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ENERGY EFFICIENCY IN BUILDINGS

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

TO

PROVIDE RECOMMENDATIONS FOR REDUCING ENERGY CONSUMPTION IN BUILDINGS

FEBRUARY 26, 2009

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ENERGY EFFICIENCY IN BUILDINGS

THURSDAY, FEBRUARY 26, 2009

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 2:38 p.m. in room SD–366, Dirksen Russell Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. Why don't we go ahead and get started. Today's hearing will focus on policies and programs to improve energy efficiency in buildings. It's important to focus on the buildings sector because it represents such a large share of primary energy use and of greenhouse gases, Greenhouse gas emissions in our economy. Technologies that improve building efficiency are often referred to as the low-hanging fruit in meeting our energy challenges because they are relatively inexpensive compared to other climate change mitigation strategies.

However, we have found that this low-hanging fruit can sometimes be hard to pick. The building sector is complex, it's fragmented. In many cases the benefits of energy efficiency have not been well understood by those in the best position to improve building efficiency.

In the last two energy bills we enacted significant energy efficiency requirements for Federal buildings, most notably adopting the 2030 Challenge for New Federal Buildings and authorizing a net-zero energy resource and development program for private sector commercial buildings. As we move forward in developing an energy bill for 2009, I hope we can support the inclusion of some bold policies that will help us to transform the building sector.

The witnesses we have here have been asked to provide comments on various programs and policy options to improve efficiency of buildings, including resource for zero energy buildings, integrated whole building design, advanced building codes, residential and commercial energy retrofits, disclosure of building energy use, and market-driven changes, and the role of green building rating programs.

Let me call on Senator Murkowski for any comments she has at this point, and then we'll call the witnesses.

[The prepared statement of Senator Mark Udall follows:]

PREPARED STATEMENT OF HON. MARK UDALL, U.S. SENATOR FROM COLORADO

Thank you, Mr. Chairman, for holding today's hearing.

Addressing our energy needs in a responsible and sustainable way is necessary for our national security, our economy and our environment. Increasing our use of renewable energy, as well as promoting new, cleaner uses of our domestic resources, such as coal, are certainly paths that we must pursue. But we also should further promote energy efficiency—after all, the most affordable kilowatt of energy is the one that is not used.

Homes and other buildings are prime targets for improving efficiency—they account for 70 percent of our electricity use. Furthermore, they use 50 percent of all natural gas in the U.S. and are responsible for 40 percent of all greenhouse gas emissions. After mortgage payments, energy costs constitute the single largest monthly expense for homeowners.

Not surprisingly, changes that improve energy efficiency are highly cost-effective investments that dramatically reduce high energy expenses for businesses and families. Energy efficiency improvements can provide a combination of direct consumer benefits that will persist for many years. By freeing up consumer spending now devoted to utility bills, and by cutting peak demand, we will reduce energy costs and defer the need for new power plants.

Sun Microsystems' new data center at its Broomfield campus in Colorado is a good example. This facility will reduce Sun's electrical consumption by 1 million kilowatts per month, enough to power 1,000 homes in Colorado. Also, it collapses 496,000 square feet of data center space into 126,000 square feet—doing more with less.

There are many examples of companies, schools and others realizing the bottom line benefits of instituting energy-efficient technology in buildings.

Today's hearing will help us explore what else the federal government can do to promote energy efficiency in buildings. I look forward to hearing from the witnesses today and would like to thank them for being here.

STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

Senator MURKOWSKI. Thank you, Mr. Chairman. I appreciate you convening the hearing today.

We recognize we've had several conversations about this, but we're going to be busy as we move forward as a committee to craft yet another comprehensive energy bill. Today's topic, how to best reduce energy consumption in buildings through energy efficiency, will be an important component of this ongoing debate and hopefully the legislation that we will draft.

Your words were pulled from my notes here. You're talking about the low-hanging fruit when we talk about energy efficiency, and I think we hear that quite often, the low-hanging fruit or the fifth fuel out there. I think most people will recognize that efficiency is the cheapest, quickest, cleanest resource that we have. It's generally characterized as a way to ensure adequate and reliable energy supplies and to simply use what we already have more effectively. It sounds like something that everybody should be doing.

We have, of course, over the years through EPAct 2005 and the energy bill in 2007 instituted steps to enhance the efficiency, but many of the programs that were authorized by Congress have not been previously funded in annual appropriations bills. We now know that the agencies are receiving unprecedented funding as a result of the stimulus and it is my hope that that money will be used efficiently to promote our energy efficiency goals.

It is important to frame the debate to ask the question, what are the goals here? What have we done to meet our energy efficiency goals? Where do we want to go with energy efficiency and how can we best pursue the new options?

As we will probably learn from today's testimony, the goal of these actions is defined differently by those appearing before us and others who discuss this issue. It may be cutting operating costs and passing those costs on to consumers. It may be conformity to uniform standards, such as imposition of Federal building codes. Or it may be reducing gases and fossil fuel consumption.

I think that one goal that we all share is increasing energy security. We say it all the time in this committee, but there really is no silver bullet for solving our Nation's energy challenges. There's certainly no silver bullet for deciding how energy efficiency is most effective. Despite our best intentions, a government-mandated standard doesn't necessarily translate into maximum efficiency in real life. But I do believe that there is a role certainly for both the public and private sectors as we grapple with this issue.

I look forward to the comments from the witnesses this afternoon and again thank you for the hearing.

The CHAIRMAN. OK. Why don't we start right in. Let me just introduce all of the witnesses and then we'll just have each of you take about 6 minutes and tell us the main points you think we need to understand from your testimony, and then we'll include your full testimony in our committee hearing record.

Professor Arun Majumdar—is that the correct pronunciation?

Mr. MAJUMDAR. Right.

The CHAIRMAN [continuing]. Is the Director of the Environmental Energy Technologies Division in Lawrence Berkeley National Laboratory. I was fortunate to visit his laboratory this last fall and he briefed us at that time and I was very impressed with what I heard.

Mr. Ed Mazria, who is the founder and Executive Director of Architecture 2030 in Santa Fe, New Mexico. We're very proud of the work he has done nationally.

Mr. Philip—tell me the pronunciation again?

Mr. GIUDICE. "Jue-DEE-see."

The CHAIRMAN. "Jue-DEE-see." Philip Giudice, who is Commissioner of the Massachusetts Department of Energy Resources.

Ms. Jennifer "AH-mann"?

Ms. AMANN. "AE-mann."

The CHAIRMAN. "AE-mann," who is the Director of the Buildings Program at ACEEE in Washington.

Mr. Ward Hubbell, who is President of the Green Building Initiative in Portland, Oregon. Thank you for being here.

Mr. Charles Zimmerman, who is the Vice President for International Design and Construction with Wal-Mart Stores, out of Bentonville, Arkansas. Thank you very much for being here.

Professor, why don't you go right ahead.

STATEMENT OF ARUN MAJUMDAR, PH.D., DIRECTOR, ENVIRONMENTAL ENERGY TECHNOLOGIES DIVISION, LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY, CA

Mr. MAJUMDAR. Chairman Bingaman, Ranking Member Murkowski—It is an honor and privilege for me to be here testifying before you. I am Arun Majumdar, Director of the Environmental Energy Technologies Division at Lawrence Berkeley Labs, which has a long history in buildings research, and also Professor in the

College of Engineering at the University of California-Berkeley. I'm a member of the U.S. National Academy of Engineering and my field of expertise is the science and engineering of heating and cooling, which is a large fraction of energy consumption in buildings.

The building sector consumes the largest fraction of building primary energy, roughly 40 percent, and is responsible for the largest fraction of carbon emissions. Buildings also offer one of the best opportunities, if not the best, to economically and rapidly reduce energy demand and limit greenhouse gas emissions.

The Energy Independence and Security Act of 2007 contains authorized legislation for a zero net energy commercial buildings initiative, or CBI, which calls for massive reduction in energy consumption by 2030. I believe this is an important and bold step. With your kind permission, I'd like to show you some charts and graphics to illustrate the potential impact and the challenges of CBI.

If we are successful in achieving the goals of CBI by 2030, if you look at the chart over here, that's the amount of energy that we will save, which is equivalent to about 4 quads. If this were to happen today, or in 2006, we would have eliminated the need for electricity from half the coal-fired power plants and could have potentially provided the balance from renewables and nuclear, a zero carbon footprint. That's the opportunity.

Now let me show you where we are today and the challenge that lies ahead of us. The two graphs in the next chart show data on measured or actual performance of 121 LEED-rated buildings. The data shows that as we go from silver to gold to platinum rating the average energy consumption does go down, and this average is better than the national average. So LEED does work on average.

But if you look at the scatter in the data, it tells a different story also. The reason is that this and all other codes and ratings are based today on design simulation, but design and actual performance do not always match.

The chart on the right out here is even more relevant. What this data shows is that as we tighten the design toward the CBI goals this way of zero net energy buildings, the measured performance can be 100 to 200 percent higher than the intent. So this is a fundamental problem.

So the key gaps today are the lack of measurement and policies requiring it, and the fragmentation of the market and the process. I have made several recommendations in my written statement. Let me highlight a few examples of how to address the gaps with a coordinated effort through technology and policy.

Lack of measurement. We need an information technology infrastructure to measure and sub-meter the performance of all public buildings, display to information to the occupants, which could influence their behavior, and create a transparent national repository of building performance. Without this, it is unlikely we will diagnose common inefficiencies, identify best practices and the best opportunities to retrofit.

This can go hand in hand with a policy that calls for standards based on measured performance, that provides some financial incentives and perhaps disincentives to align the goals of a fragmented industry.

Non-fragmentation. A building is made up of materials, HVAC systems, lighting, windows, appliances, etcetera. These components and subsystems are supplied by different companies who don't interact with each other. Yet when these components are assembled in a building they do interact with each other, and sometimes they fight each other and waste energy. It's like driving a car with your brakes on.

The standards based on measured performance would align the industry toward a common goal. But unless we use science and technology, science and engineering, to develop new technologies that design and operate buildings as an integrated system, we are unlikely to get to zero net energy buildings in an affordable and scalable way.

To address the challenge at adequate scale I have made several recommendations, but here is one. To address it at scale and to address the fragmentation, I have recommended that we create multiple regional centers of excellence where researchers and practitioners from multiple national labs, industries, academia, and other critical building-related organizations and stakeholders can collaborate and jointly address integration between basic R and D and market transformation, and also across science and technology, policy, education, and training.

That ends my oral testimony, Senators. Thank you very much for the opportunity to appear before you and testify.

[The prepared statement of Mr. Majumdar follows:]

PREPARED STATEMENT OF ARUN MAJUMDAR, PH.D., DIRECTOR, ENVIRONMENTAL ENERGY TECHNOLOGIES DIVISION, LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY, CA

Chairman Bingaman, Ranking Member Murkowski and distinguished members of this Committee, it is an honor and privilege for me to be here to testify before you to provide recommendations for reducing energy consumption in buildings.

I am Arun Majumdar, Director of the Environmental Energy Technologies Division (EETD) at the US Department of Energy's Lawrence Berkeley National Laboratory, and Professor in the Departments of Mechanical Engineering and Materials Science and Engineering at the University of California, Berkeley. My field of expertise is the science and engineering of heating and cooling, which accounts for approximately 40-60 percent of the energy consumption in buildings. I am a member of the US National Academy of Engineering, and, over the years, I have served in an external advisory capacity for various federal agencies, including DOE Basic Energy Sciences. I am currently a member of the Advisory Committee of the National Science Foundation's Engineering Directorate.

My Division in LBL was created in 1973 in response to the energy crisis then and focused a substantial part of its efforts over these past 35 years on reducing energy consumption in commercial and residential buildings. It has contributed to various aspects of energy efficiency, such as building codes and appliance standards, creation of the building design software tools, technologies for internet-based demand response between buildings and the grid, electronic ballasts for fluorescent lamps, low-emittance and electrochromic windows, materials and coatings for cool roofs, and to many demonstration projects such as the New York Times Building in Manhattan and the San Francisco Federal Building. Furthermore, the Division has had major influence on the global buildings sector by educating, training and collaborating with people in federal and state agencies, private industry, non-profit organizations, philanthropic foundations, as well as in international governments and organizations. I will draw upon this experience in my testimony of how to reduce energy consumption in buildings in the future.

In August 2008, in response to the authorization of the Commercial Buildings Initiative (CBI) of the Energy Independence and Security Act (EISA) of 2007, DOE's Office of Energy Efficiency and Renewable Energy (EERE) launched a National Laboratory Collaborative on Buildings Technology (NLCBT), with the goal of coordinating the R&D activity of five national laboratories that have expertise in this

field. I applaud EERE's efforts in bringing the national labs together. The NLCBT includes two members each from the EERE Buildings Technologies Program, as well as from Argonne National Lab, National Renewable Energy Lab, Lawrence Berkeley National Lab, Oak Ridge National Lab, and Pacific Northwest National Lab. Over the last six months, the NLCBT has worked closely to develop some common goals and approaches. I am one of the Berkeley Lab's representatives in NLCBT. While I have been influenced by the discussions, my testimony here reflects my views and those of Berkeley Labs and University of California, Berkeley.

I also want to bring to your attention the work recently completed by National Science and Technology Council's Committee on Technology. Their Building Technology Research and Development Subcommittee, representing 21 Federal agencies, released a report[1] on High-Performance Green Buildings in October 2008. This document lays out a framework for R&D activities within the Federal government to achieve the aggressive net-zero energy goals set out within EPAct 2005 and EISA 2007. DOE's laboratories were a critical contributor to the development of this agenda.

1. WHY BUILDINGS AND WHY NOW

We are living in a critical time. Energy security and climate change are two of the most important challenges of our lifetimes, and need urgent attention. The decisions we make and the paths we take now will determine the future health, security and well being of our Nation and the world. It is clear that there is no single solution to the problem. The challenge is so massive and urgent that it requires multiple simultaneous responses and solutions. I firmly believe that reducing energy consumption in buildings by a very substantial margin must be part of the solution. Otherwise, we are unlikely to adequately address the challenges of energy and climate change.

Most economic and technical analyses suggest that buildings offer one of the best opportunities, if not the best, to economically and rapidly reduce energy demand and limit green house gas (GHG) emissions. The buildings sector consumes (see box) the largest fraction of US primary energy (roughly 40 out of 100 quads) and is responsible for about 40% of the CO_2 emissions, which is more than either transportation or industry. The buildings sector also provides a significant fraction of the US GDP and employment, and hence it could play a critical role in stimulating the economy. The electricity transmission/distribution system largely exists for buildings, and buildings can provide some level of thermal and/or electrical storage to complement the grid, which will be even more important to address issues related to intermittency in renewable energy supply.

The U.S. building sector (residential and commercial):

- employs 8 million people; contributes to 10% of the U.S. GDP;
- consists of about 115 million households and 5 million commercial buildings;
- energy consumption is split roughly 50:50 between commercial and residential buildings
- consumes 72% of the electricity and 55% of natural gas, and 40% of the US primary energy (larger than either transportation or industry);
- per year, consumes 40 quads of primary energy, 2.7trillion KW-hr, and accounts for 40% of CO_2 emissions or about 2300 MMT CO_2 equivalent.
- has a utility bill of about $400 billion per year while the construction sector is about $1,000 billion per year;
- By 2030, EIA estimates 16% growth in energy consumption, which will require additional 200 GW of electrical capacity.

Looking ahead, the US will add about 1.5-2 billion square feet per year of new floor space[2] in commercial buildings. The US has about 115 million "households" today, that is likely to grow to 140 million by 2030 based on population growth estimates. If we maintain business-as-usual, Energy Information Administration (EIA) estimates[3] that by 2030 we will experience a 16 percent growth in buildings energy consumption. This amounts to approximately 200 GW of additional electricity capac-

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

[2] In rough terms 2 billion square feet would be equal to 2000 Forrestal buildings or over 19,000 typical Home Depots.

[3] Annual Energy Outlook 2009 Early Release, Energy Information Administration; http://www.eia.doe.gov/oiaf/aeo/pdf/aeo2009__presentation.pdf

ity by 2030, which at a cost of about $2-5/W capital expenditure,[4] would require investments on the order of $500-1000B over the next 20 years, or approximately $25-50B/year.[5] While some investments in the supply side are necessary to keep up with demand, we cannot operate with a business-as-usual approach for the demand side: We must take some bold steps for significant reductions in energy consumption. Investments to reduce energy demand have been proven to be more cost-effective than increasing supply, as has been the experience in California.

While each building is unique, buildings often utilize similar materials and equipment, so that technologies developed for the buildings sector can be widely replicated, offering substantial leverage for these research efforts. Given the long lifetimes of residential and commercial buildings, often more than 50 years, technology development should include advances in materials, equipment, and strategies for retrofitting buildings for improved energy efficiency.

The Federal Energy Independence and Security Act (EISA) of 2007 contains authorized legislation for a Zero-Net Energy Commercial Buildings Initiative, which calls for 80-90% reduction[6] in energy consumption for:

- All newly constructed commercial buildings by 2030
- 50% of the commercial building stock by 2040
- All commercial buildings by 2050

From here on, I will focus my comments on commercial buildings only.

Figure 1 shows that if by 2030, we achieve reductions in energy consumption of 80% in new construction and 50% in existing buildings, the site energy saved will be about 4 Quads (about 1200 billion kW-hr) per year.* If this were to happen in 2006, it would have essentially eliminated the need for electricity from approximately half the coal-fired power plants. This would have saved 400 MMT-CO_2 emissions per year. The remaining load of 4 Quads could have been supplied by electricity produced by nuclear, hydroelectric and other renewable sources, and one could have reached a zero-carbon footprint for the commercial buildings sector. Yet, achieving these goals in a cost-effective, reliable, and scalable way will be very challenging. In new buildings, the potential energy savings with current technology are 40 to 60% compared to current code,[7] but these are rarely achieved in practice and it is difficult to reach the EISA'07 goals for 2030 cost-effectively.

It is critical to continue current research, development, demonstration and deployment (RDD&D) activities in buildings, extending known technologies. In addition, the U.S. needs an aggressive and bold approach for advanced RDD&D to realize the full opportunity in the buildings sector to address the challenges of energy security and climate change.

2. FRAMEWORK OF A NATIONAL STRATEGY

The goal of zero-net energy building (ZNEB) is bold and I believe the right one. The scale and magnitude of this challenge is daunting, but if successful, the US could witness significant increase in jobs, technological leadership with global impact, and a modernized infrastructure that has been largely underserved for the last 30 years.

Despite the scale of the problem and perhaps the best opportunity that it offers to reduce energy demand and carbon emissions, the budget for EERE's Buildings Technologies Program is on the order of $100M/year, which includes only about $12M/year for the Commercial Buildings Initiative. With these limited resources, the program has done a remarkable job in conducting some R&D, but has necessarily focused mostly on technology deployment through the creation of the Commercial Buildings Energy Alliances. While this is necessary and important, it is not sufficient.

Our past successes in building energy efficiency have taken 10-20 years to move from lab invention to mainstream market impacts as documented by NAS studies

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[4] Cost estimates based on today's fuel prices are about $2/W for pulverized coal, $0.8/W for combined cycle gas turbine, $1.8/W for wind, $3/W for integrated gasification combined cycle, $5/W nuclear

[5] For example, a recent industry study based on the EIA's 2030 projections, estimates that 214GW of new generating capacity at an investment cost $697 billion will be required under a Reference Scenario. Transforming America's Power Industry: The Investment Challenge 2010-2030. Prepared by: The Brattle Group for The Edison Foundation. November 2008.

[6] Zero-net energy building reduces 80-90% energy consumption compared to benchmarks, and uses renewable energy to provide the remaining 10-20%.

* All figures and charts have been retained in committee files.

[7] Note that current codes are for designed intent, and not based on actual performance. See Section 3(ii) for details.

and other reports. We need to accelerate the process. It is critical that the Nation have a strong, long-term commitment to a balanced portfolio and a seamless pipeline of integrated RDD&D ranging from basic research to market transformation. This would require coordination, integration, alignment, and leveraging among several key thrusts, all of which require innovations:

i. science and technology;
ii. policy and finance;
iii. technology deployment and market transformation
iv. work force development through education and training.

Any one thrust alone cannot successfully address the challenge, but collectively they can.

The short-term goals ought to be focused on creating jobs, but without a long-term R&D base focused on science and technology, the US could be out-innovated by Asia and Europe, which in some cases are currently more advanced than the US. With a well-coordinated bold RDD&D program, the US has the intellectual capital and the capacity to be a global leader. EISA'07 authorizes $20M/yr for the Commercial Buildings Initiative in 2008, ramping up to $200M/yr between 2013-2018. It is unclear whether this level of investment is sufficient to address the challenge.

3. WHAT ARE THE KEY BARRIERS, GAPS AND CHALLENGES

While the numbers are compelling for reducing energy consumption in buildings, in reality it has been difficult to reduce energy consumption in buildings because:

i. The Value of energy efficiency is uncertain and unappreciated.—Energy is usually a small (if any) part of building design, which focuses mostly on cost, aesthetics, comfort, and function. There is no clear market signal for reducing energy consumption. Since building energy performance is rarely measured (see ii below), and there are large uncertainties in designed performance, the value of energy efficiency is fraught with uncertainties, making it difficult to evaluate and to have financial transactions without legal implications.

ii. Actual performance does not often correlate to design intent.—Today's building codes are for designed energy performance, NOT for measured or actual energy performance (see Fig. 2 later). Code-compliant solutions are typically much worse than best practice; by definition they represent the worst, cheapest building that can be legally built and occupied. There are no requirements for performance measurement, and only about 5% of new buildings are ever commissioned—95% are operated without ever testing their systems upon completion of building construction.

iii. The Buildings industry is fragmented (see Appendix A-Chart 3).—The buildings industry is fraught with functional gaps as well as management discontinuities that lead to ineffective coordination between operational islands. There is virtually no feedback loop from occupied buildings back to designers, beyond lawsuits, that might correct past mistakes.

iv. Lack of systems integration in building design and operation.—Building components (cement, steel, insulation, glass windows, coatings, sheet rock,. . .) and systems (lighting; heating, ventilation and air conditioning (HVAC); appliances) are developed by independent firms whose products are tested for individual performance independent of each other. While this must be encouraged and is necessary, it is insufficient. A whole building approach to design and operation, where these components are integrated in a way that they reduce energy consumption through cooperation, is rarely used, which commonly leads to significant system-level inefficiencies.

v. Lack of quantitative energy consumption evaluation.—Building operators often have neither the training nor the information handoff from builders they need to properly operate the building to meet performance expectations. Most operators are flying blind with three sets of uncorrelated data: (a) a time dependent snapshot of performance; (b) real-time complaint calls, and (c) an "after-the-fact" monthly utility bill. Most buildings don't have proper instrumentation or an Energy Information System to integrate, digest and display actionable performance data for the operator.

vi. Incentives for energy efficiency are not aligned.—In leased buildings, the building designers and developers specify components and decide how they are integrated in the design, primarily based on capital expenditure and not generally on energy efficiency. On the other hand, occupants' patterns of energy consumption determine how much energy is actually used, which is related to the operational expenses. The dichotomy of capital and operational cost between

owner and user leads to split incentives, and makes it difficult to spread financial benefits or burdens due to efficient use of energy.

Since the Commercial Buildings Initiative is focused on achieving zero net energy in buildings, it is worth noting as an example, a recent study of some high-performance buildings. Frankel[8] recently conducted an analysis of 121 LEED[9] buildings (certified, silver, gold and platinum rated) that were in the low-to-mid range in energy use intensity (EUI in kBTU/sqft), and studied their actual versus design performances. Figure 2 plots the spread of measured EUI, and ratio of actual-to-design energy use as a function of design EUI. While this may not be a definitive study and perhaps does not contain a sufficiently large statistical sample, some trends and indications are worth noting:

a) While the average EUI of LEED rated buildings is lower than the national average, there is a large amount of scatter. Hence, LEED rating is useful on an average, but design intent does not generally correlate with actual performance in individual buildings.

b) For buildings with lower design EUI (i.e. towards zero net energy building), the discrepancy between the actual and designed EUI is larger, showing that it becomes more challenging to accurately predict performance as the performance goals are tightened.

There are multiple reasons for why this is so and details can be found in Frankel's study. Clearly, further studies are required, but some of the gaps and challenges are well known in the buildings community and can be acted upon now.

4. RECOMMENDATIONS FOR SCIENCE AND TECHNOLOGY

The US needs a comprehensive and balanced R&D program to achieve significant reductions in energy use in commercial buildings through innovations. To complement existing near-to mid-term technology development with longer-term development of transformative technologies, we need to integrate basic and applied R&D much more than has often been the case in the past. Today, building commissioning and simple retrofits may be cost-effective, but they reduce energy consumption on average by only 15-20%. On the other hand one can design and build new buildings that almost reach zero-net energy goals,[10] but at a higher cost and not easily scaled up to wide market introduction. The science and technology challenge is two fold: (a) how to reduce energy consumption to approach zero-net energy goals; and (ii) how to achieve this in a cost-effective, measurable and scalable manner. The innovations ought to focus not only on new technology but also towards dramatic reductions in risk and cost in existing technologies that would enable deep market penetration. Here are some potential elements.

i. Information Technology Infrastructure for Fundamental Data Gathering, Processing and Management.—As suggested by Fig. 2, design intent and current simulation tools are insufficient to model and predict energy use in buildings. The US needs a significant program in collecting, analyzing, and displaying measured performance of all public buildings. Without these data, it would be very difficult to identify common inefficiencies, best practices, and best opportunities for smart retrofits. Furthermore, there is a need for tools to process and manage the data such that it is readily available and can easily be mined. This addresses 3(i), 3(ii), and 3(v).

ii. Whole System & Process Integration for Design and Operation of Smart Buildings.—To achieve the goals of zero-net energy buildings, optimizing individual components for energy efficiency, while necessary, is unlikely to be sufficient. We need a whole building approach that can treat the building as a system and minimize the energy consumption of the whole system while still optimizing comfort and other performance metrics. Furthermore, given the fragmentation of the buildings industry, sophisticated tools are required that help

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[8] M. Frankel, "The Energy Performance of LEED Buildings," presented at the Summer Study on Energy Efficient Buildings, American Council of Energy Efficiency Economy, Asilomar Conference Center, Pacific Grove, CA, August 17-22, 2008.

[9] Leadership in Energy and Environmental Design (LEED) is a Green Building rating system introduced by the US Green Building Council (http://www.usgbc.org/). LEED is a third-party certification program and the nationally accepted benchmark for the design, construction and operation of high performance green buildings.

[10] P. A. Torcellini, M. Deru, B. Griffith, N. Long, Shanti Pless, R. Judkoff, "Lessons learned from field evaluation of six high-performance buildings," Technical Report NREL/TP-550-37542, June 2006 (http://www.nrel.gov/docs/fy06osti/37542.pdf)

in integrating the process of building design, build and delivery, which promotes feedback and iteration. This needs:

a. science-based approach that couples building science (thermodynamics, heat transfer, fluid mechanics, sensors, materials, components. . .) with architecture (structure, façade, comfort, aesthetics, . . .) and information science (communication, computations, control) that will lead to deeper understanding and pathways of how to integrate subsystems that will cooperate and collectively reduce energy consumption as a system.

b. the above endeavor will form the foundations for tools for accurate simulation, analysis, optimization and data mining that can be used for both building design and operation

c. continuous visualization, monitoring, reporting, diagnostics and demand-response of buildings—self-tuning buildings. This addresses 3(iii) and 3(iv).

iii. High-Performance Building Components and Sub-Systems.—Inefficiencies in buildings can largely be attributed to thermal management as well as inefficient lighting. Hence, it is necessary (but not sufficient) to focus R&D effort on innovations in:

a. Building Fabric/Envelop Materials and Device Technology: We need to identify new approaches for cost-effective super-insulations for both walls and windows. "Smart glass" or dynamic shading whose properties are dynamically controlled and adjusted to minimize cooling and maximize glare-free daylight are also necessary. Integration of phase change materials ("energy storage") into buildings must be investigated.

b. Mechanical Equipment, Controls, and Thermal Storage Technologies: HVAC accounts for over 30% of the total commercial building energy consumption. A robust program could help develop the next generation of HVAC and controls suitable for use in buildings with loads approaching 10-20% of today's loads. New opportunities for further improving efficiencies include enhancing heat transfer using technologies such as micro-channels and nano-scale surface treatments, or supplementing or substituting for vapor-compression cycles with thermoelectric, magnetocaloric, thermoacoustic, absorption, or other systems. Indeed, cooling technologies in the buildings, industry, and transportation sectors account for about 10% of primary national energy use and are a major driver of peak utility loads, among other impacts. Cooling technologies in use today also use hydrofluorocarbons as working fluids, which are strong greenhouse gases. Advances in this area could have broad application and significant benefits.

c. Electrical and Lighting Equipment Technology and Controls: Lighting accounts for about 12% of energy use in homes but often 30-50% in commercial buildings. While steady progress is being made with improved lamp efficacy with gas discharge and solid-state lighting sources, large savings can also come from robust, reliable, addressable and dimmable networked controls that allow light levels and distribution to be dynamically tuned to meet user needs over space and time. The next most important source of energy use is "miscellaneous electric loads" (MELS), such as computers, appliances etc. A robust effort is needed to find ways of minimizing and controlling these loads without inconveniencing occupants. This addresses 3(iv).

iv. Integration of Buildings with Grid & Novel Energy Storage Concepts.—A goal of net-zero energy buildings requires both substantial increases in energy efficiency (up to 70 percent or more) with the balance provided by some form of renewable energy generation, either on-site (e.g., photovoltaic) or from off-site renewable generation. Research is needed to reduce the cost and enhance the performance of approaches to integrate renewable energy and energy storage systems. Research is also needed to capitalize on saving opportunities available from integrating intelligent buildings with the emerging smart grid. This addresses 3(iv).

v. Field Test Beds and Reconfigurable Test Facilities.—A wide diversity of real buildings ought to be used for collecting data and understanding common inefficiencies, best practices and best opportunities for reducing energy consumption. However, if one needs to incubate, debug and "crash-test" new technologies, they could potentially pose safety and occupational hazards to the occupants. Testing in facilities that are reconfigurable allows pinpointing of technical problems and rapid correction of design flaws, and also allows for "crash-testing" and debugging new technologies before they are rolled out in real build-

ings with occupants. They also provide much-needed measured evidence to builders and operators that proper systems integration can indeed significantly reduce energy consumption. Furthermore, such test facilities can also be used for education and training. This addresses 3(i)-3(v).

vi. Advanced Construction Methods.—Often, poor on-site assembly result in buildings that adversely affect their energy use performance. New construction approaches are needed that are more effective at achieving energy efficiency and renewable energy integration. Advanced techniques also reduce construction wastes and enable utilization of newer materials with lower embedded energy and carbon emission consequences. This addresses 3(iv).

5. RECOMMENDATIONS FOR POLICY AND FINANCE

To achieve the zero-net energy goals given the barriers, gaps and challenges identified in Section 3, market forces alone are unlikely to enable market transformation. Innovations in policy must be used, but these need to be researched and evaluated for feasibility as well as impact on energy consumption, economics, law etc. Here are some elements—some of these are fundamental shifts from current policies, but these are necessary to achieve the bold goals outlined before.

i. National Building Standards Based on Measured Performance.—This requires new policy to benchmark and label all commercial buildings based on measured performance. Measuring and disclosing real building energy performance consistently and reliably across the commercial building sector is essential to stimulate market awareness and demand for valuing and achieving improved energy performance levels. This addresses 3(i) and 3(ii), and will be enabled by 4(i).

ii. New financial instruments, valuation and performance-based compensation.—There are many aspects of commercial buildings finance that could be altered to encourage investment in higher performance building solutions, such as: (a) grants, subsidies, tax credits, or other financial incentives to defray higher first costs associated with the design, construction, and operation of efficiency and renewables integration and subsequent measured performance; (b) including building actual performance parameters in real-estate valuation; (c) developing and promoting alternative leasing provisions that address split incentives—such as between owners and renters. This addresses 3(v) and 3(vi), and is enabled by 4(i) and 4(ii).

iii. Incentives for action—tax rebates and utility programs.—There is a wide and growing array of tax incentives and utility programs to promote energy efficiency more aggressively. The options proposed here build on this foundation to identify and implement a comprehensive, integrated set of financial and business incentives to supplement existing energy price signals that: (a) Develop and expand utility incentives; reward higher measured performance; (b) Decouple sales and revenues for utilities nation-wide; (c) Develop and expand tax credits for high performance buildings based on measured performance; (d) Develop programs for capital subsidies, grants, and loans; (e) Promote expedited permitting for high performance buildings. This addresses 3(v) and 3(vi), and is enabled by 4(i) and 4(ii).

iv. Incentives for Retrofits and Upgrades.—Since the lifetime of commercial buildings is generally more than 50 years, we must promote retrofitting and upgrading the existing building stock. Financial programs that could amortize the initial cost for upgrades over a time period could substantially minimize the financial burden for retrofits.

6. RECOMMENDATIONS FOR TECHNOLOGY DEPLOYMENT AND MARKET TRANSFORMATION

In the commercial buildings area, there is a market transformation challenge that includes educating, incentivizing and assisting stakeholders involved in building design, construction and operation. The market is fragmented and incentives are not always aligned. While the proposed National Building Standards and affiliated financial incentives and disincentives might push the market towards common performance goals, other levers are also needed. Some examples are:

i. Standards generally provide the bare-minimum performance requirements for products in the market. Programs such as EnergyStar® can help pull the top of the market, which then helps identify and make possible the next generation of standards. These activities can be further expanded and strengthened.

ii. Conduct technology demonstrations and field performance evaluations for new technology

iii. Test products to ensure they meet manufacturers' claims and conduct independent assessments of technology cost and performance

iv. Create a best practices network domestically and internationally that will provide guidance for design and operation of new and existing buildings based on location and building type/use

v. Conduct studies of human behavioral responses to energy use and evaluate ways to better fit products and processes to natural responses

vi. Conduct studies of institutional responses to energy use and identify mechanisms that can more effectively assist implementation of cost-effective energy efficiency and renewable energy technologies into the buildings sector.

7. RECOMMENDATIONS FOR EDUCATION AND TRAINING

From my experience as a University professor interacting with undergraduate and graduate students both at Berkeley and other universities, I can safely say that the youth of this Nation are ready to roll up their sleeves and save the world. We are in one of the rare "moonshot" moments in history, where we have the opportunity to harness and galvanize the intellectual horsepower of the youth. We must grab this opportunity to attract the best minds and unleash them to address one of the biggest challenges of our lifetime and truly change the course of history. However, we need a framework for this purpose, part of which I have described in the previous sections. We also need adequate resources. Some of the recommendations I propose below go beyond the buildings program, and could be used in DOE and possibly other federal agencies:

i. Initiate a significant program of graduate student and post-doctoral fellowships as well as young investigator awards that will attract the best young minds to energy science and technology, and help create intellectual capital for the nation.

ii. Initiate a program to support joint curricula at universities or R&D centers that combines various aspects of science, engineering, architecture, business, public policy and law to collectively address the needs of the buildings industry, as well as for energy issues in other sectors of our economy.

iii. Combine research and education through the use of test facilities for education and training.

iv. Create education/training bootcamps that rapidly enable retraining for students and existing professionals

In the current marketplace, many stakeholders are unaware of proven existing methods, while others may have an interest in energy efficiency yet lack the ability to implement effective measures. Construction, commissioning and operations of more efficient buildings often require skill sets that are not yet widely available. The DOE program should include an expanded, robust training program for existing design professionals, contractors, commissioning agents, etc. as well as developing accreditation and certification programs, higher education programs that foster high-performance, integrated design, and other activities.

