built to the same code can lead to dramatically different energy consumption data.

The Task Force has therefore determined that to achieve substantial efficiency gains across all buildings and to ultimately get to zero (or near zero) net energy commercial buildings, it is essential to move to performance standards based on energy use per square foot. Such performance standards for different building types are part of the cutting edge approach to the way buildings are designed and constructed. The Task Force believes that setting an aggressive yet achievable performance standard and then ratcheting down that standard over time will increase demand for new technologies and design approaches, unleashing the market for innovation.

Because there is great variation in the energy demand across commercial buildings, it is unreasonable to expect that all building types can meet the same energy performance standards. For example, a laboratory that needs to run equipment and ventilation systems require greater energy usage than a warehouse or small office building. For this reason, the U.S. Department of Energy (DOE) has classified commercial buildings into 16 general types. The Task Force proposes to adopt this classification and establish a kBtu per square foot performance standard for each of these building types.

These performance standards for new construction could be phased-in over time, providing the opportunity for markets to adjust, advances in technology to develop, and expertise among building professionals to mature. Within existing buildings, introducing Energy Certificates (see Recommendation C6) will enable building operators and occupants to better understand and manage energy use, helping them meet performance standards.

U.S. Department of Energy Commercial Sector Building Types

1. Office/Professional
2. Non-refrigerated warehouse
3. Education (includes academic buildings & classrooms, secondary and high schools)
4. Retail
5. Public Assembly (includes community center, convention centers, libraries)
6. Service
7. Religious worship
8. Lodging (includes dorms)
9. Food Services
10. In-patient health care
11. Public order and safety (includes jails, police facilities and courthouses)
12. Food sales
13. Out-patient health care
14. Skilled nursing
15. Laboratory
16. Refrigerated warehouse

Performance Standards

The Task Force's recommendations to establish performance standards for building types with a maximum energy use per square foot would result in a dramatic improvement to the efficiency of buildings. Currently similar buildings with similar purposes can have widely varied energy use data, depending in part on program and building design.

Performance standards will lead to more consistent energy use among building types and more predictable energy costs.

Due to the complexity and size of the commercial sector and the wide ranging types of buildings, the Task Force recognizes that the implementation details will require further analysis and perhaps adjustment for economic and technical practicality. In addition, the Task Force recognizes that, within the commercial sector, it will be particularly important to implement these recommendations such that (1) they include an appropriate degree of flexibility, (2) responsibility for energy performance is shared among owners, operators, and occupants (including tenants), and (3) care is taken to avoid encouraging sprawl by recognizing the overall energy and environmental benefits of density and urban development.

Standards for New Construction and Major Renovations

For commercial and state-owned buildings, the Task Force recommends defining a "major renovation" as a project with a total construction value exceeding 30 percent of the building's assessed value (or asset replacement value), or, in the case of partial renovations, a dollar amount prorated by the ratio of the square footage being renovated to the square footage of the whole building, exclusive of tenant improvement work. Where the cost to construct a building addition amounts to 30 percent or more of the assessed value, both the addition and the existing building should comply with the standards.

C1 Mandate maximum energy performance standards for new buildings and major renovations over 10,000 square feet based on best available U.S. Department of Energy "Commercial Building Benchmark Models." (Target implementation: January 1, 2012)

The Task Force recommends that the Commonwealth adopt, as an amendment to the building code during the next IECC code amendment process (anticipated to occur in 2011), initial energy performance standards for new commercial buildings and major renovations exceeding 10,000 gross square feet. These standards, prescribing mandatory limits on the allowable total annual energy use per square foot by specific building types, should be based on the U.S. Department of Energy's "Commercial Building Benchmark Models" for Climate Zone 5A, which identifies target energy use approximately equivalent to 30 percent better than the energy performance associated with the most current version of ASHRAE.

These performance standards should be further specified as follows:

- Establish mandatory performance limits that specify kBtu/sq ft/yr targets based on the DOE models for specific building types and prescribe formulas for computing performance.
- Following the adoption of the BBRS Stretch Code (see sidebar p.10), the Task Force recommends that the 2012 Stretch Code be revised to establish an energy performance standard that results in a 25 percent energy reduction from the new base energy performance standard adopted in 2012.
- To the extent that the building use or number of occupants per square foot varies from the norm for any given building type, the energy

DOE's Commercial Building Benchmark Models

The basis for the proposed commercial sector building energy performance standards is the output from the U.S. Department of Energy, Building Technologies Program commercial building benchmark models for specific building types (i.e., office, education, hospital, etc.). These models estimate energy use for each building type using the well-established EnergyPlus simulation tool, which accounts for interactions between climate, internal gains, building geometry, construction materials, usage patterns, and HVAC and renewable energy systems.

A key step in the modeling process was the development of a set of representative building configurations, which DOE accomplished using data from the 4,820 "non-mall" buildings contained in the 2003 Commercial Buildings Energy Consumption Survey (CBECS). Using these "existing stock" models, DOE incorporated changes to simulate the construction of each building as if it were new and in compliance with the most recent version of the ASHRAE 90.1 standard. The output of these models is a base measure of "energy use intensity" (measured in kBTU per square foot), by building type, that can serve as a benchmark for the establishment of performance standards (e.g., 30 percent lower intensity than the base).

Stretch Building Code

The Stretch Code, proposed to be adopted by the BBRS in May 2009 for new construction and major renovations will be made available to any municipality that seeks a more stringent building code for projects within its jurisdiction. Once adopted, the stretch code would be the new mandatory base code for that municipality.

performance standards may be modified through an appeals process or alternative performance standards based on kBtu/person.

- Square feet measures should include all conditioned space, e.g., heated basements, attics, penthouses, stairs, and ancillary facilities, measured in accordance with American Institute of Architects D101 standards (the measurement standard used by most construction cost indices).
- For mixed-use buildings comprising two or more distinct types, base and stretch maximum limits should be calculated as a weighted average of the limits for each use type, with weights assigned in proportion to the square footage dedicated to each type.

NREL: Five Priorities for Building Efficiency Improvement

1. Thermal Insulation
   - including air-tight building envelope with high performance glazing
2. Lighting Equipment
3. Plug and Process Load
4. HVAC Components
5. Passive Strategies
   - daylighting, natural ventilation, passive solar heating, passive solar avoidance

- The proposed state Office of Building Energy Performance (see Coordinated Implementation Section on page 38) should direct the process for refinement of the models to account for variations in state climate zones, building size, and/or other appropriate parameters, as well as development of base maximum limits for any building type for which DOE does not offer a corresponding benchmark model.
- While applicable to all Massachusetts commercial buildings greater than 10,000 square feet, conformance with the standards should be allowed on either an individual building or portfolio basis (including multiple-owner portfolios).
- The code amendment should establish an appeals process and utilize early cases to obtain feedback that can be used to modify the standards as appropriate.

C2 Improve building code prescriptive requirements for new buildings and major renovations. (Target implementation: January 1, 2012)

The Commonwealth should upgrade the building code's prescriptive standards to ensure actual performance improvement for new construction and major renovations. Specifically, the Board of Building Regulations and Standards (BBRS) should, by code amendment:

- Adopt ASHRAE 90.1-2007, and thereafter the latest version of ASHRAE 90.1, within one year of its publication on a three-year cycle. The recently adopted International Energy Conservation Code will remain in effect.
- If ASHRAE 90.1-2010 does not specifically address plug loads, the Commonwealth should, by December 31, 2011, establish, subject to technical feasibility, a maximum plug load standard. Tenant responsibility for maintaining these standards should be encouraged under model lease provisions.

Case Study: Garthwaite Center for Science & Art, Cambridge School of Weston, Weston, MA

Building and project type: The Garthwaite Center at the Cambridge School of Weston is a two-story, combined assembly/education/laboratory space occupying a total of 22,000 square feet. This project, completed in August 2007, involved construction of a new building while addressing both budget and site/space constraints.

Key elements of the design process: The project team worked closely with the school community to ensure achievement of the school's educational and sustainability objectives. In general, team sought to optimize energy performance and thermal comfort through load reduction, passive solar strategies, efficient mechanical and plumbing systems, and incorporation of renewable energy.

Energy-related features: The Garthwaite Center utilizes primarily natural ventilation, with a digital control system that enables remote monitoring, temperature setbacks, and adjustment for dynamic occupancy. Interior temperatures remain stable as a result of the passive solar strategies and super-insulation of the building envelope. A wood pellet-burning boiler provides approximately 80 percent of the building's heating needs. A variety of strategies including exterior glass with high visible light transmission and efficient lighting fixtures dramatically reduce the electric lighting load. In addition, the building was designed for future installation of a sun-tracking photovoltaic system.

Performance: The Garthwaite Center has been in use for just over one year, so actual energy consumption data are not yet available. However, energy modeling completed during the design process determined that the building can be expected to consume a total of approximately 27 kBtu per square foot, well below what is typical for a building of similar size and type.

Lead architect: Architerra, Inc., Boston, MA

Source: American Institute of Architects, *www.aiatopten.org*, accessed January 30, 2009.

Photo credit: Chuck Choi

- The Commonwealth should strongly encourage ASHRAE to develop and include in its next update an actual air-tightness standard with mandatory testing and verification to ensure performance, limited to the area of upgrade, as tested appropriately (total pressurization of the building is ideal yet partial testing is possible if subject to additional auditing). Ventilation and indoor air quality, as prescribed by code, are critical.
- In addition, the Commonwealth should actively promote, though not require, the New Building Institute's "Core Performance Standards," as well as modified PassivHaus techniques and solution concepts, as suggested guidelines for high performance building materials and systems.

C3 Mandate revised energy performance standards for new buildings and major renovations, indexed to exemplars in Massachusetts and elsewhere. (Target implementation: January 1, 2018)

Five or more years after the adoption of initial energy performance standards, the Commonwealth should adopt, as a further amendment to the building code, revised mandatory limits on the allowable total annual energy use per square foot for each of 16 different commercial building types indexed to the actual metered performance of the most energy-efficient Massachusetts or other Climate Zone 5A buildings for each building type. The Task Force makes this recommendation because standards based on actual energy use are inherently achievable and reflect the complex interaction of energy performance parameters, including climate, design, construction, and operations.

These revised performance standards should be further specified as follows:

- Base Code maximum limits should be indexed to the actual average energy performance of exemplary buildings in Massachusetts and other locations in Climate Zone 5A, in accordance with a methodology (to be determined) for setting the standards. 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.
- Update and revise the Stretch Code such that the maximum limits equal the actual average energy performance of exemplary buildings in Massachusetts and other locations in Climate Zone 5A, in accordance with the standard-setting methodology. For example, new building standards could be 100 percent of the average annual energy use per square foot for the 20 best exemplars, as annually reported. (Using this example, "stretch" standards would continue to be 75 percent of "base" standards.)
- Maximum limits should be adjusted every three years to reflect the annual updating of energy ratings for all Massachusetts buildings (see Recommendation C1). As high-performance buildings proliferate and improve, energy performance standards will thus tend to ratchet downward over time, helping to achieve the establishment of a zero net energy standard by or before 2030.

Building Commissioning Strategies

The building commissioning process ensures that all building systems perform according to the contract documents, the original design, and the owner's operational needs. This systematic approach typically includes the building's HVAC, controls, lighting, hot water, security, fire, life, and safety systems.

Retro-commissioning is a systematic process that identifies low-cost operational and maintenance improvements in existing buildings.