8. CONCLUDING REMARKS AND OVERALL RECOMMENDATIONS

Given the magnitude of energy use in buildings, the opportunity it offers for reducing carbon emissions, and the scale and urgency at which RDD&D needs to occur, the US needs a sustained and well-coordinated public-private partnership of adequate scale. Furthermore, it is important to create a balanced portfolio and an integrated seamless pipeline of RDD&D activities ranging from basic to applied R&D and finally to market transformation. Here are some recommendations to enable this:

i. Increase linkages between the Building Technologies Program in EERE with other programs within EERE and with other offices of DOE (e.g. Office of Science, Office of Electricity Delivery and Energy Reliability) so that the intellectual horsepower and knowledge-base within DOE can be leveraged and brought to bear on this challenge. Some of this has been done but more is possible. Identify linkages and leveraging between DOE and other federal agencies to coordinate RDD&D efforts.

ii. Use the geographical distribution, domain expertise, and availability of intellectual capital of the national laboratories to create on a competitive basis, multiple Regional Centers or Institutes of Excellence of adequate scale where researchers and practitioners from multiple national laboratories, industries, academia and other critical buildings-related organizations can collaborate and jointly address integrated RDD&D in the buildings sector. The Centers could

complement each other in focus areas and collectively address the needs of the Nation in a comprehensive manner.

Thank you very much for giving me the opportunity to appear before you and testify.

The CHAIRMAN. Thank you very much.

Ed, why don't you go right ahead.

STATEMENT OF EDWARD MAZRIA, FOUNDER AND EXECUTIVE DIRECTOR, ARCHITECTURE 2030, SANTA FE, NM

Mr. MAZRIA. Thank you, Senator Bingaman, Senators. Thank you for having me testify. You have before you a booklet that we prepared.* I'm going to call out the page numbers and they're in the lower left-hand corner. We'll start at page 2, and I'll talk to each one of these, each one of these graphics.

So on page 2 you'll see that the building sector is not only the largest energy-consuming sector in the U.S., it is growing at the fastest rate.

Page 3, the building sector today is responsible for now 50.1 percent of total U.S. energy consumption. That's in 2008.

Page 4. You can break that down even further. Building operations, what Arun was just discussing, is responsible for 42 percent in 2008 of total U.S. energy consumption.

Page 5. Of U.S. electricity consumption, the building sector is responsible for 75 percent of all the electricity produced in the United States. That's just building operations.

Page 6. This is electricity consumption. It illustrates that the rate of electricity consumption by the building sector is increasing dramatically and will continue to increase between now and 2030. The entire projected increase in electricity consumption between now and 2030 is due just to building operations.

7. We issued the 2030 Challenge targets a few years ago calling for all new buildings and major renovations to meet an energy consumption performance standard of 30 percent below the regional average for that building type and then moving on to carbon neutral by the year 2030. 50 percent of the regional average is roughly equal to about 30 percent below our latest building codes.

8. Everyone from the Federal Government; we now have five States; many, many local governments have adopted the targets; most of the professional organizations; the EPA supports the targets through Target Finder.

9. In 2005 at the G–8 summit the parties, with the support of the United States, committed themselves to "with resolve and urgency," to cost-effective energy efficiency standards for buildings based on a 30-year payback. That's the definition of "cost effectiveness."

Page 10. NREL completed a study for Greensburg, Kansas, showing that at 30 percent more efficient it would cost about $4,000. If you amortize it over 30 years, over the life of a mortgage, your energy savings far outweigh that; that a homeowner on an annual basis will save about $512 a year. The little chart on the right illustrates that at cost-neutral you would go to 58 percent below code.

*Document has been retained in committee files.

Page 11. The DOE completed a study for 30 percent below code in all different climate zones in cities and they came up with the same results, below ICC 2006.

Page 12. So we're calling for the Federal Government to update the National Energy Conservation Code 2010, 30 percent below our current code standards, IECC 2006, and ASHRAE 90.1 2004; and on a 6-year cycle, 2016, 50 percent below code, 2022, 75 percent, 2028 carbon neutral, giving the States 2 years to get up to speed, and at the 50 percent make it a true performance code because performance codes don't pick clean energy technology winners and losers.

We're also calling for the DOE to put out reach codes so that those States and cities and counties that want to go beyond the standards can do so, and we really need reach codes to take precedence over any Federal appliance standards.

14. The public building sector represents 7 percent of total building square footage in the U.S. The private building sector represents 93 percent. The public building sector is not decreasing yet in terms of construction as of November and I still don't think it's decreasing now. The private building sector is tanking and taking the entire economy down with it.

So we've called for an economic recovery, a 2-year, 9 million job investment plan, asking the Federal Government to put in $200 billion, roughly $96 billion a year, in a housing mortgage interest rate buydown and a commercial building accelerated depreciation program, tied to the energy reduction targets that we just called for: 30 percent below, 50 percent, 75 percent, and carbon neutral.

That would create 9 million new jobs almost instantly, a trillion dollars of new private investment. For every dollar public spent, private money has to be spent. A new renovation market, huge consumer savings, and we would drive down energy consumption.

The tax base from the 9 million new jobs would pay for the plan on an annual basis. The way it works, if you go to the next page, page 17, let's just take a buy-down to 2.5 percent. If you wanted to get a 2.5 percent mortgage, you'd have to meet a standard of 75 percent below code, and those mortgage interest rates could change depending upon how many jobs you wanted to create.

Next page. This is how it would work. To get the 75 percent below code you would need to spend about $51,000 to tighten up your building and put a solar system on and do a number of things. That's about 25 percent in additional cost that it would cost for a new building. Let's just say you have a mortgage of $272,300 at 6 percent. Your monthly payment would be $1600 a month. So in order to get the 75 percent below and to get a 2.5 percent mortgage, you'd have to invest the $51,000.

If you rated that into your new mortgage, then, if you go to page 21, you would have a new mortgage of $304,550. You will have spent $51,250 on the solar system, on tightening up your building, but now your new mortgage, with a tax credit, would be $1203 a month.

So if you go to page 22, your original mortgage payment would be 1632 a month, your new monthly payment would be 1200. You would save 429 on your mortgage. You would save 145 on energy savings on a monthly basis. Your total monthly savings would be

575. That money goes back into the economy. You will have spent $51,000 or more putting people back to work.

If you do that, you basically bring back, page 23, every conceivable industry in the United States because they're all tied to the building sector, from demolition through architects and engineers, hardware, wood, plastics, you name it.

The last page, 24, illustrates if you implement the codes between now and the year 2030 that we're able to then not only stabilize the building sector, but begin to get some major reductions in terms of building energy consumption.

Thank you.

The CHAIRMAN. Thank you very much.

Mr. Giudice, why don't you go right ahead.

STATEMENT OF PHILIP GIUDICE, COMMISSIONER, MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES, BOSTON, MA

Mr. GIUDICE. Great. Thank you, Chairman Bingaman and Ranking Member Murkowski, members of the committee. On behalf of Governor Patrick, the Commonwealth of Massachusetts, and the National Association of State Energy Officials, I appreciate you asking me to be here as a witness and I appreciate your confronting our energy and our climate challenges.

The prior speakers talked about the energy consumption that does exist in buildings and the opportunities for savings, substantial savings. We concur completely that there is gigantic opportunities for significant savings here that would spur our economy and help to address our climate and energy needs.

In Massachusetts we've been working on many of these issues for decades. We've been doing energy efficiency programs with utilities, investing in specific incentives through the utilities for both new building and existing buildings to reduce their energy consumption. We've just now adopted new regulations, new legislation that actually will call for our utility efficiency programs to spend everything that is cheaper than buying energy from the market. That looks like it'll be two or three times as much energy efficiency activity going on in the State of Massachusetts than we have to date of 3.5 cents to to get energy from energy efficiency and we're paying 8 or 9 cents from the wholesale market. So a significant uptake in energy efficiency programs.

The Regional Greenhouse Gas Initiative is going to spur a significant amount of that growth, and the stimulus funding that has just recently been provided is going to further that dramatically and tremendously and we're quite appreciative of being able to deliver on the promises that have been laid out.

Second, we've been pushing renewable energy in Massachusetts. One example is our solar programs, a 250-megawatt goal. In the last year we've had a threefold increase in solar companies in Massachusetts to get on people's homes and businesses, put solar panels on there. We used to have 20 or 30 or 50 companies doing it. Now it's over 150 companies in Massachusetts. A little bit of private money, a little bit of State money, and spurring substantial growth and really seeing it change there.

Third, we've attacked building codes. We had our own State's building code mechanisms in the past and now with this new legis-

lation that we passed in the State we've adopted the International Energy Conservation Code and have automatic updates whenever that gets updated, as well as training and compliance requirements for building inspectors to assure that we're fulfilling that.

So that's some of the stuff that's going on in Massachusetts. Lots is going on on a voluntary basis around the country that we're quite excited about, including in Massachusetts. The LEED standards that have been talked about, the green building initiatives activities, very exciting, Energy Star for buildings and Energy Star for appliances—all very good steps. NASEO is partnering with the Real Estate Roundtable to work on commercial buildings, getting rankings and ratings and help to reduce their energy consumption and energy monitoring.

But much more is needed. It really behooves on the Federal leadership to really take the next steps here. Working this on a State by State basis doesn't move us fast enough or far enough.

Department of Energy has an ability and we would encourage them to take that initiative to put in place national building codes at 50 percent improvements in energy efficiency from the existing standard building codes across the country, regionally specific because what works in the Northeast doesn't work in the Southeast or the West or the Southwest, but nonetheless substantial improvements in building codes.

Clearly they're going to have to work with all kinds of industry and collaborators to make that work, but I encourage this body to give DOE very strict deadlines and very strict expectations that we're going to move massively to much more significant building codes.

Second, we need to address some of the issues of our buildings. Right now we design buildings to leak and they need to leak to actually allow fresh air to come in and be able to power our gas boilers and furnaces and hot water heaters in our basements. That's not the right way to be dealing with these issues.

We do know, and it's on the shelf right now, technologies that are sealed combustion, direct air from the outside to work the furnaces, and then we can really seal up these buildings really, really tight, monitor the humidity, monitor the CO_2 content inside very inexpensively, have air-to-air heat exchangers to be able to transfer outside air into inside air, and then not have to have these buildings leak to make them healthy buildings.

We also need to move—and there was a mention of this before—to much more specific and significant energy labeling of buildings. It would be great for every buyer of a building, be it a renter or purchaser, to be able to know precisely what that energy consumption has been and what the expected energy consumption going forward is, just like we do when we buy a car; we know what the miles per gallon is. This is completely doable and we would like to see significant movement along that front.

Then we have to remember that it's not just about large commercial and residential single family homes. Significant populations obviously live multifamily, live in manufactured housing, and it's often not addressed in building codes to the sufficient level that it needs to be. We encourage significant steps to focus on those folks,

who are often some of the most vulnerable economically amongst us, because tremendous opportunities exist there as well.

So I applaud the actions being taken today and the expectations over the next months of what's going to come out of this process. I know that we're going to go boldly with the challenges in front of us. But I would caution us to think about a decade from now or more we will very likely be looking back and wishing we were bolder at this time in what we get accomplished. So if that can be any helpful for us all to just move as far along the path right now, because it is really the time and the opportunity to do so much more with the challenges in front of us.

I thank you for your attention.

[The prepared statement of Mr. Giudice follows:]

PREPARED STATEMENT OF PHILIP GIUDICE, COMMISSIONER, MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES, BOSTON, MA

Chairman Bingaman and members of the Committee, on behalf of Governor Patrick and the Commonwealth of Massachusetts, and the National Association of State Energy Officials (NASEO), thank you for taking on the energy and climate challenges. We look forward to continuing to work with you, as the federal government takes a leading role in the months and years ahead in confronting our energy future.

You have asked me to address use of energy in buildings, which accounts for approximately 39% of total energy consumption in the United States, and more than half of all energy use in several states, such as my own. It is critical that we drastically cut our use of fossil-fuel energy to meet these needs, in order to improve our energy security, protect against the rising prices of energy which are sure to come after our economy recovers, and to address the worldwide threat of climate change. As my testimony will demonstrate, it is also very doable to dramatically reduce our energy waste in buildings. Technologies and building practices exist today which would provide the same or better comfort with a fraction of the energy consumed. We simply need to be much more strongly motivated to fully deploy these better approaches.

Massachusetts strives to be a leader in promoting the use of energy efficiency and renewable energy sources to meet the electricity, heating, and hot water needs of buildings, but there is much more for us to do. Let me briefly list a few of our programs, but then move on to address specific areas that are of most interest in terms of designing federal policies.

First, for over three decades we have continuously provided incentives to businesses and homeowners to install efficiency measures in their own buildings. Legislation passed last year will greatly increase these subsidies, as it mandates that electric and gas utilities invest in all efficiency that is less costly than purchasing more electricity and gas supplies.

Second, we have supported development of clean, renewable energy, both through a renewable portfolio standard for electric utilities and through specific funding for research, development, and installation of renewables. Under Governor Patrick's leadership, we are two years into a program to install 250 megawatts of solar photovoltaics by 2017—with 7.2 MW awarded in 2008, spurring a 300% increase, to 150, in the number of solar companies in Massachusetts. Last year we broke into the top five states[1] in terms of solar PV market size in the U.S.; and we are now aggressively pushing development of wind power and biomass in the state.

Third, we are focused on energy efficient building codes for residential and commercial construction. Massachusetts passed a raft of energy and environmental legislation in 2008, including a provision that requires us to adopt the most recent version of the International Energy Efficiency Code within one year of its publication, and specific initiatives to train inspectors and assure full code compliance. We have also developed an advanced or 'stretch' code, for voluntary adoption by towns and cities that wish to go significantly beyond these base code standards, in order to accelerate our transformation of the building construction and renovation sector in our state.

[1] "Tracking the Sun" report from Lawrence Berkeley National Labs—Feb 2009 http://eetd.lbl.gov/ea/emp/reports/lbnl-1516e.pdf

Congress and the President have made a huge effort to increase energy efficiency and promote renewable energy with the recently passed stimulus package. Mr. Chairman, your efforts have been in the forefront of these energy efficiency issues for many years. The package's funding of $3.1 billion for the State Energy Program, $5 billion for Weatherization, $3.2 billion for the Energy Efficiency and Conservation Block Grant and $300 million for Energy Star appliance rebates can all make a huge difference in promoting energy efficiency in buildings. The expansion of the existing homes tax credit to 30% and $1,500 will be strongly promoted by the state energy offices as part of our comprehensive effort to improve energy efficiency in homes. We hope that additional funding of $100 million can be provided in the near future to fund training and technical assistance to improve energy codes, and especially to train contractors, local code officials, architects and others to comply with higher building code standards.

ENERGY CODES, PAST, PRESENT AND FUTURE

Allow me to focus particularly on energy codes for new construction. This is a critical area, since once constructed a building will be consuming, or wasting, energy for the next 50 to 100 years, and in many cases much longer. It is relatively simple to construct commercial and residential buildings with measures that ensure 20% to 50% less energy waste than current leading codes, and the incremental cost is generally low. The additional cost may even approach zero if the building is planned and designed thoughtfully. However, if this opportunity is missed, then once a building is completed it is far more difficult and expensive to greatly improve the efficiency through retrofits. Thus, ensuring that initial design and construction is done with full attention to high energy performance standards is vital.

Yet we know that developers of buildings, and purchasers, all too often are concerned primarily with minimizing the initial capital costs of a building. Exceptionally few building developers, designers or owners care about lifecycle energy costs of a building. Quickly building the aesthetically pleasing, least expensive initial cost building is seen time and again as the way to make the most money when developing real estate. Stringent energy codes are needed and need to be fully followed to reduce energy waste. In our current economic circumstances, where construction may be difficult to finance and energy costs are low, it is especially tempting to minimize the initial capital costs of construction and to disregard opportunities to save on future energy use. But our economy will recover within the next few years, energy prices will rise again, and buildings constructed today will be with us for a very long time.

Valiant voluntary efforts to increase awareness of the energy choices in buildings has had an affect. More and more tenants are asking for green buildings. Programs such as LEED and Energy Star are raising awareness. Even today, in a difficult real estate market, there is significant demand in Massachusetts for "green" high-efficiency buildings, in both the commercial and residential sectors. However, market forces alone are not moving us fast enough or far enough to reduce our energy wastage.

ICED—TEA BUILDINGS

There is a litany of what's wrong in our current practices. For instance, the result of the current status quo is all too often what has been called 'Iced-Tea buildings.'

While iced-tea is typically served at a temperature only slightly cooler than tap water, it requires both energy extremes of boiled water and frozen water to produce.

This is an apt analogy for how our current buildings are designed to operate. Typically using over-powered heating and cooling equipment, often running simultaneously, in an attempt to achieve a desired temperature that varies within a narrow range of only around 65-75 degrees Fahrenheit throughout the year. Due to building envelopes and labyrinthine ductwork networks that leak air and are poorly insulated, these buildings need to be regularly topped off with heating and cooling to maintain their precarious state of comfort. In addition to massive energy use, many buildings use water with similar abandon, and yet despite all these energy inputs we have widespread mold and air quality concerns, leading to the relatively modern 'sick building' phenomenon.

Modern technology provides excellent opportunities to provide occupant comfort while minimizing energy waste. Yet, in general, the owners and managers of buildings fail to utilize this technology well. I've been in commercial buildings in winter that are running roof top chillers on a high rise to cool IT equipment, when simple air to air heat exchangers would have done the same thing for a fraction of the energy needed.

In many, perhaps most, cases buildings are never commissioned. Commissioning is the last item on the punch list before occupancy, and even if completed it is seldom a thorough job. Consequently buildings' heating, cooling, ventilation and other systems are never adjusted in order to perform correctly.

A representative of a major commercial building controls company recently visited my office. I asked how many of their commercial buildings were fully utilizing their building control systems to minimize their energy consumption. He estimated that at best 10% of their systems were ever commissioned and fewer still are re-commissioned at any point subsequent to initial installation of the systems.

Even when buildings operate appropriately on day one, the complexity of modern controls, and the thousands of mechanical moving parts in modern commercial buildings, means that they will not continue to operate optimally without ongoing monitoring, maintenance and commissioning. This is rarely in the budget, but even more importantly these complex systems are not designed for longevity and ease of use. Instead, they resemble proprietary black-boxes with future consulting revenue potential for the designer, rather than appropriate technology to meet the building operators' long-term needs.

The building that our agency is located in is an unfortunate example. We are in a privately-owned high-rise, several floors of which house state agencies. Not that many years ago the building was renovated, and it has fully automated timing systems and motion sensors for the lighting. Yet until recently, due to malfunctioning controls, and the difficulty of making adjustments, the lights on most floors have been on all night every night. The private offices and conference rooms have motion sensors, but many of these have not been adjusted correctly, so that the lights stay on for more than an hour even when no one is present.

Tenants also commonly lack incentives to control their own electricity, heating, and cooling usage, because they don't pay utility bills based on their specific consumption, as separate from other occupants of the building. This could be corrected by submetering of utilities, which modern technology increasingly has made feasible and affordable. In Europe such sub-metering is expected, but in the U.S. it remains the exception rather than the rule.

There is a saying that what is measured can be fixed, but what is not measured will be ignored. This is highly applicable to energy consumption in buildings. When someone purchases a building or takes out a lease, they rarely know what the structure's past energy consumption has been or what it's specific energy-related features are. If purchasers and prospective tenants knew what their future energy bills were likely to be, they would demand efficiency improvements before making financial commitments. For this reason, it is essential that past energy use of buildings be calculated in a standardized way, such as BTU's per square foot, and that these figures be publicly available. Then these numbers need to be converted to an easily understandable universal ranking system, such as an A to F scale. This is being done in several European countries, including the United Kingdom, Germany, and Austria. ASHRAE has just announced that it will develop such a scale, and in Massachusetts our Zero Net Energy Buildings Task Force is recommending that we begin mandating such rankings, first for new construction, and eventually for all buildings in the state.

While we have these systemic problems within the construction sector, at the same time we also have the technical knowledge and design professionals to avoid and solve these problems. It is a relatively easy option to set our sights higher and choose a different path, one that achieves dramatic increases in energy efficiency, while also improving indoor air quality and day lighting. A movement to zero-energy buildings is within our sights, as California and Massachusetts have recognized, with other states giving this goal increasing attention.

One primary barrier to these intertwined and complementary goals is one of capital, or 'first' costs, and investment in design. We no longer build the way we used to a century ago, not just because we have better technology and materials, but also because our real estate industry does not have incentives to afford the time or the capital to invest in new construction the way that humanity has in the past.

TRANSFORMATIONAL, NOT INCREMENTAL, IMPROVEMENTS IN ENERGY CODES

Massachusetts urges a 'step change' in energy codes to reflect the policy imperative of moving our buildings away from exorbitant use of fossil fuel-generated heat, light and power—the Iced-Tea model—towards efficient and integrated design. We believe that a dramatic shift in energy awareness in the design and management of buildings is needed to reduce our long-term energy costs, improve our energy security, and address climate change. Massachusetts and several other states are act-

ing to update codes, but we urge Congress to consider federal action, and a state and federal partnership to ensure an adequate response at the state level.

Historically, energy codes in the U.S. have not been set at the federal level. But this is a time for change, and federal leadership on energy codes is needed. Moreover, a federal and state partnership could reinvigorate the construction industry by raising standards across the board, reaching for and achieving high-performance buildings. Eventually our buildings will have to be net-zero consumers of fossil fuels, so efficient that their consumption can be balanced by on-site production of renewable energy, and we need to be designing for that future now.

CURRENT CODE DEVELOPMENT LEADS TO INCREMENTAL ENERGY IMPROVEMENTS

Current code updates from the International Codes Council (ICC), which creates the

International Energy Conservation Code, IECC) and ASHRAE are iterative, incremental processes that largely protect the status quo of building construction. ICC and ASHRAE are non-profit membership organizations, essentially private, unelected, undemocratic bodies. These organizations do self-select for the most technically minded code officials, however, decisions are made by whoever happens to show up at meetings, as voting has to be in-person. Votes at IECC are won by whoever organizes the most people around their issue. For example, at last year's Minneapolis annual meeting over 1,000 people voted on requiring sprinkler systems in new residential homes, while only 150 or so voted on adoption of most other provisions. These included a package of measures to improve energy efficiency by 30% that DOE, NASEO and others had worked for two years to develop. The 30% energy efficiency improvement vote was taken at 1:30 am on a Sunday morning, and failed to pass by five votes. What was passed is estimated to improve energy efficiency by 12% to 14%. This is far too timid an improvement. The time is now to be much bolder.

DOE SHOULD PUBLISH A NATIONAL BUILDING CODE WITHIN SIX MONTHS

We need more advanced building energy efficiency codes and we need specific incentive funding to implement these codes and train local code officers, builders and contractors.

During the last Congressional session advocates pushed legislation which said that if the latest IECC (2009) does not improve efficiency by 30% over the last version, then DOE must write its own code which does raise efficiency by 30%. Such legislation should be proposed again, including possibly with higher efficiency goals. This would substantially improve upon the relatively small efficiency gains that typically flow from the ASHRAE and IECC updates.

DOE has begun development of model energy codes that are 50%, not 30%, better than existing code. These need to be implemented, and could form the basis for a national minimum code in the next two to three years. This level of improvement will require more attention to building design, including continuous air and radiant barriers in the building envelope, higher minimum standards for windows, increased use of insulation, and a rethinking of heating and cooling systems; but existing off-the-shelf technology can meet these goals.

In order to provide for state innovation, federal legislation could specify that a national code from DOE set an aggressive minimum floor which states must adhere to, but each state is free to set even stricter standards for its own code. Since there are large climate differences among the states, along with economic differences, a federal code should preserve the variance in code requirements by climate regions.

We would also recommend that if a federal code is developed, there be a requirement to update it every three years, as the IECC and ASHRAE do now. Technologies are constantly changing, and much progress would be missed by waiting more years for updates. This is a primary reason why Massachusetts passed a law mandating that we always update to the most recent IECC code, because until recently it had taken us eight years between one update and the next one.

In addition to building codes, efficiency standards for appliances, electronics, and other equipment are critical to reducing energy use, particularly because 'plug-loads' are rising rapidly as a fraction of total energy use in buildings. Federal standards for equipment are an integral part of ensuring energy smart codes. The performance and sizing of heating and cooling equipment in particular need renewed federal action, and a commitment to regular future updates. Massachusetts has petitioned DOE to set it's own higher performance standards for heating equipment; but for all states it is essential that the federal bar is raised, and that the new generation of renewable heating equipment options are fully developed and promoted.

SPECIFIC RECOMMENDATIONS FOR FEDERAL CODE REQUIREMENTS

Federal Energy Star standards for new buildings need to be improved in several specific areas:

Heating systems should not require leaky buildings—Heating with any fuel should require sealed combustion units. This technology is already in widespread use today, and is far safer and more efficient, not least because it doesn't require a hole in the building shell to vent fumes to the outside.

Solar thermal—the Energy Star program already has a proposed Advanced New Home Construction package that would require solar water heating in Southern U.S. climate zones (zones 1-3). We would like to see this implemented and consideration given to solar thermal throughout the U.S.

Higher insulation standards—the same draft Advanced Energy Star package has also proposed 50% improvements in insulation above the latest IECC requirements.

Move away from forced-hot air heating—heating or cooling with forced air in leaky buildings is a recipe for inefficiency. Hot water heating and cold water cooling is not only more efficient and more comfortable, it is also much more compatible with efficient use of solar thermal, geothermal and biomass pellet or woodchip heating systems. Exemplary heating and cooling systems include radiant floor heating in Northern climates, efficient mini-split ductless heat pumps in mixed climates, and radiant water cooled wall and ceiling panels in cold climates. None of these systems require any ducts, so leaky, dusty, mold-inducing air delivery can be a thing of the past. While traditional air-conditioning is likely here to stay for a while, lets make it compete with other more efficient and healthier technologies.

'STRETCH CODES'—MASSACHUSETTS AND FEDERAL

There will always be a market for buildings built 'beyond code' by progressive builders and owners who value leadership in this area. To date the EPA and DOE have filled this residential market with the Energy Star for Homes program, and left the commercial sector more to private and non-profit groups such as the LEED green building programs.

In Massachusetts, as in many states, there is a growing Energy Star for Homes market. Even during the dramatic housing downturn, Energy Star homes are retaining value and showing rapid sales. However, the Energy Star base requirements are only a 15% energy improvement over the 2004 IECC code, and in the higher tier a 35% improvement. These goals equate to a Home Energy Rating System (HERS) score for new homes of 85 and 65 respectively, where zero would be a zero-energy home.

Our newly proposed Massachusetts advanced or 'stretch' code builds on the extensive research and sound building science of the Energy Star Homes program. But based on actual buildings constructed in the past two years we have proposed a minimum standard HERS score of 60, improving to 50 in three years time—roughly 30% to 40% better energy performance than current Massachusetts code (which yields a HERS score of around 92). Thus, our proposed stretch code would be substantially more aggressive than the existing Energy Star Homes program. Last year, 270 homes built in Massachusetts achieved a HERS score of 60, despite there being no financial incentives at that time to go below a score of 70.

Our stretch code is paving the way for future improvements to our statewide base code, based on 3rd party certified performance and heading rapidly towards a zero energy future. A more detailed plan of action for our state will be released in March by the Zero Net Energy Buildings Task Force commissioned by Governor Patrick last year. California has also called for zero net energy buildings in the next decade, in quite different climate zones from New England. Matching or exceeding the current Massachusetts and California targets would be a logical step to take nationwide, and we believe that the program staff at the EPA and DOE have done the work to prepare for this opportunity. They just need leadership from Congress and the executive branch to send the signal to step up the planning and roll out a more forward-looking Energy Star standard for new home construction.

EXISTING BUILDINGS—RENOVATIONS, ADDITIONS, AND RETROFITS

New construction matters, but particularly in old states like Massachusetts, it is just the tip of the iceberg. We have massive energy liabilities in our existing building stock, both residential and commercial. As previously mentioned, we have a well developed energy efficiency retrofit program operated by our electric and gas utilities, that is undergoing rapid expansion, but we need to do more.

NASEO is working to promote Home Performance with Energy Star and we are members of the National Home Performance Council. We are attempting to more aggressively promote comprehensive energy efficiency improvements in existing homes.

As a result our stretch code also applies to renovations or additions to existing residential units, requiring any major projects to meet the same 3rd party verified improvements as new construction, but with a maximum HERS rating of 70, or in some cases 85, improving to 60 and 75 respectively in three years time. We are confident that bold action will strengthen, not weaken our real estate sector, and add green jobs and skills to our workforce.

For existing construction that is not undergoing major renovations or additions—which is most of our housing—we also need to dramatically improve efficiency. At present this cannot be done through building code requirements, but can be brought about through providing financial carrots to building owners. Massachusetts has had such incentives for many years, through programs operated by our electric and gas utilities, and we are in the process of greatly expanding those programs due to legislation passed in 2008.

We have long had residential energy auditors, insulation contractors, and plumbers making our aging housing stock more energy efficient. And for decades we have had engineers examining our commercial office buildings, city halls, hospitals, and industrial facilities replacing outdated lighting, motors, refrigeration equipment, and more.

The measures covered by the programs have varied over time, but include steps as simple as caulking and weather-stripping leaky doors and windows, and as complex and expensive as switching out a 50-year-old boiler for a brand new energy-efficient one. Often, commercial and industrial customers will get a comprehensive energy audit from experienced engineers that will provide a list of more than a dozen energy efficiency measures that will reduce energy expenses, cut pollution, and improve aging capital.

These programs have been highly cost effective, delivering great benefits to the Commonwealth. These include energy bill savings through direct reductions in energy use by homes and businesses that have made efficiency upgrades. But the benefits go farther than that. Energy efficiency reduces demand for electricity from the regional electricity grid, which means that all these measures significantly reduce pollution from power plants and forestalls the need to build new expensive peaking power plants.

Under our 2008 law, the state will make energy efficiency programs compete on price with traditional energy supply. Utility companies will be required to purchase all available energy efficiency improvements that cost less than it does to generate power to meet the same energy need, ultimately saving money on consumers' electricity bills. And it will be done not as an add-on to utility bills, but as an integral part of the way utility companies meet their customers' energy needs.

MULTI-FAMILY AND MANUFACTURED HOUSING

Within the existing building stock, multi-family and manufactured buildings stand out for special attention. Such homes represent over a quarter of the housing units in the U.S. and comprise 20% of energy consumed by all housing units, yet receive little attention in the implementation of energy efficiency programs. Saving energy is more difficult in such housing, both because many residents are low-income and because a large majority are renters. The 'split incentive' between tenants and landlords is a major barrier to efficiency investments.

Given the limited program experience to date, now is the time to encourage innovative approaches, to evaluate these approaches, and based on these evaluations to develop broader programs. We suggest a competitive grant program to seek creative solutions to multi-family and manufactured housing efficiency. Administered by DOE, this program would provide grants to state and local government agencies as well as nonprofit organizations to create effective, replicable projects. Priority should be given to projects that provide substantial energy savings while targeting recipients with the greatest financial need. Prioritizing highly cost effective programs with significant matching funds will help maximize the return on federal grant funds. We recommend funding of about $50 million in the first year, rising to about $500 million in year five for multi-family homes.

In the area of manufactured housing, models in Maine and New Hampshire are instructive. We recommend providing rebates through state energy offices in cooperation with state housing finance agencies. $10,000 rebates to individuals in pre-1976 manufactured homes in order for them to move to Energy Star homes would

be a good start. $2 billion would address 10% of the over two million pre-1976 manufactured housing units.

There are some successful local programs in operation, including in California, Massachusetts, and Vermont, but these are few and far between. Programs could be developed to encourage retirement of old manufactured homes (over 60% of mobile homes are at least 20 years old), to invest in efficiency upgrades for new or existing publicly assisted housing, or to institute multifamily heating system retrofits.

Historically, manufactured homes have been some of the least energy efficient units, provided for the least financially able members of society. Yet such housing is also an efficient method for producing well-constructed and sealed homes, from both an air and water tightness perspective. This makes manufactured homes some of the lowest hanging fruit on a heavily laden tree. Technologies such as structurally insulated panels, coupled with energy recovery ventilation systems and ductless mini-split heat-pumps can and should transform the manufactured homes sector, so that formaldehyde and mold scandals and energy poverty are things of the past.

CURRENT EXAMPLES OF STEP-CHANGES IN BUILDING CONSTRUCTION

If these recommendations sound bold, let me briefly relate two examples that show how major changes in building design are being made today.

Zero Net Energy Buildings in Massachusetts.—In the small town of Townsend, in northern Massachusetts, we learned of a small construction firm building affordable housing with HERS ratings of zero and minus two. These are zero-net energy buildings, using no fossil fuel, and heated and cooled with solar thermal and photovoltaics. Equally remarkable, they are affordable housing units, although the builder has also pre-sold several market-rate houses in the same development. This is but one example of a nascent but growing trend across the U.S. and around the world.

Efficiency and solar heat in Upper Austria.—In Upper Austria, a region about the size and population of Connecticut that gets less sunshine than Montreal, Canada,[2] the regional government passed legislation last summer requiring solar thermal space heating to be provided on all new residential buildings. This is also a requirement in Israel and Hawaii, where there is considerably more sunshine.

In Upper Austria they were able to do this because they also have very strong building energy codes that minimize the number of BTU's needed to heat a home. Their new buildings are currently required to be three times as energy efficient as average existing buildings on a square meter basis. Their energy star equivalent program pushes 'Passive Haus' standards that have energy demands less than 10% of existing buildings, and their zero energy homes number in the thousands. They also require all publicly funded buildings to have an energy audit and an energy certificate showing how that building performs on an A-F scale. They now have over 70,000 buildings[3] with publicly available energy certificates, and seven square feet per capita of solar thermal panels.

Their stated goals are to reduce building energy use a further 39% by 2030 and to move to 100% renewable heating, cooling and electricity in buildings, thereby achieving zeronet energy buildings sector-wide and statewide.

In Upper Austria there used to be a significant market share of oil heating, just like the northeastern U.S. states today. In 1999 36% of new homes installed oil heating systems. By 2007 this had dropped to less than 1%, and they tell us that there were only 17 new oil heating systems installed in Upper Austria last year. The oil heating industry has disappeared in a decade, yet this has not led to an expansion of natural gas. Instead, renewable energy heating from solar thermal, biomass wood chips and pellets, and biogas from agricultural waste, have grown from an impressive 32% of new installations in 1999 to a 76% market share in 2007. Upper Austria now exports their pellet boilers and solar thermal heating and cooling technology throughout Europe. In Massachusetts, we will be hosting our second Upper Austrian delegation this April.

CONCLUSION

We must all look to the future and design and build for it now. That requires educating the public, both private citizens and companies, on the vast potential for im-

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[2] Data from NASA for Lintz, Upper Austria 1,216 kWh/m^2, and Montreal, Canada 1,319 kWh/m^2

[3] Data from the Energy Agency of Upper Austria: http://www.esv.or.at/esv/index.php?id=33&L=1

proving the efficiency of our buildings. Energy labeling of all homes and commercial space is critical, much as refrigerators and cars are labeled today. We need to know if our buildings are an 'A' or an 'F' and be able to make choices about the 'miles per gallon' equivalent of a building that we are considering a 30 year mortgage or a four year lease on. Massachusetts is committed to doing this, but we, like Upper Austria, are only a small state with big ideas. We encourage a federal—state partnership, to raise national standards while allowing state innovation to transform our energy landscape.

I am encouraged by your engagement in this matter, and as my testimony has indicated, encourage us all to be bold. I suspect that decades from now, no matter how bold we think we are being in this process today, we will look back at this time and wish we had been bolder.

The CHAIRMAN. Thank you very much.

Ms. AMANN.

STATEMENT OF JENNIFER AMANN, DIRECTOR, BUILDINGS PROGRAM, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY (ACEEE)

Ms. AMANN. Thank you, Chairman Bingaman, Ranking Member Murkowski, and members of the committee. I appreciate the opportunity to testify here today. My name is Jennifer Amann and I'm Director of the Buildings Program for the American Council for an Energy Efficient Economy. ACEEE is a nonprofit organization dedicated to increasing energy efficiency as a means of promoting economic prosperity, energy security, and environmental protection.

Buildings in the U.S. account for approximately 40 percent of our national energy consumption. As you've noted, energy efficiency is the fastest, cheapest, and cleanest energy source we have, so tapping this resource in our buildings is a critical step toward economic recovery and climate protection.

In collaboration with a range of stakeholders in the energy efficiency, environmental, and business communities, ACEEE is developing consensus recommendations for enhancing our existing efficiency programs and creating new initiatives that will accelerate an overhaul of our building stock. Our recommendations include improvements to existing policies, such as advanced building codes, appliance and equipment standards, and efficiency tax incentives, that have been covered by other witnesses or that will be addressed in future hearings.

These programs have an ongoing role to play in a comprehensive suite of efficiency policies and programs, but my recommendations on those are covered in greater detail in my written testimony.

Today I wanted to focus my comments on some new programs that we're developing to yield deeper levels of energy savings and to broaden the reach of our existing programs. Specifically, we urge adoption of: first, a building training and assessment center program based on the industrial assessment center program that DOE has operated successfully since 1976. The skills of well-trained technicians, designers, and contractors are needed to achieve and maintain buildings that operate productively, efficiently, and with minimal environmental impact.

The BTAC program will leverage existing programs at our universities, community colleges, vocational tech schools, and apprenticeship programs and develop new programs to expand and accelerate the numbers of qualified individuals with the appropriate skills and capabilities. BTACs would serve as an important source

of new work force in the field and its graduates would be in high demand for their expertise and experience.

Second, comprehensive building energy use disclosure, to provide building owners and potential purchasers and renters access to the information they need to understand the efficiency of a given building and opportunities for improvement. Through the program, EPA and-or DOE would develop ratings based somewhat on existing rating programs to help compare the efficiency of homes and commercial buildings. The rating systems would build on these existing ratings and should include a measured component based on estimated or actual energy use and a modeled component based on building's construction, envelope, and major energy systems.

Public disclosure of building energy ratings should be required for all public buildings, and for privately owned buildings disclosure should be encouraged for the parties to a purchase, finance, or lease transaction, along with annual disclosure of measured ratings to tenants of large buildings.

Third, we recommend a residential retrofit program. Tapping into the energy efficiency potential in our homes puts money in pockets and creates durable domestic jobs in energy efficiency that can never be sent overseas. Congress should act to implement a national home efficiency retrofit program, expanding on the EPA home performance with Energy Star program that now operates in 22 States.

To encourage greater participation in the program, Congress should establish a performance-based rebate system rewarding high levels of efficiency with higher rebates. The expanded program should include support for the training of contractors and home energy raters who would help implement the program.

This program has the support of more than 160 organizations and businesses, including energy and environmental advocates, contractors, and their related trade associations.

Fourth, we recommend a commercial retrofit program that would be established to encourage the near-term launch of large-scale deep retrofitting of private and publicly owned commercial buildings or portfolios of buildings. The program would provide an incentive to building owners for efficiency improvements of no less than 20 percent, with incentives calibrated to encourage 30 percent savings or greater. Partial payment of the incentive would be granted upon completion of the efficiency project and the remainder conditioned on verification of actual performance over a 3-year period. This program has support among energy and environmental advocates and the commercial real estate community.

Fifth, we recommend a multifamily and manufactured housing program. We propose Congress establish a competitive grant program to seek creative solutions to multifamily and manufactured housing efficiency. These homes represent more than a quarter of building housing units and comprise 20 percent of residential energy consumption. These homes demand special attention because it's proven difficult to implement energy efficiency programs in this sector and because of the disproportionate numbers of low to moderate income families that live in these homes and that have the greatest difficulty making efficiency investments without assistance.

These programs would be administered by DOE with grants provided to State and local government agencies, as well as nonprofit organizations, to create effective, replicable projects. Priority should be given to projects that provide substantial energy savings while targeting recipients with the greatest financial need. Further details on each of these program recommendations can be found in my written testimony.

In order to succeed, the new programs must receive adequate funding and we see several potential mechanisms for allocating program funds. State and local stimulus funds may be a source of funding for programs with significant administration or coordination by State and local governments. Similarly, any new stimulus funds can be directed toward the recommended programs.

Other potential sources include emissions allowances resulting from climate legislation or appropriations made as part of the normal budget process to allow for startup of climate-related programs prior to final passage of climate legislation.

Even if funds are not immediately available, we recommend that these programs be authorized so that they're ready when and if funds become available.

If implemented, our recommended policies and programs would reduce peak demand by about 41,000 megawatts, which is the equivalent to the power produced by 136, 300-megawatt power plants. Carbon emission reductions would total approximately 53 million metric tons in 2030, the equivalent of taking 9 million cars off the road. In addition, the savings would amount to approximately 3 percent of total projected U.S. energy consumption in 2030.

These policies would also yield significant economic benefits, including consumer energy bill savings of $12 billion in 2030 alone, and substantial additional building energy savings could be achieved with passage of a strong stand-alone Federal energy efficiency resource standard.

So in conclusion, buildings represent the largest energy-using sector of the U.S. economy. Improving the efficiency of our new and existing building stock should be a core component of our energy and climate policies. The policies and programs recommended here will impact all Americans by reducing energy expenditures, creating jobs, and cutting carbon emissions. We urge you to give serious consideration to these policies and to include them in upcoming energy legislation.

I'm happy to answer any questions that you may have.

[The prepared statement of Ms. Amann follows:]

PREPARED STATEMENT OF JENNIFER AMANN, DIRECTOR, BUILDINGS PROGRAM, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY (ACEEE)

SUMMARY

Buildings in the U.S. account for approximately 40% of our national energy consumption. Improving the efficiency of our buildings can free up energy resources to reduce the need for additional power generation and free up money for productive use and investment in our families, communities and enterprises. Energy efficiency is the fastest, cheapest, cleanest energy source we have; tapping this resource in our buildings is a critical step toward economic recovery and climate protection.

In collaboration with a range of stakeholders in the energy efficiency, environmental, and business community, ACEEE is developing recommendations for enhancing our existing efficiency programs and policies and creating new initiatives

that will accelerate an overhaul of our existing buildings stock. Our recommendations focus on: 1) increasing the availability and adoption of high efficiency appliances, equipment, and building components in new and existing buildings; 2) training the highly-skilled workforce needed to design, operate and maintain buildings and building systems to optimize energy efficiency; 3) improving information on building energy performance available to building owners, operators, purchasers, and renters; and 4) improving the efficiency of existing residential and commercial buildings through comprehensive building retrofits.

Specific recommendations include improvements to existing policies including advanced building codes, appliance and equipment standards, and energy efficiency tax incentives and adoption of new programs to retrofit residential and commercial buildings with additional attention directed to multifamily and manufactured housing, train a skilled workforce to design and operate buildings for optimal energy performance, and provide for disclosure of building energy consumption.

If implemented, these recommended policies and programs would reduce peak demand by about 41,000 megawatts with carbon emissions reductions totaling approximately 53 million metric tons in 2030.[1] The peak demand impacts are equivalent to 136 power plants of 300 MW each. The carbon emissions reductions are equivalent to taking 9 million cars off the road for a year. In 2030, annual savings would total 3.19 quads of primary energy,[2] including 153 billion kilowatt-hours (kWh) of electricity and 1,500 billion cubic feet of natural gas. These policies would also yield significant economic benefits including consumer energy bill savings of $12 billion in 2030. In 2020, impacts would be about 50% of the 2030 impacts. Substantial additional energy will be saved by the Energy Efficiency Resource Standard.

INTRODUCTION

My name is Jennifer Amann and I am the Director of the Buildings Program for the American Council for an Energy-Efficient Economy. ACEEE is a nonprofit organization dedicated to increasing energy efficiency as a means of promoting economic prosperity, energy security, and environmental protection. For more than 25 years, ACEEE has contributed in key ways to energy legislation including the Energy Independence and Security Act of 2007, the Energy Policy Acts of 2005 and 1992, and the National Appliance Energy Conservation Act of 1987. ACEEE's niche is to conduct research on successful and promising technologies and programs and base our policy recommendations on the results of this research. I am here today to provide recommendations for reducing energy consumption in buildings through improved implementation of authorized DOE programs and through other innovative federal energy efficiency policies and programs. I thank you for the opportunity to testify here today.

Buildings in the U.S. account for approximately 40% of our national energy consumption.[3] This doesn't have to be the case. Within our homes, businesses, schools, and gathering places there exists a tremendous resource of wasted energy that can be captured and put to productive use elsewhere. Improving the efficiency of our buildings can free up energy resources to reduce the need for additional power generation and free up money for productive use and investment in our families, communities and enterprises. Energy efficiency is the fastest, cheapest, cleanest energy source we have; tapping this resource in our buildings is a critical step toward economic recovery and climate protection.

Over the past forty years, energy efficiency has been an important factor contributing to U.S. economic growth—while income per capita doubled over the period, energy resources to meet the needs of our growing economy increased by only 50%.[4] Moving forward, efficiency has an even more critical role to play in addressing our current economic downturn, aggressively reducing carbon emissions, and shoring up our energy infrastructure. ACEEE studies demonstrate the large potential for energy savings in new and existing buildings using existing technologies and practices. A recent analysis, focusing on the state of Maryland, found that electricity use re-

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[1] Note: These are carbon emissions, not carbon dioxide emissions. Carbon dioxide emissions will be 3.67x the carbon emissions.

[2] A "quad" is a quadrillion Btu's. The U.S. uses about 100 quads annually.

[3] Energy Information Administration. 2008. Annual Energy Outlook 2009 Early Release. http://www.eia.doe.gov/oiaf/aeo/index.html. December. Washington, D.C.: U.S. Department of Energy.

[4] Ehrhardt-Martinez, K. and J.Laitner. 2008. The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture. May. Washington, D.C.: ACEEE.

ductions of 29% by 2025 are not only achievable, but cost-effective.[5] Emerging technologies offer the promise of even greater savings well into the future.

Existing efficiency policies save American citizens and businesses money every day while reducing pollution and easing demand on our energy infrastructure. Appliance and equipment standards already in place will save more than 5 quadrillion Btu, over 4% of U.S. energy consumption in 2020.[6] Building energy codes have contributed to reductions in new home and commercial building energy use, savings consumers an estimated $1 billion or more per year in energy costs. These policies have an ongoing role to play in a comprehensive suite of buildings energy efficiency policies and programs.

New programs and policies can build on the success of these programs to yield deeper levels of energy savings and to broaden the reach of programs to improve energy efficiency throughout our diverse building stock. These policies will build on our growing understanding of building science; promote the latest best practices in construction, retrofits, and building operations and maintenance; and enable a new generation of highly-skilled building professionals to keep our building operating productively, efficiently, and with minimal environmental impact.

The American Recovery and Reinvestment Act of 2009 demonstrates Congress' recognition that building energy efficiency improvements can play an important role in saving consumers and businesses money and creating new jobs here in the U.S. The legislation provides a mix of grants, rebates, loan guarantees, and tax incentives for retrofitting federal buildings and low-income housing, expanding state-based efficiency programs, and increasing adoption of high-efficiency appliances and equipment. These investments in a more efficient buildings stock are a good start, but more needs to be done. We have a great opportunity to build on this momentum by strengthening existing buildings efficiency policies and creating new programs to address certain critical gaps.

In collaboration with a range of stakeholders in the energy efficiency, environmental, and business community, ACEEE is developing recommendations for enhancing our existing efficiency programs and policies and creating new initiatives that will accelerate an overhaul of our existing buildings stock. Our recommendations focus on: 1) increasing the availability and adoption of high efficiency appliances, equipment, and building components in new and existing buildings; 2) training the highly-skilled workforce needed to design, operate and maintain buildings and building systems to optimize energy efficiency; 3) improving information on building energy performance available to building owners, operators, purchasers, and renters; and 4) improving the efficiency of existing residential and commercial buildings through comprehensive building retrofits.

SPECIFIC RECOMMENDATIONS

Below we provide a number of specific policy recommendations; some are relatively minor tweaks of existing programs while others are new programs that will require significant funding to succeed. Following the recommendations, we discuss potential mechanisms for funding any new programs.

Improving Existing Policies

Advanced Building Codes: In order to meet long-term energy goals, it is important that new buildings be as energy-efficient as is economically justified, since it will be much more expensive to retrofit these buildings after they are completed. Model code organizations are in the process of updating building codes to achieve aggressive levels of savings. The International Energy Codes Council recently adopted changes to residential building codes and will consider additional changes in the coming months. The American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) has set a 30% savings target for the pending 2010 update of their model commercial building code. To support these efforts, the 2007 House energy bill contained a provision calling for DOE and states to update energy codes for new buildings. This provision directed DOE to support efforts by model code organizations to update building codes to reduce energy use of new buildings by at least 30% by 2010, and 50% by 2020.[7] As new codes are finalized, states were directed to either adopt these model codes or their own state-specific equivalents.

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[5] Eldridge, M. et al. 2008. Energy Efficiency: The First Fuel for a Clean Energy Future Resources for Meeting Maryland's Electricity Needs. February. Washington, D.C.: ACEEE.

[6] Nadel, S., de Laski, A., Eldridge, M., and Kliesch, J. 2006. Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards. Washington, D.C.: ACEEE

[7] The 50% goal is a qualification level for energy efficiency tax credits adopted by Congress in 2005.

Funding and technical assistance to states was authorized. This provision should be adopted in 2009, with the date for the second new code accelerated to 2016. Six years between code upgrades is reasonable, particularly since the 50% savings level is already being promoted by federal tax incentives enacted by Congress in 2005.

In addition, Congress should consider provisions to allow higher minimum equipment efficiency requirements in building codes (i.e., levels exceeding federal equipment efficiency standards) provided the code offers an explicit pathway for meeting code levels with equipment just meeting federal minimums (e.g., by including other efficiency measures to make up for the lower efficiency equipment).

ACEEE estimates that by 2030, this building code provision would save 1.4 quads of energy (including 75.7 billion kWh of electricity and 567 billion cubic feet of direct natural gas), with carbon emissions reductions totaling approximately 23.4 million metric tons in 2030. The policy would also yield significant economic benefits including net energy bill savings for customers of $5.13 billion in 2030.

Appliance and Equipment Standards: Federal minimum efficiency standards have been set by Congress on more than 40 products. New legislation should add a few additional products, based on negotiations now underway with industry to develop consensus recommendations on several products. New legislation should also clarify aspects of the process by which DOE periodically revises these standards including: clarifying DOE's authority to set multiple performance standards for a product (this was in the House and Senate 2007 energy bills, but dropped from the final bill); directing DOE to consider the impact of carbon emissions and the impact of the energy savings on energy prices when setting standards; strengthening the "rebuttable presumption test" for setting standards when efficiency savings are highly cost-effective, and setting standards on "BR" reflector lamps, a major loophole in current DOE standards. We understand the Committee is likely to have another hearing on appliance and equipment efficiency standards and we will provide further comments for that hearing, including energy savings estimates.

Energy Efficiency Tax Incentives: In addition to the recent changes to the tax incentives available for energy efficient equipment and building upgrades, Congress should adopt long-term extensions of the tax credit for high efficiency new homes. The new homes credit has been particularly effective, spurring the construction of more than 20,000 highly-efficient homes in 2007 (2008 data not yet available). Also, the amount of the efficient commercial buildings tax deduction should be increased from $1.80 to $3 per square foot, as participation at $1.80 per square foot is very small. To increase the effectiveness of the tax incentives, Congress should also make certain policy changes such as simplifying and clarifying the commercial building tax incentive paperwork requirements and including labor costs in any extension of residential retrofit credits (for labor-intensive measures such as insulation and duct sealing, a credit limited to a small percentage of material cost has very little value or impact). We also recommend adoption of a tax credit to cover the costs of approved certifications for contractors. We have not yet analyzed the energy savings from such a provision.

New Policies and Programs

Building Training and Assessment Center Program: Higher performance buildings that save energy by operating with greater energy efficiency are readily attainable today. These buildings are dependent on well-trained technicians, designers, and contractors to perform optimally. The effort and resources to properly train, recognize, and reward these individuals can yield enormous benefits given high and unpredictable energy costs. By carefully designing and engineering commercial and institutional buildings to be more energy-efficient, up to 50% of energy costs can be eliminated for owners of new buildings and potential savings in existing buildings of 20% to 30% or more. However, even well-designed commercial buildings may run 10-15% below expected energy performance levels because of poor installation, poor commissioning, and operational errors. Improving building energy efficiency is a cost-effective way to make buildings more affordable, improve comfort, and reduce costs for building owners.

We recommend that Congress establish a Building Training and Assessment Center (BTAC) program, based on the Industrial Assessment Center (IAC) program that has operated since 1976. This program has been one of DOE's most effective programs, training industrial engineers and providing them with practical hands-on experience by providing free energy audits to industrial firms. While there are existing building engineer and building and equipment technician training programs in some parts of the country, there is a fundamental need for more students trained in these skills and for increased levels of hands-on training addressing the real-world problems encountered in the field. The BTAC program will focus on leveraging existing programs at universities, community colleges, vocational-tech schools (secondary

level), and apprenticeship programs, and developing new programs to expand and accelerate the numbers of qualified individuals with these skills and capabilities. BTACs would serve as an important source of new workforce for the field, and its graduates would likely be in high demand for their experience and expertise, as have the graduates from the IAC program. Graduates from the programs will be prime candidates for high-paying, high-skilled jobs.

In the BTAC program, engineering students in universities across the country will work closely with professors to provide free building energy assessments. The audits performed for commercial and institutional buildings will emphasize easy-to-execute, inexpensive energy saving measures for the buildings. The BTAC program will improve the operational efficiency and performance of thousands of buildings across the country, creating energy and dollar savings for owners and tenants. In addition, the technicians and building operators trained in the program will have the skills needed to maintain these energy savings and will be guaranteed practical experience in real buildings. By providing continuing education for building technicians, BTACs can work with local firms and technicians to improve capacities already in the market. A more detailed description of the program is attached to this testimony.

Building Energy Disclosure: Building owners and potential purchasers and renters rarely have access to the information they need to understand the energy efficiency of a given building and opportunities for improvement. This information can motivate owners to upgrade their buildings, and help prospective buyers and tenants select more efficient buildings. Through the Energy Star buildings and new homes programs, EPA has a good track record in this area. Moving forward, a more comprehensive and effective building energy use disclosure program can have a much greater impact.

We recommend that EPA and/or DOE develop a rating system designed primarily to help home buyers and renters compare the energy efficiency of homes, and rating systems to help buyers and tenants compare the energy efficiency of commercial buildings of the same type. The rating systems should include an operational component based on estimated or actual source energy use (adjusted for weather and operating conditions) and an asset component based on the construction, envelope and major energy systems. The rating methods may be different for new and existing buildings but should attempt to yield comparable ratings. Existing ratings such as the Home Energy Rating System and the Energy Star benchmarking system for commercial buildings may be the basis for these ratings. To ease comparisons, the rating systems should include the efficiency of a similar building that meets the model building energy code as of the date of the rating and of a similar building that meets Energy Star criteria.

These rating systems should form the basis for building energy disclosure requirements. Rating and public disclosure of building energy consumption should be required for all public buildings. For privately-owned buildings, disclosure should be encouraged for the parties to a purchase, finance or lease transaction along with annual disclosure of operational ratings to tenants of large buildings. The program should include provisions for DOE and EPA to work with states, counties and local governments to implement programs that encourage building owners to have publicly accessible certificates showing the individual building's performance relative to similar buildings, the building's energy efficiency potential, and the location and type of transit services within walking distance of the building.

If implemented, building disclosure will directly save approximately 8.2 billion kWh of electricity and 68 billion cubic feet of direct natural gas, with carbon emissions reductions totaling approximately 2.7 million metric tons in 2030. The policy would also yield significant direct economic benefits including energy bill savings for customers of $580 million in 2030. These are only direct benefits from assessments conducted under the program. In addition, the increased number and quality of building engineers and technicians will enable substantial additional energy savings which we have not attempted to quantify.

Residential Retrofits: The untapped potential of our homes to operate efficiently is a drag on consumer spending, as dollars are wasted on energy. Tapping in to this potential puts money in pockets and creates durable, domestic jobs in home efficiency that can never be sent overseas. Congress should act immediately to implement a national home efficiency retrofit program to save Americans money and stimulate the economy. This program would expand the EPA Home Performance with Energy Star comprehensive retrofit program that now operates in 22 states and should encourage much greater participation in the program by establishing rebates for homes that undertake comprehensive energy efficiency retrofits. The rebate would be performance based, rewarding higher levels of energy efficiency improvement with higher rebates. Funding for the state-administered rebates could

initially come out of stimulus funds being given to states and cities, with longer-term funding provided under climate legislation. The expanded program should include support for the training of contractors and home energy raters who would help implement the program. A more detailed description of the program is attached to this testimony.

Significant environmental and economic benefits would result. For homeowners, the benefits are meaningful and immediate. The average homeowner will spend around $2,300 on energy bills this year, and a performance retrofit will likely reduce these costs by about 25%, corresponding to nearly $6,000 in energy savings through the 10th year. This money represents extra cash for necessities or disposable income that will be injected back into the larger economy. At a national scale, the benefits of home retrofits are enormous. If the program reaches a million homes per year the 10 year energy savings would be enough to fully power about 15 million homes for a year. Scaling up the home efficiency industry would provide about 50,000 net jobs. This program has the support of more than 160 organizations and businesses including energy and environmental advocates, contractors, and related trade associations.

If implemented, residential retrofits will save approximately 26 billion kWh of electricity and 560 billion cubic feet of direct natural gas, with carbon emissions reductions totaling approximately 13.3 million metric tons in 2030. Energy savings in 2030 total 0.84 quads with energy bill savings for homeowners of $3.1 billion in that year.

Commercial Retrofits: Improving the efficiency of commercial buildings can yield higher returns for owners, increase tenant retention, and improve the productivity of workers, students, and others using the facilities. Congress should establish a program that would encourage the near term launch of large scale, deep retrofitting of private and publicly owned commercial buildings or portfolios of buildings. The program would provide an incentive to building owners for efficiency improvements based on demonstrated energy savings of no less than 20% with incentives calibrated to encourage 30% savings or greater. The Energy Star Building benchmarking program would be used to document and verify performance and the incentive would take the form of a rebate per square foot. A loan guarantee, proportional to the targeted energy savings level, would be established to enable upfront investment in energy efficiency projects. Partial payment of the incentive would be granted upon completion of the efficiency project and with the remainder of the incentive conditioned on verification of actual performance over a three year period. This proposal was initially developed by the Real Estate Roundtable and NRDC. This would be another program for which initial incentives might come out of stimulus funds, with long-term funding incorporated into climate legislation.

ACEEE estimates that commercial retrofits would save approximately 40 billion kWh of electricity and 266 billion cubic feet of direct natural gas, with carbon emissions reductions totaling approximately 11.9 million metric tons in 2030. Energy savings in 2030 total 0.67 quads with energy bill savings for businesses of $2.6 billion in that year.

Multi-Family and Manufactured Housing: Multifamily buildings and manufactured (mobile) homes offer a vital opportunity to save significant amounts of money through energy efficiency program implementation. These housing types represent more than a quarter of U.S. housing units and comprise 20% of residential energy consumption. Multifamily and manufactured homes demand special attention because it has proven difficult to implement efficiency programs targeting these homes and the disproportionate numbers of low to moderate income families have the greatest difficulty making efficiency investments without assistance.[8] Given the limited experience with such programs to date, we recommend a process that will encourage a variety of innovative approaches for trial and evaluation. The most successful approaches could be developed into broader programs.

Past experience has shown that multifamily buildings have the potential to realize energy efficiency savings up to, and even exceeding, 20%. To tap the potential savings, we propose that Congress establish a competitive grant program to seek creative solutions to multifamily and manufactured housing efficiency. These programs would be administered by DOE, with grants provided to state and local government agencies as well as non-profit organizations to create effective, replicable projects. Priority should be given to projects that provide substantial energy savings while targeting recipients with the greatest financial need. Prioritizing highly cost

[8] According to the 2005 Residential Energy Consumption Survey (EIA 2007), 71% of households in multi-family buildings and 80% of households in manufactured housing are low-income (earning less than $40,000), while 28% in each housing type are living below the poverty line ($20,000).

effective programs with significant matching funds will help maximize the return on investment of federal grant funds. A more detailed description of the program is attached to this testimony ACEEE's preliminary estimates indicate that this program would yield 0.15 quads of energy savings in 2030, with consumer energy bill savings of $570 million and carbon emissions reductions of 2.4 million metric tons.

Energy Efficiency Resource Standard: Though not specifically a buildings energy efficiency policy, the substantial majority of savings from an energy efficiency resource standard would come from energy efficiency improvements in residential and commercial buildings. Providing each major electricity and natural gas distributor with a simple and equitable target for achieving energy savings will serve to drive investment in cost-effective energy efficiency as an energy resource for large-scale acquisition. Eighteen states have enacted successful energy efficiency resource standards; a national policy would expand the savings and benefits throughout the country and yield national emissions reduction and price reduction effects that would benefit all states, including those that have already enacted the standard. ACEEE estimates that by 2020, a well-designed federal energy efficiency resource standard would reduce peak demand by about 90,000 megawatts with carbon emissions reductions totaling approximately 260 million metric tons in 2020. The policy would also yield significant economic benefits including net energy bill savings for utility customers of $144 billion and the creation of 260,000 net jobs. Our analysis only looks at energy savings targets through 2020, and thus energy savings drop off somewhat in 2030 as measures installed in earlier years wear out. If targets are increased over the 2020-2030 period, much higher 2030 savings would result.

FUNDING THE RECOMMENDED PROGRAMS

In order to succeed, the new programs we recommend must receive adequate funding. We see several potential mechanisms for allocating the necessary program funds. State and local stimulus funds may be a source of funding for programs with significant administration or coordination by state and local governments, such as the Residential Retrofit and Multifamily and Manufactured Housing program. Similarly, any new stimulus funds could be directed toward the recommended programs. Other potential sources include emissions allowances resulting from climate legislation or appropriations made as part of the normal budget process to allow for start up of climate-related programs prior to final passage of climate legislation. Even if funds are not available immediately, we recommend that these programs be authorized so they are ready when and if funds become available. Several new programs were authorized in the Energy Policy Act of 2005 and Energy Independence and Security Act of 2007 and first funded under the American Recovery and Reinvestment Act. We anticipate a similar process with emerging 2009 energy legislation authorizing programs that could be funded under future climate legislation.

OVERALL SAVINGS

ACEEE has developed estimates of energy savings and carbon emissions reductions associated with each of the recommended policies and program. The table below summarizes our preliminary estimates of savings for each provision we discuss. Together, the recommended improvements to existing policies and adoption of new policies and programs will save 3.19 quads of primary energy in 2030, avoiding 41,000 mega-watts of peak demand and creating annual consumer energy bill savings of $12 billion. The peak demand reductions are equivalent to the output of 136 300-MW power plants. Carbon emissions reductions from the buildings programs will total approximately 53 million metric tons in 2030, the equivalent of taking 9 million cars off the road.[9] Substantial additional energy will be saved by the Energy Efficiency Resource Standard.

CONCLUSION

Buildings represent the largest energy using sector of the U.S. economy. Improving the energy efficiency of our new and existing building stock should be a core component of our energy and climate policies. The policies and programs recommended above will impact all Americans by reducing energy expenditures, creating jobs, and cutting carbon emissions. We urge you to give serious consideration to these policies and to include them in upcoming energy legislation.

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[9] Note: Based on 6 metric tons of CO_2 per vehicle per year.

Savings Estimates for Potential Buildings Provisions
ACEEE's assessment of the potential energy, carbon, and economic savings

Annual Energy Savings Estimates			2020						
Title	Subtitle	Section	Electricity (TWh)	Avoided Peak Demand (MW)	Direct Natural Gas (BCF)	Indirect Natural Gas (BCF)	Oil Savings (Million barrels per day)	Primary Energy Savings (Quads)	Carbon (MMT)
EERS	*Energy Efficiency Resource Standard*		282.2	90,763	1,366	1429	195	2.94	70.8
Buildings	*Advanced Building Energy Codes*	Residential	10.9	2,946	93	55	8	0.21	3.5
		Commercial	21.6	5,842	143	110	15	0.37	6.4
	Building Labeling/Disclosure	Residential	1.7	470	18	9	1	0.02	0.6
		Commerical	2.5	682	16	13	2	0.04	0.6
	Energy-Saving Home Retrofits		14.2	3,830	247	72	10	0.09	6.5
	Multifamily and Manufactured Housing		6.6	1,842	59	35	5	0.13	2.3
	Commercial Building Efficiency Retrofits		34.5	9,315	16	175	24	0.39	7.1
	Building Training & Assessment Centers(BTACs)		0.122	33	0.8	0.62	0.08	0.0021	0.036
Subtotal			92.4	24959.5	593.2	468.2	63.9	1.2	27.3
Total			374.5	115722.4	1958.5	1897.1	259.0	4.2	98.1

Savings Estimates for Potential Buildings Provisions
ACEEE's assessment of the potential energy, carbon, and economic savings

Annual Energy Savings Estimates			2030								
Title	Subtitle	Section	Electricity (TWh)	Avoided Peak Demand (MW)	Direct Natural Gas (BCF)	Indirect Natural Gas (BCF)	Oil Savings (Million barrels per day)	Primary Energy Savings (Quads)	Carbon (MMT)	Carbon Dioxide (MMT)	Gross Consumer Savings (Billion 2005$)
EERS	*Energy Efficiency Resource Standard*		188.6	60,648	549	921	126	2.58	41.7	153.0	$ 144.10
Buildings	*Advanced Building Energy Codes*	Residential	20.2	5,458	223	99	13	0.44	7.3	26.8	$ 1.64
		Commercial	55.5	14,985	344	271	37	0.94	16.1	59.1	$ 3.49
	Building Labeling/Disclosure	Residential	2.8	789	35	14	2	0.07	1.1	3.9	$ 0.24
		Commerical	5.4	1,468	33	27	4	0.09	1.6	5.7	$ 0.34
	Energy-Saving Home Retrofits		25.6	6,921	560	130	18	0.84	13.3	49.0	$ 3.12
	Multifamily and Manufactured Housing		3.3	900	116	17	2	0.15	2.4	8.7	$ 0.57
	Commercial Building Efficiency Retrofits		40.0	10,800	288	203	28	0.67	11.9	43.6	$ 2.58
	Building Training & Assessment Centers(BTACs)		0.2	42	0.9	0.8	0.11	0.0025	0.044	0.16	$ 0.010
Subtotal			153.0	41322.7	1576.8	761.2	103.9	3.2	53.7	197.0	12.0
Total			341.5	101927.5	2124.5	1681.8	229.6	5.8	95.3	281.0	158.1

The CHAIRMAN. Thank you very much.
Mr. Hubbell, go right ahead.

STATEMENT OF WARD HUBBELL, PRESIDENT, GREEN BUILDING INITIATIVE, PORTLAND, OR

Mr. HUBBELL. Mr. Chairman, Ranking Member Murkowski, and Senators: I appreciate the opportunity to come and talk to you today. I'd like to talk to you about voluntary green building rating systems and the role that we have seen that they can play in accelerating our common objectives of improving our energy efficiency in buildings.

I represent the Green Building Initiative, which is a nonprofit organization dedicated to accelerating the adoption of green building practices by mainstream builders and designers. First let me say that we strongly support the increased focus on improving the energy efficiency of existing buildings. New building design remains a very important issue, but existing buildings represent a much larger opportunity for improvements.

According to the DOE's building data base, there are fewer than 200,000 new commercial buildings constructed each year versus more than 5 million that exist today. So the opportunity for improvement there is fairly obvious.

My organization owns the U.S. rights to the Green Globes Environmental Assessment and Rating System for Commercial Buildings. Green Globes is web-based and interactive and therefore easy to use and affordable for any type of building or budget. Green Globes includes two modules, one for new construction and one for existing buildings. They can be used separately or together to create an ongoing cycle of benchmarking, measurement, and improvement.

Because of its affordability and ease of use, Green Globes has been used to evaluate dozens of U.S. Federal buildings as well as State and local government facilities, like the Arkansas Department of Environmental Quality Headquarters and the Summit County, Colorado, Recycling Center. Green Globes has been used by higher education institutions, like Drexel University, who recently certified their entire campus, and a number of local school districts.

It's also been used by a growing list of global corporations like Dow Chemical and Newell Rubbermaid that need a credible but cost-effective certification for a large portfolio of commercial buildings.

Voluntary green rating systems like Green Globes help incentivize building design and building operation in three important ways. First, they define goals beyond mandatory code in critical areas such as energy conservation and carbon reductions.

Second, they provide the means to measure progress against these goals so that building owners can set priorities, measure outcomes, and plan improvements.

Third, rating systems create a market dynamic that rewards those who go beyond what is required. The financial sector, for example, has begun to reward green certification through green insurance policies and green mortgages, and there is mounting evi-

dence supporting the marketing benefits of green building certification.

Now, given the interest and goals of this committee, I would now like to describe how Green Globes addresses energy efficiency and carbon reduction specifically. To our knowledge, Green Globes allocates a greater percentage of its points toward energy conservation than any other comprehensive green building rating system in operation today. More than a third of its points are weighted in energy and a building must first be at least 25 percent more efficient than average before earning any points in energy.

Our system is integrated with U.S. EPA's Energy Star program and benchmarks against actual building data from the building Department of Energy CBECS data base. We currently report on carbon emissions based on direct energy consumption and in our next version of the standard we will require a performance goal that is based on calculating carbon dioxide equivalency in order to reflect the true carbon footprint of the building.

We will also incorporate scoring to reflect cradle-to-grave carbon emissions and embodied energy of hundreds of common building assemblies, so that material selections can also be evaluated against global climate impacts.

Green Globes is the only green building rating system that requires a rigorous onsite building inspection prior to certification, and will soon become the first and only American national standard for commercial green buildings. A similar ANSI standard, I should note, for residential green building was recently published by the National Association of Home Builders and the International Code Commission.

In conclusion, I'd like to leave the committee with three observations. First, green design is important, but it's only part of the equation. Effective building operation and maintenance is necessary for substantial nationwide reductions in energy use and carbon emissions.

Second, although good energy benchmarking data exists through the Department of Energy and EPA's Energy Star program, there is a need for better data on building performance. The State of California's Cal Arch data base appears to be a good model and we would encourage the DOE to look closely at it.

Finally, while many will follow good green design and construction practices because it's the right thing to do, many more will do so for an economic return. For that reason, better information on the economic benefits of certified green buildings will likely increase their numbers.

Thank you very much.

[The prepared statement of Mr. Hubbell follows:]

PREPARED STATEMENT OF WARD HUBBELL, PRESIDENT, GREEN BUILDING INITIATIVE, PORTLAND, OR

Chairman Bingaman, Ranking Member Murkowski and members of the committee, thank you for the opportunity to discuss voluntary green building rating systems and the role they can play in helping to increase the energy efficiency of buildings nationwide.

I represent the Green Building Initiative, a non-profit organization dedicated to accelerating the adoption of green building practices among mainstream design and building professionals.

First let me say that we strongly support the increased focus on improving the efficiency of existing buildings. While new building design remains a very important issue, existing buildings represent a much larger opportunity for energy improvements due to sheer numbers.

On average, there are fewer than 200,000 new commercial buildings constructed each year, versus 5.5 million that exist today, many of which could be made significantly more energy efficient.

ABOUT GREEN GLOBES®

My organization owns the US rights to the Green Globes environmental assessment and rating system for commercial buildings. Green Globes is unique in that it is web-based and interactive, and therefore easy to use and affordable for any building type or budget.

Green Globes includes two modules—one for new construction and the other for existing buildings. They can be used separately or together to create an ongoing cycle of benchmarking, measurement and improvement.

Because of its affordability and ease of use, Green Globes has been chosen for evaluating buildings:

- By federal agencies such as the US Departments of Health and Human Services, Interior, Veterans Affairs, State and the General Services Administration.
- By local governments like Summit County, Colorado; and state agencies such as the Arkansas Department of Environmental Quality;
- By higher education institutions like Drexel University and a number of local school districts; and
- By a growing list of global corporations with a need for credible but cost effective certification.

HOW GREEN RATING SYSTEMS CAN ACCELERATE ENERGY EFFICIENCY

Voluntary green building rating systems like Green Globes can help incentivize better building design and operation in three important ways:

- First, they define goals beyond mandatory codes in critical areas such as energy conservation and carbon reductions.
- Second, they provide the means to measure progress against these goals so that building owners can set priorities, measure outcomes and plan improvements.
- And third, rating systems create a market dynamic that rewards those who go beyond what is required. Private sector incentives such as green insurance products and green mortgages are evidence of the financial sector's response to green certification and there is a growing body of information supporting the marketing benefits of green building certification.