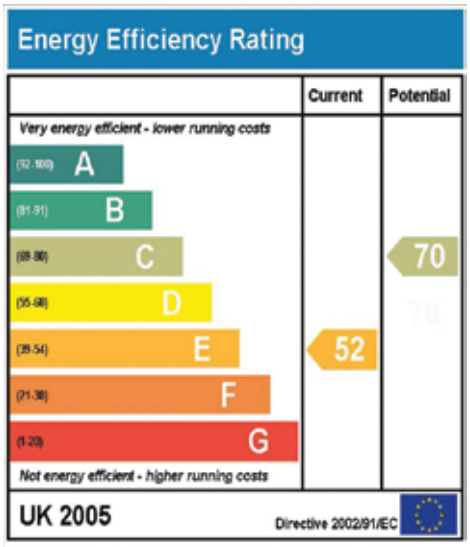
This information was obtained from Green California at: *www.green.ca.gov/CommissioningGuidelines/default.htm*

C4 Require new construction and major renovation to be "solar-ready" and actively promote solar installations (Target implementation: July 1, 2010)

As part of the 250 MW solar PV by 2017 goal set by Governor Patrick, and to prepare for the day when solar PV is more cost-effective and commonplace, the Commonwealth should:

- Strongly encourage all new construction and major renovation projects to include solar PV.
- Further amend the building code to include a requirement that, wherever feasible, new construction and major renovation of all commercial buildings will result in "solar-readiness" with respect to orientation, roof configuration, and electrical systems.

C5 Require all public school construction projects that receive state funds to execute design and construction in accordance with the Massachusetts Collaborative for High Performance Schools (MA-CHPS) standard and the new State Government energy standard (Target implementation: July 1, 2009)



UK Energy Certificate

Building Commissioning Costs

A 2004 report on building commissioning costs and effectiveness conducted by the Lawrence Berkeley National Laboratory, Portland Energy Conservation Inc., and Energy Systems Laboratory, Texas A&M University found:

1. Across a sample of 150 existing buildings:
   - Median whole-building energy savings of 15 percent and a corresponding payback time of 0.7 years.
   - Median savings were approximately $45,000 per building and ranged as high as $1.8 million.
2. For 74 new-construction cases, a median payback time of 4.8 years.
3. Accounting for non-energy impacts can drastically reduce payback times to zero or below in many cases.

Full report can be found at: *http://eetd.lbl.gov/emills/PUBS/PDF/Cx-Costs-Benefits.pdf*

The Task Force recommends that all schools adhere to the non-energy provisions of the MA-CHPS standard along with the energy standards required for all new state government construction and major renovation projects outlined in Recommendations S1 through S8 in this report (see pages 27 to 29). This new energy standard would require schools to:

- Follow certain prescriptive requirements
- Meet a minimum kBtu per square foot energy performance standard
- Incorporate a minimum amount of onsite renewable power
- Install appropriate metering
- Track and report all energy consumption
- Commission and retro-commission all buildings
- Provide training for building operators and occupants

Measurement and Reporting of Energy Performance

C6 Require annual "Energy Certificates" for individual buildings to make comparative energy use visible and to educate building occupants, operators, and consumers. (Target implementation: January 1, 2012)

The Governor should call for legislative action to require, by the end of 2011, that each commercial building in the Commonwealth publicly display an annual "Energy Certificate" that reports total annual energy use as compared with other buildings of its type. This requirement should be modeled on similar requirements currently in effect in Germany, Austria, and the United Kingdom. In developing this requirement, the Commonwealth should consider adopting the following specifications:

- Phased implementation, beginning with buildings of a certain minimum size, subject to the availability of a sufficient number of energy auditors.
- Creation of a "standard assessment procedure" for determining a building's energy rating.
- Development of a standardized format for the "Energy Certificate" which discloses kBtu/sq ft/yr and mTonsCO2e and ranks buildings A through F.
- Provisions for self-reporting of total annual energy use (in kWHs, therms, and gallons), based on easily obtainable utility and fuel provider bills, many of which are becoming digital and could be publicly reported, subject to random audit by a licensed energy assessor.
- Certificate renewal a maximum of every three years.
- Random audits conducted by the Commonwealth to ensure compliance with energy certificate reporting requirements.
- Monetary penalties for fraudulent reporting, with collected fines directed to a fund to train and license energy assessors.
- Building owner responsibility for the cost of energy assessments (and audits), but with provisions for financial assistance and for owners to claim the full amount as a state tax credit (or rebate for non-taxable entities), to the extent not rebated from utility efficiency funds.
- Development of a mechanism allowing building owners to appeal their energy rating.

C7 Require electricity sub-metering for new buildings and major renovations and make substantial progress toward sub-metering existing building energy use, including thermal energy. (Target implementation: January 1, 2012)

The Governor should task DOER to:

- Develop requirements for electricity sub-metering for new buildings and major renovations, at least by building floor (and in some instances, such as malls, by tenant).
- Determine and publish best practices for thermal energy sub-metering.
- Determine the most appropriate strategy, including a specific timeline, for the sub-metering of all existing buildings.

Regulatory Incentives

C8 Expedite state permitting for projects that meet the stretch code. (Target Implementation: July 1, 2009)

The Commonwealth should devise permitting incentives to spur new construction and major renovation projects that demonstrate the ability to meet the Stretch Code commercial performance standards.

- The Secretary of Energy and Environmental Affairs (EEA) should encourage proponents of ZNEB projects to request an expedited review under the Massachusetts Environmental Policy Act (MEPA) through a Single Environmental

Corporate Tax Credits

At least 25 states in the U.S. have established tax credits, deductions, or exemptions to incentivize investment in energy efficiency and/or renewable energy technology for commercial buildings. These credits apply to a range of technologies and energy conservation measures, from wind turbines, photovoltaic systems (PV), and cogeneration to efficient interior lighting, weather-stripping, and building insulation.

The Task Force recommends that the Governor review and build upon existing tax credits such as these to elevate best practices for energy conservation and renewable energy measures within the commercial sector.

Some examples include:

- **Oregon**'s Business Energy Tax Credit provides credits to commercial sector investments in energy conservation and renewable energy resources. Tax credits can be received for 50 percent of the total cost, with a maximum credit of $10 million; and can be applied to project costs as well as loan fees and permit costs.
- **Georgia** established in 2008 the corporate Clean Energy Tax Credit for renewable energy and certain energy-efficient equipment. Renewable energy projects receive a credit equal to 35 percent of the cost of the system; lighting retrofit projects receive $0.60/square foot; and a $1.80/square foot credit can be applied for energy-efficient products. Eligible technologies include lighting controls/sensors, daylighting, solar water and space heating, wind, biomass, geothermal heat pumps, and PV.
- **Montana**'s Alternative Energy Investment Tax Credit allows certain commercial and net metering alternative energy investments to receive a tax credit of up to 35 percent against corporate tax on income generated by the investment.
- **North Carolina** offers a Renewable Energy Tax Credit equal to 35 percent of the cost of eligible renewable energy property constructed, purchased or leased by a commercial taxpayer. Credit limits include a maximum of $2.5 million per installation for all solar, wind, hydro and biomass applications for commercial facilities, including PV, daylighting, solar water-heating, and space-heating technologies.

Source: Database of State Incentives for Renewable Energy (DSIRE), *www.dsireusa.org*, accessed January 18, 2009.

Impact Report (EIR), and further recommend that the Secretary give due consideration of the environmental benefits of ZNEB projects when issuing decisions on the request for a Single EIR. In addition, the Secretary should allow ZNEB projects to "opt-out" of the requirements for analysis of greenhouse gas emissions under MEPA pursuant to the Opt-Out Provision of the EEA Greenhouse Gas Emissions Policy and Protocol.

C9 Develop, and urge cities and towns to adopt, a model zoning by-law that further promotes the stretch code projects. (Target implementation: January 1, 2010)

The Commonwealth should develop and promote the adoption of model zoning by Massachusetts cities and towns that expedites local permitting for stretch code projects. The model zoning should include:

- Permitting practices that will result in the issuance of permits for projects that meet the stretch performance standards (as well as applicable environmental, health, and other regulations) within 180 days consistent with the timeline established by Chapter 43D ("Expedited Permitting");
- Density bonuses, such as increased floor area ratios, and other incentives for stretch code projects that reuse previously developed sites or buildings, contain a mix of uses, are located within one quarter mile of public transit or in a dense urban area, or otherwise advance the objective of zero net energy buildings;
- Language, for municipalities that wish to encourage but not mandate the use of the stretch code, zoning that offers developers

density, expedited permitting, and other incentives for voluntary construction of stretch compliant projects;

- Measures implementing Chapter 40A Section 9B ("Solar Access") in order to encourage the use of solar energy systems and protect solar access by regulating the orientation of streets, lots, and buildings, maximum building heights, minimum building setback requirements, limitations on the type, height, and placement of vegetation, and other provisions; and
- Provisions providing for the by-right permitting of wind power facilities or other appropriate renewable energy generation facility.

Energy Performance of Existing Buildings

C10 Establish energy performance standards for existing buildings that become more inclusive over time. (Target implementation: January 1, 2014)

In order to ensure ongoing improvement of the energy performance of existing building stock, the Governor should direct the Department of Energy Resources to develop legislation establishing, through further building code amendment, a phased sequence for energy performance standards for existing buildings.

- In the first phase, a subset of existing building owners should be required to submit plans for upgrading their buildings to comply with "base" energy performance standards on the basis of actual post-occupancy measurement. For example, the requirement could begin with buildings greater than a certain total square footage, with applicability to smaller properties in succeeding years.
    - "Base" post-occupancy standards for existing buildings should be similar to "base" pre-construction standards for new buildings, with adjustments made, as appropriate, for the age of the building.
    - The requirements should also include a schedule by which existing buildings of different sizes must meet the energy performance standards (for example, within three to five years of the date by which they are required to submit plans).
    - Energy performance should be evaluated based on actual kBtu/sq ft/yr as certified by a building's most recent annual Energy Certificate (see Recommendation C6). Failure to conform to the requirements should trigger a fine, with any collected proceeds dedicated to funding an investment tax credit (see Recommendation C12) or other incentive.
- The legislation should specify a second phase, to begin within seven years (i.e., by 2016), in which all existing commercial buildings would be required to comply with existing building "base" performance standards upon sale, giving building owners in the marketplace seven years to implement efficiency upgrades sufficient to achieve actual performance in compliance with the standards, or pay fines upon any property rights transfer.
- As a final phase, the legislation should specify that within ten years all commercial buildings, not just those being sold or leased, would be required to comply with "base" performance standards. This provision is aimed at improving the energy performance of buildings which are owner-occupied or owned to hold (not typically marketed), including schools, universities, hospitals, assembly, and worship. The lead-time for compliance is a full decade, allowing owners of such properties ample time to plan and budget.
- The legislation should include a provision allowing owners of existing buildings to meet the performance standards by an alternative process, such as obtaining an independent energy audit and establishing a cost-effective solution for achieving energy-efficient upgrades to the maximum extent possible.

Case Study: Gilman Ordway Building at the Woods Hole Research Center, Falmouth, MA

Building and project type: The Gilman Ordway Building at the Woods Hole Research Center is a three-story, combined laboratory/commercial office space occupying a total of 19,200 square feet. This project, completed in June 2003, combined the renovation of an historic, 17-room Victorian home and the construction of a 12,500 square foot addition.

Key elements of the design process: The project team adopted an integrated, whole-building design process that included retaining the services of an energy systems consultant all the way through construction. Of particular note, the team made early decisions to create a building that would not require onsite use of any fossil fuels and that could be easily replicated by maximizing the use of available "state-of-the-shelf" technologies.

Energy-related features: The Gilman Ordway is an "all-electric" building that utilizes a grid-connected, net-metered photovoltaic array (88 panels rated at 26.4 kW), a closed-loop, ground source heat pump system, and a solar thermal water system. In addition, building performance was further enhanced through the incorporation of:

- Icynene spray foam insulation of all exterior walls and roof assemblies
- Offset-stud framing in exterior walls to eliminate thermal bridging
- Double- and triple-glazed, Low-E glass
- Energy recovery ventilators using enthalpy wheels to recapture exhaust heat and moisture and to precondition incoming fresh air
- An extensive energy monitoring system
- High efficiency lighting controls and occupancy monitors
- High efficiency appliances and office machines

Performance: Metered data from the first year of building occupancy (October 2003 to September 2004) indicated that the Gilman Ordway solar array produced approximately one-third of the 90,000 kWh required to meet the building's energy demand. Total building energy consumption was recorded at 16 kBtu per square foot, compared to just over 70 kBtu for other buildings at the Research Center.