GREEN GLOBES AND ENERGY

Given the interests and goals of this committee, I would now like to describe how Green Globes addresses energy efficiency and carbon reduction.

To our knowledge, Green Globes allocates a greater percentage of its points toward energy conservation than any other comprehensive green building rating system in operation today. More than a third of our points are weighted in energy and a building must be at least 25% more efficient than average before earning any points for energy consumption.

Our system is integrated with US EPA's ENERGY STAR program and benchmarks against real building data from the US Department of Energy's Commercial Buildings Energy Consumption Survey (or CBECS) database.

We currently report on carbon emissions based on direct energy consumption and in the next version of our tool, we will require a performance goal that is based on calculating carbon dioxide equivalency (or CO_2e). Additionally, the cradle to grave carbon emissions and embodied energy of common building assemblies has been addressed and weighted helping teams to evaluate their material selections against global climate impacts as well.

Because credibility is a key to the success of an organization such as ours, it is also worthwhile to note that GBI has a rigorous third-party assessment requirement. Highly trained and qualified assessors review paperwork to assess evidence of compliance to our protocols as well as visit the building prior to awarding a Green Globes certification. We are the only green building rating system to include site visits as a requirement to certification.

Finally, GBI has further elevated the level of rigor expected of green building rating systems by being the first to take a commercial building rating system through a third-party codified consensus process. As such, GBI is on track to release this

year the first American National Standard for commercial green buildings, which will incorporate the improvements mentioned earlier in my testimony.

I will also note that there is already an American National Standard for residential green building, which was recently published by the National Association of Home Builders and the International Codes Council. Truly, these organizations and ours are working to make mainstream buildings and the concept of going 'beyond code' more than just a lofty goal.

CONCLUSION

In conclusion, I'd like to leave the committee with three observations:

1. Green design is important, but it's only part of the equation. Effective building operation and maintenance is necessary for substantial nationwide reductions in energy use and carbon.

2. Although good energy benchmarking data exists through the Department of Energy, and has been built upon by the EPA through the Energy Star program, there is a need for more Energy Star tools and better data on building performance. I note for the committee that the state of California's Cal Arch database appears to be a model worth investigation and we would encourage the federal government to look closely at it and other efforts that can further build and improve upon on our existing baseline data.

3. Finally, while many will follow good green design, construction, and operations practices because it's the right thing to do, many more will do so for an economic return on investment. For that reason, more and better information on the economic benefits of certified green buildings and Energy Star buildings will likely increase their numbers.

The CHAIRMAN. Thank you very much.

Mr. Zimmerman, go right ahead.

STATEMENT OF CHARLES ZIMMERMAN, VICE PRESIDENT, INTERNATIONAL DESIGN AND CONSTRUCTION, WAL-MART STORES, INC., BENTONVILLE, AR

Mr. ZIMMERMAN. Chairman Bingaman, Ranking Member Murkowski, and distinguished members of the committee: My name is Charles Zimmerman. I'm International Vice President of Design and Construction for Wal-Mart Stores, Inc., and I'd like to thank you for your work on this important issue, for holding this hearing today, and for inviting us to appear.

Since energy is Wal-Mart's second largest operating expense, it should be no surprise that we have been focused on energy efficiency practically since our founding. We have always recognized what many others have not: Energy truly is a controllable expense.

Because nearly one-third of Wal-Mart's energy consumption is in the form of lighting, we have developed over the years one of the most energy efficient lighting systems in the world. In fact, the installed lighting load in one of our newer stores is nearly 50 percent less than the baseline requirements established in the Energy Policy Act of 2005. This truly innovative system results in the fact that during daylight hours our sales floor lighting is either off or significantly dimmed. This is possible thanks to a sophisticated daylight harvesting system comprised of hundreds of skylights per store, that are connected to sensors and state-of-the-art control technologies. This allows our sales floor lighting system to continually modulate the amount of energy needed based on the natural light available.

This system is so dynamic that it even gradually ramps the lighting levels up and down as clouds pass over the store. The result is a building where most of the lighting is dynamic and only on to

the degree that conditions warrant. This is just lighting. Similar efforts are under way with HVAC and refrigeration.

Recently, at the request of Wal-Mart, Lennox International has developed a new rooftop heating and air conditioning unit that it has marketed as being, and I quote, "the most efficient unit of its kind," end quote. Lennox also states that this equipment is up to 66 percent more efficient than U.S. Department of Energy regulations. Today every rooftop unit purchased in the U.S. and Canada for all of our new stores and retrofits is this Lennox super-high efficiency unit.

Of course, as efficient as all this equipment is, without proper control technology it will never meet expectations. That is why every Wal-Mart store in the U.S. includes a sophisticated energy management system that allows us to monitor and control the lighting, temperature, humidity, and refrigeration in each and every one of our stores from our home office in Bentonville, Arkansas. If an associate in Denver leaves the door to a walk-in cooler open, we know it. If a store manager in Bernalio overrides the daylight harvesting system, we know it. If a freezer in Ketchikan is icing up and needs defrosting, we know it, and we can do something about it from Bentonville.

As efficient and forward-thinking as our energy practices have always been, we have very aggressive goals in our sustainability and energy efficiency efforts for the future as well. In October 2005 we announced plans to reduce the greenhouse gas emissions in our already energy efficient existing buildings by another 20 percent by 2012. We also announced plans to develop a new store prototype that will increase efficiency by another 25 to 30 percent by October 2009.

So how are we doing in achieving these goals? With regards to our existing stores, we recently approved capital for this year alone for more than 1,200 energy-related retrofit projects in our 4,000 U.S. stores. This is on top of a similar program last year and more than likely a similar program next year. A majority of these projects have paybacks between 2 and 3 years. When it comes to our new store program, we have been equally aggressive and have seen promising results there as well.

As proud as we are of these accomplishments and innovations, we're even more proud to share what we are learning with everyone, including our competitors, like Target, Best Buy, and Costco, and several Federal agencies like the EPA, DOE, and OMB. The best thing about the information we are sharing is that it's not theory; it is proven results of real initiatives with real paybacks.

While Wal-Mart is not waiting for legislation to cause us to act proactively in the area of energy efficiency, we would encourage Congress to continue to look at new incentives that will help others to act proactively as well, whether it be expanding the penetration of smart metering or smart grid technologies or adopting energy efficient building codes which set a floor for building performance to ensure that the lowest-hanging fruit of efficiency upgrades are met at abroader range of buildings.

We hope that our experience proves insightful and helpful and we stand ready to assist you in any way we can.

Finally, as you contemplate energy policy we encourage you to remember the every day Americans like the roughly 150 million shoppers who pass through our U.S. stores every week. More than ever before, we see these consumers struggling to make ends meet. We see them choosing between healthy food or their prescription medication. We see them leaving the toys out of the cart to make room for baby formula and diapers.

At Wal-Mart our energy efficiency practices not only help us save energy and protect the environment; they also help us keep costs low for our consumers.

We at Wal-Mart applaud Congress in its efforts to communicate the necessity and the benefits of energy efficiency.

Thank you for your time and allowing me to speak on behalf of Wal-Mart on this very important topic, and we look forward to working with you to effectively and constructively address these issues. Thank you.

[The prepared statement of Mr. Zimmerman follows:]

PREPARED STATEMENT OF CHARLES ZIMMERMAN, VICE PRESIDENT, INTERNATIONAL DESIGN AND CONSTRUCTION, WAL-MART STORES, INC., BENTONVILLE, AR

Chairman Bingaman, Ranking Member Murkowski and distinguished Members of the Committee:

My name is Charles Zimmerman, and I'm Vice President of International Design and Construction for Wal-Mart Stores, Inc. In my current role, I'm responsible for coordinating the Architectural and Engineering System Design for all of our international retail facilities.

Prior to joining Wal-Mart's international division earlier this month, I was the U.S. Vice President of New Prototype Development and the captain of the Sustainable Buildings Network, where I oversaw our company's efforts to make our buildings more energy and water efficient, and lower their overall environmental impact. In that role, I led a team of architects and engineers to experiment, pilot, and deploy a range of clean technologies in our buildings. I helped design Wal-Mart's most recent two experimental stores—where we test a range of emerging technologies in real world applications; and then develop our fleet of High Efficiency stores across the country where we pilot promising technologies from our experimental stores to see how they succeed in different climatic regions; and finally deploy the most successful technologies across all our new store prototypes and into our retrofit of existing stores.

On behalf of Wal-Mart and our 2.2 million associates around the world I would like to thank the Committee for its work on this important issue and for holding this hearing today. Wal-Mart appreciates the opportunity to participate in this critical discussion.

Our company holds a unique position in the world of energy. While there are no firm statistics, it is widely understood that Wal-Mart is one of the largest "private" purchasers of electricity in the United States. In fact, the only entity thought to purchase more energy in the U.S. than Wal-Mart is the U.S. Government. Since energy is also Wal-Mart's second largest operating expense, it should be no surprise that we have been focused on energy efficiency practically since the day we were founded.

Fortunately, our global presence gives us a great opportunity for energy efficiency comparisons. As Wal-Mart has continued to expand into other countries, our primary mode of expansion has been to acquire existing stores in those countries. Therefore, it is interesting to note that the stores we have built in the US are actually more energy efficient than those we have acquired in any other country thus far. This is even true for stores in countries with much more stringent energy regulation and much higher utility rates than the US; such as the UK and Japan. In fact, our stores in the UK actually use twice the energy per square foot, and our stores in Japan one and a half times as much energy per square foot as our stores in the US.

We have always recognized what many others have not: energy is a controllable expense.

Because nearly one-third of Wal-Mart's energy consumption is in the form of lighting, we have developed during the last decade, what we feel, is one of the most effi-

cient lighting systems in the world. In fact, the installed lighting load in one of our newer stores is nearly 50% less than the baseline requirements established in the Energy Policy Act of 2005.

This truly innovative system results in the fact that during daylight hours, our sales floor lighting is either off (or at the very least) significantly dimmed. This is possible thanks to a sophisticated daylight harvesting system comprised of hundreds of skylights per store that are connected to a sensor and state of the art control technology. This allows our sales floor lighting system to continually modulate the amount of energy needed, based on the natural light available. This system is so dynamic that it even gradually ramps the lighting levels up and down as clouds pass over the store. In our non-sales floor areas such as offices, break rooms and restrooms, lighting is controlled by occupancy sensors that turn off the lights when no one is in the space. Even our freezer case lighting has now evolved into a display of advanced technology as it is now comprised of "LEDs" or "Light Emitting Diodes". The result is a building where most of the lighting is dynamic and only "on" to the degree that conditions warrant.

And this is just lighting; similar efforts are underway with HVAC and refrigeration.

At the request of Wal-Mart, Lennox Industries has developed a new rooftop heating and air-conditioning unit that it marketed as "the most efficient unit of its kind". Lennox also states that this equipment is "up to 66% more efficient than U.S. Dept. of Energy regulations". EVERY roof top unit purchased in the US for all of our new stores and retrofits for over the past year has been this unit.

Of course as efficient as all of this equipment is, without proper control technology it will never meet expectations. That is why every Wal-Mart store in the US includes a sophisticated energy management system that allows us to monitor and control the lighting, temperature, humidity and refrigeration in each and every one of our stores from our home office in Bentonville, Arkansas.

If an associate in Sacramento leaves the door to a walk-in cooler open, we know it. If a store manager in Chicago over-rides her daylight harvesting system, we know it. And if a freezer in Miami is icing up and needs to be defrosted, we know it. And we can correct the situation from Bentonville.

As efficient and forward-thinking as our energy practices have always been, we have very aggressive goals in our sustainability and energy efficiency efforts for the future.

In October of 2005, we announced plans to reduce the greenhouse gas emissions in our already energy-efficient existing buildings by another 20% by 2012. We also announced plans to develop a new store prototype that will increase efficiency another 25%—30% by October of 2009.

So, how are we doing in achieving these goals?

With regards to our existing stores we recently approved capital for more than 1,200 energy related retrofit projects in our existing 4,000 US stores. This is on top of a similar program last year, and more than likely a similar program next year. A majority of these projects have paybacks between two and three years. And remember, these are in already efficient stores that have daylight harvesting systems, heat reclaim systems, energy management systems, etc.

When it comes to our new store program, we have opened in the last two years 8 of what we refer to as our "higher efficiency" prototypes. These stores are predicted to be up to 20-40% more efficient than our earlier prototypes, depending upon the climate zone. We are now in the midst of a 6 month strenuous audit of these facilities until the end of July in order to quantify exactly what the savings are prior to rolling them out to our entire program.

As proud as we are of these accomplishments and innovations, we are even more proud to share what we are learning with everyone, including our competitors.

In the past two years or so we have shared the details on our energy initiatives and their related paybacks with the Environmental Protection Agency, the US Department of Energy, the Defense Science Board, the Office of Management and Budget and with our retail competitors, Office Depot and Best Buy. We have even shared our story with the Pentagon and with the National Academy of Science. We have also taken representatives from Food Lion, Target, Publix, Costco and many others on tours of our recently opened stores that featured some of our newer energy efficient technologies. The best thing about the information we are sharing is that it is not theory; it is the proven result of real initiatives with real paybacks.

I am often told by others that until there are new technologies or until there is additional legislation, energy efficiency will never achieve mainstream attractiveness. Believe me, the technology exists, we are proof of that, and while Wal-Mart is not waiting for legislation to cause us to act proactively in the area of energy efficiency, we would encourage Congress to continue to look at new incen-

tives that will help others to act as well, whether it be expanding the penetration of "smart metering" and "smart grid" technologies that would allow utilities, businesses and individuals to enjoy the kind of energy saving information management abilities that we have adopted; or adopting energy efficient building codes which set a floor for building performance to ensure that the lowest hanging fruit of efficiency upgrade benefits are met at a broader range of buildings. We hope that our experience proves insightful and helpful and stand ready to assist you in any way we can.

Finally, as you contemplate energy policy, we encourage you to remember the kinds of everyday Americans like the roughly 150 million shoppers who pass through our U.S. stores every week. More than ever before, we see these consumers struggling to make ends meet—we see them choosing between healthy food or their prescription medication; we see them leaving the toys out of the cart to make room for baby formula and diapers. At Wal-Mart, our energy efficiency practices not only help us save energy and protect the environment, they also help us keep costs low for our consumers.

And by making sure we have everyday low prices on products like energy efficient light bulbs, home winterization kits, and cold-water laundry detergent, we are helping Americans save money on energy costs, and live better.

In conclusion, I'm very proud to work for a company that has committed to, and is actively moving towards, a goal of eventually being supplied by 100% renewable energy; I am proud to work for a company that is demonstrating its commitment to environmental sustainability while saving consumers money; and I am proud that the company encourages me to pro-actively share our innovations with the world.

We at Wal-Mart applaud Congress in its efforts to communicate the necessity and the benefits of energy efficiency.

Thank you for your time in allowing me to speak on behalf of Wal-Mart on this very important topic. We look forward to working with you to effectively and constructively address these issues.

The CHAIRMAN. Thank you very much. Thank you all for your excellent testimony.

Just for the information of folks, I've got a note here that we're going to have probably two roll call votes starting about 3:45. So I'll take 5 minutes and ask questions and then I'm sure my colleagues will, and we'll see if anyone else has questions after that.

We're trying, as you all know, to figure out what this Congress could do and the Federal Government could do to accomplish the objectives that you've all talked about in various ways. One of the suggestions, one concrete suggestion, is the one that Ms. Amann refers to and that is that we take this provision that the House of Representatives passed in 2007 containing a provision calling for the Departments of Energy and State to update energy codes for new buildings. The provision directed the Department of Energy to support efforts by model code organizations to update building codes to reduce energy use of new buildings by at least 30 percent by 2010 and 50 percent by 2020.

Let me ask some of the rest of you. Ms. Amann, you're on record saying we ought to go ahead and adopt that. Are some of the rest of you familiar with that? Is that the right way to go? Mr. Mazria, do you think that's the right way for us to go, or should we do something different or in addition to that? What are your thoughts?

Mr. MAZRIA. I think it's the right way to go, but I think it needs to be tightened up a little bit. We have a group that talks, of about 15, 20 organizations, and we've come to I think a tentative conclusion that we ought to go on a 6-year cycle: 2010, 30 percent; 2016, 50 percent; and then on out, giving the DOE the authority to tighten it up as we move out in time. I think you'll find that most organizations will support that.

The CHAIRMAN. Now, this really just addresses new building construction as I understand it?

Mr. MAZRIA. I think it's if you go in for a building—if you go in for a permit, then——

The CHAIRMAN. Then you have to update.

Mr. MAZRIA. Then you'd have to update, yes.

The CHAIRMAN. Upgrade to the code.

Mr. MAZRIA. Yes.

The CHAIRMAN. Is there something in addition to this? If we were to take your new improved version of this House-passed legislation and go with that, is that sufficient to the purpose or should there be something else that relates to retrofitting existing buildings. Or what are your thoughts there? Go ahead.

Mr. MAZRIA. On that point the discussion has been around reach codes. What reach codes are is for the Department of Energy to actually generate codes that go out in time, but make them available for cities and States and counties to adopt if they want to be out in front, because right now you have many cities and States that are adopting standards that are much better than code. You have Dallas, you have albuquerque, you have Santa Barbara. There are all sorts of cities, and these codes are all over the place.

So if we have a set of standards that cities and States can adopt, that are way beyond code, that would be really helpful. But that has to take precedence over any appliance and equipment minimum standards that the reach codes would have to take precedence. I think that would stimulate a lot of innovation in this country.

The CHAIRMAN. Mr. Giudice, I think you referred to the International Energy Codes that you've adopted, I guess, up in Massachusetts. How does that relate to what I've been asking about here? I mean, is this the same thing?

Mr. GIUDICE. It is similar. There's ASHRAE and the International Energy and Conservation Codes, which are parallel code bodies. The idea of going to a 30 percent better is a good step. I do think that DOE should be tasked with the idea of maybe going to 50 percent better on a national code basis at this juncture and to get back to the Congress as to whether or not that's doable. So that that would push us even further faster on this.

The International Energy Conservation Code, which drives a lot of the energy code-setting, is a body that has had sort of a difficult process to really move codes further. there was an important initiative this last summer to move it to a 30 percent step and the process did not result in getting to that 30 percent step because there was so much sort of resistance to that kind of a change. It ended up getting I think a 12 or 13 percent improvement of the International Energy Conservation Code.

It signifies to me the difficulty of these sort of incremental processes that are being tried to be worked on almost a voluntary basis on the national. Great intentions, great collaboration, but it sort of gets to be they get kind of ground round to the lowest common denominator, instead of aspirational and more significant steps, which I think this policy code do, as well as, as Ed was indicating, initiating every specific potential stretch codes for towns and States to adopt in addition to the base Federal codes.

The CHAIRMAN. My time is up. Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman.

Mr. Zimmerman, I was suggesting to the chairman up here that we in the government could use a little bit of help. If you guys know that a refrigerator needs defrosting in Ketchikan and you can do something about it in Bentonville, Arkansas, we could use your help here.

Mr. ZIMMERMAN. We'd love to help you replace these incandescent lights.

[Laughter.]

Senator MURKOWSKI. Actually I was going to suggest, Mr. Chairman, you spoke about dynamic lighting. Do you think the way that we should start is by opening up the blinds and by getting some natural daylight in here. We do need to work on this.

Mr. ZIMMERMAN. Senator, you might also note that the air conditioning is on in this room in February, to offset the heat gain from those lights.

Senator MURKOWSKI. We are probably the best example of the highest inefficiency in lighting and in cooling and heating here in these buildings. We need to be a better role model in this area. So I appreciate you pointing that out.

Professor Majumdar, you spoke to the integration and how we can be smarter in these systems. The comment that you made was that "design and performance don't always match." We have great plans in mind, but if the systems don't come together in your building—if you're doing things right in one room and right in another room, but they're not talking to each other, we can be at odds and basically defeating this efficiency.

How do we adequately allocate the $4.5 billion from the stimulus bill?

I was quite concerned to learn that we don't have standards that are clearly set, to allow for this interoperability, and exchange of communication. It sounds like we're doing much the same when talking about efficiencies and making sure that we have a level of interoperability and a connection.

How do we make sure that we've got integrated systems when we're putting those buildings together or when Wal-Mart is retrofitting some of their old stores. Are we able to do what you have said we need to do in terms of integration.

Mr. MAJUMDAR. Thank you, Senator Murkowski. I think that's a great question. I think in terms of integration—first of all, let me just say that you mentioned the stimulus as well. I think this is a great opportunity. Obviously with the stimulus we want to create jobs immediately and we want to put their double-pane windows and fluorescent lighting, etcetera.

But I think this is a great opportunity to put in a measurement security to actually what we are doing is working or not, so that once, 2 years from now, 3 years from now, we can actually quantify that this is actually happening. That's sort of the basic—if you want to see what's going on 2 years from now, we'll have some numbers. So that's one.

The second thing is the integration today. As I mentioned, it's not working in most buildings and the buildings are fighting each other: We are using HVAC cooling when we are almost freezing outside. That's part of the integration.

So if you think about, let's say, a computer. It has a microprocessor, it has a display, it has memory. How does it integrate? It integrates because of a few things. There's an operating system that coordinates the activity of all that, and that operating system, if you may, for a building is not there today. We need to develop the science and technology, the engineering——

Senator MURKOWSKI. Do we have that science and technology, that engineering?

Mr. MAJUMDAR. Absolutely. We have elements of that and we need to devote some R and D toward developing the sort of open source, the integration, the building operating system. Right now the building operators are doing a heroic job trying to manage thousands or hundreds of zones and trying to use their intelligence, which is great. But at some point when the building becomes really complex and it's fighting each other—you know, the building operator, it's asking too much of them. I think some element of automation is a good thing out here, just like we have in other sectors. I think that's where some of the R and D ought to be focused.

Senator MURKOWSKI. I know that the chairman and I are working on some legislation that would hopefully speak to exactly what you're talking about within the R and D area.

Mr. Giudice, you mentioned the energy labeling and I think it was Mr. Hubbell that also spoke to the energy certification. I think your reference was: When you buy a car, on the sticker it tells you your expected miles per gallon and other details.

But that is when you first buy the car, but a couple years down the road, if perhaps you haven't kept up with your tune-ups. The performance isn't really there.

In terms of energy labeling, are we envisioning this to be static or how do we make sure that there's continual truth in advertising with our energy labeling?

Mr. GIUDICE. Yes, it's an important issue. As some speakers have talked about it, it can't be just about what the design was. It has to be about how it's actually operating. So I think at every significant transaction—when a new lease owner comes in, when a building is sold—there has to be a public disclosure of what the energy consumption on a per square foot basis is for that building and how that ranks and rates against similar usage type buildings in similar climates.

It's very doable. We're actually working a zero net energy building task force in Massachusetts and that's one of the recommendations that's going to come out of that.

Senator MURKOWSKI. Do you have energy auditors that would go in and do that assessment?

Mr. GIUDICE. It's not even requiring energy auditors. You can use Web-based tools to load up what the energy consumption has been. We're going to take all public buildings actually in Massachusetts, both State and local, and load up the data so that we're watching the energy consumption, we'll know the square footage of them and we can rank and rate them accordingly, and start the public disclosure of what our building consumptions are.

Energy Stars are useful. That has a useful profiler tool that can help bring some of that in. It's just a matter of building on what exists today.

I did want to touch on the building control systems. There is standards like Zigby that actually are interoperability standards for new building control systems. I worked with a company INTERNOC—I've only been in public service here for 2 years—that is working nationwide on talking to building control systems and enabling them to drop load when the peak demands are really high, and working with even proprietary systems as well as some of the open architecture systems.

So there's a lot of technology that exists today. It's just a question of rolling it out and making it more widespread.

Senator MURKOWSKI. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator CANTWELL.

Senator CANTWELL. Thank you, Mr. Chairman, and I thank the panelists for being here.

Professor Majumdar, I wanted to start with you if I could about standby power. Obviously, you probably know a lot about what we're doing at the Federal Government on standby power, but its obvious focus is on domestic appliances and the use of power that they consume when they're in off mode. The estimates are they account for about 10 percent of all household power consumption.

In the 2007 bill, we inserted the requirement that electronic devices purchased by the Federal Government use less than one watt of power while in standby mode. Do you have some assessment of how we're doing with this? I know the House expanded that language, but how well are Federal agencies doing in complying with this, and what else we need to do?

Mr. MAJUMDAR. Thank you for the question, Senator Cantwell. I think this is a very important issue. There's a lot that can be done. I'm not the expert in this, but there are people in my staff in LBL who are working on this. From my understanding, right now it's about 10 percent, about 40 appliances on average in California.

That there is technology that exists that could bring down to a few percent, like 1 or 2 percent. But right now I think if I remember in ISA 2007 it sort of goes appliance by appliance, whereas this is a horizontal issue and so one could do it sweeping it at one level and that could be done.

In terms of actual progress that has been made, that's a matter for the Department of Energy. I don't know exactly how it is progressing. I can get back to you on that after talking with DOE.

Senator CANTWELL. You don't think anybody's measuring it?

Mr. MAJUMDAR. I am not familiar with it. I'm not quite sure, but I can get back to you.

Senator CANTWELL. OK. Thank you. We'll ask DOE. But you think it's an important area for us in building savings?

Mr. MAJUMDAR. It is a low-hanging fruit. It has to be done.

Senator CANTWELL. Thank you.

The other issue I'd like to ask either Mr. Zimmerman or Mr. Hubbell about is China. While we're focusing here on the United States, China is expected to have half the world's building construction in the next 10 years. So while we look at what's happening in the United States, obviously it's no comparison to what

will happen in China. They are less efficient per square meter on their building code standards.

I was interested in what either one of you think are the opportunities for us to work with them. The Pacific Northwest Lab is already working with them to try to help get energy efficiency standards compliance in China. But I was wondering what potential you see there for U.S. markets in lighting, motion sensors, advanced windows, all of that.

Mr. ZIMMERMAN. Actually, we rank all of the countries we operate in, nearly 20 countries now, and China ranks about third or fourth in energy efficiency. Of course, our stores in China are fairly new. While we have a 25 to 30 percent goal for our new buildings in the U.S., China actually—Wal-Mart China has a 40 percent goal.

In Beijing we recently opened up our first store that is 100 percent lit with LED lighting. While we're using a lot of LEDs in the U.S., our general sales floor lighting is still T8 fluorescent. In our Wal-Mart China store in Beijing it's all LED. They're also doing things with motion activation on their cases, etcetera.

So we're working with our suppliers in China. We recognize that our global greenhouse gas footprint is small compared to our suppliers, and a lot of those suppliers are based in China. So we're working not only with our suppliers, but our stores, to even exceed our U.S. goals.

Senator CANTWELL. Mr. Hubbell.

Mr. HUBBELL. Senator, we're a domestic organization, so I don't have a lot to say about China, other than to point out in our part of the world, the Pacific Northwest, there's a lot of design expertise in building design, building operation, that I know is being exported to China. I think that's a very good thing.

The other thing I would say about that is in the rating system business, which is the business that I'm in, I think that there can be some helpful things in China if we share with them the expertise we have in evaluating buildings, recognizing that a plaque on the wall is not the objective; the performance goal is the objective. But I think educating the Chinese and others about how market dynamics and other things can be created through recognition and certification I think could be something that we could talk to them about.

Mr. ZIMMERMAN. May I add one more thing, Senator? My title, "International Vice President, Design and Construction," that's new for me. Until a month ago I was in our U.S. program. Part of the reason I'm in international now is to take the best practices we're learning in the U.S. share them with our other countries, and vice versa. Many of the things we're doing in the U.S. we're doing in China. We're watching closely this LED experiment in China so that we can roll it out to our other countries as well.

Senator CANTWELL. I'm very appreciative of the best practices, but I look at this and I think this is an enormous, enormous opportunity for U.S. businesses and companies and services that they provide on efficiency. If China's going to have half of the buildings in the world in the next 10 years, then having U.S. access to those markets to help them would be a great source of economic revitalization for us.

So thank you for your work.

The CHAIRMAN. Senator Sessions.

Senator SESSIONS. Thank you, Mr. Chairman.

Mr. Zimmerman, being of a practical bent, let me ask you, does Wal-Mart take the view that all of their energy conservation practices should pay for themselves over some period of time in savings? In other words, the cost of implementing the new system you desire to pay for itself?

Mr. ZIMMERMAN. You know, I don't know if that—that's not necessarily a policy, but that's the reality. When I present any initiative, I present a payback, and so far those paybacks have been in the 2- to 3-year range. Given the environment today, that's an easy decision for our company to make, is to invest in those type technologies.

Senator SESSIONS. That is very easy to invest in. Anything that will pay back in 2 or 3 years I think is clearly a winner. What about 5, 6, 8, 10 years? Is there some point that a business would begin to wonder or you would have a cutoff as to whether it would be good business?

Mr. ZIMMERMAN. Currently, if it's in the 5- to 6-year range we target our new store construction first and we work through making things more efficient, value engineering the process, so that we can drive the return even better to get it into our retrofit program. If you're starting to get out 10 years, we'd have to start looking at other benefits from a standpoint of maintenance, etcetera.

But again, we haven't run across any initiatives that really get beyond about that 5-year window.

Senator SESSIONS. So how much have you reduced, say in a model store, how much do you feel like that you've saved in that store?

Mr. ZIMMERMAN. In Senator Bingaman's State we opened up a store in Bernalio, New Mexico, about a year ago now. It's one of our eight higher efficiency pilot stores. They represent what our new prototype going forward we anticipate to be. It's about 25 to 30 percent more efficient than the stores we would have been building in 2005. Again, the stores in 2005 had heat reclaim systems, energy management systems, daylight harvesting systems. So that's a decrease on an already very efficient base.

Out in more western climates such as Las Vegas, California, where you have very arid climates, we're seeing even closer to a 40 to 35 percent decrease in energy.

Senator SESSIONS. Do you have an opinion as to whether or not the average retail store, whether a grocery store, a clothing store, that's not focused on this issue, how much they might reasonably save if they were to utilize practical cost-saving energy efficiencies?

Mr. ZIMMERMAN. Looking at the other retailers we've acquired in other countries, like in Japan, where those buildings have been designed and maintained under the umbrella of the Kyoto Protocol, we use 50 percent less energy per square foot in our U.S. stores today than we do in those Japanese stores. I would venture to guess we would be able to save similar savings in most of the U.S. retail environments. That's why with the Department of Energy we formed the Retail Energy Alliance, to share what we're doing with our competitors.

Senator SESSIONS. That's very significant. The 40 percent of our energy, I think, Ms. Amann, that you said, that's the total counting gasoline and everything else? Buildings utilize 40 percent? That's more than I—I've heard that figure, but I guess I didn't believe it or it didn't register on me. But that's quite a bit, so if you could reduce that by 40 percent or 50 percent with cost-efficient technology.

Now, Mr. "GUY-diss"?

Mr. GIUDICE. "Jue-DEE-see," yes.

Senator SESSIONS. "Jue-DEE-see." You mentioned solar. Now, that makes me a little nervous. If you've got to get there with solar, my impression is that today solar will not pay for itself. Is that right?

Mr. GIUDICE. It depends on the kind of solar. There are solar thermal technologies that can augment, especially in the South, Southwest area, very cost-effectively other thermal technologies. But you're right, solar PV today is not cost competitive. The reason to invest in solar PV today is not because it's a stable circumstance. We have seen PV pricing come down significantly over the last decades and right now it's actually coming down with the slackening of the market, coming down very substantially over the last couple of months. We've seen the alternatives—the cost of natural gas-fired generation and so forth—over the last years go up.

The Department of Energy suggests that in the 5- to 10-year timeframe and maybe less for some places that have particularly expensive power, it will be cheaper to buy electricity from PV on your roof than it is by buying it from the conventional grid. That's not today and I wouldn't bet on that for all of our investments, but I think it is appropriate to put some resources toward those technologies and to help them come down the cost curve and have it a viable option for us as we move forward.

Senator SESSIONS. Those are all good ideas. When the government rates appliances, air conditioning, heating systems, and all of that, do you do them by brand name? Is there anyone that—I guess you can't, or do we, explicitly recommend one brand name, or is there any private groups out there that have got the gumption to stand there: This is the best brand name to buy for energy efficiency?

Professor Majumdar.

Mr. MAJUMDAR. Yes. Again, I'm not an expert in this particular topic, but from my understanding it is by the type of the device and the actual energy used. So they have to meet those standards. Again, these are measurements—these are performance based on measured standards and that's how it is done.

Senator SESSIONS. But historically the government hasn't said, Brand X is better than Brand You?

Mr. GIUDICE. In Energy Star labeling they actually get brand specific and model specific. I think it can move much more dramatically forward. There are also independent bodies that will rank and rate specific brands on their energy consumption. But I do think the national government can take a much more proactive role, and I think we have to look at a lot of those performance standards also, which really aren't testing the right things from an energy consumption standpoint. How we're actually using air con-

ditioning doesn't actually relate directly to the SERE ratings that air conditioners, for instance, are rated on.

So there's lots to be done in terms of appliance standards and appliance testing.

Senator SESSIONS. Yes, briefly.

Ms. AMANN. I would just agree that there's a lot to be done in terms of improving our rating systems so they better match what's happening in the field. Then as far as the programs that are run by EPA and DOE on Energy Star and others, they set a performance standard and any manufacturer that can meet that qualifies. But you can get specific information, so you could go in and find the best product from those lists.

Senator SESSIONS. Mr. Giudice, just briefly—my time is up. I read something critical of Energy Star. Do you share those criticisms?

Mr. GIUDICE. I think that it's easy to look in the rear view mirror and say things could have been better, and I don't think it has gone nearly far enough. But we have to understand. Kind of, it has filled the void from a national leadership standpoint and it has done it very well, and has moved a lot of awareness. A lot of the mass market, a lot of consumers, look at that Energy Star rating and it triggers something in them.

So not perfect, but nothing is. I think it has added a lot of value, and I think there's tremendous opportunity to build further on that.

The CHAIRMAN. Let me just ask one other follow-up to what Senator Sessions was asking about. Do we have reliable, well recognized ratings for manufactured housing, so that if I go on a lot to buy a mobile home I can make a judgment there that this is the most energy efficient mobile home or this one is substantially below par?

Mr. GIUDICE. I don't think we do from my knowledge. It would be very simple to——

The CHAIRMAN. I would think that would be the simplest thing to accomplish, if you were looking at trying to rate building construction or building efficiency.

Mr. GIUDICE. Agreed.

The CHAIRMAN. Let me ask if Senator Murkowski has any additional questions.

Senator MURKOWSKI. Just very quickly, Mr. Chairman. It follows up on comments from Senator Sessions here as well.

You had mentioned, Mr. Hubbell, that Green Globes is a voluntary certification standard. There's been a little bit of a push or activity at the State and local levels to impose, whether it's Green Globes or LEED or other standards. Should Federal legislation specifically name or identify Green Globes—kind of unfair to you, sir, because you represent them—but lock us into that standard, if you will?

Mr. HUBBELL. You know, Senator, I'm of the opinion that it's not the rating system that matters; it's the performance goal.

Senator MURKOWSKI. Right.

Mr. HUBBELL. So what I think is more appropriate and productive for public policy would be to set performance goals, and if rating systems can accelerate our progress to those. But let's not let

the plaque on the wall be the objective. Let's let the energy performance and the carbon reductions be the objective, and that's been our approach all along. So that would be how I would answer it.

Senator MURKOWSKI. Anyone else?

Mr. Giudice.

Mr. GIUDICE. One quick reaction is I do think that moving the minimum standards much, much higher through building codes is a necessary step. We can't just rely on the voluntary efforts and just sort of publishing benchmarks. We actually have to in my mind take the bad choices off the shelves, because there are so many broken aspects of the energy picture.

Senator MURKOWSKI. But would you do that through performance standards or measurements?

Mr. GIUDICE. I would do building code-based performance standards, so that we have to get to a much higher minimum standard in our buildings, and then I would rank and rate the buildings above that standard.