Lead architect: William McDonough + Partners, Charlottesville, Virginia

Source: American Institute of Architects, *www.aiatopten.org*, accessed January 30, 2009

- The legislation should also require re-commissioning at least every five years, from 2014 forward for all buildings over 100,000 square feet and from 2019 forward for all buildings over 20,000 square feet. Landlords would be responsible for base building systems only. Buildings that meet certain performance levels, such as a minimum energy certificate rating, or those where comprehensive energy improvements are planned should be exempt from this requirement.
- The legislation should require reporting of all Massachusetts Energy Certificate ratings (see Recommendation C6) in corporate annual reports filed with the Secretary of State.
- The legislation should require that five years following post-occupancy, a building designed and constructed to meet the new building and major renovation performance standard must meet any future existing building standard if that standard would improve the building's energy performance.

Financial Incentives

C11 Launch a competitive ZNEB construction grant and zero-interest construction loan program to spur exceptional projects of each commercial building type. (Target implementation: January 1, 2010)

To foster the development of exemplary buildings, the Governor should direct the appropriate state agencies to collaborate with utility providers to create a competitive zero net energy building construction grant and zero-interest construction loan program providing a catalyst for public and private construction of new zero net energy buildings and deep energy retrofits in the commercial sector, for which proponents must demonstrate compliance with Stretch performance standards. The intention is to create up to 100 exemplary projects across a wide range of locations and building types over 5 years.

- Grants and zero-interest rate loans would be awarded based on a competitive RFP process, for early-stage projects, and funds advanced at the time of construction financing (perhaps as buy-down for construction loan interest rates).
- Grants and zero-interest loans would target the incremental costs of design and construction strategies necessary to achieve the zero net energy objective.
- Grants and construction loans would be awarded based on the potential of the projects to achieve zero net energy and demonstrate solution concepts for minimum practical energy performance and, where practical, onsite renewable energy generation, as supported by energy modeling and project plans and specifications completed to the design development level.
- Preference for grants and zero-interest loans should be given to projects that most clearly embody smart growth principles.
- Recipients of grants and loans would commit to commissioning, a post-occupancy survey, and a written case study based on the AIA/COTE Top 10 Green Building format.

C12 Establish an investment tax credit to support widespread energy improvements across all building types. (Target implementation: January 1, 2012)

The Commonwealth should establish a new energy improvement tax credit to stimulate investment in both new and existing buildings that reduce energy loads and generate renewable energy while exemplifying smart growth.

- The tax credit (or direct rebate if the developer owner is an entity without tax liability) would be for qualified expenditures on weatherization, energy-efficiency, and renewable energy.
- The tax credit would offset actual expenses on new building or deep energy retrofits. For example, an incentive of up to $5.00/sq ft could be provided for building projects that meet the stretch code maximum energy performance, as validated by actual performance for at least one year after substantial completion.

- To encourage renewable energy growth, the tax credit would be increased proportionally up to 100 percent to reflect the extent to which total annual energy use is supplied by renewable energy generated as a direct result of project investment. For example, a deep energy retrofit that met the "Base Code" and supplied 50 percent of its total annual energy use with an onsite wind turbine would be eligible for an initial investment tax credit of $2.50/sq ft, to be increased by 50 percent for the renewable portion to $3.75 /sq ft.
- The legislation should ensure that incentives also avoid validating sprawl. For example, new buildings utilizing this tax could be required to achieve a LEED rating, including specific LEED "Sustainable Sites" credits.

C13 Expand eligibility for renewable energy rebates. (Target implementation: January 1, 2010)

The Governor should direct the Massachusetts Renewable Energy Trust to expand its current incentive programs and make thermal energy technologies eligible for rebates for commercial and residential projects to make these technologies more affordable. These technologies can include, but not be limited to, solar thermal heating and hot water, ground source heat pumps, and various biomass heating technologies.

C14 Allow building owners to sell metered renewable energy to tenants and encourage power purchase agreements. (Target implementation: January 1, 2012)

The Governor should call for utility regulatory reform to allow building owners to sell utility-metered renewable energy to tenants. Cumulative multi-project incentive caps should be removed to allow power purchase providers to offer services to an unlimited number of customers and to achieve scale.

Residential Building Sector Recommendations

Residential sector recommendations rely on the implementation of four interdependent strategies to achieve broad market acceptance and universal adoption of zero net energy buildings. These strategies for the Commonwealth include:

1. Establish a Massachusetts Home Energy Scoring System;
2. Create energy-use performance standards for new homes and retrofits;
3. Cultivate and disseminate case studies of new and retrofitted homes; and
4. Prioritize deep-energy reduction retrofits to existing homes.

The Task Force determined that understanding energy use in residential buildings (defined as one- to four-family residences, or multi-family buildings of three stories or less), both as predicted in the design phase for new construction and through actual use for the existing housing stock, is paramount to reducing energy consumption. Further, establishing minimum performance standards for new homes and major renovations and obtaining energy performance information for all residential buildings in the Commonwealth is essential. Monitoring building performance, allowing for transparency of this data, and highlighting case studies and exemplars should follow from this initial work. While some of the first examples of zero net energy residential buildings will be from new construction, the largest area of energy reduction opportunity lies in existing buildings, and thus the current housing stock should be targeted for deep-energy retrofits alongside new design and construction.

Standards for New Construction and Major Renovations

R1 Amend the residential building code to set a base and revised stretch code maximum HERS ratings for new homes and major renovations (Target implementation: January 1, 2012)

- The maximum base code HERS rating should be 70 and revised maximum stretch code rating should be 50.
- The Task Force recommends a reduction in the maximum HERS ratings (relative to the current HERS reference home) every three years when the state building code is updated, with the goal of requiring a zero rating for homes constructed after 2030.

Energy Performance of Existing Buildings

The Task Force recommends creation, on two parallel tracks, of a Massachusetts Home Energy Scoring System to ensure that all homes in the Commonwealth and their occupants receive an accurate energy rating. The first track would focus on HERS-based energy modeling (building asset rating) applied at specific points of leverage. The second track requires comprehensive acquisition of measured energy consumption data from utilities and other sources (operational rating) and conversion of such data into a performance metric.

Achievable HERS Ratings

After a broad review of HERS-rated homes in New England, the Task Force concluded that cost-effective improvements to the building envelope and mechanical systems can, in 2009, improve a new home to a HERS rating of 60—prior to factoring in onsite renewable energy. By 2012, a HERS index of 50 (again, prior to adding renewables) is reasonably attainable. With extremely high-performance windows, and precise construction details, especially with regard to air-sealing, the lower limit approaches 40. When onsite renewable energy technologies are added, such as photovoltaic panels and solar thermal, many homes will be able achieve a HERS rating of 20 or lower.

What is a HERS rating?

A HERS rating is a score resulting from an analysis of a home's projected energy efficiency in comparison to a "reference home," which is assigned a HERS Index of 100 and is built to the specifications of the 2004 IECC building code. The lower a home's HERS rating, the more energy efficient it is. For example, a home built precisely to code has a HERS rating of 100, while a zero net energy home has a rating of zero. Each one-point decrease in the HERS rating corresponds to a one percent reduction in energy consumption compared to the HERS reference home. Thus, a home with a HERS rating of 85 (the minimum threshold for EPA ENERGY STAR certification) is 15 percent more energy efficient than the reference home.

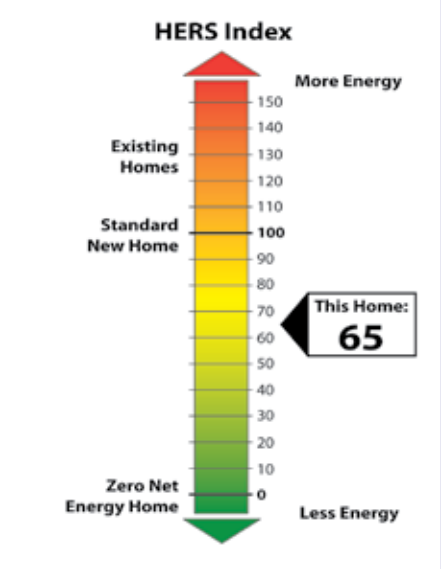
Approximate Breakdown of HERS Percentage Points:

40 points for building envelope

20 points for HVAC systems

40 points for electricity load

The difference between anticipated energy usage and actual energy usage, however, must be kept in mind—a home with a HERS Index of 0 may, in practice, not achieve zero net energy over time for a variety of reasons, notably occupant behavior. On the other hand, a home with a HERS Index of greater than 0 may nonetheless, with vigilant and disciplined occupants, achieve zero net energy.



Based on a limited data set, a reasonable assumption is that a typical existing home in Massachusetts has a HERS rating of between 100 and 150 and therefore uses up to 50 percent more energy than a home built to the IECC 2004 code. The HERS Index, established by the Residential Energy Services Network (RESNET), is a nationally accepted standard used by, among others:

- Massachusetts Board of Building Regulations and Standards (BBRS) as a compliance mechanism for meeting the state energy code
- United States Green Building Council's (USGBC) LEED for Homes Green Building Rating System
- U.S. Environmental Protection Agency's (EPA) ENERGY STAR Homes Program
- U.S. Department of Energy's (DOE) EnergySmart Home Scale (E-Scale)
- Energy Efficient Mortgage (EEM) lenders

R2 Develop a Massachusetts version of the Home Energy Rating System. (Target Implementation: January 1, 2011)

- The Commonwealth should develop a Massachusetts-specific version of the well-established HERS rating software. As a first option, the Commonwealth should explore the modification and use of existing software to achieve this objective.
- If existing software, after modification, cannot provide data on anticipated energy use that is not highly correlated with actual use under specific Massachusetts conditions, the Commonwealth should develop a Massachusetts-specific HERS software program that could account for micro-climates and include weather data for Massachusetts cities and towns.

Residential Case Study: New Construction, Townsend, MA

Transformations, Inc., a residential development company (www.transformations-inc.us) based in Townsend, is pioneering zero net energy homes in the Commonwealth. In 2008, Transformations Inc. was chosen among six builders to participate in the state's investor-owned utilities Zero Energy Challenge, a competition to encourage builders to plan and develop a home with a HERS Index below 35 before December 2009.

Carter Scott, President of Transformations, Inc. brought together a team of design and energy experts to not only meet the challenge, but to figure out how to get all the way to zero while still building a below market rate affordable new home. The team designed a three-bedroom 1,232-sq/ft house called the "Needham," which has scored a "-4" HERS rating, which means the home is producing more energy than it is using.

To get to (below) zero, the home includes a super-insulated thermal envelope with PV and solar water heating.

Roof (R-Value 75): 5 inches of high-density polyurethane foam and 13 inches of high-density cellulose all along the slope of the second-floor roof rafters; 2x12s and a 2x4s held off by 3 inches for a thermal break separation

Walls (R-Value 49): 2x4 outside wall; added a second 2x4 wall for a total depth of 12 inches; filled 3 inches with high-density polyurethane foam (HDF) and 9 inches with cellulose

Basement Ceiling: 3 inches of HDF and a layer of R-30 fiberglass batts

Windows: Paradigm triple-pane model with Low-E and krypton gas

Heating/Cooling: Mini-split-system air-source heat pumps—Mitsubishi Mr. Slim split-ductless air-source heat pump; Lifebreath 155 ECM Energy Recovery Ventilator

Onsite Renewable Energy: Electricity—Evergreen Solar's 30 Spruce Line 190-watt PV panels to create a 5.7-kW system; Hot Water—SunDrum Solar's solar water-heating system

The heat loss on the "Needham" is only 10,500 BTUs, which is the equivalent of two 1500 watt hair dryers and an 80-watt light bulb. This is the amount of energy it takes to keep the inside of the house at 70 degrees when it is 6 degrees outside.

"It has been incredibly satisfying to design and build a home that will essentially emit no greenhouse gases and cost the homeowner next to nothing for their heating, air conditioning, and electrical usage."

– Carter Scott, President, Transformations, Inc.

R3 Require the calculation of a HERS rating for residential buildings in conjunction with specific transactions, inspections, or renovations. (Target implementation: January 1, 2012)

- In addition to requiring a HERS rating for all newly constructed residential homes and major renovations, ratings should be required at key leverage points in order to establish energy ratings broadly within the existing residential building stock. Initially, a HERS rating should be required at times when it would be valuable to prospective home buyers or renters, and when it would influence building upgrade decisions. Care should be taken, however, to ensure that rating requirements do not dissuade homeowners from undertaking efficiency measures or offering units for rent, and should allow for the appeal of a rating. Occasions when ratings could be required include:
  - At the time of sale, so that prospective buyers have access to essential, validated information regarding the anticipated energy performance of the home.
  - As a prerequisite for receiving utility or state subsidies for non-emergency HVAC equipment upgrades, weatherization improvements, or renewable energy systems, where the cost of the HERS audit is reasonable in proportion to the overall cost of the upgrade.
  - Because it is conceivable that an individual home might meet several of these criteria in succession within a short period, a policy of establishing a "shelf life" for a HERS rating should be implemented, such that a rating might remain valid for a period of time (e.g., five years), or until the next significant change to the building envelope or mechanical equipment occurs.
  - Financial support should be provided to help pay for HERS ratings, including, but not limited to, state funds, fees paid by the builder (for new construction), fees paid by the homeowner, and ratepayer-based utility incentives. The typical cost of a HERS rating for a home is estimated to be between $800 for a fairly simple new home up to $1,200 or more for a complex existing home.

R4 Measure annual energy use in all residential buildings. (Target implementation: January 1, 2012)

- DOER should use its broad authority under Chapter 25A Section 7 to obtain from utility providers comprehensive energy usage (electricity and natural gas) information for each household. DOER should prepare a

Retrofit: Existing Home, Gloucester, MA

HERS Index 10

Attic: R-76 with radiant barrier

Walls: R-43 (5" closed-cell foam added)

Windows: Triple-pane, Low-E, argon (R-5)

Air sealing: Reduced to 300cfm50

Lighting: All LED/SSL and CFL

Appliances: All ENERGY STAR

Onsite Renewable Energy:
4.3-kW solar electric system
3-panel solar hot water system

Photo credits:
Above: Marc Breslow; Below: John Livermore

The Value of Obtaining Both Asset and Operational Performance Data: The Task Force's recommendations for the residential sector include the collection of both asset performance data (through HERS ratings) and operational performance data (through the acquisition and aggregation of existing energy use data). The asset-level data provide an important measure of predicted energy consumption, enabling comparisons to other homes and the identification of opportunities for efficiency upgrades. The operational-level data are an important complement, providing not only a much quicker path to universal characterization of home energy use (since generating HERS ratings for all existing homes could take many years), but also creating important signals for consumers who can view their energy use relative to a benchmark.

The Task Force understands that no tracking system is perfect, but emphasizes how critical it is that the Commonwealth begin efforts as soon as possible to track and report energy consumption data on a comprehensive basis, as such efforts will help to inform future energy reduction strategies.

common measurement of energy consumption for each household by converting kilowatt-hours, gallons (of fuel oil), and therms to MMBtu (Million British Thermal Units), which would then be suitable for use in calculating metrics such as KBtu per square foot per year or MMBtu per bedroom per year.

- Although not easily obtainable, DOER should also seek to gather energy consumer data for heating oil, liquid propane, cord wood, and pellets used in individual homes.
- DOER should track these data on an annual basis in a publicly-available, online database that maintains confidentiality while at the same time allowing homeowners and home occupants to benchmark building performance and measure changes in energy use.
- DOER in coordination with the MassSAVE Program should develop an online education tool that will enable homeowners to "score" energy use in their residence and compare it to benchmarks.

R5 Launch a deep energy retrofit pilot demonstration program to showcase the materials and methods, costs and benefits, and challenges and innovations associated with bringing an existing New England home to zero net energy performance. (Target implementation: January 1, 2010)

- DOER should direct electric and gas utilities to fund a pilot demonstration of 250 deep energy residential retrofit projects pursuant to the Least Cost Procurement provision of the Green Communities Act (Section 11). These pilots should be designed to determine the cost-effectiveness of deep energy retrofit over a reasonable time frame, particularly when coordinated with specific maintenance activities, such as re-roofing, re-siding, and window replacement.

Measurement and Reporting of Energy Performance

R6 Develop a zero net energy performance monitoring protocol for residential buildings. (Target implementation: January 1, 2011)

Because zero net energy home design and construction is in its beginning stages, there is much to be learned about the performance of these buildings. Tracking the results of building performance will inform and grow the market for new technologies and product development for zero net energy homes.

- MassSAVE in coordination with the MA Energy Efficiency Advisory Council should

According to the U.S. Department of Energy, the average single-family home in New England uses about 165 MMBtu per year; in comparison, the energy demand of a New England Energy Star home, or a home that has undergone readily achievable energy efficiency upgrades, would be closer to 90 MMBtu per year.

Residential Case Study: Existing Building – Deep Energy Retrofit, Arlington, MA

When their duplex needed a new roof and siding, Alex Cheimets and his condo mates decided to make a long-term investment in energy efficiency, opting for "super-insulation" of the 3,200 sq/ft Arlington home. With six inches of solid foam insulation on the roof (R-58) and four inches on the exterior walls (R-40), this home is only one of a handful of super-insulation retrofit projects in the U.S.

At a cost of approximately $90,000, the renovation wasn't cheap. However, an innovative public/private collaboration between MA DOER, NSTAR, and a group of product sponsors helped make the retrofit possible—through energy modeling, rebate, and grant/in-kind support. The "Arlington House" has become an important pilot project for deep energy retrofit, providing a critical learning opportunity for the future of super-insulation in Massachusetts.

Photo credit: Alex Cheimets

In addition to the insulation, the entire building envelope was tightened with air sealing, new doors, and thermally stable fiberglass framed double-pane Low-E windows. Air quality is ensured with the installation of CO sensors and heat recovery ventilators which exhausts stale air, and warms incoming fresh air. As a pilot project, both DOER and NSTAR will monitor the building performance by tracking fuel consumption as well as temperature and humidity.

Although super-insulation of the Arlington house was expensive, typical siding and roof replacement would have cost an estimated $50,000. The additional investment of $40,000 to super-insulate is expected to reduce energy use in the home by 70 percent, resulting in an estimated annual cost savings of between $2,500 - $4,000, dependent upon the price of fuel.

At current market rates, the estimated additional cost of super-insulating (compared with only doing required regular maintenance) is $25,000 to $50,000 per home. Industry experts and policymakers agree that in the future, with energy efficiency mandates and the growth of the "green market," demand for super-insulated houses will increase, and competition will push down the cost of labor and materials.

develop and issue a zero net energy building performance monitoring protocol.

- Subsequently, the Commonwealth should develop a pilot "case study" program that identifies, monitors, and tracks (over a minimum period of five years) the ongoing building performance of selected zero net energy homes across the state. Energy usage and other factors (e.g. indoor air quality, durability, temperature, humidity etc.) must be closely monitored in a statistically valid sampling of projects by a variety of means, including data loggers.

Regulatory Incentives

R7 Develop and promote the adoption by municipalities of model zoning provision that addresses regulatory barriers to zero net energy homes. (Target implementation: January 1, 2010)

The Governor should direct the Executive Office of Energy and Environmental Affairs in coordination with the Executive Office of Housing and Economic Development to develop and encourage the adoption of model zoning that would:

- Allow wall insulation added to the exterior of existing structures to extend into otherwise required building set-backs.

- Implement Chapter 40A Section 9B ("Solar Access") in order to:
    - Encourage the use of solar energy systems and protect solar access by regulating the orientation of streets, lots, and buildings, maximum building heights, minimum building setback requirements, limitations on the type, height, and placement of vegetation, and other provisions; and
    - Provide for the issuance of special permits to protect access to direct sunlight for solar energy systems
- Exempt, with the exception of structures located within a historic district approved by a municipality pursuant to Chapter 40C ("Historic Districts"), glazing from window restrictions that inhibit optimization of solar design.

Financial Incentives

R8 MassSAVE Energy Efficiency Program administrators should expand the current home energy weatherization rebate program to promote incremental super-insulation retrofits of existing homes. (Target implementation: July 1, 2009)

- Current utility incentives should be expanded to apply to additional building envelope and efficiency improvements not currently eligible for rebates.
- Another rebate for consumers who undertake additional building envelope improvements should be established and made available based on building performance (criteria to be established) after a period of one-year from the date of the completed retrofit work.
- The Energy Efficiency Advisory Council should resolve to expand and continue incentives associated with deep energy retrofits for the 2010-2012 Utility Energy Efficiency Plans.

R9 Join with banks to co-sponsor a mortgage write-down program to finance deep energy retrofits with no change in mortgage payments. (Target implementation: January 1, 2010)

- The Governor should direct appropriate state agencies to work with banks and lending institutions to develop and co-sponsor a mortgage write-down program to provide state-guaranteed mortgage financing for energy-related improvements to existing buildings. (A similar idea was proposed by Architecture 2030 in December 2008.)

R10 Establish a residential zero net energy revolving loan fund, and investigate the feasibility of a zero net energy bond, to finance deep energy retrofits for existing homes. (Target implementation: January 1, 2012)

The following parameters are recommended for both a revolving loan fund and a bond:

1. Zero money down.
2. Monthly payment should be equal or less than 75 percent of average monthly savings.
3. Payment made through property service (i.e., water or energy utility).
4. Payment obligation assigned to property.

- The loan fund should be managed by a quasi-state agency such as MassDevelopment.
- In addition, the EOAF, EEA, in coordination with MassDevelopment, and MassHousing, should investigate the feasibility of a "zero-net energy bond" for residential retrofit financing. The residential bond could be set up to have a payback term of ten to twenty years.

Recommended Standard for State-Owned Construction

The Task Force recommends adoption of the following combined prescriptive, performance, and commissioning standards for state-owned construction or major renovation projects. For state buildings, this standard would supersede only the energy components of the Massachusetts LEED Plus standard; all non-energy sections of the Massachusetts LEED Plus standard would still apply. In addition, all applicable requirements of the current State Building Code (780 CMR) regarding energy efficiency would continue to remain in effect, as well as any updates or revisions. The Task Force recommends an effective date of **July 1, 2009** (except as noted) for this new energy standard for all projects that complete the study phase following this date.

The interim standard recommended for state managed construction projects is based on an accelerated adoption of the performance based standard recommended for the commercial sector. This standard would be in place until statewide adoption of the commercial standard, at which time a review committee would determine whether a new, more stringent standard would be feasible and appropriate. Additionally, the state standard includes other components that make it one of the most aggressive in the nation, most notably the minimum renewable energy requirement and the regular re-commissioning of all buildings.

NBI Core Performance Standard

The Core Performance Requirements are designed to achieve significant, predictable energy savings in new commercial construction by specifying performance in the following categories:

1. Air barriers
2. Indoor air quality
3. Below grade exterior insulation
4. Opaque envelope
5. Fenestration
6. Lighting controls
7. Lighting power density
8. Mechanical equipment efficiency
9. Dedicated mechanical systems
10. Demand control ventilation
11. Domestic hot water efficiency
12. Outside air economizers

(*http://www.advancedbuildings.net/corePerf.htm*)

S1 Adopt a prescriptive standard applicable to the new construction or major renovation of state buildings.

The prescriptive standard should require conformance with each of the following elements.

- Design and construct the building to meet the prescriptive requirements of the current version of the National Building Institute's Core Performance Standard. Specifically, design and construction should adhere to the requirements of Section 1 - Design Process Strategies, and Section 2 - Core Performance Requirements, except when in conflict with any other recommendation in this section. In such cases, the recommendations in this report should be adhered to. Adherence to Section 3 - Enhanced Performance Strategies should be considered, but should not be required.
- Optimize building orientation and configuration to maximize daylighting, passive solar exposure, natural ventilation, site shading and other passive climatic responsive features. However, projects should be exempt from this requirement if they can demonstrate that site constraints eliminate opportunities for orientation benefits.
- Meet specifications to be developed by July 1, 2009 by Division of Capital Asset Management (DCAM) and DOER for solar-ready roofs and structures.