Senator MURKOWSKI. Coming from the States' perspective, you are OK with a national standard?

Mr. GIUDICE. I am. It's got to be regionally specific, but I think this is a challenge and an opportunity and a need for national leadership, that doing it on a State by State basis is just going to take too long and it's going to be too much of a hodge-podge of solutions.

Senator MURKOWSKI. It's something that we in Alaska look at very carefully, of course, because we're a little bit up there in the cold and the dark, except we're in 2-hour sunlight——

Mr. GIUDICE. Six months a year.

Senator MURKOWSKI. But it is something that I appreciate the recognition that you've got to acknowledge the regional differences that we all face.

Mr. Hubbell.

Mr. HUBBELL. I just want to add to that. I think what public policymakers can do is define the criteria for good rating systems. I think it's important, for example, that rating systems be developed through an open consensus process. I think it's important that rating systems sufficiently address energy and carbon reductions. I think rating systems ought to rely on life cycle assessment and real building data.

So those are things that I think that the policymakers at this level and all the way down can create as hurdles for those of us in the rating system business, if you will, and let the powers of competition do their thing. Knowing what your criteria are, we're working real hard to make sure that our rating system meets that.

Senator MURKOWSKI. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Sessions, did you have another question?

Senator SESSIONS. No, thank you.

The CHAIRMAN. Let me thank the witnesses. This is very useful testimony and we will conclude the hearing with that. Thank you.

[Whereupon, at 3:57 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

RESPONSES OF JENNIFER AMANN TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. What are some examples where the market has moved energy efficiency in the right direction regardless of government mandates?

Answer. The combined efforts of manufacturers, retailers, contractors, utilities and other energy efficiency programs have moved the market toward adoption of more efficient technologies. Particular successes include compact fluorescent lamps, adjustable speed drives, T8 fluorescent lamps, and several categories of Energy Star qualified appliances and electronics.

Question 2. The federal and state governments have been engaged in several standardized programs to promote energy efficiency in the last few decades. It is also true that there have been advances in energy efficient technology without the government playing a role. Please describe the pros and cons of these two approaches.

Answer. While each approach has pros and cons, the most effective strategy is to use government and market approaches to complement each other. Government support of R&D often plays an important role in the development of new energy efficiency technologies. Programs such as Energy Star help build the market for high efficiency products and leverage the efforts of utilities, manufacturers and retailers to increase adoption of high efficiency products. Government mandates in the form of codes and standards can capture the full energy savings benefits of these advances once they are proven in the market and ensure that all consumers reap the benefits of investments in energy efficiency R&D and program activity.

Question 3. The recent stimulus bill directs billions to energy efficiency measures. How can these funds be targeted to be most effective?

Answer. These funds should be targeted toward the full array of cost-effective efficiency opportunities in the residential, commercial, and industrial sectors. Programs designed to reward actual performance can maximize energy savings and cost-effectiveness. Good opportunities can be found in comprehensive retrofits of existing buildings; promotion of very high efficiency appliances, equipment and other products; improvements in building codes including assistance to states for training of code officials and inspectors; and training of building contractors and service providers. Existing programs operated by state and local agencies, utilities and other program implementers have the infrastructure in place to get stimulus funding into the market rapidly.

Question 4. Also, as you know, $3.1 billion of energy efficiency block grants came with preconditions, namely energy efficiency rulemaking measures and updating building codes. Are you concerned with the inevitable delay in getting the energy efficiency funding out to states and localities?

Answer. As passed, the energy efficiency block grants provided through the ARRA require states to demonstrate that they are making their best efforts to pass specific regulatory actions such as decoupling and updated building codes, but do not require that these new rules be formally enacted or in place. This should reduce the delay in getting funds distributed to states and localities. DOE has recently published guidance on how the process will work and I understand that a considerable number of governors have already submitted certifications.

Question 5. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the development and establishment of zero net energy commercial buildings which applies to any commercial building newly constructed in the

United States by 2030 as well as 50% of the of the commercial building stock of the United states by 2040. Groups such as the American Institute of Architects (AIA) have endorsed an immediate 50% reduction in fossil fuel-generated energy and a 10% reduction target every five years until new and renovated buildings achieve carbon neutrality in 2030.

Have we made any progress on these initiatives?

Answer. Through its Commercial Buildings Initiative, the Department of Energy is working on industry partnerships, research, and tool development—all important activities laying the groundwork for meeting the stated goals for zero net energy commercial buildings. Details of their efforts are available on the DOE website at www1.eere.energy.gov/buildings/commercial_initiative/index.html.

Question 6a. Like some of our other panelists, your testimony highlights a number of programs we endorsed during EPAct and EISA that haven't obtained the necessary funding for implementation or only recently received funding under the American Recovery and Reinvestment Act (stimulus).

Do you believe that Congress should authorize new programs with more stringent guidelines when many of our existing programs are not yet up and running, or have been tested?

Answer. Many of the new programs we recommend target markets or opportunities that have not received adequate attention in the past or where unusually high barriers to energy efficiency exist. These programs do not necessarily require more stringent guidelines so much as they expand the depth and reach of our efficiency policies. Authorization of these programs can lay the groundwork so they can be rolled out when funds are available. In the case of the recent stimulus bill, many good programs were not included for funding since there was not prior authorizing language.

Question 6b. How can we best spend the money that has now been allotted for these programs? What should our priorities be if an opportunity for more funding comes along?

Answer. States and municipalities must be given the support and assistance needed to enable them to run robust and effective programs. One critical need is technical assistance and training for contractors selling and installing energy efficiency measures and other market actors influencing product selections and purchase decisions. EPA has a lot of experience with this type of assistance through the Energy Star program, but unfortunately EPA Energy Star was not funded under ARRA.

A key priority for any additional funding should be retrofits in residential and commercial buildings including multifamily and manufactured housing. Retrofits yield significant energy savings and carbon reductions while creating jobs and saving consumers and businesses money that can be redirected to other important needs.

RESPONSE OF JENNIFER AMANN TO QUESTION FROM SENATOR CANTWELL

Question 1. I understand standby power is a growing source of energy consumption in buildings. While the typical power loss per appliance is low—about one to 25 watts—when multiplied by the billions of appliances in buildings across America, and the fact that they occur basically 24 hours a day, standby losses are estimated to account for about 10 percent of all household power consumption.

To try and address this problem, I inserted an amendment in the 2007 energy bill that required that any electronic device or appliance purchased by the federal government use less than one watt of power while in standby mode. I was pleased that the House subsequently expanded this provision to incorporate standby power into all products already subject to federal efficiency standards.

Are there other steps you believe we could be taking at the federal level to reduce standby power loads?

Answer. In addition to the constructive efforts currently underway to reduce standby power consumption, there are other actions with the potential to yield greater energy savings. An increasing number of appliances and electronic products are incorporating networking capabilities allowing for communication with home and/or external networks. Research is needed to better understand "network modes" as one of the many low power modes comprising "standby power," in terms of power use and opportunities for managing and minimizing power consumption in network modes. Standards recently finalized in the European Union (eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:339:0045:01:EN:HTML) also provide a useful model for further federal action on standby power. In particular, a horizontal standard covering standby power for most energy-using products could capture savings from a broader range of product types and eliminate the need for developing standards on a product-by-product basis.

RESPONSES OF WARD HUBBELL TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. What are some examples where the market has moved energy efficiency in the right direction regardless of government mandates?

Answer. Systems like Green Globes®, which bake in' energy metrics and environmental programs like EPA's Energy Star program, are gaining significant acceptance in the marketplace. Green Globes in particular has embraced the already successful Energy Star program—which has proven to help building owners arrive at performance that keeps them in the top 25% of buildings nationwide. We drive our users to 'design to achieve' Energy Star while they are pursuing Green Globes-New Construction certification. The market incentives that we create for owners to seek Green Globes certification, in turn encourages them to pursue Energy Star and other measures that reduce energy consumption.

Other incentives such as green insurance products and green mortgages also prove that the market is driving the move towards reduced energy consumption and environmentally-friendly buildings. These products exist because there is market-driven demand and because it makes business sense to encourage the development of buildings that use less energy, reduce waste and have a high indoor air quality.

Question 2. The federal and state governments have been engaged in several standardized programs to promote energy efficiency in the last few decades. It is also true that there have been advances in energy efficient technology without the government playing a role. Please describe the pros and cons of these two approaches.

Answer. Governmental involvement (whether it's on the local, state or federal level) has been successful in helping spur innovation and adoption in all areas of energy efficiency, through incentive programs, such as tax rebates, abatements, expedited permits, etc. Governmental bodies have also played a large role in helping educate the general public about the need for energy efficiency and the various benefits (environmental, economic) associated with these practices. However, this involvement can also lead to an unfair competitive market, especially if the involvement of a local, state or federal government favors one particular approach, or one particular organization. Governmental involvement is essential to the growth and expansion of energy efficiency practices and technology; however it must be done in a way that is fair and allows for an open and competitive free market.

Another area of concern is that there has been a strong emphasis on rewarding good design and construction practices without measured (documented) energy savings being part of the package. Government can help the marketplace by finding ways to reward a more holistic approach to creating more efficient portfolios. Examples would be creating innovative policy that de-emphasizes first cost budgeting in favor of more holistic budgeting that accounts for long term maintenance and operations costs and potential savings. Additionally, design, bid, build strategies are not always the most effective for achieving desired performance goals. Government should be asking how can we change our own procurement policies to encourage integrated design, delivery, and operations (e.g. a 10 to 30 year view of costs/savings vs. 1-3 year view of immediate budget limitations).

Question 3. The recent stimulus bill directs billions to energy efficiency measures. How can these funds be targeted to be most effective?

Answer. The best way to meet our energy efficiency goals is to ensure that the nation's existing building stock is performing efficiently. The only way to do that is to measure, benchmark, and plan for improvement. Government grants to non-profit associations with standards and tools that can assist in making the benchmarking and planning process easier so that it can be done by every building owner in the country would create exponential benefits. These market generated tools can then be used by government (without naming one tool in particular) to gauge the before and after success of dollars invested versus dollars/energy saved.

Additionally, there is a great need for education. Government dollars focused on helping organizations deliver training to the masses of building owners, operators, managers, and related workforce would be dollars well spent.

Question 4. Also, as you know, $3.1 billion of energy efficiency block grants came with preconditions, namely energy efficiency rulemaking measures and updating building codes. Are you concerned with the inevitable delay in getting the energy efficiency funding out to states and localities?

Answer. While delays are a concern, a bigger problem will exist if the necessary rulemaking and building code updates are hastily done without proper vetting and input from the building community. These preconditions can, and will, have a significant impact on the entire building community, and considering the devastating business climate they are currently facing, any new rules and code updates must be done with full input from architects, engineers, designers, building owners and

other relevant organizations. We should also use this opportunity to incentivize the use of a feedback loop to determine the actual building performance that is achieved by these measure. Energy Star and green rating systems that utilize Energy Star tools could be beneficial to this effort.

Question 5. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the development and establishment of zero net energy commercial buildings which applies to any commercial building newly constructed in the United States by 2030 as well as 50% of the of the commercial building stock of the United states by 2040. Groups such as the American Institute of Architects (AIA) have endorsed an immediate 50% reduction in fossil fuel-generated energy and a 10% reduction target every five years until new and renovated buildings achieve carbon neutrality in 2030.

Have we made any progress on these initiatives?

Answer. While it's too early to know if these initiatives will ultimately be successful, these programs have increased awareness about the need to reduce energy consumption and focus on efficiency. However there is still a lot of work that needs to be done. The next step for these goals to be met is for the focus to shift to actual building performance data, instead of just looking at design.

Question 6a. As I understand it, the concept behind systems like Green Globes and the US Green Building Council's LEED standards was to promote sustainability practices through voluntary leadership actions.

This seems to be an expanding market. Do you think we should be specifically naming Green Globes, LEED, or any other program in federal legislation?

Answer. It is essential that whatever language is ultimately included in federal legislation be worded in a way that allows for options. This means being inclusive of all nationally recognized and credible existing rating tools while still allowing for the development and use of rating tools that are not yet in existence. Listing any rating tool by name in legislation will ultimately give that tool an inherent advantage in the marketplace, limiting competition and impeding innovation. Therefore, it is imperative that if one rating tool is going to be named, all other nationally recognized rating tools are also named.

The ideal option is legislation that rewards a specific performance outcome and allows the architects, engineers, owners and tenants to decide what, if any, rating tools will help them meet those goals. However, this is not always practical; as the oversight required to implement this type of performance based program can be extensive. That is why green rating tools are helpful, as a certified green rating from a credible organization (such as GBI or USGBC) is a sign that at least a minimum amount of sustainability and efficiency measures have been met.

If legislation does reference green rating tools, the best option is to set forth criteria that an acceptable rating system must meet in order to be recognized, and require that all rating tools meeting the criteria be named in the subsequent rules. The legislation must be carefully worded to ensure the process of judging and selecting qualified rating tools is fair and free of preconceived bias.

Question 6b. Have any challenges arisen due to these state and locally driven initiatives?

Answer. The major challenges arise when a given piece of legislation only recognizes one rating tool. As discussed above, this sole-sourcing isn't just bad public policy, but will also, in all likelihood, hamper the development and adaptation of green building practices. Every building and every project is different, and there is no one-size-fits-all solution to green building. Architects, engineers, owners and tenants need options, and whether it is an elementary school or a skyscraper, being able to choose which rating tool works best for a given project is vital to long-term growth and success of green building.

Question 7. Please describe how your rating system works with private sector incentives such as green insurance products and green mortgages.

Answer. Insurance companies, such as Liberty Mutual, AON, Travelers, and Fireman's Fund offer premium discounts and other incentives to ensure that buildings are built, enhanced and restored to achieve green certifications. The marrying of green rating system certification and mortgages and insurance is a natural alignment allowing for similar market based goals to be accomplished. For instance, buildings that are Green Globes certified have achieved compliance with requirements that are intended to reduce maintenance and indoor environmental issues that are of great concern to insurance providers.

Question 8. Once a building becomes certified, is there additional follow-up with the building owner concerning the operation of the building and its overall sustainability?

Answer. GBI is investing substantial time and resources to educate its current users and the general public about applying life cycle approaches to buildings. For

instance, our training includes a discussion of 5-8 year asset management strategies and how Green Globes for New Construction and Green Globes for Continual Improvement of Existing Buildings work together. GBI offers, in addition to our New Construction tool, the Continual Improvement of Existing Building (CIEB) tool to not only benchmark existing buildings but also to provide assistance in the operations and maintenance activities required to improve and maintain a green high performing building. Recertification of existing buildings is currently required every three years.

Question 9. Please describe the point system your rating system is based upon. In order to achieve the 1,000 points, how did you rank the areas of assessment?

Answer. The 1,000 points in Green Globes for New Construction breakdown is as follows (and Green Globes-CIEB is ranked similarly):

- Energy—360 points
- Indoor Environment—200 points
- Site—115 points
- Water—100 points
- Resources—100 points
- Emissions, Effluents and Other Impacts—75 points
- Project/Environmental Management—50 points

As detailed above, 36% of the total points allocated in Green Globes is focused on Energy, the largest percentage of any rating tool in the U.S. Green Globes also uses the Energy Star Target Finder program for new construction and the Energy Star Portfolio Manager for existing buildings.

Projects that achieve a score of 35% or more become eligible for a Green Globes rating of one, two, three or four globes, as follows:

- One Globe: 35-54%
- Two Globes: 55-69%
- Three Globes: 70-84%
- Four Globes: 85-100%

Response of Ward Hubbell to Question From Senator Cantwell

I believe another promising area for improving the efficiency and many other aspects of our nation's buildings is adding on green roofs. On efficiency benefits in particular, according to the EPA, the surface temperature of a green roof can be as much as 90 degrees Fahrenheit cooler than the surface of a traditional rooftop.

Question 1a. Since your testimony did not specifically address green roofs, could you talk about what potential roles do you see for green roofs in achieving higher levels of building energy efficiency?

Question 1b. What is the energy savings potential of green roofs and what federal incentives and programs might help to accelerate the deployment of green roofs nationwide?

Answer. Vegetated roofs are believed to be effective in minimizing heat island effect. Green Globes rewards the use of vegetated roofs within our Energy section. We did not have sufficient time to gather our technical experts to assess data that may be relevant to actual measured savings from studies of green roofs. We would be happy to follow up with staff following this submission.

Question 1c. Do you believe the Federal Energy Management Program an effective vehicle for the acceleration of green roof deployment in the federal building sector?

Answer. Our technical committee members have extensive experience in vegetated roof systems as well as in FEMP vehicles. However, we were not able to obtain sufficient input in time for inclusion in this document. We would be happy to follow up with staff following this submission.

Responses of Edward Mazria to Questions From Senator Murkowski

Question 1. What are some examples where the market has moved energy efficiency in the right direction regardless of government mandates?

Answer. Unfortunately, without government mandates, the market moves the Building Sector towards increased energy efficiency slowly, escalating development only when the country enters a recession and/or the price of energy increases dramatically. This can be seen clearly in the graph on Page #2 of my testimony. The drop in Building Sector energy consumption is most apparent with the spike in oil prices that began with the 1973 Arab oil embargo and continued through the short recession that followed, and during the early 1980's recession when oil reached the equivalent of $103.76 barrel (today's dollars) following the 1979 Iranian Revolution.

After the crisis ended, lighting and energy management technologies that were initiated during this period continued to develop, albeit slowly, due in part to state initiatives and mandates. For example, lighting technology continued to improve with the introduction of higher efficiency lamps (T-8, T-5, and compact fluorescent bulbs) and electronic ballasts. Several states (California, for example) adopted stricter energy codes for commercial buildings that were partly responsible for the development of markets for these more-efficient lighting products. Over time, these advances in energy-efficient technology were adopted more widely by the building sector. But government programs were instrumental in promoting the early use of these advances and creating markets so the costs for these products could be reduced.

Question 2. The federal and state governments have been engaged in several standardized programs to promote energy efficiency in the last few decades. It is also true that there have been advances in energy efficient technology without the government playing a role. Please describe the pros and cons of these two approaches.

Answer. Relatively little has been accomplished in building sector energy efficiency over the past few decades, so it is difficult to single out the pros and cons of each approach. The two approaches seem to only work well when they work in tandem. For example, when fossil fuel prices increase dramatically, business and industry look to innovate and deliver alternatives to the marketplace, while governments deliver market incentives, new building codes, and fund R&D and technology transfer through universities, research institutions and national laboratories.

This was evident during the energy crisis of the 1970's and early 1980's. At that time, there were major advances in Building Sector technologies—in glazing materials (heat mirror and low-e coatings), passive and active solar energy systems design and applications, passive and active cooling applications, natural ventilation systems, phase-change materials, moveable insulation, building simulation modeling programs, daylighting systems and controls, energy management systems, night setback thermostats and occupancy sensors, solar hot water heating, solar thermal electric generation and storage, photovoltaics and advances in low-energy lighting systems, to name just a few. While some of these technologies continued to advance slowly over the past twenty-four years, relatively little has happened in developing innovative new energy efficiency and building energy technologies and systems. The energy intensity of commercial buildings has changed little over this period (total energy use per square foot increased), while a decrease in the energy intensity of housing was offset by an increase in housing size.

Government programs also play a critical role in advancing building sector technologies due to the relationship between construction costs and energy costs. For many commercial or leased building projects, capital costs for construction and operating costs for energy use are budgeted and paid for from different accounts. The project owner pays for the building design and construction, while the tenants pay for the resulting operating costs for energy and resource use. In this fiscal environment, government programs (state energy codes and tax credits, for example) have been very important in advancing the adoption and promoting the improvement of cost-effective, energy-efficient technologies.

The situation we find ourselves in today, with three major crises converging at the same time—foreign energy dependence, climate change and a deep economic recession—is very different from anything we have ever experienced before. I believe both approaches to the Building Sector, which is at the center of all three crises, must play a critical role if we are to successfully meet these challenges.

Question 3. The recent stimulus bill directs billions to energy efficiency measures. How can these funds be targeted to be most effective?

Answer. I have carefully read through the American Recovery and Reinvestment Act 2009, specifically to analyze the bill's requirements on energy efficiency. I find that only in some cases are there requirements, and that the few programs with requirements are somewhat vague. There are no benchmarks or energy reduction targets (which are essential to attaining real and significant reductions) mentioned in the bill.

What this means is that many of the building projects put forward in response to the bill will have minimal energy reduction strategies, and as a result, minimal energy reductions.

The following language, if included in the energy bill, would help to prioritize projects and serve as a guideline for projects submitted for grants. While the language does not prohibit any projects from going forward, it makes clear that projects will be competing for funds and meeting specific energy reduction targets will be a priority consideration in the judgment criteria.

This language also sets the benchmark based on i) CBECS and RECS for federal and federally-owned buildings as called for in the Energy Independence and Security Act 2007, and ii) ASHRAE and IECC for other buildings. In addition, it also allows the Secretary of Energy to set other benchmarks and reduction targets, since there are states that have their own codes with specific criteria.

The following language would send a strong message to the building community that significant energy reductions are important, and that the federal government will lead the way:

> A. That any new and renovated federal buildings receiving stimulus money be required to meet the 2010 energy reduction standard set by the Energy Independence and Security Act of 2007. Funding preference will be given to projects that achieve overall energy savings compared to the Commercial Building Energy Consumption Survey 2003 for commercial buildings and Residential Energy Consumption Survey 2005 (RECS) for residential buildings (or other comparable codes, standards or measurement protocols authorized by the Secretary of Energy) of, in the following order of priority—(1) carbon neutral, (2) 85 percent, (3) 70 percent, (4) 55 percent.
>
> B. For any new building construction or renovation project grants made with stimulus money by state and local governments, preference shall be given to projects that achieve overall energy savings compared to ASHRAE 90.1-2004 for commercial buildings and IECC 2006 for residential buildings (or other comparable codes, standards or measurement protocols authorized by the Secretary of Energy) of, in the following order of priority—(1) 75 percent to carbon neutral, (2) 50 percent, (3) 30 percent.

Question 4. Also, as you know, $3.1 billion of energy efficiency block grants came with preconditions, namely energy efficiency rulemaking measures and updating building codes. Are you concerned with the inevitable delay in getting the energy efficiency funding out to states and localities?

Answer. The answer to this question is multifaceted and requires some explanation.

Since professional architects and engineers design most commercial and public buildings and large-scale housing developments, it is instructive to look at A/E firm billings to project future Building Sector construction activity. It takes 6 months to a year or two to design and prepare construction documents for a building project, a few months for bidding, a month or two for contract negotiations and another month or two for construction start up. Billings for housing began to decline sharply at the end of 2007, followed by a decline in commercial and industrial project billings in early 2008. It was not until August of 2008 that we began to see a decline in public building project billings. At the end of 2008, while construction in housing and commercial buildings were in steep decline, construction in the public sector was steady with school construction up 6% and government building construction up 6% (Page 14 of my testimony).

Most of the stimulus money and energy efficiency block grants for buildings are slated for the public building sector. Projects that have been designed but shelved for lack of tax dollars will be pulled off the shelf as shovel ready. Other projects will begin the design process taking advantage of efficiency block grant monies. As a result, the public building sector should continue on without a construction downturn for another few years.

While I do not foresee a delay in using the efficiency block grant money, the anticipated building energy consumption reductions will fall short unless the actions recommended in answer #3 above are implemented.

Question 5. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the development and establishment of zero net energy commercial buildings which applies to any commercial building newly constructed in the United States by 2030 as well as 50% of the of the commercial building stock of the United states by 2040. Groups such as the American Institute of Architects (AIA) have endorsed an immediate 50% reduction in fossil fuel-generated energy and a 10% reduction target every five years until new and renovated buildings achieve carbon neutrality in 2030.

Have we made any progress on these initiatives?

Answer. Yes, interest in the 2030 Challenge energy reduction targets has increased significantly since we issued the 2030 Challenge in January of 2006. Many state and local governments, professional organizations, A/E firms and institutions have adopted the targets and have begun to implement them, and many more would like to do so. However, without clear and sustained leadership and support from the federal government, these efforts will not be enough. Specifically, we will not see any significant reductions in the rate of increase in building sector energy consump-

tion, let alone a decline, until the National Model Building Energy Code Standards are updated as indicated on Pages 12 and 13 of my testimony.

My emphasis on performance standards is deliberate. By setting performance rather than prescriptive standards, Congress will not be picking energy and efficiency technology winners and losers. The marketplace, individual practitioners and building owners will determine the most cost-effective strategies that meet the performance standards. Many new strategies and technologies will emerge (and existing ones will re-emerge) to meet the particular conditions of various climatic regions and economic conditions. Performance standards bring out the best in our competitive and entrepreneurial spirit and create a level playing field for all technologies.

For this approach to be most effective, performance standards and 'reach codes' must preempt federal minimum appliance standards to insure the emergence of new technologies, systems and design practices.

Also, I would ask that the Committee be mindful of the dates for the Model Energy Code updates specified on Page 12 of my testimony. The dates correspond with the 2007 Energy Independence and Security Act's initiative for the development and establishment of zero net energy commercial buildings in the United States by 2030 as well as 50% of the commercial building stock of the United States by 2040. They also coincide with the code standard update cycles set by IECC and ASHRAE. For example, the 2016 date for the 50% standard is critical and is set to coincide with the 2018 IECC code release date of April 2017. The next IECC code cycle is not until 2024. The dates specified on Page 12—2016, 2022, and 2028, giving the states two years to adopt the code standards—meets both the 2030 Congressional target date and code cycle upgrade timelines.

Question 6. As part of your vision to stimulate the economy, you provide a plan that would adjust interest rates on homes, pursuant to their energy reduction capability, and an accelerated depreciation schedule for commercial buildings, who demonstrate energy savings. Please describe who would manage these mortgage and depreciation programs.

Answer. The Plan would leverage the benefits of energy reductions by offering for both existing and new homes, through Fannie Mae and Freddie Mac, mortgage financing with reduced interest rates in proportion to the energy reduction target reached. The Treasury Department is currently doubling its financial support to Fannie Mae and Freddie Mac. It will buy as much as $200 billion of preferred stock in the two mortgage companies, twice as much as previously promised. This support provides the capital to implement the Plan and tie the Treasury's support of Fannie and Freddie to private investment and job creation.

The new 'conforming' mortgages would be no larger then that allowed by law. The interest rate buy-down schedule would be determined by available funds and the level of job creation desired. For existing homes, a minimum amount of private investment in efficiency would be required according to the energy reduction target and mortgage rate offered. Homeowners taking advantage of the Plan would be required to have an energy audit and a certification that the work was performed properly. Equity can be built into the Plan by allowing existing efficiency and solar tax credits to be used up to a maximum mortgage amount or home value. Tying the mortgage rate buy down to minimum energy reduction targets insures that every federal dollar spent will stimulate private investment and create jobs.

Since my testimony, the US Treasury and the Federal Reserve are expected to offer refinancing through the Term Asset-backed Loan Facility (TALF) next month to help free up money for the commercial real estate sector. Given this new development, the way to create jobs through commercial building energy reductions is through existing federal, state and local programs. At the federal level we recommend increasing The Energy Efficient Commercial Buildings Deduction from $1.80 per square foot for the 50% energy consumption reduction (cost savings) to 1) $3.50 per square foot for meeting a minimum 50% energy consumption reduction target below ASHRAE 90.1-2004, 2) $5.00 per square foot for meeting a minimum 75% energy consumption reduction target, and 3) $6.50 per square foot for a building that is carbon neutral.

Building energy consumption from non-depletable energy sources collected on site or provided from within a development would be considered an energy reduction. The tax deduction should be offered for a period of 3 years.

Question 7. I understand that there have been several green mortgage products developed to assist homeowners interested in these types of improvements. How different would your program be from these types of products?

Answer. Interest in 'green' homes has increased dramatically in the past few years. There are rebates, tax breaks and cash incentives for green homes offered by states and local governments. Fannie Mae provides a 'green mortgage' program where the added value of a home's energy efficiency translates into more buying

power not necessarily a lower net monthly outlay. The program is for both new construction and existing properties.

The problem is very few people are applying for these incentives and mortgages. Right now, the public is averse to purchasing big-ticket items and increasing their monthly outlay, regardless of how small.

Our Plan is very different. By tying the mortgage interest-rate buy-down proposed in our Plan to specific energy reduction targets and homeowner investments, three highly beneficial and desired results are achieved: 1) new demand for Building Sector jobs is immediately generated, benefiting not only the Building Sector, but all the industries and sectors that support the Building Sector, 2) a homeowner's monthly mortgage payments and energy bills are significantly reduced, providing disposable income and making it much more likely that they can meet their payments, and 3) creation of a new $236 billion per year renovation market that does not currently exist. A mortgage buy-down that is not tied to aggressive energy reduction targets and private investment will not create many jobs or new business opportunities.

Question 8. Is it reasonable to demand Net Zero Energy performance from existing buildings, regardless of size, and geographic location? What obstacles exist in practice, to obtain net zero energy?

Answer. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the establishment of 50% of the commercial building stock of the United States to be zero net energy by 2040. In the Act, the definition of a 'zero-net-energy commercial building' is:

> a commercial building that is designed, constructed, and operated to—(A) require a greatly reduced quantity of energy to operate; (B) meet the balance of energy needs from sources of energy that do not produce greenhouse gases (GHG); (C) therefore result in no net emissions of greenhouse gases; and (D) be economically viable.

Given this definition, I believe it is possible to achieve zero-net-energy for 50% of the commercial building stock of the United States by 2040 for the following reasons; i) over the next 30 years three quarters of the built environment in the US will be either new or renovated; ii) low-rise commercial buildings, which are easier renovate to zero-net-energy, make up 77% of total US commercial building stock; iii) most existing buildings can reduce their energy consumption using economically viable and readily available, strategies, technologies and equipment; and iv) the definition allows for existing buildings that cannot produce as much clean (non-GHG emitting) energy on-site as they consume, to purchase clean energy from a local or central utility.

Response of Edward Mazria to Question From Senator Cantwell

I believe another promising area for improving the efficiency and many other aspects of our nation's buildings is adding on green roofs. On efficiency benefits in particular, according to the EPA, the surface temperature of a green roof can be as much as 90 degrees Fahrenheit cooler than the surface of a traditional rooftop.

Question 1a. Since your testimony did not specifically address green roofs, could you talk about what potential roles do you see for green roofs in achieving higher levels of building energy efficiency?

Answer. Green roofs and cool roofs (solar reflective roofing membrane or surface) are part of a new generation of roofing strategies that have a high potential to reduce energy consumption in buildings. Each has advantages and disadvantages that are well documented in government literature. It must be noted however, that green roofs provide benefits beyond energy savings, such as storm-water management, filtering and reducing the temperature of water runoff, cooling ambient air temperatures (heat island effect), and increasing green space (see: Reducing Urban Heat Islands: Compendium of Strategies, EPA 2008).

Question 1b. What is the energy savings potential of green roofs and what federal incentives and programs might help to accelerate the deployment of green roofs nationwide?

Answer. The energy savings potential of green roofs depends on local climatic conditions and individual building and roof characteristics, such as size, use and insulation values. Greater energy savings are weighted toward a reduction in summer heat gain through shading, thermal mass and evapotranspiration, rather than in winter heat loss. Of critical importance in low-rise green-roofed buildings is their thermal resiliency, or their ability to maintain acceptable interior conditions when exterior conditions reach extremes (heat waves and cold spells), especially during a blackout or brownout.

The Cities of Portland, OR and Chicago, IL have been very successful with their green roofing efforts by offering density bonus incentives in their zoning codes. This type of policy promoted nationally may accelerate green roof deployment. Federal tax credits to building owners are another avenue. We believe however, that updating the National Model Building Energy Code Standards (Page 12 of my testimony) will lead to the greatest deployment of all building energy savings strategies and technologies.

Question 1c. Do you believe the Federal Energy Management Program an effective vehicle for the acceleration of green roof deployment in the federal building sector?

Answer. Yes, the Federal Energy Management Program is charged with assisting federal agencies to use energy, water, and other resources wisely; green roofing is an effective design option that accomplishes these goals.

EVALUATION OF STUDY TITLED "ACHIEVING 30% AND 50% OVER ASHRAE 90.1-2004 IN A LOW-RISE OFFICE BUILDING", PREPARED FOR NAIOP (COMMERCIAL REAL ESTATE DEVELOPMENT ASSOCIATION), PUBLISHED DECEMBER 2008

After a thorough review of the NAIOP-commissioned energy efficiency study, it is my professional opinion that the study is of no value and is intentionally misleading for the following reasons:

1. The study analyzes a square-shaped, four-story office building configuration with completely sealed windows and an equal amount of un-shaded glass on all four sides of the building. In other words, the study analyzes an extremely inefficient and outdated building design typology.

2. The study looks at only three cities and climates—Newport Beach, Chicago and Baltimore—and does so without changing the design of the building to respond to these very different climates.

3. Of the numerous energy saving measures that can be applied to, or integrated into a building design, the study analyzes only five measures.

4. The study intentionally does not analyze any of the readily available (and well known) low-cost, no-cost and cost-saving measures that reduce a building's energy consumption. For instance, the study does not investigate changing the shape of the building, its orientation or form; redistributing windows or using different windows to take advantage of natural light for daylighting or sunlight for heating (office buildings are day-use facilities); shading the glass in summertime to reduce the need for air-conditioning; using operable windows for ventilation (not even in Newport Beach with its beautiful year-round climate); or using low-e glazing. It also does not investigate employing a heat recovery system, cost-effective solar hot water heating system or energy management control system. In fact, the study fails to analyze so many of the no-cost and inexpensive energy-saving options available, that it is impossible for the building configuration studied to reach commonly achievable energy-consumption-reduction targets.

5. NAIOP contends that its analysis is "aimed at understanding the practical and economical impacts" of energy efficiency measures available. Yet, the study intentionally analyzes high-cost, low-energy-reduction measures to falsely demonstrate that increases in efficiency are expensive and unachievable. For example, the roof area in a four-story building is only 25% of the building floor area. Increasing the insulation values in the roof well beyond code will yield only marginal efficiency results and at steep costs. However, seven roof insulation options are analyzed in this category (see Graph 1. below).*

6. Upgrading to commonplace low-e double glazing is 6.5 times more efficient at half the cost per square foot than upgrading to R-38 roof insulation, yet the study does not consider this option.

7. The study is statistically irrelevant. A four-story office building represents less than one percent (approx. 0.29%) of commercial building square footage and 0.08% of all building square footage in the US.** A four-story, square office building with equally distributed sealed glazing on all four sides is a small fraction of this 0.08%.

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*Graph has been retained in committee files.

**Source: US Energy Information Administration, 2007 Building Energy Data Book, Tables 2.2.3 and 7.4.2, and the EIA AEO 2008, Tables 4 and 5.

RESPONSES OF PHILIP GIUDICE TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. What are some examples where the market has moved energy efficiency in the right direction regardless of government mandates?

Answer. Over the past three decades there are relatively few instances in which the market alone has moved toward energy efficiency without some local, state, or national mandates or other government involvement. Interest by producers and consumers in energy efficiency has tended to rise and fall with the price of gasoline and other fuels. It would be great for markets and the private sector to move us toward a much more energy efficient world without government intervention but it is not doing so at present.

For a host of reasons, minimizing the first cost of a purchase is weighted dramatically higher in priorities than minimizing life cycle costs, by both consumers and producers. This tendency contributes to a classic tragedy of the commons situation whereby each individual perceives themself as being better off by minimizing their first cost of a purchase, even though as a society we are all worse off by consuming far more energy than we need for the comfort, convenience and work we need to accomplish. The fact that individuals would also actually be better off from a life cycle cost standpoint provides an even greater impetus for government intervention. Much more energy efficiency will allow consumers and society to consume far less energy and producers will produce more valuable products. A relatively small amount of government intervention can and does provide dramatic benefits for all.

EnergyStar labeling is a powerful example of public-private partnership, where the combination of branding and development of consensus standards has raised the bar for energy efficiency across many types of appliances and equipment. Products from computers to windows to power supplies are more efficient than previously. Equally important, the EnergyStar brand is widely recognized, respected and accepted as a standard of energy efficiency. Unfortunately, the consensus standards set in EnergyStar are often only modest improvements over what existed before, and so the acceptance of EnergyStar in the public mind as the efficiency standard may actually inhibit more ambitious energy efficiency. The public does not recognize that further highly cost-effective product improvements are possible and available, and thus does not buy those higher-performing products.

Domestic appliance efficiencies showed little gain until federal standards mandated improvements. A "golden carrot" competition to produce a highly efficient refrigerator in the 1990's demonstrated that such products could be manufactured, but the industry responded by producing a few very high-end models that didn't find a significant market. Nonetheless, with federal standards now in place through legislation, the average refrigerator now consumes half the electricity required by a typical 1990 refrigerator.

Periodically updated and constantly improving appliance standards based on the performance of a top tier of the most efficient appliances available could provide exactly the private—public process to stimulate continuous innovation and much greater energy efficiencies. This ever-escalating performance standards approach is being utilized in Japan and is helping to stimulate innovation and much more efficient appliances.

Energy Services Companies (ESCOs) operate in the private sector but tend to specialize in niches, such as institutional buildings. ESCO's utilizing privately financed shared-savings approaches have effectively improved clients' energy efficiency. However without support from ratepayer-funded utility programs or public funds, ESCOs are not able to provide as deep energy savings as possible and miss many opportunities that could result in improved savings lasting decades rather than several years. Unsupported ESCO work tends only to capture the lowest hanging fruit and not the fullest potential of savings.

One notable example of a market moving towards higher energy efficiency with a small amount of government support is data centers. EPA and DOE's green computing initiatives have helped bring a spotlight on data centers' needs and options. Also, California's state-run energy efficiency programs, which have specific tailored programs for data centers administered by the investor owned utilities, have been very helpful. These government programs have sparked much greater interest and awareness of energy efficiency in data centers and much better practices are emerging.

In the past, data centers added processing power and servers without regard to their energy consumption. Increasingly data centers are recognizing that their single largest cost is the cost of energy for their operations—more than the cost of hardware, software, telecommunications, personnel and buildings. With this recognition, innovation has been unleashed and new solutions have emerged. Software is helping to realize a three fold or more increase in storage capacity from the same

servers. Servers and processors have been redesigned to consume much less electricity and produce much less heat. Cooling requirements are being focused on exactly the components that need cooling and not the empty space between. All in all great strides are being made at the best data centers to produce the same amount of useful output while consuming much less energy.

Question 2. The federal and state governments have been engaged in several standardized programs to promote energy efficiency in the last few decades. It is also true that there have been advances in energy efficient technology without the government playing a role. Please describe the pros and cons of these two approaches.

Answer. The most effective energy efficiency efforts are those in which both the private and public sectors play strong interactive roles. Energy efficiency has 'public good' benefits in addition to the private benefits to the end-user, therefore, economic theory suggests that appropriately targeted government regulation is likely to improve the market outcome. As a result, there are relatively few circumstances in which the market has found solutions completely on its own, leading to more energy efficiency without at least some governmental participation.

The underlying reason for this is the relatively low cost of most forms of energy, even in high-cost regions like New England. The low cost of energy until very recently has been coupled with the further perception that energy costs only amounted to a very small percentage of operations costs in all but the most energy-intensive industries. Without the drivers of high costs and the negative impacts high energy costs have on competitiveness, there has been little motivation across most sectors of the economy to pursue energy efficiency for its own sake. Higher energy prices and increasing concern about climate change are just now having a serious effect on attitudes toward energy use at home and at work.

Over the past 30 years the first impetus for increased energy efficiency came from low income households. Low income families, including the working poor, have had virtually no income growth during this period, but these families typically occupy the leakiest homes and must use the least efficient heating and cooling equipment. DOE's Low Income Weatherization Assistance Program was for many years virtually the only national energy efficiency and conservation program. In Massachusetts our low income program regularly delivers 20% to 30% energy savings for each family served and provides a national model for programs in other states. That program is also a model for the deeper savings that we are now beginning to implement in ratepayer-supported energy efficiency programs.

Government, non governmental organizations, and the private sector all have roles in energy efficiency. The EnergyStar consensus standards process shows the impact that cooperative action can bring. But EnergyStar is not the leading edge of energy efficiency—the consensus process slows upgrading of EnergyStar standards primarily because private sector partners impede adoption of better standards. Homes can be built that are far more energy-efficient than the EnergyStar New Homes standard, with only small increases in first cost, costs that are offset in just a few years by superior performance.

Government has a role in setting strong, responsive standards where the private sector has failed to do so. Government solutions are needed in the form of strong building codes that are enforced on the ground, strong appliance standards for highly efficient heating and air conditioning, strong standards that eliminate electricity waste from "instant on" electronic appliances and other "vampire" electricity consumption.

Government mandates have produced results and should continue to be used, but there needs to be room for regional variation based on differences in climate, and for experimentation. In most cases where the federal government has set efficiency standards it has pre-empted state standards. This leaves the unfortunate situation in which high-cost states like Massachusetts are not allowed to have stronger standards than the out-of-date federal standards allow. The most egregious example concerns gas-fired furnaces. A federal standard, which will become effective only in 2015, raises the minimum furnace efficiency from 78% to 80%; while most furnaces purchased for private homes in Massachusetts are currently at 90%. Yet tenants, who are often in the lower income brackets, must continue to pay for the operation of inefficient furnaces because we cannot mandate landlords to provide better efficiencies.

Question 3. The recent stimulus bill directs billions to energy efficiency measures. How can these funds be targeted to be most effective?

Answer. Collaborative strong working relationships between the states and the federal government can and will provide a basis for assuring that the stimulus funds are put to work quickly, transparently, productively and get the results we all need. State energy offices and the well-established weatherization agencies and

service providers have long-standing established relationships with their federal counterparts to do exactly what is needed. There are no single silver bullet answers to the question of how to best achieve energy efficiency, and the right solution in one state is not necessarily the right solution in another state due to varied climate, industry makeup, age of building stock, etc.

Question 4a. Also, as you know, $3.1 billion of energy efficiency block grants came with preconditions, namely energy efficiency rulemaking measures and updating building codes. Are you concerned with the inevitable delay in getting the energy efficiency funding out to states and localities?

Answer. We are not concerned about these requirements for Massachusetts or any state. Massachusetts has fulfilled the requirements fully. Further, as specified in the ARRA bill, the requirements are not onerous for any state to commit to working towards regulations that support increased energy efficiency and better building codes.

Question 4b. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the development and establishment of zero net energy commercial buildings which applies to any commercial building newly constructed in the United States by 2030 as well as 50% of the of the commercial building stock of the United states by 2040. Groups such as the American Institute of Architects (AIA) have endorsed an immediate 50% reduction in fossil fuel-generated energy and a 10% reduction target every five years until new and renovated buildings achieve carbon neutrality in 2030. Have we made any progress on these initiatives?

Answer. California and Massachusetts have active policy development to push forward zero net energy buildings (similar to carbon neutrality) for both the commercial and residential sectors. During the past year Massachusetts convened a Zero Net Energy Buildings Task Force, which issued its report on March 11. The report can be found at this link: http://tiny.cc/aJRwi

The Task Force and report were built around a goal set by Governor Patrick to achieve universal adoption of zero net energy buildings for new construction by 2030. We have defined this goal as:

> 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 he total amount of energy consumed onsite.

Among the key commercial-sector recommendations are that energy performance standards be set for all new buildings and major renovations, differentiated by building type, by January 1, 2012. These standards would then be updated in future years, and specifically tied to "exemplars," meaning the highest-performing new buildings in the Commonwealth, by January 1, 2018. Performance standards would be established for existing buildings by January 1, 2014. Also important is a recommendations that all commercial buildings display "energy certificates" that make visible their energy use in comparison to recognized standards, by January 1, 2012.

A key early step in this direction is improving the efficiency requirements in the state's building code. A 2007 law requires that the Commonwealth adopt the latest version of the International Energy Conservation Code (IECC) within one year of its publication. We have now proposed to go beyond the IECC by adopting a "stretch code" that would be available for municipalities to adopt at their option. The Stretch Code is now being considered by our Board of Building Regulation and Standards (BBRS). It would require that most commercial buildings above 5,000 square feet (excluding several types of "specialty" buildings) use 20 percent less energy per square foot than would occur under the ASHRAE 90.1 2007 standard, which is widely used in the United States as the basis for state commercial building codes. Modeling conducted by the two largest electric utilities in Massachusetts has shown, for several particular buildings, that the 20 percent reduction can be achieved with lifetime savings on energy bills that are far larger than the incremental addition to initial capital costs. For example, in one case of a mid-sized office building that has been completed, modeling estimated a three-year payback on the capital costs, which was reduced to one year after the incentives provided by the utility, National Grid.

Question 5. You highlight a number of energy efficiency programs that Massachusetts has successfully undertaken. Which ones, in your opinion, have been the most effective? Why?

Answer. We are now meeting approximately 8% of our electricity needs through efficiency rather than greater electricity supply. In fact, we are effectively saving electricity at about 3.5 cents per kWh, compared to approximately 9 cents for the cost of conventional supply. A primary means through which this has been accomplished is effectively spending substantial funds on well designed, measured and

verified efficiency. These funds have been collected through the systems benefit charge (SBC) on electric bills at a rate of ¼ of a penny for ever kWh distributed by investor owned utilities in MA. As of 2006, out of the nine states with the highest rankings for their electric efficiency programs, Massachusetts had the highest level of total spending, at $125 million, which constituted 1.5% of total electric revenues.[1] For natural gas programs spending was lower (but this will change under the least-cost spending law passed in 2008), at $25.6 million in 2006, yet this still ranked us fourth in the nation, as measured by efficiency spending per unit of gas consumption.[2] For the 2003-2005 time period, estimated lifetime benefits from all the utility programs is estimated at $1,229 million, compared to $504 million in spending by the utilities and program participants (businesses and residents), for an average benefit to cost ratio of 2.84.[3]

These levels of spending enable Massachusetts utilities to provide appropriate incentive levels to businesses, homeowners, and owners of rental property for the completion of efficiency measures. Because of the serious marketplace barriers to energy efficiency that are largely inherent in the economy (average ownership of a building by one company or household only lasting a few years; lack of information; lack of certainty over the gains from efficiency; shortages of capital funding; "split incentives" when the owner of the facilities is different from the party paying the energy bills; energy prices that do not reflect full societal costs of energy use), such incentives are vital to convince building occupants to engage in efficiency.

The keys to having successful energy efficiency programs are straightforward in concept but not necessarily in execution. Successful programs require all of the following:

- Identify an efficiency need not being successfully addressed in the marketplace;
- Identify a cost-effective strategy to meet the need, including appropriate marketing, incentive type and delivery, presentation to the target market, and implementation strategies;
- Test models in pilots, adjust, implement at full scale;
- Evaluate and adjust, substantially revise or end, as appropriate.
- Educate and train an appropriate work force
- Enlist people in their homes and businesses to take active roles.
- Rigorous measurement and verification of results

In Massachusetts, utility-based incentives have, on average, paid for about 60 percent of the capital cost of installing energy-efficient equipment. Among the various programs, efficient lighting provided 54 percent of the total energy savings for commercial, industrial, and residential sectors combined, with HVAC (heating, ventilation, and air conditioning) providing another 23 percent.[4]

Among the programs that have led to increased consumer purchases of high-efficiency light bulbs, light fixtures, and appliances are "negotiated cooperative promotions." Rather than require consumers to fill in and mail back a rebate form in order to obtain an incentive, which yields lower participation levels, cooperative promotions subsidize retailers to directly reduce their prices on these products. These promotions have been a major aid in raising sales of items such as compact fluorescent bulbs (CFLs), torchiere lamps that take CFL bulbs, and EnergyStar rated appliances. In 2006, these programs provided incentives for the purchase of 4 million CFLs discounted to $1-$2/bulb. Equally, or more important, an additional 5 million CFLs were purchased through other channels in the state, as years of CFL incentives have yielded their widespread acceptance among consumers.

Also important has been the availability of energy audits at a major discount to businesses and free to homeowners. Since the possible gains from efficiency are largely unknown to the public, particularly for their own individual buildings, the hurdle of paying several hundred to several thousand dollars for an initial evaluation of their potential savings is a major obstacle. Providing these evaluations at low or zero cost gives building owners the information they need to consider making efficiency investments, without first having to make a substantial cash outlay before they have an idea of the potential benefits. However, we also know from long experience that audits alone do not generate energy efficiency. Homeowners, renters and businesses also need technical, process and financial assistance to undertake energy efficiency improvements.

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[1] "The 2008 State Energy Efficiency Scorecard," ACEEE, October 2008, Table 4, page 7.

[2] ACEEE, Table 8, page 11.

[3] "Massachusetts Saving Electricity: A Summary of the Performance of Electric Efficiency Programs Funded by Ratepayers Between 2003 and 2005 , Executive Office of Energy and Environmental Affairs Massachusetts Division of Energy Resources," April 2, 2007, page 2.

[4] Massachusetts Saving Electricity. . .", page 7.

For low-income residential households efficiency services are provided at zero cost, since such households lack the capital to pay for even a small fraction of installation costs. We estimate that for the 2003-2005 time period, lifetime utility bill savings for these households were $140 million, with a large fraction of the savings coming from reduced winter heating bills, in contrast to other customers, who obtained most of their savings on electricity. Installations focus on air sealing and insulating buildings, and where necessary replacing heating systems.

Question 6. As we know, it does no good to mandate a code if the standards are not adequately enforced. Do you have any challenges with ensuring code compliance? If so, what are they?

Answer. Code compliance is enforced by municipal building inspectors in Massachusetts and almost all other states. There is clearly a challenge here, due to shortages of staffing that make it difficult for the inspectors to adequately check on all projects, the fact that inspectors see their primary mission as insuring the safety of buildings, and also due to inadequate training programs for the inspectors on efficiency requirements and on the need to enforce the energy code. With increased funding that is becoming available from several sources, including the federal stimulus bill and the Regional Greenhouse Gas Initiative auction proceeds, the Commonwealth plans to provide greater assistance to cities and towns on both these fronts. Under the Green Communities Act passed in 2008, we are required to provide assistance for training of the inspectors.

In the case of our 'stretch' code proposal to go beyond the existing building code, we are moving the burden of energy code enforcement for residential homes away from the overburdened municipal building inspectors by requiring a 3rd party certified rating and inspection from a certified rater. These raters are already used by a host of voluntary programs including the Energy Star Homes program, the DOE home rating initiative, the LEED for homes program and the recently announced National Association of Home Builders Green Homes program. Third party inspection may well prove to be the most desirable path for ensuring that homes are built to at least the minimum performance standards embodied in the existing energy efficiency codes and the more aggressive codes to come. Still, it will be a challenge to develop and deploy a corps of home energy raters in a time of slow new construction.

Question 7. You mention that several European countries, including the UK, Germany and Austria have implemented standardized building energy calculations that are made available to the public, and that ASHRAE has just announced that it will develop such a scale. Has there been any feedback on the success, or any challenges that may have arisen, due to this measure in Europe?

Answer. There is broad agreement that effective action on building codes is necessary but by itself is insufficient without a complementary approach to rating building performance. Building energy ratings allow the real estate market to factor in the energy efficiency of a building in the purchase price or lease or rental costs of a building. The UK, Germany and Austria have been leading adopters of this approach, but it has been developed in response to a standardized European policy called the EU Energy Performance of Buildings Directive. The original European Building Energy Directive of 2002 is summarized here: http://www.diag.org.uk/media/18835/cibse_briefing.pdf.

However, the EU is in the process of finalizing an expansion of this directive given its success. A press release on the revisions to the EU directive is available here: http://tiny.cc/6wQIT

The UK policy to fulfill the EU buildings directive is available here: http://www.diag.org.uk/

Question 8. Your testimony provides a number of examples where states are moving forward with their own energy efficiency programs. Are states taking the lead in this area? If so, please describe whether or not a 'one-size fits all" approach may impact different jurisdictions.

Answer. Some states are taking a lead with energy efficiency programs. For the most part the most active leaders are the same as those from the last 20+ years: Massachusetts, California, the Pacific Northwest, Wisconsin, Minnesota, Vermont, Connecticut, and New York. These states have developed critical mass in their infrastructures, and have maintained and extended their energy efficiency efforts over time. They have also been laboratories for each other and for states that are just beginning to ramp up their efforts. There has been a great deal of cross pollination among the most active players, including state governments, utilities, NGO's and other professional energy efficiency organizations. Emerging states include Maryland, Illinois, New Jersey and others.

Different strategies are appropriate for different states and regions, due mainly to variations in climate conditions. These have been expressed in state government

requirements and incentive programs, and also in the regional specificity of both model building codes published by ASHRAE and the IECC, and in Energy Star standards. Such differences are appropriate and should continue, but there also many areas where climate is not relevant to a standard, and in these situations uniform national standards are appropriate.

The federal role, expressed by DOE and EPA, has been most effective in nurturing existing efforts and extending the knowledge base in almost all aspects of energy efficiency. National Laboratories—Lawrence Berkeley, Oak Ridge, National Renewable Energy Laboratory and the Pacific Northwest National Laboratory—have made many contributions through technical studies, evaluations, and direct assistance to state and utility programs. The National Labs have been a baseline resource and should be supported and further encouraged in their efforts.

Question 9. Please describe how the weatherization program has worked from your state's perspective. There remain differences in weatherization standards from area to area. Do you support further modifications to harmonize standards of the weatherization program to ensure that providers are maximizing the efficiency gains made in these building projects?

Answer. The Low Income Weatherization Assistance Program is the oldest national energy conservation and efficiency program in the country. It's precursors date to 1975; the program as we know it today was first funded through the Federal Energy Administration, now the Department of Energy, in the late 1970"s. Since that time the program has evolved greatly from minimal 'low-cost no-cost efforts that used part-time trainees, to the current programs that use the evolved knowledge of building science, experienced contractors and local program administrators to provide systematic approaches that provide substantial real savings to low income homeowners and renters. The Massachusetts program typically achieves savings in the 20-25% range for all fuels. In Massachusetts and other states, the DOE funds leverage additional funds from utility energy efficiency programs, so that the average expenditure per home from all sources is now in excess of $3,000. The program emphasizes treating the house as a system . The program provides additional non-energy benefits, such as healthier environments.

Housing types, climate, and living arrangements vary across the country. The specific solutions needed to address Boston and New York apartment dwellers are different from those in single family housing in Virginia or New Mexico. Certainly some variation is appropriate to accommodate specific conditions. What should not vary is a national approach that addresses all fuels, heating and cooling needs as appropriate, and most importantly takes a systemic approach to addressing energy needs. What should also not vary are bold goals for reaching the low income population's energy needs broadly and deeply, energy efficiency solutions based in proven science and techniques, strong training and quality control, and finally, strong educational efforts to enlist low income households in energy efficient behaviors.

Response of Philip Giudice to Question From Senator Cantwell

Question 1. I understand standby power is a growing source of energy consumption in buildings. While the typical power loss per appliance is low—about one to 25 watts—when multiplied by the billions of appliances in buildings across America, and the fact that they occur basically 24 hours a day, standby losses are estimated to account for about 10 percent of all household power consumption.

To try and address this problem, I inserted an amendment in the 2007 energy bill that required that any electronic device or appliance purchased by the federal government use less than one watt of power while in standby mode. I was pleased that the House subsequently expanded this provision to incorporate standby power into all products already subject to federal efficiency standards.

Are there other steps you believe we could be taking at the federal level to reduce standby power loads?

Answer. The issue of standby power losses is an important one given the growing percentage of energy use in buildings now taken by 'plug load,' of which standby losses are a significant portion.

One way to tackle this issue is to ensure that standby power requirements are in place for all DOE appliance standards in addition to peak usage requirements. Some of the existing DOE appliance standards have not been updated since the 1990s and may presume that appliances are switched off completely when not in use, rather than continuing to require electricity. The energy star appliances program has required these standards for many years, but might benefit from a review of its potential to do more on phantom loads on small appliances such as cellphone chargers.

In addition there needs to be significant consumer education to raise awareness of the issue of standby power as simple and non intrusive behavioral changes can do a lot to mitigate this energy use. The use of power bricks to combine electric plugs on one device with an on-off switch (and optionally a timer switch) is one simple and low cost mitigation strategy that requires primarily end user education to implement.

One effective way to do this education and outreach is through the implementation of building energy rating standards and home energy audits as these typically break out the primary uses of energy and would illustrate the significant role of plug load from appliances in the overall building energy load. Utility and public information programs are another potentially effective means of educating the public, as well as businesses. Standby losses in computers, copiers and all sorts of office equipment represent significant but often unrecognized business costs. Networked computers, which still represent the bulk of business personal computers are generally shipped with power management features turned off because network administrators continue to specify that as the default setting.

RESPONSES OF ARUN MAJUMDAR TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. What are some examples where the market has moved energy efficiency in the right direction regardless of government mandates?

Answer. Heat pumps were developed in the 1950s without government mandates, in part motivated by reducing operating costs of electric heating. Joint private and public R&D contributed to efficient technologies, for example refrigerator compressors (NRC, 2001) and condensing gas-fired furnaces (DOE and industry, ca. 1981). It is useful to note that industry first attempted condensing gas-fired furnaces in 1928, but the units suffered excessive corrosion and early failure. Subsequent private efforts similarly failed until a joint DOE-private program beginning in 1979 identified materials that solved the corrosion problem[1]. Prior to the existence of government programs, such as development of test procedures and labels, little information existed in the market about energy efficiency. Voluntary government programs, e.g., Energy Star, have helped move the market toward higher energy efficiency. Market adoption of these technologies was assisted by state-mandated utility incentive programs, as well as by mandatory regulations such as state building codes and federal energy efficiency standards. The existence of a persistent government program for updating energy efficiency regulations has likely shifted the amount of private R&D toward energy efficiency from other issues.

Note that manufacturers frequently introduce energy-saving features when they add new functionality or features to a product. However, in my view, there are relatively few cases where manufacturers have modified a device solely to raise its energy efficiency in the absence of government programs. Furthermore, manufacturers sometimes convert the efficiency gains into higher performance, such as greater acceleration in cars, larger refrigerators, or brighter lights, rather than only giving consumers greater energy savings.

In general, market forces push higher energy efficiency when efficiency is a side benefit of some other technological improvements. The development of switch-mode power supplies about 1998 resulted in large increases in the efficiency of small power supplies for consumer electronics (first cell phones, then laptop computers). The initial impetus for this technology was their reduced weight and waste heat. They also permitted huge reductions in standby power use.

Another example is the change from CRT to LCD computer monitors. The main feastures of LCD monitors are light weight, efficient use of desk space and improved resolution. That changeover is almost complete, and the LCDs use ½ to ⅓ the power of CRTs for screens of the same size. LCDs are typically advertised as "flat screen" rather then "energy efficient" ones.

For the case of efficient electronic ballasts for fluorescent lamps, government programs (e.g., state minimum efficiency standards) appear to be solely responsible for the uptake of the efficient technology[2].

Question 2. The federal and state governments have been engaged in several standardized programs to promote energy efficiency in the last few decades. It is also true that there have been advances in energy efficient technology without the

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[1] James R. Brodrick, Alex Moore, "Conquering carrion", ASHRAE Journal, April 2000, pp.29-33

[2] Koomey, Jonathan, Alan H. Sanstad, and Leslie J. Shown. 1996. "Energy-Efficient Lighting: Market Data, Market Imperfections, and Policy Success.". Contemporary Economic Policy. vol. XIV, no. 3. July (Also LBL-37702.REV). pp. 98-111.)

government playing a role. Please describe the pros and cons of these two approaches.

Answer. These two approaches (government programs and market advances) are complementary, not conflicting. Competitive markets lead to innovation. Large corporations seek to maximize profits and can invest capital in a variety of opportunities world-wide. However, there are market failures as well. For example, in commercial buildings, builders or landlords select the energy-related equipment while consumers pay the energy bills, leading to misalignment in incentives to reduce capital cost versus energy efficiency. Market failures limit the private profits available from commercializing energy-efficient technologies that are attractive from a societal benefit-cost perspective.

Government programs can align private profits from efficient technologies with societal benefits (lower operating costs, lower emissions of pollutants and greenhouse gases and associated health and productivity benefits). Those government programs—such as labels, government procurement, tax credits to manufacturers and consumers, utility incentives—help create or expand markets for efficient technologies, whether those technologies are originally researched and developed with private or public funds. As an example of the convergence of private and public interests, appliance manufacturers sometimes negotiate simultaneously three government programs that support energy efficiency: i) updates to energy efficiency standards, ii) Energy Star levels and iii) tax credits to manufacturers and to consumers.

On the research front, a recent study of R&D100 awards found that, in contrast to 30 years ago when about 80% of winners were large firms acting on their own, today roughly two-thirds of the winners involved collaborations across companies and increasingly with the public sector. Factors that likely contributed to this include the increasing complexity of technology and the corresponding challenges of any single company to bring sufficient technical expertise to bear, and the value of the public sector in catalyzing research and bringing disparate parties around a common problem. Further work is needed to evaluate this issue, but it may be indicative of the larger challenges facing the R&D enterprise[3].

Question 3. The recent stimulus bill directs billions to energy efficiency measures. How can these funds be targeted to be most effective?

Answer. The economic stimulus package offers a unique opportunity to make energy efficiency investments in a way that not only creates jobs in the short term, but also addresses long-term goals of energy efficiency.

Consider the long-term first. The Commercial Buildings Initiative (CBI), as legislated by EISA'07, requires the US to approach zero-net commercial buildings by 2030 (within the next 20 years). As I have identified in my written and oral testimonies, there are two major gaps today:

- Lack of measurement of building actual energy performance and policies requiring it
- Lack of integration in design and operation of buildings

The stimulus funds could play a very critical role in overcoming some of these barriers. As an example, consider Figure 1 which shows a flow chart and feedback loops of how long-term goals could be achieved, and identifies in the gray box where and how the stimulus funds could play a critical role.* In collaboration with states, counties, and cities, here are some early steps that the stimulus funds could help achieve:

1. Create and deploy an integrated information technology (IT) infrastructure (hardware, communications, and software) to obtain sub-metered energy performance of all public buildings.
2. Create generic non-proprietary energy-related operations and maintenance dashboard visualization architectures and apply them to every public, so that facilities managers can begin reducing their energy use immediately.
3. Create a national repository to collect and store standardized energy performance data of every public building.
4. Develop efficient and accurate modeling and simulation tools through calibration to data so the models can be used to rapidly identify retrofit measures that can have the maximum energy savings at minimum cost.
5. Deploy those retrofit measures.

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[3] Fred Block, Matthew R. Keller, "Where Do Innovations come From? Transformations in the U.S. National Innovation System, 1970-2006", The Information Technology and Innovation Foundation, 2008

* Figures 1–4 have been retained in committee files.

If these key steps outlined here are enabled by the stimulus package, they could pave the way in the long-term for:

(i) buildings that continually optimize their own performance;
(ii) whole building integration for both design and operation;
(iii) real-time continuous commissioning, prognostics and diagnostics;
(iv) validation of reductions in energy consumption;
(v) lessons learned and best practices of what energy efficiency measures provide the maximum benefit, which can be used for new building design and operation;
(vi) national commercial whole-building energy labels (like mpg) of both 'asset' (modeled potential) and 'operational' (actual measured performance) types.

Here are some early steps that have been taken locally:

a) Given our location in the Bay Area, there have been preliminary discussions between LBL to partner with local cities (Richmond, Berkeley, Emeryville, Oakland) to introduce the IT infrastructure to measure the performance of all public buildings in these cities.
b) LBL has also helped General Services Administration (GSA) come up a plan of how to introduce an infrastructure of measurement and feedback control to create "smart" GSA buildings.
c) UC Berkeley campus is also considering introducing the IT infrastructure in the campus buildings.

While I am aware of only the above-mentioned steps in our locality, I suspect such steps are being taken in other localities as well. I believe the national laboratories in partnership with the federal and state agencies could play a role as regional centers to provide the necessary guidance and stewardship for using stimulus funds to achieve long-term energy efficiency goals.

Question 4. Also, as you know, $3.1 billion of energy efficiency block grants came with preconditions, namely energy efficiency rulemaking measures and updating building codes. Are you concerned with the inevitable delay in getting the energy efficiency funding out to states and localities?

Answer. I believe it would be most appropriate for DOE-EERE to respond to this question. Having said that, in my view, the benefits from these block grants will be substantial. For the purpose of stimulus, minimizing delay is best since job retention and creation are urgently necessary. However, if we are to connect the dual goals of short-term job creation to long-term energy efficiency, it would be useful and prudent to create a plan (see response to Question #3), which could provide guidance to states and localities for ongoing implementation of cost-effective efficiency measures after the stimulus is over. As I mentioned before, the national laboratories in partnership with the federal and state agencies could play a role as regional centers to provide the necessary guidance and stewardship.

Question 5. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the development and establishment of zero net energy commercial buildings which applies to any commercial building newly constructed in the United States by 2030 as well as 50% of the of the commercial building stock of the United states by 2040. Groups such as the American Institute of Architects (AIA) have endorsed an immediate 50% reduction in fossil fuel-generated energy and a 10% reduction target every five years until new and renovated buildings achieve carbon neutrality in 2030. Have we made any progress on these initiatives?

Answer. I believe it would be most appropriate for DOE-EERE to respond to the question of how much progress has been made on the above-mentioned initiatives. Having said that, I will provide some details of what measures have been taken so far.

In response to EISA'07, DOE launched the Commercial Buildings Initiative as part of the EERE Buildings Technology (EERE-BT) Program. In August 2008, DOE created the National Laboratory Collaborative on Buildings Technology, which consists of a team of 12 people (2 from each of the 5 national laboratories and 2 from EERE-BT program) to better support DOE's CBI activities. That group has now begun to become engaged in a new round of planning the RDD&D agenda, and has recently been asked by EERE to create a roadmap for CBI. EERE-BT program has updated its multiyear plan that begins to address the issues raised in EISA'07 with respect to CBI. EISA also requires DOE to designate a consortium to assist DOE in the management and implementation of the program. A Federal Register notice was released to address this and responses are now being evaluated by EERE-BT.

The Architecture 2030 ZEB goals that have been adopted by the AIA and many cities and other organizations are generally consistent with the DOE EISA ZEB goals. While EISA sets only the long term performance target, Architecture 2030

sets a specific timetable that starts immediately with a mandate that all new buildings use 50% less energy than current building stock. While these goals are achievable in principal, with motivated owners and skilled design teams, they are not easily met today for a variety of reasons related to technology, finance and design process so that in fact only a very small number of buildings achieve the Architecture 2030's initial 50% target. We also lack a comprehensive data collection and reporting program that would make it practical and efficient to track progress toward these long term goals.

Question 6. There are several rating programs available to use in obtaining differing "green" building ratings. Within your testimony you reference a study by Frankel concerning one such program and raise the issue of whether there is a means to improve the correlation between design intent and actual performance in individual buildings rated by these programs. Are there ways to accurately predict overall performance of these 'green' rated buildings?

Answer. Green building ratings address many performance factors, and overall the "green building rating" movement has been a positive force to focus additional attention on the importance of energy efficiency in our building stock. Different green building rating systems assign different levels of priority to achieving energy efficiency. So there are many claims for green buildings in which energy efficiency has not been a major driver in the design of the building, which is one reason why one sees a wide range of energy performance even from buildings with the same green building rating. But even if we focus solely on energy, as I noted in my testimony, there has been a historical disconnect between "design intent" and actual measured performance. There are some fundamental "understandable" reasons why measured performance may not meet design expectations. Consider for example a case where designs are formulated around a building with one 8-hour shift, with a low density of staff, and little office equipment, and energy predictions are made accordingly. Now consider the situation some time later when construction is complete and the building owner now uses two 8 hour shifts, more people per shift, and adds extensive amounts of new energy consuming equipment, e.g. servers. In this case we would expect the measured performance to be much larger than predicted. This could potentially be addressed if the simulation is modified to incorporate such changes and additions to buildings energy use.

While significant progress has been made in our current simulation tools, such as Energy Plus, over ones that were developed in the 1980s (e.g. DOE-2), more can be done, especially to make them useful for operations as well. The designers and their consultants may not be adequately trained in the use of the tools or may not have adequate understanding of the new efficiency technologies to be employed. Inappropriate materials and equipment substitutions may have been made compared to original designs, thus compromising performance. New and complex controls and operating systems may not have been adequately commissioned to ensure their proper operation. Occupants of the building may not fully understand how control systems work, thus reducing performance and increasing energy use. Operators often do not have the real time energy metering, monitoring, visualization and interpretation tools that would allow them to reliably operate the facility to achieve energy performance targets. In order to bring measured performance into alignment with design intent and expectations, each of these issues must be properly addressed.

In the future, if information regarding occupancy, lighting, HVAC, appliance use, and other energy consuming activities are integrated with advanced simulation tools, it is highly likely that we will reduce the mismatch between design intent and actual performance.

Question 7. Please describe the most effective steps to move towards reductions in risk and cost in existing technologies that could enable a deeper market penetration to meet zero-net energy goals.

Answer. Your question properly identifies a key focus on the role of innovation to enable these new ZEB designs. We not only need entirely new, disruptive scientific breakthroughs that dramatically increase performance but we need innovation that addresses cost and risk as perceived by designers and owners as well. I have identified these in my written testimony as well.

The specifics will vary with different technologies and building systems but let me illustrate with some examples. Daylighting strategies are good examples of the "integrated systems" I described. They can reduce electric lighting use by 50-80%, and they are reportedly used in many of the high performance buildings today. However the dimming ballasts that help capture the lighting savings are far too expensive to be routinely used or specified. We have been advised by manufacturers that if the technology moved from small niche markets to much larger mainstream markets, then new investment in cheaper more effective integrated chip technology and volume production could reduce current costs by 80%. So we would propose a na-

tional program of cost-shared demonstration projects with states, utilities, etc to create these high volume mainstream markets to provide deeper market penetration at much lower cost. These systems also involve integration of sensors and controls, and proper calibration and maintenance over time. Today these functions are complex, costly, risky—and therefore not widely used. We believe that an aggressive RDD&D effort-that links sensor improvements in the lab with field demonstrations of measured performance with state and utility partnerships, would rapidly move these systems into mainstream markets and could greatly accelerate progress toward these goals. We are confident that these systems will work as we have already partnered with owners, state agencies and suppliers to produce such an integrated daylighting/shading system in the New York Times building in Manhattan. We would invite you to visit this building to see first hand the potentials for these systems. The challenge is now that noted in your question: moving from single examples to widespread application and use.

Many building owners and developers do not believe that an integrated system will actually reduce energy consumption in a building. However, we know from practice that even partial integration (lighting only or HVAC only) can lead to such reductions, and if a building is fully operated like a system, reductions can be much more. We need testbed facilities around the country that are reconfigurable, and which demonstrate that a fully integrated building can dramatically reduce energy consumption, much more than is achievable today through simple retrofitting and retrocommissioning. Such regional facilities would make deep reductions in energy consumption credible to building owners, and it would enable to them make financial decisions based on actual data. This would reduce risk and enable a deeper market penetration.

Question 8. Please describe how you would develop a science-based approach towards Whole Building Systems.

Answer. A building is made up of materials, HVAC, lighting, windows, appliances etc. These components and sub-systems are supplied by different companies, which don't generally interact with each other. Yet, when these components are assembled in a building, they do indeed interact with each other, and sometimes fight each other and waste energy. We need a science-based approach to develop deeper understanding of how these components interact with each other. Based on that fundamental understanding, we need to develop tools to design and operate buildings. The design should integrate physical sciences and engineering (see below) with architecture and information science and technology. An example of such a tool is what we are calling the "Building Operating System", which is the "intelligence" or the brain behind building operation. It will take in sensor data from lighting, HVAC, plug loads, and occupancy, and then make decisions of how the achieve the right comfort and indoor environment and yet exploit cooperation between sub-systems to reduce overall energy consumption of the system. While feedback control system do exist for HVAC or lighting individually, a Building Operating System for all the energy systems in a building does not exist today.

The Building Operating System must be based on fundamental understanding of how fluid and heat flows in the building, the dynamics of building systems and how to use feedback control to stabilize the system. Figure 3 shows the time and length scales involved. It is necessary to use the basic science of thermodynamics, fluid mechanics, heat transfer and feedback control systems as the underlying "foundational science" in the next generation simulation and operational tools.