- Meet minimum renewable energy generation requirements as follows:
    - All new construction and major renovation projects that enter into the formal design stage after July 1, 2009 should seek to ensure that at least 5 percent of the project's projected electricity consumption, or 5 percent of the projected thermal energy consumption, or any combination thereof (e.g., 2 percent of electricity and 3 percent of thermal), is derived from onsite renewable energy systems.
    - Periodic review and modification of the minimum renewable energy requirement such that by 2030 all new construction and major renovation will result in a zero net energy building (i.e., 100 percent of onsite energy demand will be met using renewable energy systems). The first review should occur no later than 2015.
    - If economic, technical, site-related, or strategic issues suggest that the required onsite renewable energy system is not warranted as an integrated building design component, the client agency should have the option of satisfying this requirement through the installation of a system of equal size at another of its own facilities or sites, within a reasonable time-frame following building occupancy.

S2 Adopt a performance standard by building type based on the U.S. Department of Energy "Commercial Building Benchmark Models" for all new construction and major renovation projects.

- Adoption of this performance standard would require the state to immediately work with the U.S. DOE to identify the latest kBtu targets for specific building types, resulting in energy performance improvements of approximately 30 percent over a building built to comply with the latest ASHRAE standards. These targets shall be established for all projects that are in or have not yet begun the study phase as of July 1, 2009.
- For project types not addressed by the DOE model, DCAM shall use similar building types to develop a target performance metric based on similar building targets and actual square footage associated with different building uses.

S3 Install advanced metering in new state buildings and state buildings that undergo major renovation.

In conjunction with the prescriptive and performance standards for new state buildings and state buildings that undergo major renovation, all projects should be required to enable the tracking, measurement, and easy retrieval of energy and water consumption data on no less than a monthly basis using a standard reporting template developed by DOER. Building level metering should be required for all energy use, including electricity, natural gas, fuel oil, steam, chilled water, and/or renewable power, as appropriate, as well as for water consumption and wastewater, although exceptions could be allowed on a case-by-case basis. This metering shall be enabled to report electronically either through the EMS system, or through another means. In multi-tenant buildings, sub-metering by tenant space should be required. End use sub-metering in large facilities is recommended, but should not be required.

S4 Verify and report energy performance.

All state-owned projects should publicly report energy and water consumption on an annual basis to DCAM and Leading by Example Program staff. In addition, new and existing state buildings should be required to display the same "Energy Certificate" required for commercial buildings (see Recommendation C6).

S5 Require commissioning and re-commissioning of buildings.

All projects should incorporate independent third party commissioning as part of the design and construction process. Commissioning should further confirm that appropriate training of operating personnel and building occupants has been completed. In addition, these projects should undergo a near-end-of-warranty period review and should be re-commissioned after five years of occupancy and every five years thereafter, unless it can be demonstrated that building energy

consumption is less than the original target. When building energy performance data indicate significant underperformance relative to the design goal prior to a five year milestone, the building should be prioritized for early re-commissioning.

S6 Provide training for building operators and occupants.

Project managers should ensure that the project design and construction team conduct appropriate training of building operations personnel. Additionally, DCAM's facility maintenance unit or another designated entity should train building occupants in energy conservation practices upon initial occupancy and periodically thereafter, but no less frequent than every 24 months.

S7 Conduct regular reviews of standard implementation.

A permanent committee comprising representatives from DCAM, DOER, EEA, as well as private sector, non-governmental and other stakeholders should be established to monitor the ongoing implementation of the standard for state-owned buildings. The Task Force recommends that:

- The Committee immediately initiate a comprehensive review of the Massachusetts LEED Plus standard to determine whether consolidation or other modification of the standard is warranted. As part of its duties, the committee should track changes to reference materials that would necessitate updates to the standard.
- The Committee shall perform an initial review of the standard's implementation experience and effectiveness prior to January 1, 2012 and every three years thereafter.
- The Committee shall determine whether this standard shall continue to apply after the commercial standard has become effective, whether state government should adopt the commercial standard for its construction projects, or whether another more appropriate, more stringent standard shall become the new standard for state government projects. Such recommendations shall be based on an analysis of feasibility, costs, and the continuing objective of leading by example. All findings and recommendations shall be made public.

S8 Recommend a new standard for state-funded projects.

- The Committee shall make recommendations regarding the applicability of this or another standard for all construction projects that receive more than 20 percent of their funding from state funds as of January 1, 2012.

Recommendations for State-Owned Demonstration Projects

In response to the Governor's request that the state develop "specifications" for the design and construction of the first public sector zero net energy building, the Task Force reviewed 80 planned projects, including new construction and major renovations, at agencies and higher education campuses that were at various stages of design. To evaluate the most appropriate projects for possible ZNEB demonstration, the Task Force used the following criteria:

- Client motivation
- Design team capability
- Achievability
- Project replicability/transferability
- Onsite renewable energy potential
- Schedule
- Project visibility/educational opportunities
- Budget
- Location

In recognition of the difficulty of actually building a zero net energy building, the Task Force decided to select three possible zero net energy projects in different parts of the state, each of which is a different size and will have different end uses. With three different design teams assigned to these projects, the Task Force recommends that DCAM learn as much as possible about zero net energy strategies in these projects, even if they all do not fully achieve zero energy status.

The three projects selected include:

- Division of Fisheries and Wildlife Headquarters, Westborough, MA
- North Shore Community College, Health and Student Services Building, Danvers, MA
- Lowell Trial Court, Lowell, MA

See pages 32 to 34 for more information on project details and preliminary analyses.

In selecting these three projects the Task Force is interpreting the meaning of "specifications" as a definition of the building scope developed at the initiation of the study phase of a project. Based on this interpretation, the three recommended demonstration projects meet the Governor's charge that the state issue specifications for the first, state-owned zero net energy building by January 1, 2010.

The Task Force further recommends that these projects proceed in accordance with the following principles and requirements:

Funding

DCAM should ensure that the available funding supports the projects' goals, including project design needs. To reach zero net energy, specific design services that are critical to project success must be

Massachusetts Maritime Academy onsite renewables: wind 660 kW, solar PV 82 kW

incorporated, including additional modeling and lifecycle cost analysis.

Project Documentation and Evaluation

- Each demonstration project process should be carefully and thoroughly documented by an independent third party throughout the planning, design, construction, and post-occupancy stages and a final report should be created for each major phase of the project.
- Because the demonstration projects are at different stages in their development, any completed steps should be retroactively reviewed and documented to identify any necessary project modifications.
- Regular progress reports should be required throughout the construction process.

Third Party Peer Review

- Industry experts should be retained to review design and construction documentation at critical project stages.

Training

- Each project should require a Facility Operations and Management Plan (FOMP) that includes training for building occupants and facility managers.

Post Occupancy and Data Gathering

- A post-occupancy study of measured building energy use should be required three years after project completion. At a minimum, the study should evaluate each building's energy use in comparison to the modeled projections and to comparable buildings. This is in addition to the annual measurement and reporting of building energy use as stated in Recommendation S4.

Measurement and Verification Systems

- The demonstration projects must have measurement and verification systems designed in the building to get more refined energy use data (i.e., a sophisticated building management system (BMS)).

State Demonstration Project Analysis

Project #1: Division of Fisheries and Wildlife Headquarters

Project Location: Westborough

Building Use: Office/light labs

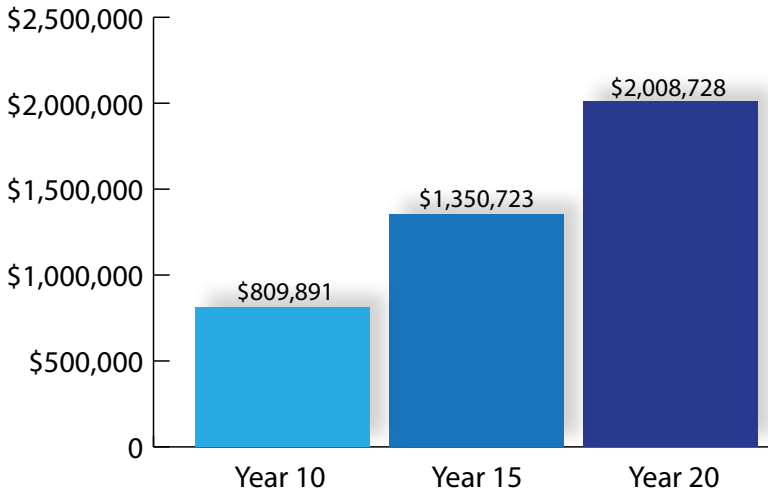
Building Type: Two-story rectangular

Building Size: 34,000 gross square feet

Project Status: The study phase has been extended to June 1, 2009 in order to better understand the ramifications of designing to a zero net energy standard.

The existing building, formerly known as the Overlook Cottage and part of the Lyman School for Boys, is sited at the high point of the campus along the north end of the developed area. The current proposed scheme calls for extensive site work, linking the development to the resources of the adjacent 1,000 acre Management Area; a significant renovation of the existing 13,000 square foot building; and the construction of a new 34,000 square foot building.

Long-Term Energy Costs: DFW Headquarters



The preliminary budgetary analysis (see chart) shows that an efficiently designed building that achieved an energy rating of 75 from the U.S. EPA's ENERGY STAR Target Finder tool would result in an approximate annual energy budget of $67,000 per year. Over 20 years, using a modest 4 percent energy cost increment, the total energy costs could equal more than $2 million. Assuming the strategies employed will be in place for 20 years and cost less than the total energy outlays, the up-front cost of the zero energy component of the project demonstrates a justification of public investment. Additional benefits accrue from more stable energy costs over time and increased savings if energy costs rise at a faster rate than projected.

Many 'green' strategies are being investigated for this project, including:

- mixed mode ventilation schemes incorporating natural ventilation and under floor air distribution
- geo-thermal heat pumps
- high performance building envelope
- storm water collection systems
- onsite photovoltaic power generation

Project #2: North Shore Community College Health and Student Services Building

Project Location: Danvers

Building Use: Nurse Education, Animal Science, Student Services

Building Type: Three-story rectangular

Building Size: 58,700 gross square feet

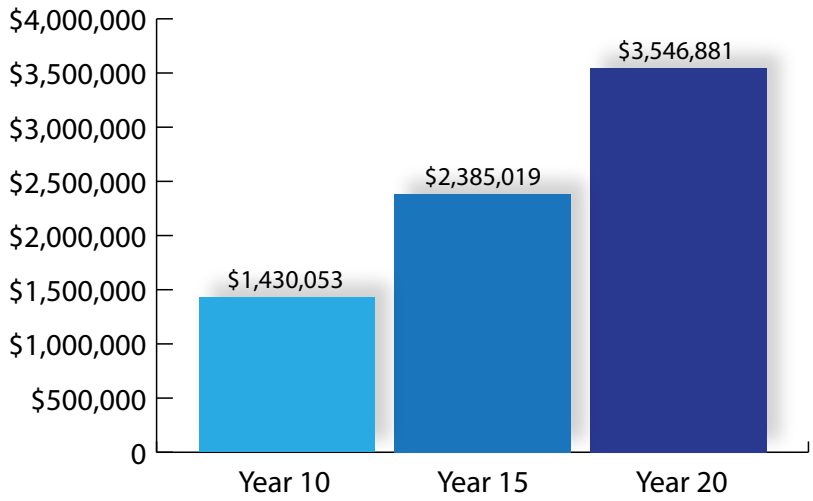
Project Status: Design Phase

North Shore Community College (NSCC) proposes to build, and open by 2011, a new 58,700 GSF building on its Danvers Campus for an estimated construction cost of $24 million. The new three-story, LEED-Certified facility will consolidate the College's Health Profession programs currently dispersed on the Danvers and Essex Aggie campuses. The new facility will also allow NSCC to reconfigure their current Enrollment Services Center and the Student Support Services into a more "student-centered" setting.

North Shore Community College and the Division of Capital Asset Management are already committed to developing a sustainable project to the greatest extent possible.

Initial analysis shows that energy costs associated with a building built to the ENERGY STAR standard (a rating of 75 from the ENERGY STAR Program) would cost approximately $119, 000 annually to heat, power, and cool. The long term energy costs rise to over $3.5 million over 20 years, assuming a 4 percent annual increase in energy costs. Thus, should the design elements below total less than the building's long-term energy costs, then the up-front capital required can be justified for its long-term benefit. Should energy prices rise at a faster rate than 4 percent, these benefits only increase.

Long-Term Energy Costs: NSCC Health Building



Efficiency and renewable strategies currently under consideration include:

- geothermal vertical closed loop system
- roof-mounted solar photovoltaic system
- energy efficient mechanical and electrical systems
- enhanced building envelope design
- solar thermal wall system to passively heat and cool the south facing façade
- natural ventilation of public spaces, such as the lobbies, corridors, and common spaces
- use of computational fluid dynamics to simulate air flows throughout the building to help the team properly integrate measures in the final design

Project #3: Lowell Trial Court

Project Location: Lowell

Building Use: Courthouse

Building Type: Seven-story cube design

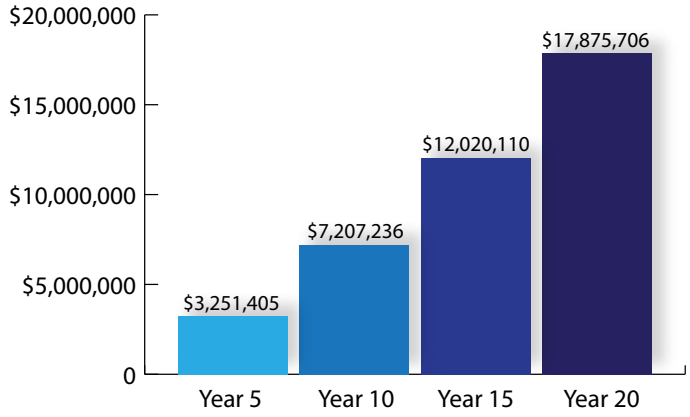
Building Size: 240,000 gross square feet

Project Status: Late Study Phase

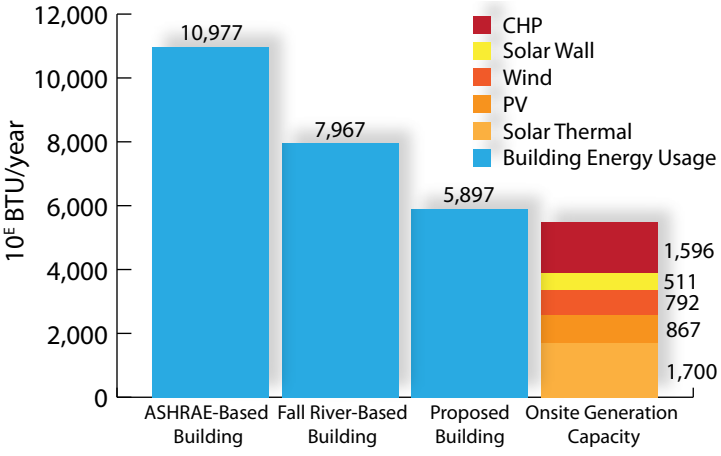
The 3.3-acre site for the new Lowell Judicial Center is located in the historic Hamilton Canal District of Lowell. The courthouse will consolidate five court divisions from several buildings into a single 240,000 square foot building. The total project cost is currently budgeted at $175 million.

Based on an assumption that a new courthouse would achieve an energy rating of at least 75 from U.S. EPA's ENERGY STAR Program before any zero net energy strategies were applied, it is estimated that the energy costs to operate the building would equal approximately $600,000 per year. Using a modest 4 percent annual energy cost increase, these costs total approximately $7 million over 10 years and almost $18 million over 20 years. If the strategies employed will be in place for 20 years and cost less than the total energy outlays, the upfront cost of the zero energy components of the project demonstrates a justification of public investment.

Lowell Court House Projected Energy Costs 5 to 20 Years



Design Team Feasibility Analysis of Achieving Zero Net Energy



The design team is currently evaluating a number of strategies designed to reduce the building's energy usage and incorporate onsite renewable power to the greatest extent feasible. Potential strategies include:

- building massing and orientation
- efficient envelope design
- daylighting control and LED light fixtures
- natural ventilation and winter gardens
- building management systems
- chilled beams and ground source heat pumps
- solar vacuum tube collectors & solar preheating of fresh air
- photovoltaics and wind turbines
- biomass fuel for a combined heat and power system
- hydroelectric power from the adjacent canals

Using many reduction strategies, the initial computer modeling indicates a preliminary reduced total annual energy use of 5,897,000 kBtu, or 25 kBtu/sq ft/yr. This would represent a 46 percent energy use reduction from the base established by ASHRAE 90.1-2004. The analysis currently underway indicates that 93 percent of this energy demand could be provided by renewable sources. The team is working to identify additional improvements and/or onsite power generation that could make up the difference.

Workforce Development, Technology Development, and Education Recommendations

Workforce Development

In addition to educating the current marketplace, implementation of many of the Task Force's recommendations will be critically dependent upon the large-scale expansion of key segments of the local, technical workforce, as well as an aggressive program to educate the current building industry workforce in its entirety, including regulators and the regulated, about new Massachusetts requirements and the strategies and tools available to meet them. This effort should build upon the many existing outreach and training programs provided by public, private, and non-profit institutions in Massachusetts.

W1 Support Home Energy Rating System (HERS) Rater training. (Target implementation: January 1, 2010)

To ensure the broad implementation of the Massachusetts Home Energy Scoring System and deep energy retrofits, increasing the number of certified HERS Raters in the Commonwealth is essential (currently, there are fewer than fifty certified HERS Raters working in the state). HERS Raters are home energy analysts who work with builders to identify energy efficiency improvements and provide third-party commissioning of homes. Their work can be as limited as simply generating a HERS Index for a particular home or as broad as helping the builder develop and evaluate a range of strategies to achieve a particular performance improvement.

- The state should sponsor training programs to grow the pool of certified HERS Raters in Massachusetts. This HERS Rater training should be included in the Massachusetts Clean Energy Technology Center's Energy Efficiency Skills and Innovation Initiative.

W2 Provide state-supported training and licensure for a sufficient number of energy assessment and auditing professionals. (Target implementation: January 1, 2011)

By 2012, the Commonwealth should ensure the training and licensing of sufficient numbers of energy assessors and auditors for commercial and residential buildings necessary to fulfill the goals of this report. The Task Force specifically recommends that the Governor direct:

- The Massachusetts Board of Higher Education in collaboration with the Department of Workforce Development, by not later than 2010, to create a building energy assessment curriculum within the state's public college and university system;
- The Office of Consumer Affairs and Business Regulation's Division of Professional Licensure, by not later than 2011, to develop a licensing and quality assurance program for building energy raters for both commercial and residential buildings; and
- The Division of Professional Licensure to waive licensing fees for the first 1,000 qualified building energy assessors and should make financial resources available to cover no less than 50 percent of the anticipated education and training expenses for at least 1,000 prospective building energy assessors.

W3 Provide state-supported training and licensure for a sufficient number of solar and other renewable energy system installers. (Target implementation: January 1, 2011)

- By 2011, the Commonwealth should institute a professional licensing requirement for installers of solar and other renewable energy systems and should establish a program to increase the number of licensed installers in Massachusetts.

Nine states, not including Massachusetts, currently have this type of licensing requirement. The North American Board of Certified Energy Practitioners provides a suitable foundation for this requirement, and should be supplemented with a state-specific component, as appropriate.

W4 Develop state-supported training programs to increase the number of energy efficiency service providers and weatherization specialists. (Target implementation: January 1, 2010)

- The state should direct and support coordinated training programs that link the MassSAVE Program and the state's technical high schools and community colleges, through curriculum development and apprenticeships, to expand the number of energy efficiency and weatherization providers in Massachusetts.

W5 Develop a comprehensive continuing education and training program for the Massachusetts building industry and regulatory authorities. (Target implementation: January 1, 2011)

- The Commonwealth should partner with representatives of all relevant building-related organizations, state regulatory bodies, and local public and private universities, to develop a comprehensive and appropriately segmented continuing education and training program designed to provide the information necessary to support and accelerate the successful implementation of the Task Force's recommendations across all professions associated with the design, construction, energy efficiency, management, operation, and regulation of residential and commercial buildings.

Technology Development

Building energy technologies should be a central element in the strategy to establish Massachusetts as global leader in clean energy research, development, manufacturing, and services.

T1 Emphasize building energy technology in the mission of the Clean Energy Technology Center. (Target implementation: January 1, 2010)

- The Governor should direct the Board of the Massachusetts Clean Energy Technology Center to make building energy technologies a central element of its research mission. By doing so, the Center could foster and integrate research and development of advanced technologies, including but not limited to, measurement systems, windows, HVAC systems, and controls integrated with renewable sources, among industry, academia and other research organizations.

T2 Support the growth of a Massachusetts technology sector focused on energy measurement and controls. (Target implementation: January 1, 2010)

- The Governor should direct the Office of Business Development to develop a program to recruit and support companies focused on the development of new building energy measurement, efficiency, and control technologies.

T3 Promulgate Massachusetts-specific energy efficiency standards for common commercial and residential appliances. (Target implementation: January 1, 2011)

- To address plug loads, the Governor should direct DOER to promulgate new regulations covering appliances that are not currently scheduled to be addressed through the federal efficiency standards development process.

Education

The broad dissemination of information and training on building energy use, in particular the technologies and practices currently available to achieve significantly improved energy performance, will be a critical element of any strategy to move toward zero net energy.

E1 Develop and disseminate a consumer guidance document. (Target implementation: January 1, 2010)

- DOER should develop and disseminate a consumer guidance document for homeowners outlining the minimum known ZNE best practices, including specific technologies and products (e.g. windows, ventilation equipment), design strategies, building techniques, and available resources such as consultants and raters. This guidance document would provide homeowners with a basic understanding of the requirements of a zero net energy home and deep energy reduction retrofit including such areas as all-sealed combustion, outside venting, indoor air quality monitoring.

E2 Develop a statewide zero net energy marketing campaign. (Target implementation: January 1, 2011)

- The Governor should direct the appropriate state agencies to develop a statewide zero net energy marketing campaign targeting residential consumers. This marketing strategy should inform consumers about incremental zero net energy strategies as well as the Massachusetts Home Energy Scoring System, helping to create understanding and buy-in among Commonwealth residents.

E3 Require elementary and secondary schools to teach students about building performance. (Target implementation: September 1, 2010)

- The Governor should direct the Department of Elementary and Secondary Education to immediately begin the process of revising the Science and Technology / Engineering Curriculum Frameworks to expand and enhance the teaching of building performance and renewable energy concepts at each grade level.
- The Commonwealth's K-12 school curriculum should also include a unit that teaches the MA Home Energy Scoring System; breaks down the energy score for each household, explains the reason for the score, and identifies what resources supply the energy.

E4 Identify, validate, and publicize project exemplars that demonstrate the potential for ZNEBs and high performance across all building types. (Target implementation: January 1, 2011)

- DOER should identify, validate, and publicize project exemplars for each of the several commercial building types within Climate Zone 5A, especially those in Massachusetts.
- DOER should maintain and host on its website a statewide "ZNE Homes Database" of exemplary projects with particularly low HERS scores and measured energy consumption. This database would identify the architects, engineers, and contractors who are setting the standard and achieving zero net energy homes. The ZNE Homes Database could also include a knowledge-base section with design and construction details, photos, videos, and documented energy usage of high-performance homes. In addition, the database would be a centralized resource to identify and link practitioners who can work with ratepayer-funded energy efficiency programs and develop plans for new construction projects or scopes of work for retrofits. Finally, creating a ZNE Homes Database provides an opportunity to track works in progress enabling the Executive Office of Labor and Workforce Development in conjunction with NARI, NAHB, NESEA, and ACI to utilize work sites as hands-on classrooms for green jobs training.
- DOER should engage consultants to verify actual performance of exemplary commercial building projects and to develop case studies based on the AIA/COTE Top 10 Green Buildings format and LEED for Homes Green Building Rating System.
- The Governor should direct appropriate organizations to collaborate in launching an annual state-wide energy efficiency awards program for new construction and major renovations. (These organizations might include the local chapters of the American Institute of Architects, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, National Association of Building Owners and Managers Association, National Association of Industrial and Office Parks, New England Women in Real Estate, Urban Land Institute, Associated General Contractors, Northeast Sustainable Energy Association, and U.S. Green Building Council.)
- State investments in research and pilot projects are needed to help identify strategies and techniques to bring down the cost of residential retrofits. The MA Energy Efficiency Advisory Council should work with DOER to develop a scope and then allocate R&D funding to conduct a range of cost-benefit-analysis and research best practices of incremental deep-energy retrofit approaches such as super-insulation, including re-roofing and re-siding.