Question 9. Please describe how you would develop an educational system to promote the type of workers needed to design whole buildings systems, and other buildings that may lead to the goal of zero-net energy buildings.

Answer. The major gap in the buildings industry is the fragmentation of the process of designing, constructing and operating buildings. This is depicted in Fig. 4, which illustrates how fragmented operational islands are created. Lack of communication and integration occurs because there are no common goals and incentives. Unless this is addressed, it is unlikely that we can achieve zero-net energy buildings in a cost effective and scalable way.

This can be addressed through integrated education programs at multiple levels. Professional architects and engineers need improved educational curricula so that every architect graduating from an accredited program has the skills to design a zero energy building. At the university levels, we must create joint curricula that integrate science, engineering, architecture, business, public policy and law to collectively address the needs of the buildings industry. Such integrated programs can provide a holistic view of all aspects of how can one reduce energy consumption in buildings. However, they do not exist today, but can be created with existing know-how. I note the superb efforts of a small group of educators, the Society of Building Science Educators, who have struggled to upgrade the quality and quantity of class-

es and training experiences that architects must master in their educational programs. Similar efforts are needed to educate a new generation of electrical and mechanical engineers. More generally, the challenge is to integrate the concepts of energy efficiency into the graduate curricula, such as architecture, engineering, business, and agriculture.

An equal or larger challenge is continuing education programs to improve the skill levels of existing professionals, and perhaps methods to help finance those who may be interested in returning to classrooms to sharpen or extend their energy design skills. We need to create education/training bootcamps and certificate programs that provide an integrated view of the buildings industry. Both professional training and continuing education programs must not only expand the knowledge base in terms of materials, products and systems, but must train designers to think and act in a more collaborative and integrated manner to address the systems integration issue I described in my presentation. The AIA and other professional groups are exploring how this "integrated design process" can be most effectively implemented to equip our designers with the process skills needed to produce a new generation of zero energy buildings.

In my testimony, I have recommended the creation of Regional Centers of Excellence that can integrate R&D with professional training and continuing education program through the use of test-bed facilities for hands-on experience. For example, if we are to achieve zero-net energy buildings through the judicious integration of IT infrastructure, advanced simulation tools and a Building Operating System, the next generation of architects, building designers and operators must be exposed to the integrated tools and approaches.

Finally, as I mentioned in my testimony, we need to initiate a significant program of graduate student and post-doctoral fellowships as well as young investigator awards that will attract the best young minds to energy science and technology, and help create intellectual capital for the nation. For many years the DOE funded a fellowship program in Nuclear Engineering to create and maintain the academic infrastructure to support nuclear energy. Now it is time to create a large, graduate fellowship program to support students pursuing Ph.D.s in energy efficiency. Such a program could be quickly established and have a long-term impact on energy efficiency technologies. My Division at Lawrence Berkeley National Laboratory and my University, UC Berkeley, would be pleased to host some of these Ph.D. students.

Question 10. Is it possible for a new building to reach the goal of zero-net energy, be cost effective, and be easily scaled up to a wide market introduction?

Answer. Your question gets to the heart of the challenge today. It is possible for a new building to approach the zero net energy goal on a one-off basis today IF an enlightened owner with a large budget selects a skilled integrated design team, and if the construction, commissioning and operations are also intelligently and skillfully executed. Even then the building type, size and climate will influence the outcome. As an example—it is much easier today to achieve ZEB levels of performance in a small office building in a coastal California climate, than to achieve that level in a highrise building in Houston that houses a data center and restaurant. Since your question addresses scaling to wide markets in a cost-effective manner, I would then have to say that this goal cannot be achieved today. It could be made cost-effective if all the benefits—not just energy savings, but productivity, livability/quality of experience, health, long-term costs of emissions, live cycle assessment—are included. Scaling up to wide market introduction will require significant effort, but may be more desirable than the consequences of inaction, including long-term costs of later retrofit, environmental consequences, etc. Scaling up will decrease the costs of achieving zero-net energy. We are confident that with policy changes (e.g. standards based on measured performance), and appropriate investment in new breakthrough technologies and systems, and with better trained designers with new design methods and better tools, these goals are attainable on the time scale envisioned by EISA'07.

While the focus of the responses so far has been zero-net energy buildings for new construction, it is important to remember that we should achieve 50% saving in existing buildings as well. This can be more difficult than new construction, and should be a significant focus of any program.

RESPONSE OF ARUN MAJUMDAR TO QUESTION FROM SENATOR CANTWELL

Question 1. I understand standby power is a growing source of energy consumption in buildings. While the typical power loss per appliance is low—about one to 25 watts—when multiplied by the billions of appliances in buildings across America, and the fact that they occur basically 24 hours a day, standby losses are estimated to account for about 10 percent of all household power consumption.

To try and address this problem, I inserted an amendment in the 2007 energy bill that required that any electronic device or appliance purchased by the federal government use less than one watt of power while in standby mode. I was pleased that the House subsequently expanded this provision to incorporate standby power into all products already subject to federal efficiency standards.

Lawrence Berkeley National Laboratory has been a world leader in identifying and explaining the standby power problem. Can you describe the standby power problem in the United States and the prospects for reducing this growing demand source?

How would you assess the how well federal agencies are complying with the standby power provisions in the 2007 Energy Bill? What have been the resulting benefits to taxpayers from reduced federal energy use?

Answer. My colleagues at Berkeley Lab estimate that standby power—that is, the electricity use of appliances while switched off or not performing their primary functions—is responsible for roughly 8% of residential electricity use and 1% of global carbon emissions. In California, for example, the average home has about forty appliances continuously drawing electricity.

EISA'07 requires DOE to take into account standby when establishing new energy efficiency regulations for new appliances and in government purchasing. The DOE can better comment on what I believe is its considerable progress towards implementation; however, I would like to reflect on three aspects that deserve further consideration.

1) First, the definition of the standby mode set out in EISA'07 is potentially restrictive and difficult for DOE to convert into effective regulations. I would recommend authorizing additional research to create a clear definition.

2) Second, EISA'07 treats standby power in the context of each appliance. In some cases it is simpler, from both technical and administrative perspectives, to think of standby as a "horizontal" issue affecting many types of products. I would recommend authorizing DOE to regulate certain kinds of functionality across many energy-using products rather than on a product-by-product basis. This approach will also be valuable when dealing with time of use pricing and with "smart" appliances communicating with the proposed "smart" grid.

3) Third, EISA'07 focused on standby power use in products already covered by energy efficiency standards. This is understandable: however, recent research by my colleagues suggests that standby power use is growing most rapidly among the hundreds of smaller products. The energy use of each of these products is small, but the combined impact is significant. I would recommend consideration of a "horizontal" approach to reduce the electricity use of these smaller devices.

With regard to Federal procurement of low standby products, I would like to note that this activity originated with a presidential Executive Order (13221) in 2001. Berkeley Lab has been active advising the Federal Energy Management Program (FEMP) in its implementation since then. For example, we advise FEMP about the appropriate standby level for each product. Products complying with the Executive Order (and now EISA) are listed on a website presently managed by Berkeley Lab (oahu.lbl.gov). No evaluation of EISA's impact has taken place but anecdotal evidence suggests that federal purchasing specifications with respect to standby power have strongly influenced the way manufacturers design equipment for both the government and public.

With regards to prospects to reduce standby power, I believe that considerable savings are still possible although the problem has become much more complex in the last decade. Increasingly, appliances and consumer electronics need to stay continuously linked to a communications network and perform other functions even when they are not truly "on". As a result, many new low-power modes are appearing, all consuming significant power. An important research task will be to ensure that consumers gain the functionality that they desire in future devices but in the most energy-efficient way possible.

RESPONSES OF CHARLES ZIMMERMAN TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. What are some examples where the market has moved energy efficiency in the right direction regardless of government mandates?

Answer. Because energy is Wal-Mart's second largest operating expense, we've been focused on efficiency practically since the day we were founded. Over the years we've taken a number of innovative steps to become more efficient, most or all of which were adopted without a government mandate. Because lighting accounts for

one third of our energy consumption, it provides a good example of energy efficiency measures we've taken. We've developed a daylight harvesting system that is utilized in more than 95% of newly constructed Wal-Mart Supercenters and Sam's Clubs. By integrating dimmable T-8 fluorescent lamps, electronic continuous dimming ballasts, computer-controlled daylight sensors, and approximately one skylight for every 1000 square feet, we take full advantage of natural daylight. Daylight harvesting can reduce up to 75% of the electric lighting energy used in a Supercenter during daylight hours. Each daylight harvesting system saves an average of 800,000 kWh per year, which is enough energy to power 73 single family homes (11,020 kWh average annual usage) for an entire year.

Question 2. The federal and state governments have been engaged in several standardized programs to promote energy efficiency in the last few decades. It is also true that there have been advances in energy efficient technology without the government playing a role. Please describe the pros and cons of these two approaches.

Answer. We believe that governments at the state and/or federal level and the private sector each have a role to play in achieving greater efficiency. Federal and state incentives and mandates have played an important part in achieving efficiency gains over the last few decades, while the private sector has driven the innovative products and practices that have helped to meet, or—in our case—exceed federal and state requirements.

Question 3. The recent stimulus bill directs billions to energy efficiency measures. How can these funds be targeted to be most effective?

Answer. We believe that state and local governments are uniquely positioned to distribute stimulus funding based on their specific needs and the criteria established in the American Recovery and Reinvestment Act of 2009.

Question 4. Also, as you know, $3.1 billion of energy efficiency block grants came with preconditions, namely energy efficiency rulemaking measures and updating building codes. Are you concerned with the inevitable delay in getting the energy efficiency funding out to states and localities?

Answer. Given that the stimulus bill became law a few short weeks ago, we believe it is too soon to judge whether or not the conditions placed on additional state energy grants will result in funding delays.

Question 5. In the 2007 Energy Independence and Security Act, Congress authorized an initiative for the development and establishment of zero net energy commercial buildings which applies to any commercial building newly constructed in the United States by 2030 as well as 50% of the of the commercial building stock of the United states by 2040. Groups such as the American Institute of Architects (AIA) have endorsed an immediate 50% reduction in fossil fuel-generated energy and a 10% reduction target every five years until new and renovated buildings achieve carbon neutrality in 2030.

Have we made any progress on these initiatives?

Answer. We have been in discussions with DOE and the National Labs regarding the potential of this program and Wal-Mart's involvement. The details of the specific program and what we will do, if anything, has not yet been determined. We'll be sure to update you as we make progress.

Question 6. Please explain how your partnerships with other private entities have led to more energy efficient products coming into the market. Have these partnerships been cost-effective?

Answer. The story of our partnership with Lennox Industries, cited in my testimony, is a great example of how we've been able to work with our partners to push the envelope in terms of efficiency gains. According to Lennox, the rooftop heating and cooling unit they developed for us is "up to 66% more efficient than U.S. Department of Energy Regulations." That unit is the one that has been installed on all of our new U.S. stores and retrofits over the past year. We believe that partnerships like this one are cost effective for us and good for our customers.

Question 7. Wal-mart has the luxury of building most, if not all, of their own stores in the United States. 'New construction stores,' provide you the opportunity to make these buildings energy efficient from day one. What steps have you had to take with existing structures in the United States, the UK and Japan that you have purchased to incorporate into a Wal-Mart? What challenges have you had?

Answer. With the exception of daylight harvesting, most of our other energy initiatives are easily retrofitted into existing stores. Our stores in all of our countries are expected to meet the same corporate / global goal of reducing greenhouse gas emissions by 20% by 2012. All of our countries share their best practices with one another as to how they are going to achieve this goal. Regarding the U.K., they have already exceeded this 20% goal in only half of the allotted time frame.

Question 8. You make a very important point that as efficient as your equipment might be, without the proper control technology, your systems will never meet energy efficiency expectations. Can you elaborate a little on the 'sophisticated energy management system' you use to monitor all of your stores from the home office in Bentonville, AR? Do you have any thoughts on how this could be translated into a smart grid system?

Answer. The Energy Management System allows us to monitor and control the heating, air conditioning, refrigeration and lighting systems for all stores and Sam's Clubs from Wal-Mart corporate headquarters in Bentonville, Arkansas. Through the EMS we are able to constantly monitor and control energy usage, analyze refrigeration temperatures, observe HVAC and lighting performance, and adjust system levels from a central location 24 hours per day, seven days a week. This system is sophisticated and complex, but the functionality it provides is quite simple: we can control our energy intensive systems in real-time to conserve and use energy more efficiently. While the households of the everyday Americans who shop in our stores may not require this level of interaction, the promise of smart grid is that a version of these very technologies will allow residential and smaller commercial consumers to similarly make informed decisions about when and how to consume energy.

Question 9. What has been the result of you sharing your information and results with EPA, DOE, etc.?

Answer. One result was the formation of the Retailer Energy Alliance (REA) at the Department of Energy. The REA provides a forum for leading retailers to share information about energy efficiency and conservation practices. Topics of focus include HVAC systems, refrigerated display cases, interior and exterior lighting systems, and integrated energy management systems.

Question 10. What was it that prompted Wal-Mart to make energy efficiency adjustments, with the end goal of ultimately achieving 100% renewable energy in your stores?

Answer. Energy efficiency has always been a business priority for Wal-Mart. In 2005, our then-CEO Lee Scott announced a new corporate sustainability initiative that had among its overarching goals for Wal-Mart to ultimately be supplied by 100% renewable energy. Mr. Scott believed that a strong commitment to sustainability would make Wal-Mart a better and more innovative company and that as a leading corporate citizen, we could contribute to America's energy security, provide more sustainable products to our customers, and maintain our commitment to low prices while addressing the real challenge of climate change.

Question 11. Have your collaborations with Lennox Industries, and perhaps others, helped bring new efficient technologies to market that otherwise may not have been developed? If so, please explain.

Answer. Our collaboration with Lennox grew out of our sustainability commitments and has been an important partnership for each of us. We've recently taken another step in our sustainability commitment by creating the Wal-Mart Green Jobs Council comprised of leading technology manufacturers to discuss ways to get more innovative technology into the field by marrying Wal-Mart's large scale market demand with innovation in design and supply of more sustainable technologies from Wal-Mart's vendor community, with the end of goal of preserving, protecting and creating more green jobs in the U.S.

APPENDIX II

Additional Material Submitted for the Record

STATEMENT OF THE DEPARTMENT OF ENERGY

BUILDING TECHNOLOGIES: PROGRAM OVERVIEW

Today, the nation's 113 million households and more than 4.7 million commercial buildings consume more energy than the transportation or industry sectors, accounting for nearly 40% of total U.S. energy use, including:[1]

- 72% of electricity and 54% of natural gas
- Energy bills totaling $392 billion each year
- Contribute to 38% of Carbon, 18% of Nitrogen Oxide, and 55% of Sulfur Dioxide emissions
- Construction and renovation accounts for 9% of GDP and eight million people are employed in the sector

The Building Technologies Program (BT) develops technologies, techniques, and tools for making residential and commercial buildings more energy efficient, productive, and affordable. BT's strategic goal is "To create technologies and design approaches that enable net-zero energy buildings[2] at low incremental cost by 2025. These efficiency gains will have application to buildings constructed before 2025 resulting in a substantial reduction in energy use throughout the sector."[3] To accomplish this goal, BT utilizes three strategies:

- Research and Development
- Technology Validation and Market Transformation
- Appliance and Commercial Equipment Standards

The R&D subprogram has a whole buildings approach to energy efficiency, considering the system interactions to develop optimal solutions to Zero Energy Buildings.

- Residential buildings are addressed through Building America and the Builder's Challenge, which conduct systems research with builder partners to reach Zero Energy Homes by 2020.
- The Commercial Buildings works towards Zero Energy Buildings through:
  - —National Energy Alliances—associations of building owners and operators who share best practices, ideas, and needs for energy efficient technologies and services
  - —National Accounts—builders and owners who commit to build new buildings that use 50% less energy[4] and retrofit existing buildings for 30% energy savings.
- Emerging Technologies develops the new technologies and strategies that address technical and market barriers to energy efficiency. These technologies include advanced lighting, building envelopes, windows, space conditioning, water heating, solar heating and cooling, and appliance technologies.

Technology Validation and Market Transformation addresses market transformation ensuring energy efficient technologies are implemented in homes and

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[1] 2008 Building Energy Data Book.

[2] A net-zero energy building is a residential or commercial building with greatly reduced needs for energy through efficiency gains (60 to 70 percent less than conventional practice), with the balance of energy needs supplied by renewable technologies.

[3] 2008 Building Technologies Multi-Year Program Plan. http://www.eere.energy.gov/buildings/publications/pdfs/corporate/myp08complete.pdf

[4] Compared to ASHRAE 90.1-2004.

businesses, through ENERGY STAR, Building Energy Codes and Energy Smart Hospitals and Schools.

Appliance and Commercial Equipment Standards program addresses the growing legislative requirements to increase energy efficiency by implementing national efficiency standards for appliances and commercial equipment. By eliminating the most inefficient technologies, the program saves consumers money and reduces energy consumption.

INTERNATIONAL COUNCIL OF SHOPPING CENTERS, INC.,
OFFICE OF GLOBAL PUBLIC POLICY,
Washington, DC, February 26, 2009.

Hon. JEFF BINGAMAN,
Chairman, Energy and Natural Resources Committee, U.S. Senate, 304 Dirksen Senate Building, Washington, DC.

Hon. LISA MURKOWSKI,
Ranking Member, Energy and Natural Resources Committee, U.S. Senate, 304 Dirksen Senate Building, Washington, DC.

RE: Hearing on Reducing Energy Consumption in Buildings

DEAR CHAIRMAN BINGAMAN AND RANKING MEMBER MURKOWSKI: Thank you for this opportunity to add to the record of your February 26, 2009 Senate Energy Committee Hearing seeking recommendations for reducing energy consumption in buildings through innovative federal energy efficiency policies and programs.

The International Council of Shopping Centers (ICSC) is the premier global trade association of the retail real estate industry. Founded in 1957, ICSC has more than 70,000 members in the U.S., Canada, and over 90 other countries. ICSC represents owners, developers, retailers, lenders, and other professionals as well as academics and public officials. ICSC has over 5,000 public sector members including mayors, city managers, and economic development and planning professionals. Among its many initiatives, ICSC promotes retail development in underserved urban and rural markets. ICSC's award winning Alliance Program encourages public-private partnerships and open dialogue on emerging issues impacting the retail real estate industry and the quality of life in local communities, including sustainability and energy efficiency.

ICSC's membership is well aware of the need to enhance energy efficiency together with overall economic efficiency—particularly in times of economic crisis. Yet ICSC is also aware that well intended efforts to impose goals for specific reductions in energy consumption may inadvertently result in economic harm to thousands of small entrepreneurs, their employees and their customers.

The shopping center industry recognizes better than anyone that "one size does not fit all." This is as true for the commercial property sector as it is for shoes.

Therefore, ICSC would like to take this opportunity to highlight a few of the distinct features of the retail real estate industry in the hope of informing the discussion as Congress moves forward with a national energy efficiency policy. Obviously, any such list will be incomplete but ICSC hopes this information can serve as the beginning of an important and necessary dialogue on diversity within the real estate industry.

TENANT MIX

The tenant mix within a shopping center or mall determines the energy consumption profile of the overall property. For example, a grocery store (with significant refrigeration requirements) will consume more electricity than a similar-sized shoe store. A restaurant may consume more energy than a comparably sized boutique. The tenants present in any particular shopping center will be determined by a wide array of economic and demographic factors—and the tenant mix will change over time.

Because of this complexity in the multi-tenant retail sector, Energy Star benchmark ratings are not available for this format of commercial property. Therefore, any federal legislation that relies upon or incorporates Energy Star ratings should reflect this fact.

COOLING AND HEATING

Shopping centers and malls generally have a central unit to provide heating, cooling and ventilation (HVAC) for the "common area" only. This general rule has many exceptions among enclosed mall properties but fewer exceptions at non-enclosed shopping centers such as the typical grocery-anchored neighborhood center. There-

fore, most retail tenants will have a separate HVAC unit on the roof. Multiple sizes and numerous manufacturers may be represented on a shopping center's roof because the size and specifications for the HVAC system serving a tenant's premises will be dictated by that particular tenant's needs and the size and configuration of its premises.

TRIPLE NET LEASES

Most shopping center tenant leases are "triple net" leases. While not unique to retail properties, the triple net lease is pervasive among shopping centers. A triple net lease is one where the tenant pays a base rent as well as the tenant's proportionate share of the expenses incurred by the landlord to operate the overall property. These expenses include real estate taxes, property insurance and some repair and maintenance costs. The tenants also typically pay for the costs to operate their premises, including electricity consumption. There are many varieties of the triple net lease and the details vary between properties—even within a single multi-tenant property—and from landlord to landlord and from tenant to tenant.

As if this contractual diversity were not enough of an obstacle to rapid changes in pre-existing procedures, the traditional "triple net" lease often lacks financial incentives for the landlord to enhance the energy efficiency of an operating shopping center or mall. The reason for this is that the landlord will typically have to bear the upfront cost of the energy efficiency upgrade, while the tenants typically would enjoy the benefits of reduced energy costs.

The retail real estate industry is developing appropriate lease clauses to deal with many of the issues created by the traditional triple net approach but it will take many years for existing leases to be replaced by newer versions that take energy efficiency and advanced sustainability practices fully into account.

"DAYLIGHTING" AND SKYLIGHTS

Similar to a modern office building, in the typical multi-tenant retail property, suspended acoustic tile panels are used as the ceiling. Suspended ceilings have generally been seen as an obstacle to the use of "daylighting" (skylights) in shopping centers. "Big Box" stores, which typically lack the suspended ceiling in favor of a "warehouse" look, have been better able to experiment with skylights and have produced impressive results for direct energy savings.

However, for smaller tenants the suspended ceiling can reduce the volume of air that must be heated or cooled, which itself can provide energy savings. And existing multi-level properties have great difficulty incorporating skylights on the lower levels. This is not to say that daylighting cannot provide specific value—only that it should be applied in the proper setting in a decision left to the private property owner.

NET METERING AND DISTRIBUTED GENERATION

Simply "saving" energy will not be enough. If America's economy is to grow with its population we will certainly need additional sources of energy together with improvements in energy efficiency.

Therefore, any federal proposal that mandates or encourages energy efficiency should count toward that goal each building or multi-tenant property's on-site renewable power generation such as solar or wind.

Currently, limitations in solar technologies and manufacturing capacities guarantee that solar is a highercost option than coal. As the technology improves and the cost-per-kilowatt declines there will still be obstacles to widespread use of on-site renewables. In particular, the absence of a consistent national standard for "net metering" means that many utility customers lack a key economic incentive to produce carbon-free power to their maximum potential. Many states have no allowance for net metering and many more have completely inadequate standards, such as extremely low generation limits, or "caps," which discourage the development of distributed and renewable power.

Net metering is simply the regulatory requirement that utilities allow interconnection for customer generated power with a direct offset or payment for each kilowatt hour produced. In those states that allow net metering, when the on-site capacity is fully consumed by the customer-generator, the economic return is equivalent to the retail price for electricity that the customer normally pays. However, many utility companies refuse to pay anything near the retail price for any excess power that is contributed to the grid by the on-site generator. Often, the utility only pays a few pennies per kilowatt hour—a rate the utilities call the "avoided cost." Yet the utility delivers that same power to other customers at the full retail price,

even if the power merely crossed the property line to the next building—or the adjacent tenant in a sub-metered shopping center.

Because individual states have traditionally regulated these market areas, there is a confusing quilt of net metering rules across the country—despite the fact that the electricity transmission system is truly a national asset. Indeed, Congress has recognized the national scope of the distribution grid numerous times, most recently in the energy provisions of the stimulus package dealing such as those addressing the "smart grid" and transmission capacity. National net metering and interconnection rules must be part of any future energy package.

CONCLUSION

The International Council of Shopping Centers and its individual members stand ready to assist Congress as it investigates and eventually addresses the nation's energy efficiency options. In particular, we look forward to helping Congress develop environmentally sound and economically sensible policies to enhance the energy efficiency of private sector buildings.

Again, thank you for this opportunity to join the conversation about this critically important issue.

Respectfully,

KENT JEFFREYS,
Staff Vice President.

STATEMENT OF CONSOL

ACHIEVING 30% AND 50% OVER ASHRAE 90.1-2004 IN A LOW-RISE OFFICE BUILDING

Prepared for: NAIOP

Date published: December 2008

ABSTRACT

This report documents technical analysis aimed at understanding the practical and economical impacts of constructing a defined low-rise office building at levels 30% and 50% above the ASHRAE 90.1-2004 Energy Standard. The model evaluated was a 95,000 square foot, four-story, Class A low-rise office building. EnergyPlus was the simulation tool used for modeling building heating, cooling, lighting, ventilating and other energy flows. Practical, above 90.1-2004 energy features were determined by identifying building enhancements with less than a ten-year utility savings' payback period. The analysis was not successful in identifying practical energy feature upgrades to achieve the 30% threshold. The best scenario evaluated achieved 23% over the ASHRAE 90.1-2004 Standard.

INTRODUCTION

Several studies have highlighted the approaches required to design highly efficient theoretical commercial buildings. Fewer though, have focused on the energy saving potential of actual real world buildings. ConSol responded to a request for proposal from NAIOP asking for an analysis of a recently constructed low-rise office building, and the practicality of building it 30% and 50% above the ASHRAE 90.1-2004 Energy Standard. The intention of this study is to form a high level understanding of the above ASHRAE 90.1-2004 Standard potential in a single model representative of a low-rise Class A office new construction.

The objectives of this study are:

- To construct an energy model that accurately predicts the energy use of the low-rise office building provided;
- To determine the baseline regulated energy use for the building model in specific climate zones in the United States;
- To determine the percent over ASHRAE 90.1-2004 that specific energy feature upgrades provide;
- To determine, via marginal cost of the energy feature upgrades, practical limits of energy features within the building model given a ten-year utility savings' payback requirement.

This report is organized into three parts: methodology, results and findings. Methodology describes the methods and assumptions used in this analysis. Results outline the energy use and energy savings potential of the features evaluated. Sum-

mary reviews the overall results of the study and describes technical barriers encountered.

METHODOLOGY

This section summarizes the methodology and assumptions used in the undertaking of this analysis.

Simulation Software

Due to the important interaction between building energy systems in commercial structures, ConSol deemed it appropriate to use EnergyPlus v2.2 for this analysis. EnergyPlus is the U.S. Department of Energy (DOE) building energy simulation program for modeling building heating, cooling, lighting, ventilating and other energy uses. It is the most advanced building simulation tool to date, building on many popular features of legacy simulation engines, such as BLAST and DOE-2, and including many new capabilities. The EnergyPlus simulations were managed via the DesignBuilder v1.6 platform. DesignBuilder was chosen for its intuitive and powerful 3D modeling capabilities as well as its ability to organize the various energy efficiency measures employed.

Simulation Methodology

A modified version of ASHRAE 90.1-2004 Appendix G was used for this analysis. Modifications include the exception of non-regulated loads, baseline glazing and energy savings, not energy cost, as the above ASHRAE 90.1-2004 metric. Percent savings are based on a code compliant building as described in ASHRAE 90.1-2004 with the exception of unregulated (receptacle and process) loads and baseline glazing percentage. It was deemed appropriate for this study to focus solely on regulated loads as only they could be affected by jurisdictional energy codes such as the International Energy Conservation Code and ASHRAE 90.1 Standard. Baseline glazing was set at 50% to most accurately maintain architectural similarity to the actual building as constructed.

Prototype Building

The scope of this project required analysis of a specific low-rise office building. NAIOP provided construction documents for a recently completed office building with its specifications in the following table:

TABLE 1: PROTOTYPE BUILDING DESCRIPTION

Feature	Description
Building Type	Low-Rise Office
Total Area	95,000 square feet
Number of Stories	4
Average Story Height	14 feet
Class of Construction	A
Percentage of Façade Glazing	50%
Glazing Sill Height	4 feet
HVAC System	VAV with Terminal Reheat and Gas Fired Boiler

Climate Zones

Of the seven International Energy Conservation Code (IECC)/ASHRAE climate zones in the continental United States (as depicted in Figure 1),* the scope of this analysis covers IECC Climate Zones 3, 4 and 5. Table 2 describes the specific cities in which the office building was evaluated. The IECC zones are categorized by Heating and Cooling Days (HDD and CDDs), and range from the very hot Zone 1 to the very cold Zone 7. Additional sub-zones A, B and C denote humid, dry and marine climates, respectively.

*Figures 1–10 have been retained in committee files.

TABLE 2: CITIES AND CLIMATE ZONES EVALUATED

City	Climate Zone
Newport Beach, CA	3B
Baltimore, MD	4A
Chicago, IL	5A

Baseline Energy Features

Energy savings are demonstrated in comparison with a baseline model that is minimally compliant with the ASHRAE 90.1-2004 Standard. Since the 90.1 Standard has separate requirements for each climate zone, the prototype building baseline was modeled individually to each climate zone via the energy feature levels listed in Table 3.

TABLE 3: ASHRAE 90.1-2004 ENERGY FEATURES USED IN BASELINE MODEL

City	Newport Beach, CA	Baltimore, MD	Chicago, IL
Envelope			
Roof	R-19	R-19	R-19
Walls	R-13	R-13	R-13 + R3.8
Floors	R-19	R-19	R-19
Glazing SHGC	SHGC all = 0.19	SHGC all = 0.25	SHGC all = 0.26
	SHGC north = 0.26	SHGC north = 0.36	SHGC north = 0.36
Glazing U-value	0.46	0.46	0.46
HVAC			
EER	10.8	10.8	10.8
Boiler Efficiency	0.78	0.78	0.78
Aux. Energy	3.34 W/sqft	3.34 W/sqft	3.34 W/sqft
Lighting			
Lighting Power Density	1.0 W/sqft	1.0 W/sqft	1.0 W/sqft

It is important to note that while the climate zones evaluated vary from mild to very cold, there are relatively little (slight) changes in the minimally compliant requirements inherent to ASHRAE 90.1-2004.

Energy Efficiency Measures Evaluated

Energy efficiency measures assessed mainly consisted of increasing efficiency in existing energy features of the building. Energy efficiency measures evaluated included:

Enhanced wall insulation
Enhanced roof insulation
Varying levels of exterior glazing
Higher efficiency window assemblies
Reduced air infiltration via the installation of an air barrier
Reduced lighting power densities
Higher efficiency HVAC equipment
Photovoltaic electricity energy generation

Of these measures, several were included as recommendations from the "Advanced Energy Design Guide for Small Offices" (ASHRAE et al. 2004). We did not evaluate all efficiency measures available to office buildings. For measures that could be included in a later study, see Summary.

Cost Data

The majority of cost data was obtained through the "RSMeans Green Building Cost Estimating Database" (Keenan et al. 2006). These costs were usually available in per square foot or linear foot quantities and were multiplied by the appropriate area or distance of material. Increased costs related to HVAC auxiliary energy (fans, dampers, etc.) were determined via "RSMeans Mechanical Cost Data" (Mossman 2005). Few studies have determined the cost increases associated with reduced lighting power density (LPD); however, the "Development of the Advanced Energy Design Guide for Retail Buildings—50% Savings" (Hale et al. 2008) provided insight to possible cost ranges. Although Hale's work was based on a retail model, it was the only reduced LPD costing data found suitable. Infiltration was assumed to decrease 0.15% via installation of an air barrier with cost data found in "Investigation of the Impact of Commercial Building Envelope Airtightness" (Emmerich et al., 2005).

Costs not available from the above sources were determined via personal correspondence with equipment manufacturers. Feature costs are assumed constant at all locations. Table 4 outlines the marginal cost increase, from code compliant material, associated with each energy feature. Marginal cost increases were found by subtracting code compliant feature cost from the upgraded energy efficiency measure cost. Cost estimates were installed costs. Labor and material were included.

TABLE 4: MARGINAL COST INCREASE PER ENERGY FEATURE

Energy Feature	Marginal Cost		Energy Feature	Marginal Cost
Lighting = 0.8 W/sqft	$60,420.00		R-26 Roof	$16,362.73
Lighting = 0.9 W/sqft	$30,210.00		R-32 Roof	$30,387.92
Infiltration = 0.35 ACH	$28,751.52		R-48 Roof	$44,413.11
HVAC—aux.energy = +10%	$29,563.73		R-48 Roof	$67,788.44
HVAC—EER = 12.0 EER	$12,409.11		R-19 Cool Roof	$4,750.00
HVAC—EER = 11.5 EER	$7,332.66		R-26 Cool Roof	$21,112.73
Boiler Efficiency = 90%	$17,500.00		R-38 Cool Roof	$49, 163.11
R-17 Walls	$2,300.65		Window Glazing = 40%	N/A
R-26 Walls	$7,870.63		Window Glazing = 30%	N/A

Payback and Utility Rates

Energy efficiency measure marginal cost divided by annual utility savings provided payback periods in years. Peak kilowatt savings were not included. State average utility prices were taken from data compiled by the Energy Information Administration (EIA 2007) and shown in Table 5:

TABLE 5: AVERAGE COMMERCIAL UTILITY PRICES PER STATE

City	California	Maryland	Illinois
Electricity ($/kWh)	0.1523	0.0847	0.1346
Natural Gas ($/therm)	1.02	1.33	1.04

RESULTS

This section summarizes the performance of the baseline models as well as the energy efficiency measures evaluated.

Baseline Annual Energy Use

The annual energy use of the baseline, minimally code compliant building is shown in Figure 2. Table 6 outlines the breakdown of energy use by building system.

TABLE 6: BASELINE ENERGY USE BREAKDOWN

	Newport Beach			Baltimore			Chicago	
	MMBtu/year	% of total		MMBtu/year	% of total		MMBtu/year	% of total
Domestic Water Heating	271.3	8.3%		271.3	5.1%		271.3	4.2%
Lighting	985.5	30.2%		792.4	15.0%		801.4	12.3%
System Misc.	1229.0	37.7%		1229.0	23.2%		1229.0	18.9%
Heat Generation	486.4	14.9%		2741.4	51.8%		4018.1	61.7%
Air Conditioning	286.0	8.8%		263.0	5.0%		197.8	3.0%
Total	3258.2			5297.1			6517.5	

An important point is the difference in annual energy use between the mild and cold climates. Even though the minimally code compliant model in Chicago has similar building features as the model in Newport Beach, the colder Chicago climate drives the annual regulated energy use to nearly double that of the Newport Beach model.

Comparison of Baseline Model to CBECS' Derived Benchmarks

Since the outputs from the EnergyPlus simulations are theoretical, it is valuable to compare these predictions to available benchmarks of energy use in comparable office buildings. The most recent Commercial Building Energy Consumption Survey (CBECS) database contains energy use estimates for nearly 4.9 million U.S. commercial buildings (EIA 2005). A brief summary comparing our model's energy estimates and CBECS' office building data is summarized in Table 7.

TABLE 7: ENERGYPLUS MODEL VERSUS CBECS COMMERCIAL DATA

	Average of ConSol EP Models MMBtu/year	CBEC Data MMBtu/year
Domestic Water Heating	271.3	494.0
Lighting	859.8	1615.0
System Misc.	1229.0	
Heat Generation	2415.3	3116.0
Air Conditioning	248.9	845.5
Total	4775.3	5225.0

Energy use from fans, dampers and other miscellaneous equipment within the HVAC system are labeled "System Miscellaneous" in EnergyPlus outputs, as opposed to the CBECS' database, which simply adds this energy consumption to the "Air Conditioning" or "Heat Generation" categories. With an approximate 9% difference in overall annual energy consumption, the baseline EnergyPlus model results are reasonable.

Energy Feature Reduction Potential

The following table and figures describe and summarize the percentage above the ASHRAE 90.1-2004 Standard baseline each energy efficiency measure provided. It is important to note that each energy feature was evaluated independently. For example, 5.73% total building energy savings was solely due to reducing the lighting system power in the Newport Beach model from 1.0 watts per square foot (W/sqft) to 0.8 W/sqft.