Coordinated Implementation

Implementation of the Zero Net Energy Buildings Task Force's recommendations will require careful analysis, coordination, and monitoring to ensure cost-effectiveness as well as adaptability to changing economic and technical circumstances over the next two decades. The Task Force believes that the best way to achieve these objectives will be through the immediate creation of an Office of Building Energy Performance through which all relevant activities can be coordinated. Since implementation will also require maintenance of a strong public-private partnership, a Zero Net Energy Building Advisory Board, comprising representatives from across the public, private, and non-profit commercial and residential building communities, should also be established, with a specific mandate of keeping Massachusetts at the leading edge of building energy technologies and practices. Together, the Office and Advisory Board would manage a portfolio of initiatives, including but not limited to:

Performance standard review and update

Central to the Task Force's recommendations are commercial and residential performance standards for new construction and major renovations. The Office and Advisory Board should be responsible for managing the process of reviewing and updating the standards over time in order to ensure that the Commonwealth continues to move aggressively on the pathway toward universal adoption of zero net energy design and construction practices.

Data collection and management

Key to the successful implementation of Task Force recommendations, and to achievement of energy performance objectives, will be the accuracy and availability of energy performance data. The Office and Advisory Board should be responsible for ensuring, in collaboration with utility providers and other parties, the development of necessary data collection protocols as well as for conducting regular data reviews and generating reports that highlight areas of progress as well as deficiency.

Incentive development and refinement

The Task Force's recommendations for financial and regulatory incentives are the result of careful consideration of a range of potential strategies and describe the approaches that would be expected to have the maximum desired effect. At the same time, the recommendations remain somewhat conceptual, and require additional analysis to ensure that their implementation would be cost-effective and would not produce any unintended results. Therefore, the Office and Advisory Board should take a lead role in providing to the incentive development process the necessary information and analytic support.

Professional education and training

Achievement of the Commonwealth's building energy performance goals is dependent upon education, outreach, and training programs that are as deep as they are broad. It will not be sufficient to have narrow segments of the architecture, engineering, and construction communities capable of delivering buildings at the highest levels of performance—each of the relevant communities, in their entirety, must be provided with the information and training necessary to guarantee an appropriate level of expertise for every building project. Similarly, the scale of the building energy-related workforce must expand dramatically. Fortunately, the foundation of a significant workforce development initiative—including non-profit entities, trade associations, and state higher education institutions—is already in place. The Office and Advisory Board should serve to coordinate and rapidly expand the necessary education, outreach, and training programs.

Public outreach

Over the next several years, the number of exemplary commercial and residential buildings, both newly constructed and retrofitted, can be expected to grow at an increasing rate. Making the public aware of these achievements will go a long way toward accelerating the understanding and acceptance of the possibilities and benefits of zero net energy construction. The Office and Advisory Board should take a leading role in developing and disseminating case studies and in publicly recognizing the most outstanding examples of building energy performance in the Commonwealth.

Conclusion: Getting to Zero

The road ahead toward zero net energy buildings is a challenging one, but one that must be traveled. The environmental and economic imperative of reducing energy use, while also making our necessary energy supplies cleaner and more reliable, is beyond dispute. Equally important to the Commonwealth is the imperative of job growth and economic development. By focusing on transforming our building sector, Massachusetts can address both of these imperatives and demonstrate innovative and necessary leadership for the nation and the world.

The preceding recommendations put forth by the Massachusetts Zero Net Energy Buildings Task Force attempt to establish a pathway that will lead to the universal adoption of zero net energy buildings and deep energy reduction retrofits throughout the Commonwealth by 2030. The Task Force believes that through a comprehensive set of policies, mandates, and programs, Massachusetts can dramatically improve building performance, reduce regulatory and financial barriers, unleash the market for technology and design innovation, bolster the state's burgeoning renewable energy sector, provide the necessary education to foster an energy-literate public, and initiate training to advance industry professionals and create tens of thousands of new "green" jobs.

It is abundantly apparent that the prospect of deep energy reduction in all buildings is substantial, warranting Massachusetts to set a bold course for zero net energy targets. As this report highlights, across the state the advent of zero net energy buildings is underway, particularly in the residential sector. These first projects are demonstrating the viability of zero net energy construction through considerable long-term energy cost savings. By adopting the recommendations in this report, Massachusetts can create the framework and business environment to expand zero net energy across all building sectors.

The Task Force believes, and as this report demonstrates, the opportunities of zero net energy construction and renovation can transform the Commonwealth, creating a prosperous future of innovation, economic development, much-needed cost and energy savings, and environmental stewardship. Governor Patrick has set the bar, and he has wisely set it high; now is the time for us to marshal our state's wealth of technological and human capital and demonstrate that no bar is too high for the visionary and capable people of the Commonwealth of Massachusetts. It is time to begin the work of *getting to zero*.

Glossary

AIA – American Institute of Architects

ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers

BBRS – MA Board of Building Regulations and Standards

BPI – Building Performance Institute

DCAM – MA Division of Capital Asset Management

DEP – MA Department of Environmental Protection

DHCD – Department of Housing and Community Development

DOE – U.S. Department of Energy

DOER – Massachusetts Department of Energy Resources

EEA – MA Executive Office of Energy and Environmental Affairs

EPA – U.S. Environmental Protection Agency

EOAF – MA Executive Office of Administration and Finance

EOHED – MA Executive Office of Housing and Economic Development

HERS – Home Energy Rating System

HVAC – Heating, Ventilation, and Air Conditioning

IECC – International Energy Conservation Code

KBTU – Kilo British Thermal Units

LEED – Leadership in Energy and Environmental Design

MEPA – Massachusetts Environmental Policy Act

MMBTU – One Million British Thermal Units

MRET – Massachusetts Renewable Energy Trust

NBI – New Buildings Institute

NREL – National Renewable Energy Laboratory

PV – Photovoltaic (solar panel)

RESNET – Residential Energy Services Network

R-Value – Insulation rating for thermal resistance

USGBC – U.S. Green Building Council

U-Value – Energy efficiency rating for windows

ZNEB – Zero Net Energy Building

Resources

Architecture 2030
http://www.architecture2030.org/

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
http://www.ashrae.org/

California Energy Efficiency Strategic Planning
http://www.californiaenergyefficiency.com/index.shtml

Communities and Local Government (United Kingdom)
http://www.communities.gov.uk/planningandbuilding/theenvironment/energyperformance/

Energy Information Administration
http://www.eia.doe.gov/

MA Board of Building and Regulations Standards
http://www.mass.gov/bbrs/

MA Department of Energy Resources
http://www.mass.gov/doer/

MA Division of Capital Asset Management
http://www.mass.gov/dcam/

MA Renewable Energy Trust
http://www.masstech.org/renewableenergy

MA Zero Energy Challenge (ENERGY STAR Homes Program)
http://www.massenergystarhomes.com/homebuyers/zeroenergy.htm

National Renewable Energy Laboratory – Buildings Research
http://www.nrel.gov/buildings/

New Buildings Institute
http://www.newbuildings.org/

Passive House Institute
http://www.passivehouse.us/passiveHouse/PHIUSHome.html

Residential Energy Services Network
http://www.resnet.us/default.htm

U.K. Green Buildings Council
http://www.ukgbc.org/site/home

U.S. Green Building Council
http://www.usgbc.org/

U.S. Department of Energy – Building Technologies Program
http://www1.eere.energy.gov/buildings/

U.S. Environmental Protection Agency – ENERGY STAR Program
http://www.energystar.gov/index.cfm?c=home.index

Appendix A: Participants

Zero Net Energy Buildings Task Force Members

Ian Bowles, Task Force Chair and Secretary
Executive Office of Energy and Environmental Affairs

David Cash, Assistant Secretary for Policy
Executive Office of Energy and Environmental Affairs

John Abrams, President
South Mountain Company

Lawrence Ambs, Professor
UMass Center for Energy Efficiency & Renewable Energy

Wagdy Anis, AIA, Principal
Wiss, Janney, Elstner Associates, Inc.

Mark Anstey, Engineer
Second Street Associates, LLC

David Barclay, Executive Director
Northeast Sustainable Energy Association

Barbra Batshalom, Executive Director
The Green Roundtable

Geoffrey Beckwith, Executive Director
MA Municipal Association

Ann Berwick, Undersecretary for Energy
Executive Office of Energy and Environmental Affairs

Alissa Bilfield
Department of Environmental Protection

Fran Boucher, Principal Engineer
National Grid

Laurie Burt, Commissioner
Department of Environmental Protection

Heather Clark, Director of Green Building
Winn Companies

Shanna Cleveland, Attorney
Conservation Law Foundation

Bruce Coldham, AIA, Partner
Coldham & Hartman Architects

Penni Conner, VP of Customer Care
NStar

Robert Culver, President & CEO
MassDevelopment

Hope Davis
MA Division of Capital Asset Management

Mike Davis
Bergmeyer Associates, Inc.

Jerry Dion, Research Supervisor
U.S. Department of Energy

Martine Dion, Senior Associate
Symmes, Maini + McKee

Lucy Edmondson, Deputy Commissioner for Policy
Department of Environmental Protection

Paul Eldrenkamp, Owner
Byggmeister, Inc.

Ken Fisher
Gensler

Robert Garrity, Executive Director
Mass Climate Action Network

Thomas Gatzunis, Commissioner
MA Department of Public Safety

Nathan Gauthier, Director
Harvard University Green Campus Initiative

Phil Giudice, Commissioner
Department of Energy Resources

Bryan Glascock, Director, Environment Department
City of Boston

Leon Glicksman, Professor
Massachusetts Institute of Technology

Cynthia Greene
U.S. EPA, Region 1

Debra Hall, Sustainability Program Developer
MA Dept. Housing and Community Development

Terry Hillery, President
The Hillery Holding Company

Jenna Ide
MA Division of Capital Asset Management

Chris Kaneb, Principal
Catamount Management Corporation

Leslie Kirwan, Secretary
Executive Office of Administration and Finance

Tom Massimo
Department of Environmental Protection

Richard Mattila, Director of Environmental Affairs
Genzyme, Corp.

Thomas May, CEO
NStar

John McBride
Commons Development Company – HBAM

Luke McKneally, Senior Project Manager
Solar Design Associates

Duncan Miller, Co-Founder
Heat Spring

William Moomaw, Professor
Tufts University

Margaret Neil, Director of Project Services
Consigli Construction

Craig Nicholson, Director of Sustainable Development
Ajax Partners

Michael O'Brien
Gilbane, Inc.

Daniel O'Connell (Former Secretary)
Executive Office of Housing and Economic Development

David Perini, Commissioner
Division of Capital Asset Management

Anne Perkins, Director, Home Ownership Program
Rural Development, Inc.

Robert Pratt, Senior Vice President
The Kendall Foundation

Thomas Riley
MA Board of Building Regulations and Standards

Deborah Rivers, Architect
Perkins + Will

Michelle Roberts, Principal & CEO
Chatham Hill Residential Design & Build, LLC/ NHBA

Marc Rosenbaum, Principal
EnergySmiths, Inc.

Carolyn Sarno, Senior Program Manager
Northeast Energy Efficiency Partnerships

Chris Schaffner, Principal
The Green Engineer, LLP

Jennifer Schilling
Western Mass Electric Company

Leith Sharp (Former Director)
Harvard University Green Campus Initiative

Rhonda Spector, VP Planning and Development
MassDevelopment

Marcus Springer, Director
Sasaki Associates

William Stillinger
Pioneer Valley Photovoltaics

Nathaniel Stinnett, Associate
DLA Piper

John Swift, Principal
Cannon Design

Bryan Urban
MIT-Fraunhofer Center for Sustainable Energy Systems

A. Quincy Vale, President
Powerhouse Enterprises

Robert Varney (Former Regional Administrator)
U.S. EPA, Region 1

Ellen Watts, Principal
Architerra, Inc.

Edward White
National Grid

Jeanne Wolf, Executive Director
Building Owners and Managers Association

Working Group Chairs

Paul Eldrenkamp, Residential Sector

Carolyn Sarno, Public Sector

Ellen Watts, Commercial Sector

Working Group Members

Richard Andre
Vineyard Energy Project

James Boyle
Sustainability Roundtable, Inc.

Michael Browne
Advanced Building Analysis

Emile Chin-Dickey
ZeroEnergy Design

Peter Fourtounis
DiMella Shaffer

David Fuller
DHCD – Weatherization Assistance Program

Mark Kalin
Kalin Associates

Lawrence O. Masland
Department of Energy Resources

Andrew Nicholls
Pacific Northwest National Laboratory

Edward Pollock
U.S. Department of Energy

Rick Reibstein
EEA Office of Technical Assistance

Michael Reinhardt
Division of Capital Asset Management

David Ruggiero
ICF

Mark Sevier
The Green Roundtable

Colleen Soden
The Green Roundtable

Steering Committee

Marc Breslow
Executive Office of Energy and Environmental Affairs

Janet Curtis
Department of Energy Resources

Paul Eldrenkamp, Residential Sector Chair

Eric Friedman
Department of Energy Resources

Elisabeth Krautscheid
Mass Renewable Energy Trust

Meg Lusardi
Department of Energy Resources

Carolyn Sarno, Public Sector Chair

Ellen Watts, Commercial Sector Chair

John Weiss, IEc Consultant

Additional State Personnel

Ian Finlayson
Executive Office of Energy and Environmental Affairs

Kurt Gaertner
Executive Office of Energy and Environmental Affairs

Technical Support

John Weiss,
Industrial Economics, Inc.

Sandra Grund
Industrial Economics, Inc.

Angela Helman
Industrial Economics, Inc.

Kara Lanahan
Industrial Economics, Inc.

Mark Price
Steven Winter Associates, Inc.

Report Design

Emily Dahl
Mass Renewable Energy Trust

Appendix B: Definition of Zero Net Energy Buildings

At its first meeting, the Task Force quickly recognized the need to answer the question, "What is the appropriate definition of a zero net energy building?"

In 2006, the Department of Energy's National Renewable Energy Laboratory (NREL) established the basic framework within which a building could be classified as "zero net energy." This framework includes four definitions which differ by boundary and metric. In general:

- **Zero net site energy** buildings produce at least as much energy as they use in a year, when accounted for at the site.
- **Zero net source energy** buildings produce at least as much energy as they use in a year, when accounted for at the source (i.e., the primary energy needed, for example, to generate and deliver electricity to the site).
- **Zero net energy cost** buildings receive payment from a utility, for energy exported from the site to the grid, that is at least as much as the payments made to a utility for energy use over the course of a year.
- **Zero net energy emissions** buildings produce at least as much emission-free renewable energy as they use from emissions-producing energy sources. Since the primary building-related emissions concern is carbon dioxide or other greenhouse gases, this definition is commonly used for zero carbon buildings.

It is important to keep in mind that the goal is zero net energy, since most buildings will be dependent upon grid-supplied energy for some of their needs, and that the "building energy" used to net out energy from the grid should derive from the use of renewable resources.

The Task Force reached consensus that zero net site energy is the appropriate definition for the state to adopt as it moves forward, as it is the easiest to measure and the most intuitive, and thus the easiest to communicate to the public. However, the Task Force also recognized that there is a difference between applying this definition to a single building and applying it to the building stock in Massachusetts. At the latter scale, it quickly becomes apparent that it may not be feasible for many buildings to achieve a verifiable zero net energy state, even if it is possible to make dramatic improvements in the energy performance of nearly any building along the continuum that ends with achievement of the zero net energy goal. Therefore, in order to ensure that the implementation of its recommendations would have the maximum possible impact in terms of reduced energy use and reduced GHG emissions, the Task Force concluded that it should recommend adoption of both an "aspirational" definition and a practical alternative, as follows:

A zero net energy building is one that is optimally efficient and, over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite. The Task Force recognizes, however, that currently, and even by 2030, a number of buildings will not be able to meet the definition of zero net energy for technological or economic reasons (or both). Therefore, the Task Force strongly recommends that where zero net energy is not feasible, buildings in Massachusetts should reduce energy loads to the minimum practical level, produce onsite as much of the required energy as reasonable from renewable resources, and purchase regionally-generated renewable energy to satisfy remaining needs.

The Task Force recognizes that this statement introduces several terms that require additional specification. First, both the aspirational definition and practical alternative place a clear emphasis on efficiency—that is, minimizing a building's energy demand—before consideration of renewable energy production opportunities. Too often, load minimization is not sufficiently emphasized during construction projects, leaving unrealized what is often a significant opportunity for additional energy savings. The recommendations provided in this report address the issue of what the "minimum practical level" should be for different types of buildings.

Second, when reference is made to "renewable" energy, additional definition is required. A building will most often achieve zero net site energy through the addition of solar photovoltaic or solar thermal technology to the building or to the building site. However, in some circumstances other technologies will be both technically and economically feasible. The definition of what "counts," per state regulation, toward satisfaction of the state's renewable portfolio standard (RPS) should serve as the guide to appropriate renewable energy resources in the zero net energy building context. Whenever the issue remains in question, the default should be to promote the most environmentally benign solution. For example, biomass consumption for heat or power at a building site should preferentially rely on a feedstock that is grown and harvested sustainably.

Third, given that many buildings and building sites will be limited in their capacity to incorporate renewable energy technology on a meaningful scale, the Task Force discussed the meaning of the term "onsite" and whether, and if so how, the pursuit of zero net energy buildings should support the broader development of renewable energy resources. The Task Force is sensitive to the need to encourage maximum exploitation of the state's and the region's renewable energy resources, but also wants to ensure that reaching the goal of zero net energy buildings will provide benefits that are in addition to those that would likely occur anyway (e.g., through the RPS). Therefore, both the aspirational goal and the practical alternative emphasize a preference for onsite energy production, whether it is building-integrated or co-located within a site boundary. Note that the site boundary can be somewhat loosely defined for this purpose; any renewable energy generation that is physically connected to a building should be considered "onsite."

At the same time, the path to zero net energy buildings should not exclude direct support for renewable energy generation that is not physically connected to a building, so the Task Force includes in its practical alternative recognition of the value of purchasing energy from regional sources. When this is the best option available, the Task Force recommends adherence to two principles. First, there should be a strong effort to limit the scope of what is considered "regional." While it is beneficial, from a societal viewpoint, to support any cost-effective development of renewable energy resources, the preference in this context should be to support the development of Massachusetts resources in order to maximize positive economic impacts. Second, purchases of renewable energy should be limited to actual energy delivery and should not include the purchase of renewable energy certificates or other credits to "offset" energy use. Again, while these products serve a very useful purpose, the goal of promoting zero net energy buildings is not to encourage an accounting exercise that achieves "zero net" by any means, but rather to realize the benefits of energy savings and production that would not otherwise occur.

Finally, the practical alternative incorporates a "reasonableness" test, based on the recognition that renewable energy is not always the best option for a building or building site. For example, it may be technically possible to cover an entire building with solar photovoltaic modules but it may not be reasonable to do so. A more cost-effective approach might be to dedicate a portion of the roof to solar energy generation and to invest more resources in additional energy efficiency improvements.

Appendix C: Related Initiatives

The promotion of low to zero net energy buildings is occurring locally, nationally, and internationally.

State and Federal Initiatives

The California Energy Commission's 2007 Integrated Energy Policy Report, recommended an increase in building efficiency standards so that, "when combined with onsite generation, newly constructed buildings can be net zero energy by 2020 for residences and by 2030 for commercial buildings." The California Public Utilities Commission (CPUC) subsequently issued a decision in which it adopted, among other things, three programmatic initiatives: (1) all new residential construction in California will be zero net energy by 2020; (2) all new commercial construction in California will be zero net energy by 2030; and (3) the heating, ventilation, and air conditioning (HVAC) industry will be reshaped to ensure optimal equipment performance. The CPUC decision also directed the state's investor-owned utilities (IOUs) to develop a strategic plan (completed in September 2008) as a first step in a new, long-term, statewide energy efficiency planning effort. That plan describes, in some detail, "a broad series of actions toward zero net energy new buildings and very low energy existing buildings . . . to set a high bar that energizes market players and other stakeholders to focus on transformational approaches."

The U.S. Department of Energy's Building Technologies Program works in partnership with states, industry, and manufacturers to improve the energy efficiency of U.S. buildings through new technologies and systems-engineered building practices. The program's goal is to transform how the approximately 15 million new buildings projected to be constructed by 2015 are designed, built, and operated. In particular, the Department's Net-Zero Energy Commercial Building Initiative mandated by Congress in the Energy Independence and Security Act of 2007, provides coordination of public and private partners working toward the goal of cost neutral net-zero energy buildings in all climate zones and for all building types no later than 2025.

International initiatives

In 2006, the United Kingdom government announced a goal of building all new homes to "zero-carbon" standards by 2016, thereby contributing to the government's goal of decreasing the country's greenhouse gas emissions by 60 percent by 2050, and by 80 percent by 2100. To achieve the zero-carbon goal, changes in building regulations' energy requirements will be phased in over the next several years. In addition, as of October 2008, most residential and commercial buildings in the UK are required to have an "energy certificate," displaying their energy performance, upon construction or at the time of a sale or lease. Other EU countries have or will have a similar requirement pursuant to the EU Parliament's 2002 Energy Performance in Buildings Directive.

Elsewhere in Europe, more than 6,000 commercial and residential buildings have been built or renovated to the Passivhaus standard – including single and multifamily residences, schools, factories, and office buildings. This energy use standard, which originated in Germany in 1990, results in extremely well-insulated, virtually airtight buildings that can be heated primarily by passive solar gain, as well as internal gains from people and electrical equipment. Although most of these buildings are in Germany and Austria, the concept is spreading worldwide, with the European Union considering its adoption as a minimum building standard by 2012.

Grassroots initiative

Architecture 2030 is a non-profit organization established by architect Edward Mazria with a goal of dramatically reducing building-related greenhouse gas emissions by changing the way buildings are designed and constructed. In 2006, Architecture 2030 issued the 2030 Challenge, a global initiative with a goal of reducing fossil fuel consumption in new buildings and major renovations by 50 percent by 2010, and making all new buildings 'carbon neutral' by 2030. Partners in this initiative include the U.S. Conference of Mayors, the U.S. Department of Energy, the U.S. Environmental

Protection Agency, the U.S. Green Building Council, the American Institute of Architects, the American Society of Heating, Refrigeration and Air-Conditioning Engineers, the International Council for Local Environmental Initiatives, and others.

Local initiatives

In early 2008, the Massachusetts New Homes with ENERGY STAR® program sponsors (National Grid, NSTAR, Until, and Western Massachusetts Electric) launched a new, high performance home-building initiative, the **Zero Energy Challenge**, to encourage builders and developers to design and construct homes using significantly less energy than traditional residential construction in Massachusetts. The competition provides four selected builders with an opportunity to compete against each other to deliver single-family detached residences with a Home Energy Rating System (HERS) Index below 35. Honors will be awarded to the buildings that achieve the lowest HERS Index, with the top three winners receiving cash awards. Similarly, the Northeast Sustainable Energy Association (NESEA) created the Zero Energy Building Award to recognize zero net energy buildings designed for the northeast climate. As an incentive for design/build teams, NESEA is offering a cash prize for the best building in the Northeast that can document zero net energy use while offering a high level of comfort, affordability, and reliability.

A zero net energy building is one that is optimally efficient and, over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite.

Massachusetts Zero Net Energy Buildings Task Force

March 2009

This report can be downloaded at:
www.mass.gov/eea

FSC Logo Here