TABLE 8: ENERGY EFFICIENCY FEATURES AND DESCRIPTIONS

Energy Feature Name	Description
Lighting = 0.8 W/sqft	Lighting power reduced from 1.0 watts per square foot
Lighting = 0.9 W/sqft	Lighting power reduced from 1.0 watts per square foot
Infiltration = 0.35 ACH	Building infiltration reduced from 0.5 air changes per hour
HVAC—aux. energy = +10%	Non direct heating/cooling energy use (fans, dampers, controls, etc.) efficiency increased by 10%
HVAC—EER = 12.0 EER	HVAC cooling equipment efficiency increased from ASHRAE 90.1-2004 minimum

TABLE 8: ENERGY EFFICIENCY FEATURES AND DESCRIPTIONS—Continued

Energy Feature Name	Description
HVAC—EER = 11.5 EER	HVAC cooling equipment efficiency increased from ASHRAE 90.1-2004 minimum
Boiler Efficiency = 90%	Service boiler efficiency increase from ASHRAE 90.1-2004 minimum
R17 & R-25 Walls	Wall insulation increased from ASHRAE 90.1-2004 minimum
R-48, R-38, R-32 & R-26 Roof	Roof insulation increased from ASHRAE 90.1-2004 minimum
R-38 & R-26 Cool Roof	Roof insulation increased from ASHRAE 90.1-2004 minimum + roofing material with solar reflectance 0.70 and emittance 0.75
Window Glazing = 30% & 40%	Exterior facade glazing ratio reduced from baseline ratio of 50%

Energy Feature Payback via Utility Savings

Figures 6, 7 and 8 describe the payback period, in years, required for each energy feature to offset its incremental cost via energy savings. The alternative colored data points labeled "PACKAGE" represent a collection of energy features modeled together. These features were chosen because together would have a collective payback period of approximately ten years. The ten-year period was established in the project scope of work and is considered acceptable to a majority of commercial developers and owners. PACKAGE features are summarized in Table 9.

TABLE 9: PACKAGE ENERGY FEATURES PER CLIMATE ZONE

Newport Beach	Baltimore	Chicago
R-26 Walls	R-26 Walls	R-26 Walls
R-38 Cool Roof	R-38 Roof	R-48 Roof
Lighting = 0.9 W/sqft	Lighting = 0.9 W/sqft	Lighting = 0.9 W/sqft
HVAC—EER = 12.0 EER	HVAC—EER = 12.0 EER	HVAC—EER = 12.0 EER
HVAC—aux. energy = +10%	HVAC—aux. energy = +10%	HVAC—aux. energy = +10%
Boiler Efficiency = 90%	Boiler Efficiency = 90%	Boiler Efficiency = 90%
Infiltration = 0.35 ACH	Infiltration = 0.35 ACH	Infiltration = 0.35 ACH

Practical Limits Over ASHRAE 90.1-2004

With the PACKAGE features noted in Table 9, the Chicago, Baltimore and Newport Beach models achieved 23.0%, 21.5% and 15.8%, respectively, over the ASHRAE 90.1-2004 Standard. These could represent the practical and economical limits of current construction within this office building model. Increased energy features from these levels would drive the PACKAGE payback period well beyond the ten-year time horizon.

Additional energy savings are required to reach the 30% and 50% goals. Outside of increasing building energy features, one way to do this would be to generate electricity via photovoltaic panels. Assuming the same incident solar radiation in Baltimore and Chicago as Newport Beach, Figure 10 describes the approximate solar system size required for the PACKAGE-enhanced models to achieve 30% over the ASHRAE 90.1-2004 Standard.

These systems would cover approximately 11,000 square feet and could be installed on the building rooftop. However, with an installed cost of over $1.1 million (Keenan et al. 2006) and a payback period between 55 and 100 years, they would be economically impractical considering the industry accepted ten-year timeframe.

SUMMARY

Findings

This study was to determine if 30%—50% savings over ASHRAE 90.1-2004 Standard in a defined office building was achievable within a ten-year payback. This report finds that 30%, let alone 50% net site energy savings, will be difficult to achieve in the low-rise office building within the ten-year payback time frame.

The Newport Beach model achieved 15.8% over ASHRAE 90.1-2004. Enhanced energy features used were: R-16 walls; R-38 roofing with a cool roof coating; reduction of lighting power to 0.9 watts per square foot; increasing HVAC cooling efficiency to 12.0 EER; increasing HVAC auxiliary energy efficiency by 10%; increasing boiler efficiency to 90; and reducing overall infiltration to 0.35 air changes per hour. At a marginal cost increase of $169,898.13, this corresponds with a 12.2 year payback via utility savings.

The Baltimore model achieved 21.5% over ASHRAE 90.1-2004. Enhanced energy features used were: R-16 walls; R-38 roofing; reduction of lighting power to 0.9 watts per square foot; increasing HVAC cooling efficiency to 12.0 EER; increasing HVAC auxiliary energy efficiency by 10%; increasing boiler efficiency to 90; and reducing overall infiltration to 0.35 air changes per hour. At a marginal cost increase of $165,148.13, this corresponds with an 11 year payback via utility savings.

The Chicago model achieved 23% over ASHRAE 90.1-2004. Enhanced energy features used were: R-16 walls; R-48 roofing; reduction of lighting power to 0.9 watts per square foot; increasing HVAC cooling efficiency to 12.0 EER; increasing HVAC auxiliary energy efficiency by 10%; increasing boiler efficiency to 90; and reducing overall infiltration to 0.35 air changes per hour. At a marginal cost increase of $188,523.45, this corresponds with an 8.8 year payback via utility savings.

Several energy efficiency measures were not included in this study due to lack of modeling capability, sufficient data or project scope. Measures that warrant future study include solar thermal technologies, geothermal heat pumps, underfloor air distribution systems, radiant space conditioning, evaporative cooling technologies and light emitting diode (LED) lighting systems.

Technical Barriers

As pointed out by Hale et al. in the "Advanced Energy Design Guide for Medium Box Retail" (2008), achieving significant levels above ASHRAE 90.1-2004 cost-effectively requires integrated building design, that is a design approach that analyzes buildings as holistic systems rather than as disconnected collections of individually engineered subsystems. Examples of this type of approach include building design that, at inception, revolve closely around the energy using systems. One approach could be the integration of day lighting, geothermal air conditioning and underfloor air distribution systems. Together, these systems could prove substantial achievement over the 90.1-2004 benchmark. However, the design and subsequent construction of this building, using a holistic approach, would be in significant contrast to standard development practices that are designed to maximize leasable area. This approach is employed by the majority of commercial development in the United States.

As modeled in Newport Beach, a geothermal system (a potential component of a holistic approach) would require more than two acres of space—an impossibility for the project site. Assuming the same bore depth, the geothermal space requirements would increase with colder climates, such as Baltimore or Chicago. In the case of

an underfloor air delivery system, architecture and mechanical design would need to accommodate distribution plenums, therefore increasing relative cost and construction complexities.

There are many examples of successful holistic designs, but in the case of this model, these approaches could be considered impractical. This design philosophy will be a hurdle for the architects and build teams of future commercial projects as it involves additional resources during design and construction.

After upgrading building energy features, solar generation is the current solution for additional energy savings over the 90.1-2004 Standard. However, installed solar cost would need to come down by a factor of five for it to meet the ten-year payback criteria. This presents a significant economic barrier. Federal, state and local incentives can further reduce this barrier.

CONCLUSION

Our model achieved 15.8% (Newport Beach, CA); 21.5% (Baltimore, MD); and 23% (Chicago, IL) over the ASHRAE 90.1-2004 Standard. This was done primarily by upgrading the building envelope insulation and increasing efficiency of energy using sub-systems. Representing the practical limit of current construction, together, these upgrades will save enough energy in approximately ten years to offset their marginal increase in cost. Solar can be used to make up the difference to 30%, but with a payback timeframe exceeding 50 years.

STATEMENT OF DONNA HARMAN, PRESIDENT AND CEO, THE AMERICAN FOREST & PAPER ASSOCIATION

The American Forest & Paper Association (AF&PA) appreciates this opportunity to present the forest products industry's views regarding recommendations for reducing energy consumption in buildings. AF&PA is the national trade association of the forest products industry, representing manufacturers of wood products, pulp, paper, and packaging and forest landowners. Our companies make products essential for everyday life from renewable and recyclable resources that sustain the environment. The forest products industry accounts for approximately 6 percent of the total U.S. manufacturing GDP, putting it on par with the automotive and plastics industries. The industry produces $200 billion in products annually and employs more than 1 million people earning $54 billion in annual payroll. The industry is among the top 10 manufacturing sector employers in 48 states.

REDUCING ENERGY CONSUMPTION IN BUILDINGS

AF&PA and its members are committed to reducing the environmental impact of buildings by encouraging energy-efficient, environmentally responsible choices during the design and construction process. Use of green building ratings systems is one of the most effective means to achieve both energy efficiency, and overall environmental responsibility. Below we summarize the positive attributes of wood building materials and green building rating systems, as well as a few concerns about the inadequacies of some systems.

WOOD PRODUCTS AND "GREEN" BUILDINGS

Wood is among the most energy-efficient and environmentally friendly of all building materials. It is less energy and carbon intensive to produce than competing materials like steel and concrete. Among other positive environmental characteristics, wood stores huge amounts of carbon, contributing to the reduction of CO_2 in the atmosphere. Wood products are a vital component of sound architectural design and construction, while providing inherent energy-saving performance. Wood buildings are readily adapted to reuse or can be deconstructed and individual products reused in new construction. Lastly, wood is a renewable resource, a characteristic of unparalleled environmental value.

Green building rating systems that do not fully recognize the environmental benefits provided by the use of wood products are flawed.

We believe that rating systems should include all credible sustainable forestry programs in the U.S. Equal credit should be given to all programs that meet a commonly accepted set of objective criteria, including globally-recognized sustainable forestry programs, such as the Sustainable Forestry Initiative® (SFI) program or the American Tree Farm System®. They should also include life cycle assessment (LCA). It is critical that rating systems be grounded in objective, scientific criteria based on life cycle impacts. LCA provides objective criteria so that a rating system

or standard yields consistent results through appropriate thresholds and baselines, and allows for the comparison of buildings in different locations on equal terms.

It is also important that green building rating systems be developed in a consensus process that meets the spirit of the American National Standards Institute (ANSI) Essential Requirements[1] or OMB Circular A119. Development of a standard under a recognized consensus process provides transparency and ensures the opportunity for meaningful participation by all groups that will be affected. A true consensus process also has procedures to ensure balance, consideration of dissenting views, and appeals procedures. ANSI is the coordinator of the U.S. standards process and provides strict objective requirements for accreditation of those processes. A credible rating system must be developed using a process that embodies the elements of consensus as defined by ANSI.

Government entities should adopt green building policies that recognize the energy-saving attributes of wood, are inclusive of forest certification programs, based on sound science, including LCA, and have been developed in a consensus process. AF&PA and its members will continue to work with all interested parties to create and promote green building rating systems that meet the above criteria.

GREEN BUILDINGS AND CLIMATE CHANGE

AF&PA recognizes that the environmental impact of buildings is significant. Construction and operation of residential and commercial buildings account for nearly 40 percent of all greenhouse gas (GHG) emissions in the U.S. In particular, the more than 500,000 federally-owned and leased buildings often consume more energy than non-governmental buildings and require billions in energy costs. It is critical that efforts to address climate change through green building construction recognize the positive environmental benefits of wood construction materials.

It has been shown that the use of wood building materials can help mitigate the climate change impact of building construction. The Consortium for Research on Renewable Industrial Materials (CORRIM), a non-profit academic research consortium, undertook a study evaluating the energy and environmental impact of leading building materials. The study concluded that the use of wood-framing in buildings resulted in the generation of 26 percent fewer CO_2 emissions than for comparable steel-frame buildings, and 31 percent fewer than for concrete-frame buildings. Also, the study found that manufacturing wood framing used at least 16 percent less energy than producing steel or concrete frames, and had other environmental benefits, as well.

In addition, the ability of wood products to store carbon is recognized internationally by climate scientists and policymakers, including the most recent guidelines from the Intergovernmental Panel on Climate Change. Nearly one-third of carbon sequestered in forests becomes sequestered in the products made from them. Wood building materials can store carbon for their useful life keeping it out of the atmosphere for decades or even centuries. The EPA estimates that the amount of carbon in wood and paper products is equivalent to removing over 100 million tons of carbon dioxide from the atmosphere every year. This is equivalent to eliminating the carbon dioxide emissions from 18 million passenger cars—13 percent of all passenger cars on the road in the U.S.

GREEN BUILDING RATING SYSTEM CONCERNS

The U.S. forest products industry has been working for several years to assure that green building rating systems provide appropriate recognition for the positive environmental attributes of wood building materials, and follow recognized standard development procedures that assure fair treatment for all stakeholders. Unfortunately, the U.S. Green Building Council (USGBC) has failed so far to incorporate this recognition into its Leadership in Energy and Environmental Design (LEED) green building rating system.

One of our primary concerns with the LEED program is its failure to recognize all credible, sustainable forestry certification programs in its certified wood credit. LEED only provides credit to builders using forest products certified by the Forest Stewardship Council (FSC). No credit is awarded for wood products produced by companies independently third-party certified to the SFI® program standard or the American Tree Farm System® (ATFS)—the two largest sustainable forest manage-

[1] ANSI Essential Requirements: Due process requirements for American National Standards (http://publicaa.ansi.org/sites/apdl/Documents/Standards%20Activities/American%20National%20Standards/Procedures,%20Guides,%20and%20Forms/2008%20ANSI%20Essential%20Requirements/2008%20ANSI%20Essential%20Requirements%20031108.pdf)

ment systems in the U.S., and both accredited by PEFC, a third-party international group. These two programs account for over 100 million acres of forestland, yet are unable to qualify for points under the LEED rating system. This point structure forces builders to either eliminate wood products from their designs, or if they nonetheless use wood, must largely import their wood from overseas to receive LEED credits for certified forest products.

Also, the LEED rating system does not recognize the positive attributes of renewable wood products. For instance, LEED provides credit for using "rapidly renewable materials," which LEED arbitrarily defines as products originating from plants grown and harvested in a 10-year cycle. U.S.-based construction lumber does not qualify for this credit since domestic timber is grown and harvested on a longer rotation. The credit thus benefits exotic crops such as bamboo from overseas or wheatgrass. This suggests that under LEED it would be "greener" to deforest an area of native trees that are being sustainably managed and replace it with a plantation crop of an invasive species like bamboo or wheatgrass. This is an outcome that would have negative consequences for the environment.

Some building codes and a number of green building rating systems rely on an American Society of Heating, Refrigeration, and Air Conditioning Engineers standard, ASHRAE 90.1, to determine minimum building energy performance, while others recognize other state-ofthe-art energy codes. Since 1999, ASHRAE 90.1 has unfairly required greater energy performance for wood wall construction than for walls constructed of other materials. Wood walls quickly become economically uncompetitive due to these more restrictive provisions. Energy codes will only be effective when equal performance is demanded from all building materials. Further, LEED relies entirely on ASHRAE 90.1 to determine energy efficiency and, in the process, not only discriminates against wood products, but gives preferential treatment to steel and concrete, which are permitted to underperform wood walls. Providing users with options in choosing rating systems will also help to mitigate these energy performance penalties imposed by LEED. Further, the Department of Energy should continue to review and revise the energy performance requirements in the codes and standards it references for this purpose.

Additionally, the federal government must turn its focus to the existing building stock. In the case of residential construction, there are more than 70-million one- and two-family dwellings across the country. New starts represent 0.7 percent of all existing one and two—family dwellings. It is important that the federal government focus on the energy performance of existing buildings to maximize impact on energy consumption.

Finally, every existing version of LEED was not developed in a consensus process open to all interested parties. Our industry specifically asked to participate and was rebuffed. The process USGBC used to create and maintain these LEED versions did not meet generally accepted criteria for development of consensus standards. While USGBC has since obtained accreditation from ANSI as a green building Standards Developing Organization, USGBC has not developed any existing edition of LEED through their ANSI-accredited process.

LEGISLATION SHOULD RECOGNIZE MULTIPLE RATING SYSTEMS

As the Committee is aware, several new green building rating systems have been developed and entered the marketplace in the past few years. Growing demand for building "green" is attracting competition in the green building marketplace. We believe this competition is healthy and will result in a rapid increase in the number of green buildings in the U.S., as well as improvements in the rating systems themselves.

As Congress continues to explore this issue and contemplates policy options, we recommend that Congress avoid policies that may stifle competitive forces that are driving the green building rating system movement. We encourage Congress to explore and evaluate the full range of systems now available in the marketplace beyond just LEED. Legislation should not pick winners and losers in the constantly-evolving green building marketplace, particularly as these rating systems are private-sector products. Solely including references to the LEED rating system prevents other credible systems, such as the Green Globes™ system for commercial construction and the National Association of Home Builders' National Green Building Standard for residential construction, from contributing to legislative goals.

CONCLUSION

AF&PA appreciates this opportunity to present its views to the Committee regarding the design and construction of these green buildings. The forest products industry supports the construction of environmentally-friendly and energy-efficient green

buildings. We believe that wood products can contribute greatly towards building green if treated appropriately in rating systems and energy codes. It is, therefore, important that legislation promoting green buildings not specify one rating system, but rather make all credible systems eligible to participate in its provisions. AF&PA and our member companies look forward to working with the Committee and Congress on this important set of issues.

STATEMENT OF J. MICHAEL MCQUADE, SENIOR VICE PRESIDENT, SCIENCE & TECHNOLOGY, UNITED TECHNOLOGIES CORPORATION

INTRODUCTION

As the Senate Committee on Energy and Natural Resources considers energy legislation, United Technologies Corporation (UTC) offers recommendations on cost effective, innovative and environmentally friendly ways to address energy efficiency using a whole building or a "systems" approach. UTC is one of the largest capital suppliers to the building industry worldwide and the development of both sustainable and energy efficient products are of critical importance to the company and the markets and customers that UTC serves.

Increasing energy efficiency in the building sector creates significant opportunities to reduce energy consumption and costs for producers and consumers, to develop new products, to commercialize existing technologies and to create and maintain "green" jobs. Increasing the efficiency of components in buildings—lighting, ventilation and other major elements—has been and must continue to be a key element of a policy to affect lower energy consumption. This document outlines an approach to realizing significant energy efficiency gains in buildings by adapting an integrated "systems" approach to design and operation. The integration of components is what a systems approach is and the full scope of a systems perspective includes the proper sizing of the components as well as the coupling of components together in novel ways. The recommendations contained herein serve the key U.S. goals of reducing dependence on foreign sources of energy, combating climate change and expanding national competitiveness:

- The federal government, in close collaboration with the private sector and academic community, should encourage investment in a "systems" approach to building energy efficiency including a focus on technology research and demonstration projects, performance based measurements, interoperable building systems, and education and manpower training.
- Congress should consider legislation that drives a market transformation in the buildings industry and strategically moves the United States toward net zero energy buildings. A focus on economic recovery, energy efficiency, climate change, tax and green building legislation is encouraged.

NEED FOR ENERGY EFFICIENCY IN BUILDINGS

The opportunity for energy savings through building efficiency gains is tremendous. The building sector consumes about 40 percent of the energy used in the United States and is responsible for nearly 40 percent of greenhouse gas emissions. Compare this with the entire transport sector which represents only about 28 percent of energy use. A 50 percent reduction in buildings' energy usage would be equivalent to taking every passenger vehicle and small truck in the United States off the road. A 70 percent reduction in buildings' energy usage is equivalent to eliminating the entire energy consumption of the U.S. transportation sector. These levels of energy reduction in buildings are achievable but the United States today lacks the market and the underlying science and technology infrastructure to broadly realize these levels of efficiency improvements.

An integrated approach is needed to reduce energy use and greenhouse gas emissions in the commercial buildings sector. The building sector is made up of multiple stakeholders and decision makers, including builders, architects, service and repair companies, owners, realtors, product manufacturers and energy suppliers. Buildings themselves are a complex web of equipment and energy sources that often have limited connections and communications. We believe that integrating the various separate technologies used in buildings, by definition a systems approach, will cut energy consumption and cost. A greater focus on systems requires coordination across technical and policy solutions and among the fragmented building industry.

UTC LEADERSHIP ON HIGH-PERFORMANCE AND SUSTAINABLE BUILDINGS

UTC takes an active industry role in addressing building energy usage. UTC is a co-chair of the three-year World Business Council for Sustainable Development (WBCSD) project on Energy Efficiency in Buildings (EEB). Along with thirteen other major multinational corporations representing various aspects of building design, construction, delivery and operations, UTC is working to identify the barriers, levers, and necessary actions to achieve market transformation and a pathway to net zero energy buildings (NZEB)—those buildings that over a period of a year on average consume no energy. Among other important findings of this project is the fact that professionals in the building industry have widely underestimated the impact of buildings on carbon emissions (by a factor of two) while significantly overestimating the cost of sustainable construction (by a factor of three). This knowledge gap is just one of several barriers to market transformation of the building sector.

Increasing efficiency in buildings boosts productivity through the reduction of energy costs. Developing better products that improve energy efficiency offers new market opportunities. In 2006, George David, at that time the CEO and Chairman of UTC, spoke at the WBCSD meeting in Beijing:

> The lessons I bring from UTC are that we can always reduce costs and increase productivity and performance. The same is true for environmental impacts and potentially to an even greater degree because companies generally haven't worked at these as hard as they have at costs and corporate profitability. Remember that more than 90 percent of the energy coming out of the ground is wasted and doesn't end as useful. This is the measure of what's in front of us and why we should be excited.

UTC has developed product offerings in the area of combined heat and power (CHP) to take advantage of so called "waste heat." By using the heat escaping from prime movers used for power generation—microturbines and reciprocating engines for example—and using this to drive heating, ventilation and air conditioning equipment—for example an absorption chiller to supply cooling or heat exchangers to supply hot water—the overall efficiency of the combined system that supplies power, heat and cooling to a building can move from around 33 percent efficiency of the individual components to nearly 80 percent efficiency of the combined system. This increase in efficiency is what a systems perspective is all about. The fact that the system is located at the point of use allows the building to productively use the waste heat and avoid transmission line losses. The onsite attribute is a key component of optimizing the system's performance.

SYSTEMS APPROACH AND GAPS

Two basic flaws in current design and operation of buildings contribute to poor energy performance. First, the design and construction of commercial buildings do not utilize methodology or tools to identify and quantify interactions, or "coupling," between subsystems. Computational tools are not used initially in the design phase nor are these couplings tracked during the changing construction process. Second, the coupling between subsystems are neither monitored nor controlled to avoid the erosion of performance in operation of the building.

The key innovation in CHP products has been to increase energy efficiency by engineering what have been separate elements into an integrated whole. This is a "systems view" of the thermal exchange, the energy production and the consumption of electric power, cooling and hot water in the building. The integration of subsystems in the CHP products can be enlarged to consider energy efficiency in the entire building, namely looking at coupling through integrated design, delivery and operation of what today are separate systems in the building.

The goal to obtain significant energy efficiency gains should be to design and operate systems and to fully couple the various elements of buildings (e.g., building material, farçade, equipment) that consume energy (e.g., lighting, heating, cooling) with other systems such as sources of information (e.g., fire alarms, access control and other security system devices) that taken together can increase functionality.

The reality of today's methodology and tools is that attempting to couple subsystems—even using higher performance (efficient) components than are routinely used today—does not regularly deliver the levels of efficiency gains needed and, in some cases, provides negative effects from inefficient integration. Case studies show that even new buildings that are constructed with the state of the art "energy efficient" technologies can fail to meet the design intent due to the detrimental coupling of the modified subsystems. A study of high performance buildings by the National Renewable Energy Laboratory (NREL) showed that even with a range of advanced component technology (ground source heat pumps, an under floor air distribution

system, daylighting, and high performance windows), when the systems were not properly integrated, the building measured a 44 percent reduction ratio versus 80 percent when all components were fully coupled. Unfortunately, the NREL results are not atypical and represent a significant barrier to wide scale adoption of high-performance integrated building systems.

The systems approach considers a building as a complex dynamic system that has considerable uncertainty in both operating parameters and the operating environment. The coupling of components is difficult to achieve and requires the development and use of new science and engineering approaches to avoid the detrimental coupling discussed in the NREL work above. The new science, design methodologies and tools will then be used to capture the complex couplings, thus enabling deployment of technologies that can take advantage of the natural dynamics of the building (e.g., natural ventilation, thermal storage concepts).

The misses in the demonstrations of highly efficient buildings point to the promises and to the shortcomings that must be bridged with additional investments in science and technology. The systems approach can realize significant gains in energy efficiency and is a clear pathway to realizing net zero energy buildings.

Technology enablers are emerging in much more capable ways of modeling and simulating building performance (computational abilities) and also much more capable ways of obtaining information from buildings and using the information for real time control and diagnostics (sensing and real time computation and embedded systems). The time is right to make national investments and to bring industry together with Department of Energy National Laboratories and universities to fully realize energy efficient buildings.

RECOMMENDATIONS

Congress should consider and enact legislation that promotes investment in energy efficiency in the buildings sector. The American Recovery and Reinvestment Act provided tax incentives to spur investment in energy efficiency, funding for energy efficiency and green buildings and support for various science and technology programs. Congress should continue to focus on energy efficiency as it considers comprehensive energy and climate change policy. For example, the Senate Energy and Natural Resources Committee will be considering legislation to require utilities to gradually increase the portion of electricity produced from renewable resources. The Committee should include energy efficiency as a component of renewable electricity or clean energy standard legislation to encourage low emission, high efficiency base load energy resources.

Also, as Congress considers climate change, energy, appropriations and tax legislation that sustains a broad portfolio of energy efficient and greenhouse gas reduction technologies, it should support a systems approach to tying these technologies together in commercial buildings and remove regulatory barriers to implementing near- and long-term cost-effective net zero energy building approaches. In addition, energy audits for existing buildings as a component of a comprehensive energy efficiency policy will help ensure that existing property is operating in the way it was designed—significantly reducing waste energy lost as a result of poorly adjusted equipment.

UTC believes that investments to fully realize the benefits of whole building design and operation must address a number of science and technology issues including technology development, standards, organization, facilities and talent.

- Recommendation I: Measurement and Transparency.—The Federal government and especially the National Institute of Standards and Technology should consider establishing common measurements to ensure that building performance can be effectively evaluated by the marketplace. Such evaluation should include the measurement of energy efficiency and indoor environmental quality.
- Recommendation II: Technology and Organization.—The Federal government should create specific research programs carried out in private-public partnerships to maximize the effectiveness of technology development and transition. Research and technology investments must be made in systems: the creation of system engineering practices and associated design processes and tools. The newly established Advanced Research Projects Authority—Energy (ARPA-E) is supported by UTC and the recommendation is to create an office within ARPA-E whose investments would solely focus on systems methodologies, tools and technologies for building energy efficiency. Projects in the ARPA-E portfolio should be conducted on a multi-year basis with joint university-National Laboratory-industry teams.
- Recommendation III: Facilities.—The Federal government should encourage public-private partnerships with incentives to promote facilities that help users

validate and test the performance of hardware and software in a real integrated building environment to reduce risk and enable wide-scale commercialization. Demonstration projects to engage key stakeholders in the buildings industry will reduce risk for deployment to the entire building stock. The DOE Energy Efficiency and Renewable Energy program portfolio should be augmented with systems technology and methods should be matured through relevant demonstration programs that are planned and executed with joint multidisciplinary university-National Laboratory-industry teams.

- Recommendation IV: Talent.—The Federal government should invest in education and training carried out to define the new knowledge and skills required by the methods, systems, and tools for deploying and maintaining systems. University and government buildings and facilities should be used as case studies and demonstration sites for advanced monitoring, control, simulation models, prototypes, component, and systems research. There must be engagement with all components of post secondary education including professional and vocational training with community colleges and other organizations for building design, construction, commissioning, energy analysis, energy accounting, and operations to ensure a talent base that can design, install and maintain building systems.
- Recommendation V: Strategic Roadmapping.—The Federal government should catalyze the movement toward a whole-buildings systems approach in the design of new buildings and the renovation and retrofitting of existing buildings in order to move toward net zero energy buildings. A national roadmap for the development of net zero energy buildings should be constructed jointly by Federal agencies and the private sector to obtain alignment among research, development, demonstration and market transition priorities from government, national laboratories, universities and private industry. The Commercial Buildings Initiative, as authorized under the Energy Independence and Security Act of 2007, may be a vehicle to implement a large and concerted multiyear initiative, with sustained funding and with industry as a full partner, to reduce commercial building energy use through a systems approach.

Thank you for the opportunity to submit this testimony to the Committee. We would be delighted to respond to any follow-up questions regarding this testimony or the recommendations contained within.

STATEMENT OF J. PAULEY, P.E., VICE PRESIDENT, INDUSTRY AND GOVERNMENT RELATIONS, SCHNEIDER ELECTRIC AND CHAIRMAN, HIGH PERFORMANCE BUILDING COUNCIL OF THE NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

Chairman Bingham, Ranking Member Murkowski and members of the committee, I am please to provide the perspective of an electrical equipment manufacturer on the issue of reducing energy consumption in buildings.

My company, Schneider Electric, is the world's electric power and control specialist. We manufacture and market a comprehensive range of products and services for the residential, buildings, industry, and energy and infrastructure markets. Our United States sales were over $3.4 billion in 2008 and we have over 14,000 employees in the United States. Our Square D brand is recognized as the industry leading brand in electrical power distribution.

The National Electrical Manufacturers Association (NEMA) is a trade association of over 400 electrical manufactures. NEMA formed a High Performance Building Council because of the extensive amount of technology and resource that NEMA members have in the energy efficiency arena. This council is a cross section of NEMA members; from lighting systems and controls, to electric motors and drives and from power transformers to building system controls and distribution equipment. For over 75 years, NEMA has been wellrespected in standards writing, and since we are the makers of the energy-efficient technologies, we are happy to be a resource to congress as legislation is formulated to make our country's buildings more efficient.

In the United States, buildings account for 20% of the overall energy consumption. In order to have a significant impact on this energy usage, it is critical that energy efficiency be implemented with a combination of both passive and active energy measures. Passive energy efficiency is achieved through the use of energy efficient devices and by using energy efficient construction for buildings. Efficient construction includes measures such as proper insulation for the building, energy efficient windows and the use of design techniques such as day lighting. Energy efficient devices are electrical devices that are designed for low energy consumption such as energy efficient lighting, transformers and similar equipment. We estimate

that you can achieve a 10-15% energy savings by taking advantage of such passive measures.

Although the passive measures are a good start, there is more to do to fully achieve the potential savings. There are active energy savings to be achieved through proper control and use of the systems within a building. A simple way to think of this is that an energy efficient lamp will save energy, but it still wastes energy if it is left switched on when not needed. By implementing permanent change through monitoring and control of energy usage, another 5 to 15% of energy savings can be achieved above the level achieved with a passive energy approach alone. This means that systems such as lighting control and adjustable speed drives for HVAC systems along with continued monitoring and feedback are critical to sustain the energy savings. Passive and active energy combined can bring up to a 30% savings in overall energy usage for the building.

The need for monitoring of the system and integration with building management systems should not be underestimated. Even the best energy saving devices and systems can quickly lose their energy saving qualities over time if they are not properly monitored. Occupants slip back into energy-wasting behavior and slight changes to even the automatic systems over time can result in a loss of savings. Through proper monitoring and maintenance these changes can be detected and corrective action taken much quicker. We estimate that up to 8% of the expected energy savings can be lost if active monitoring of the building is not in place.

In summary, energy efficiency must be looked at with a lifecycle approach. Passive energy measures are used to fix the basics of the building. An active energy approach is then implemented by optimizing the system through automation and control of the energy using systems. Finally, monitoring of the system along with proper maintenance are used to continuously improve the system to achieve maximum savings.

As DOE programs are implemented and federal policies are developed, the entire lifecycle of the energy efficiency systems must be taken into account. Focusing on only passive systems will yield some incremental results, but not achieve the level of savings that is possible with a complete approach to energy efficiency.

Thank you for the opportunity to provide the perspective of the electrical equipment manufacturing community on what we see as a very important issue for the United States.

STATEMENT OF NAIOP, THE COMMERCIAL REAL ESTATE DEVELOPMENT ASSOCIATION

STUDY SHOWS LEVELS OF ACHIEVABLE ENERGY EFFICIENCY IN BUILDINGS

Results show efficiencies unable to reach 30 percent mandates

HERNDON, Va., February 24, 2009—NAIOP, the Commercial Real Estate Development Association, today released a report that demonstrates the levels of energy efficiency that standard office buildings can reach while remaining economically feasible.

The study was initiated to determine if commercial development could achieve reduction targets of 30-50 percent above the ASHRAE 90.1-2004 standard—the benchmark often cited in legislation and other calls for mandatory reductions.

Using a recently completed four-story, 95,000 square-foot, Class A office building as the prototype, the research modeled the prototype in three climate zones represented by Chicago, Ill.; Baltimore, Md.; and Newport Beach, Calif.

Findings show that although significant energy efficiencies can be achieved (varying by climate zone), reaching a 30 percent reduction above the ASHRAE standard is not feasible using common design approaches and would exceed a 10-year payback. The study concluded that achieving a 50 percent reduction above the standard is not currently reachable.

"The study provides an unbiased insight into the energy targets practical to commercial development today," said Thomas J. Bisacquino, NAIOP president. "Identifying an energy reduction level that is both environmentally responsible and equitable to the developer is essential in protecting the prosperity of commercial real estate."

ABOUT THE STUDY

The study was conducted by ConSol, a California-based independent energy-modeling firm, using the Department of Energy's EnergyPlus v2.2, a building energy simulation program for modeling building energy uses.

Modeling included enhanced wall and roof insulations; varying levels of exterior glazing; higher-efficiency window assemblies; reduced air infiltration via the instal-

lation of an air barrier; reduced lighting power densities; higher-efficiency HVAC equipment; and photovoltaic electricity energy generation.

Using technologies and methods to increase effectiveness, the maximum efficiency reached was 23 percent in the Chicago model. Results across the climate zones vary by more than seven percent, given baseline energy uses in domestic water heating; lighting; heat generation; air conditioning; and fans, dampers and HVAC equipment.

Overall, energy savings, cost increases and payback periods are:

- Chicago: 23 percent in energy savings; $188,523.45 cost increase; 8.8 year payback;
- Baltimore: 21.5 percent in energy savings; $165,148.13 cost increase; 11 year payback;
- Newport Beach: 15.8 percent in energy savings; $169.898.13 cost increase; 12.2 year payback.

"With the results of achieving higher efficiency targets differing so greatly across the climate zones, the study reveals that a 'one-size-fits-all' approach to mandatory energy reductions does not work in legislation or other mandates," said Bisacquino. "It is important that policymakers and others realize the economic consequences that imposing mandated targets will have on the development industry."

Study results show that employing solar generation technologies could close the gap between the efficiencies achieved in the study and the 30 percent above the ASHRAE 90.1 -2004 standard. However, at an installed cost of more than $1 million and a payback of up to 100 years, it far exceeds practical and economical limits.

Additionally, elements of a holistic, integrated design approach that could yield higher energy efficiencies were identified as impractical in the study's building prototype, which represents more than 50 percent of total new Class A commercial construction. For example, in the Newport Beach model, a geothermal system (a component of a holistic approach) required more than two additional acres of space—an impossibility for the project site.

"We recognize that some buildings are able to achieve higher energy efficiencies by employing various holistic design approaches," said Bisacquino. "These approaches could become more economically feasible with new technologies and federal, state and local incentives."

NAIOP commissioned the study as a proactive approach to engage the commercial development industry in advancing an economically prosperous and sustainable built environment. "We are encouraged that study results show that increased energy efficiency and building profitability are not opposing concepts," said Bisacquino.

NAIOP has an ongoing commitment to providing its members with tools, resources and education to aid in the employment of best practices for energy efficient development. In June 2008, NAIOP introduced an Energy Policy (www.naiop.org/resourcecenter/greenresource/energypolicy.cfm) that encourages the development industry to employ every technically feasible, cost-effective, sustainable strategy available to increase energy efficiency of new and existing buildings, and advances public policies that accelerate ongoing energy efficiency and sustainability gains.

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